Research Quality and Organisational Factors: An Investigation of the Relationship

DR.ING. THESIS
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Preface

This thesis has been written as part of the Research Quality Programme at the Norwegian Institute for Studies in Research and Higher Education (NIFU). The programme has been funded by the Strategic Planning Division of the Research Council of Norway. I have been affiliated with the Department of Industrial Economics and Technology Management at the Norwegian University of Science and Technology (NTNU) as a doctoral student.

After finishing a project on university-industry relations at NIFU in 1995, I was asked to participate in the Research Quality Programme and to commit myself to writing a doctoral thesis within that field, as outlined in the programme proposal. I saw this as an opportunity for combining some of my research interests and themes from my educational background like innovation management and organisation theory, and as a chance to enter the interesting field of sociology of science. The study of research quality and its organisational influences also implied a continuation of a line of inquiry at NIFU connected with publication productivity in academia.

The major part of the work has been carried out at NIFU in Oslo. I have also spent about one year in total at NTNU in Trondheim, as required by all dr.ing. students. In addition, I was one semester (autumn 1997) in New York City as Visiting Scholar at the Science Policy Institute, State University of New York at Purchase. The first drafts of the present monograph were made during that period. The research quality chapters (two and five) are based on *Hva er forskningskvalitet? En intervjustudie blant norske forskere* (by M. Gulbrandsen & L. Langfeldt, NIFU Report 7/97). Some of the conclusions about tension and organisational factors have been published in *Forskningspolitikk* 2/2000 and *Forskning* 3/2000.

I would like to thank my main supervisor, professor Sigmund J. Waagø of NTNU, for accepting the task of supervising this complex thesis, for giving valuable comments and for seeing me through the doctoral process. NIFU research director Svein Kyvik, who has been leader of the Research Quality Programme, has given me much feedback and support during the last five years and has been a source of both challenge and security. Professor Henry Etzkowitz has also made important comments, and he has introduced me to international networks and co-operative projects that have been a source of inspiration for me, particularly in times of low motivation for finishing the thesis. Inspiration and comments have moreover come from Ulf Sandström and Jouni Kekäle.

Many NIFU colleagues have made useful remarks to various parts and drafts of the thesis and/or the interview guide, and given other types of support. Thanks to Liv Langfeldt, Jens-Christian Smeby, Dag W. Aksnes, Inger Hagen, Egil Kallerud, Hans Skoie and Karl-Erik Brofoss. NIFU has a good working climate, friendly colleagues and not least excellent library resources and service-minded librarians – Anne Rollefsen and Synnøve Standal.

Jorid Øyen of the Department of Industrial Economics and Technology Management at NTNU has been an important help in the final work phase by arranging the printing of the thesis and by helping to organise the disputation. My father, Johan M. Gulbrandsen, has spent much time reading a final draft looking for errors, inconsistencies and weaknesses in the text, and he has been a good discussion partner concerning the mysteries of the English language.

I would also like to thank the Research Council of Norway for funding this work and for showing interest in my findings at several occasions during the work phase. Furthermore, the informants must be thanked for their time and reflections.

My final thanks go to my wife Elin and my daughter Kristine for their love and support through five years of high workloads and varying degrees of motivation and frustration.

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J. Magnus Gulbrandsen

Summary

The problem in this thesis can broadly be defined this way: *How can the relationship between research quality and organisational characteristics be described?* Many scientists have reportedly produced higher quality work in some research units than they have in others – the social environment has somehow been conducive to the quality of the research products. But how can we characterise these environments? In which way do they influence research quality? And how can this «better work» be described?

Perspective and main research proposals

Research quality has been a popular object of study in recent years, not least following policy documents in which «quality» is a central concept. On the other hand, many investigations have looked at research organisations to find determinants of «performance» or «productivity». However, with only a few exceptions, these studies have used rough quantitative measures of «performance» and have not tried to go deeply into the constituents of «good» versus «bad» performance. The present thesis aims to fill some of the «gap» between these two bodies of literature. As far as I know, this is the first investigation that combines an in-depth focus on research quality with an elaboration of organisational aspects. In addition, my organisation theory perspective – the organisation is partly seen as set of «tensions» that may need to be «balanced» – is relatively new, and has rarely been applied to studies of research units despite strong recommendations.

The question of «good research» has naturally been elaborated as long as humans have carried out research. The philosophy of science has particularly dealt with the validity of scientific inquiry, and the sociology of science have also provided input to the discussion about quality, for instance by elaborating an «ethos» for science. Recent investigations of research quality are rarely inspired by themes like «objectivity», «validity», «truth» and «rationality», maybe because these concepts often are seen as controversial and ambiguous. Based on previous empirical and non-empirical investigations, I have chosen to focus on four elements of quality: solidity, originality, scholarly relevance and utility value. My first main research proposal is: R*esearch quality can be divided into several more or less incommensurable elements, and these elements together constitute major «tensions» in research work*.

On the organisational side, numerous theories, concepts and «organisational paradigms» can be found in the literature, and the criteria for selecting a particular view are unclear and debated. My theoretical starting point is that research organisations can be characterised by *tensions* or «paradoxes» connected with certain aspects or dimensions. There seems to be a certain amount of «creative tension» in the best research units, and high-performing units have been found to display «contradictory» characteristics where factors of *security* and *challenge*, that seem counter to each other, are present simultaneously. Some of the tensions that have been discussed are elitism versus egalitarianism, freedom versus responsibility and basic versus applied research focus. A common claim in the literature is that tensions need to be «balanced» or «maintained» if the organisation is to be innovative and productive over

time. My second main research proposal is: *Research organisations can be characterised by a number of tensions reflecting conflicting criteria of research quality.*

I have chosen to focus on organisational dimensions that emerge as central in earlier investigations of research unit performance. Only a few factors have consistently been established as important: contacts/communication and the calibre of the research staff. A number of other (more or less) important characteristics have been pointed out: leadership, organisational culture/climate, size of groups, financial and material resources, and formal organisation of work, e.g. autonomy and the composition of research groups. My analysis is centred at the *meso* level. Individuals produce research (alone or in collaboration), but they do so in a context. I assume that the meso level is the most productive in generating useful and important theories about the relationship between quality and organisational factors.

Much literature suggests that there is a two-way relationship between quality and organisational aspects. Research quality is not only the result of the efforts of individuals in a context, it is also an influence on researchers' motivation, the pride in what they do and their relationship with others. Furthermore, I see differences between fields of learning (natural science, social science, medical science, technology and the humanities) and institutional settings or sectors (university, institute and industry) as central intermediary variables. Many investigations, both of research quality, research unit performance and individual «publication productivity», have found major differences between fields and between sectors. However, it is not obvious from the literature whether there are common traits to research units regardless of such contexts. My third and final main research proposal is: *The factors that influence quality elements are similar across different organisational and disciplinary settings.*

In addition to contributing to the theory about research quality and research organisations, the thesis has a practical objective – to identify relevant characteristics to improve the management of research and to stimulate research units. In this respect, a thorough literature review seems necessary to inform policy debates. Parliamentary reports on research and strategy initiatives from the Research Council of Norway have called for more knowledge about good research and good research units.

Methodological issues

Following the exploratory purpose of the investigation, its theoretical starting point and its main research proposals, as well as the nature of my object of study, I selected a qualitative methodology with data collection based on «focused interviews». A semi-structured interview guide was made that aimed to touch on all central issues identified from the literature, but with room for flexibility and follow-up questions. A sample of senior researchers, mostly of a certain repute, was selected. The informants, 64 in total, represent universities, institutes and industry in ten different disciplines – basic biomedicine, biotechnology, chemistry, clinical medicine, economics, engineering cybernetics, French language, mathematics, philosophy and sociology. Two assumptions lie behind this choice of method. First, research quality is largely a tacit concept, and explicating the tacit dimension requires a not too structured gathering of data. Second, research quality is defined by central researchers in each discipline through decision-making related to publications, projects and appointments.

My analytical approach follows long traditions in the social sciences. I have looked for broad similarities and differences in the statements of researchers asked to talk about research quality and its determinants. The similarities and differences are initially taken at «face value», i.e. seen as a (more or less good) reflection of the motivations and actions of researchers. I have then constructed a more generalised version of research quality and its relationship with organisational factors. The quality of the methodological approach is discussed in terms of the traditional criteria reliability and validity, based on the assumption that these are important also in qualitative research. To assure the quality of the data and the analysis, I have for instance discussed the fundamental issues of language use and validity in interview studies, and applied a computer programme for data analysis. In addition, I have presented a broad and balanced selection of quotes from the informants and done tabulation and simple counting whenever possible.

Research quality

Turning to the empirical part of the study that deals with research quality, it should first be noted that the meaning of «research» (or e.g. «applied research») varies between scientists, which may be a reason for different specifications of good research. There seems to be more agreement on conceptions of quality. A single research work/project has to satisfy certain specific and/or minimum demands to be «good», while in the long run research works are judged more along a scale of «excellence». 59 informants expressed that my decomposition of quality into four elements was a good or fairly good reflection of their own fundamental criteria of good research. Eleven informants expressed that the decomposition lost one or several central aspects. Probably the most difficult aspect to incorporate into my concepts is a research work's *mediation quality* (how well it is written, for some also how/where it is published). This was particularly mentioned by scientists from soft fields.

Two clear dimensions of originality emerge from the interviews: incremental versus radical and theoretical versus practical. This can vary between settings (discipline and sector), but also with the phase of development of a research field. Only a few informants used the word «solidity» themselves – the vocabulary regarding this aspect seems particularly closely related to the nature of work and the specific methods applied in each field. Relevance was a very difficult term to define. There may also be tensions between what is relevant to users and to other researchers, and between what is relevant in the short and in the long run. Still, it seems natural to maintain a distinction between internal and external relevance (utility), although only the latter made sense to many of the applied researchers. External relevance or utility can be an appropriate demand to basic research given a broad definition, but not given a more short-term and purely «economic» definition.

Disciplinary differences found in prior studies are mainly confirmed. Research quality ideals and dilemmas seem more fundamentally dependent on the institutional affiliation of the researcher, though. The main distinction lies in the weight put on intra-scientific and extra-scientific relevance. At universities, focus is mainly on scholarly relevance and merely a potential for external utility, if regarded as important at all. External utility is on the other hand the main quality criterion for industrial research. What «side» the institute sector belongs to, seems to depend on characteristics of the discipline and not least the special history and environment of each institute. To some degree, however, some institute researchers seem to be «caught in the middle» between what they view as almost incompatible demands for both intra-scientific interest and external utility.

I claim that the first main research proposal has been confirmed, but only partly. There is obviously tension between quality aspects, and the decomposition into four elements worked quite well for a large majority of the informants. However, it is evident that all decompositions, also the one I have proposed, loses a «facet» or «aspect» of research quality. Even after long interviews with experienced researchers prepared to talk about quality, a tacit and «personal» factor remains that is not covered by originality, relevance etc. Good research is something that one «feels» or «experiences» as much as «analyses», and many informants ended long attempts at explication with the phrase «you know good research when you see it». Individual preferences were expressed, and it is difficult to regard this tacit and subjective component as anything but a legitimate and integrated part of research quality that escapes decomposition and to some extent elaboration.

Tensions in research organisations

The second main research proposal can also be claimed partly confirmed. Throughout the investigation, I have elaborated many organisational tensions. These can be tied to research quality in two different ways. First, some organisational aspects can promote one component of quality and restrain another. For instance, user control is beneficial to utility value, but may restrain originality. To make a piece of research solid, original and relevant implies balancing forces that affect the researchers' time use, attention or perspectives. Second, tensions can be «creative», i.e. a source of new ideas and approaches.

The literature mainly recommends that tensions need to be «balanced» – research organisations must incorporate and «sustain» aspects that seem paradoxical. This is corroborated by my findings. Good research units do not choose between social support and more «merciless» criticism and quality standards, they select both, e.g. by creating a good working climate for doctoral students combined with expectations that they contribute to the international literature. Furthermore, they do not aim to be large or small, but rather try to combine the advantages of a small unit (high degree of interaction, flexibility) with those of a large one (stability, better access to funding).

However, three other types of organisational tension can be described that do not necessarily reflect conflicting quality demands. First, we have seen that research units can be characterised by tensions typical of innovative organisations, e.g. the conflict between «chaos» and organisation/efficiency. Second, we have seen that a balance between «security» and «challenge» often is seen as necessary for researchers to remain motivated and creative. Third, some organisational tensions can be due to varying political interests in and around research units, or due to conflicts between «ideal research units» and e.g. workers' rights.

Organisational characteristics

The main findings related to specific organisational characteristics also deserve a brief review in this summary.

Individual-level variables. Numerous studies have looked for characteristics that distinguish the eminent scientists from the rest, the high performers from the low. Regarding psychological characteristics, good scientists reportedly have high inner motivation or dedication to research work. Many investigators have failed to find a relationship between indices of abilities and performance, but this can be due to methodological difficulties. Furthermore, some have found that good researchers have high ego strength, personal dominance, much stamina, capacity to work hard and long-term, and a high tolerance for ambiguity and abstraction. The high performers also work longer hours than other scientists and they often work on an array of problems and/or approaches simultaneously. However, it is sometimes stressed that individual variables do not exist in a vacuum, i.e. the individual's environment can influence whether abilities will be turned into good performance.

This latter point finds support in my interviews. No «archetypal» good researcher emanates from the data, and many informants stressed the role of e.g. one's colleagues, resources and working climate when it comes to providing the feedback, recognition and inspiration needed to support a high performer. Still, a few descriptions emerged consistently: good scientists are highly motivated, they have large workloads and they often work on several problems, methods and tasks simultaneously. Contrary to earlier investigations, my informants emphasised the general social and communication skills of researchers.

Leaders and leadership. Earlier investigations do not provide clear results about the importance of a research unit's leader. At the group level, some describe beneficial effects of having a «good» and «experienced» leader. Others find that leaders rarely are central to performance or that they more often contribute to e.g. destroying creativity rather than promoting it. However, a few authors argue that leaders play an important indirect role, for instance by shaping the culture of the unit, by fostering an «innovative spirit» or by increasing «morale». At the department level, few studies have been carried out, and the literature indicates that the department head has a more political and externally oriented role.

My findings support the claim that group leadership mainly is an indirect or negative influence on quality. One explanation is that there is a strong ideal of «non-interference» – leaders should not «interfere» in the activities of others, particularly the seniors' work and in the university sector. Another reason could be that important tasks like feedback and supervision, project acquisition, maintenance of contact with the international community and coordination of scholarly work, not necessarily are seen as the leader's task, or indeed as having anything to do with «leadership» at all. In addition, I have hypothesised that most leaders do not influence quality very much, only the extraordinarily talented or the poorly qualified individuals do, and they could be rare. The combination of high professional competence and very good social skills seems particularly uncommon. At the department level, an external and political leader role was confirmed, and the position was described as more important in units without group work.

Autonomy/freedom. The literature frequently stresses that good research units are characterised by «autonomy» or «freedom», often combined with a «loose organisational structure». This is seen as a prerequisite for creativity. However, a strong focus on individual autonomy is often found a typical feature of low-rated university departments and poorly performing institute and industrial R&D units. In high-performing units, autonomy is coupled with a common vision, strong group «cohesiveness», active supportive leadership, and high degree of interaction or external pressure. This is supported by my data. Autonomy or lack of bureaucracy was upheld as important, particularly for creativity. Still, it needs to be balanced, e.g. by «a certain structure» or «clearly defined responsibilities» to ensure co-ordination of work and systematic feedback and assistance for support staff and young scientists. A few informants emphasised that autonomy is subjective – what is vital, is that the researchers perceive that they have some individual responsibility and control of own activities. It can be added that group work (formal or informal) generally was viewed as very beneficial to quality.

Diversity of people. Previous investigations mainly indicate that research units (groups in particular) perform better if they consist of people with moderate differences in age, rank and professional backgrounds. My data confirm this relationship. The informants particularly emphasised that both juniors and seniors are needed, and some were concerned with variations in competence, «personality types» and that both male and female researchers should be present in a group. To reap the benefits of interaction, there still has to be a professional common denominator. Some interviewees indicated that there may be a drift towards homogeneity in research units over time.

Diversity of tasks. Regarding this point, the results from earlier studies are clear. Good researchers and organisations do not carry out research only, but they are also active e.g. in teaching, other types of research (basic/applied/strategic), development work and technical consultancy. Particularly engineers and applied scientists can benefit from involvement in many different activities. Again, the results are confirmed by my interviews. Almost all informants emphasised that teaching can be positive to research quality, because it can be a source of inspiration, ideas, feedback and dialogue, as well as a driving force behind reflection, keeping oneself updated, having a broader approach and thinking more rigorously. Development and consultancy work was seen as positive in applied units and by some professors. This helps ensure user relevance and makes researchers more aware of «real» problems. In good units, there is an interplay between professional tasks that is stimulating for the researchers. Diversity (people/tasks) is beneficial to performance for several reasons: diversity increases a unit's intellectual resources, it increases knowledge and skills that contribute indirectly, and it improves people's perception. Another effect is that the individual «tightens up» in a positive way and makes an improved effort.

Group size. There are many investigations of the relationship between group size and research performance, and the results are not unambiguous. Some find a positive relationship, others a negative one and others yet none at all. One reason could be that the effects depend upon other variables like group cohesiveness, the experience and skills of the leader and the disciplinary setting. This latter claim is confirmed by my data. «Optimal» size is conditional, for instance on the characteristics of the work to be done, the leader, the people in the group and the group's wider environment. Many elaborated upper and lower limits concerning the number of group members, and it is evident that small and large groups may have disadvantages. In most disciplines, the margins seem quite wide, however, like «more than two» and «less than ten». As long as there are good opportunities for professional interaction with external colleagues, policies aiming to make groups larger are not likely to have any significant impact on research quality.

Department size. Few investigations have focused on department size, and this does not seem very central to research performance. My data confirm this – both small and large university departments can be appropriate when it comes to producing good research. In institutes and industry, the informants put much weight on the characteristics of the leader when discussing size at the level above groups/projects. It can be added that there may be other arguments for a certain size of departments, for instance «covering the discipline», offering teaching and supervision within many different specialities and administrative benefits (economies of scale or advantages of being small).

Resource levels. No earlier investigation has concluded that resources are an important determinant of research performance, and subjective measures of resources display stronger (yet still small) correlation with quality than more objective indicators do. The lack of importance is confirmed by the present study – a basic level of funding and quality of equipment is required to do scientific work at all, but much money and the best equipment can never guarantee good research. However, units aiming to be among the internationally leading need to have conditions that are «competitive». Many researchers nevertheless emphasised the need for enough time (or patience from contractors) to make the work sufficiently solid and original, and some «slack» or flexibility in the budgets for travels, guests and other expenses. A majority (mainly university professors) claimed that present funding levels leave little room for flexibility, recruitment and e.g. the study of anomalies and serendipitous results.

Informal organisational aspects. Norms, values, working climate, innovative spirit and other informal organisational characteristics (often synthesised in the term «culture») have been elaborated in many previous investigations. The culture of a research unit has in various ways been found a central determinant in a large number of studies. This issue is seen as a precondition for creativity and internal communication and as a source of both challenge and security for the individuals. My interviews concentrated on «working climate», and most informants described this as a central influence on quality. Research work is demanding and requires high levels of inspiration and effort, and very few researchers will manage to remain motivated and productive in a poor working climate, it was claimed. I find that in good research units, the cultural aspects often imply a certain balance between friendly encouragement and ambitious feedback, as well as a middle way between no internal competition and intense competition. Furthermore, I have argued that since good research units often are characterised by high degrees of tension or strain, a good working climate (elaborated with e.g. «friendly atmosphere» and «lots of humour») may be necessary to deal with the ambiguities and conflicting forces in research organisations.

Communication. A high degree of interaction is an essential feature of good research units. Earlier investigations have found that external/international communication is the most important in basic research, while inter-organisational and internal contacts are the most important for applied scientists. Some investigators claim that internal communication is central in all settings. I have found support for both these assertions – communication patterns vary with sector, but good internal interaction was nevertheless described as pivotal by almost all informants. The main sector difference is that user contacts were put much weight on by most applied scientists, but only by a few of the university professors. International scientific communication was emphasised by the industrial interviewees, but this may be due to particular characteristics of my informants. Industrial and particularly institute informants underlined that they needed to maintain close contacts with both users and universities. A «hybrid» combination of contacts is probably necessary for applied units that simultaneously need to ensure user relevance and to maintain competencies in the long run to remain viable. In addition to conferences, seminars, project collaboration etc., my informants stressed the importance of general interaction, e.g. eating out together or going to the pub. Scientific communication is obviously a type of social exchange with expectations of reciprocity and balance based on trust. Friendship and general social interaction contributes to building trust, which in turn leads to increased scholarly exchange. This exchange is a two-way process, hence, if you have nothing to contribute, e.g. because your projects have been «too applied» or confidential, you may be shut out of important scientific communication processes. This can be dramatic, because communication is not only a source of feedback and inspiration, but also can be a means of gaining access to unpublished information, research materials and other resources.

I see the third main research proposal as largely confirmed – the mechanisms or processes that constitute the link between research quality and organisation factors seem the same across institutional and disciplinary settings. In the interview material, no clear disciplinary differences can be seen when it comes to the benefits of external contacts and internal interaction, the role of diversity of people and tasks, the negative effects of isolation and personal conflicts and the need to identify and recruit scientific talents. The processes through which creativity and motivation can be influenced seem the same everywhere, and almost all informants proposed a strong link between motivation and productivity. A sharp relationship between creativity on the one hand and freedom, little «bureaucracy» and an open and tolerant culture on the other hand, was maintained in all settings. Concrete resource and equipment requirements and communication patterns vary between settings, but the processes by which research quality is influenced by organisational factors nevertheless appear very similar. Different specifications of solidity demands, criteria of originality and types of relevance can largely provide explanations for the variations in organisational specifications. Thus, some processes and relationships are similar in all settings, and they constitute a common denominator for all types of research work. It must be added, however, that this does not mean that «diversity» is not a primary characteristic of the research system as a whole. On the contrary, the focus on «scholarly relevance» in some units and «practical utility» in others makes a tremendous difference. What I have argued is that organisational aspects and mechanisms influence the same elements of quality regardless of setting.

Implications

My analysis has theoretical implications primarily for literature concerned with research quality and literature seeking to understand research organisations. The efforts to link these two traditions also have some implications. I have shown that a moderately complex decomposition of quality is valid in many types of research work. In addition, my elaboration of terms like originality, solidity and relevance has taken the quality literature a step further, as most

of the earlier investigations largely have left such terms undefined. These specifications can help understand the dilemmas evident in various types of research assessments. My focus not only on universities but also on institutes and industrial R&D units has furthermore yielded a useful insight into quality criteria of «entrepreneurial science» – research that aims to contribute both to fundamental scholarly development and to practical aims. There is still a need for more in-depth studies of, for instance, how originality criteria can vary within a research field according to its phase of development and a research unit's orientation towards the international scientific community and user groups.

This investigation has elaborated many earlier processes and relationships found in literature that has looked at research organisations and performance. My comprehensive review and contribution with new qualitative data is of course important to the accumulation of knowledge in this field of inquiry. Many earlier findings are confirmed, some are questioned and a few new ones are sketched. For instance, more than earlier investigations, I have found that general social skills are an important characteristic of good researchers. The reason may be that the research system is becoming increasingly collaborative. Ever more group work, focus on meeting external needs and on ambitions of becoming «world-leading» in select fields, may require a new type of researcher in contemporary R&D work. Of particular interest is perhaps my elaboration of organisational tension. I have specified a number of such tensions and the role they may play in research units. We have seen that they reflect conflicts between quality criteria, and in this respect, tension can be a key word for linking the quality literature with the organisational literature. Tensions may also be seen as a prerequisite for maintaining motivation and creativity as well as an indication of some of the different values and interests that exist in research organisations. The tensions influence individuals' attention, time use, perspectives and relations with others, and a «balance» between opposing forces seems an important factor behind quality and productivity. These findings may also be of theoretical value to students of organisations in general.

An investigation of research quality and research units naturally has practical implications. Fundamentally, I see a good understanding of quality and how it can be influenced as a prerequisite for good management of research and efficient policies. We have seen that the relationship between quality and organisational factors is very complex, and it is not possible to extract a few simple «golden rules» for policy and management from my analysis. For instance, both small and large research units may be good, and the question of size is contingent upon a lot of other factors. This may serve as a starting point for a general practical advice. Answers to central policy and management questions about allocation of resources, distribution of rewards and overall organisation of research work always depend upon the context, e.g. the discipline, sector, phase of development (like new versus old units), characteristics of the leader and the personnel, and the present culture and ambitions. This may imply that the task of improving quality and creating better organisations is largely one for the active researchers, not for the central/top managers and policy-makers. Researchers need to discuss and reflect upon issues concerning organisation and management, as well as experiment with new approaches suited to their particular goals and situation. My interviews can give rise to doubts about whether reflection, discussion and experimentation are at satisfactory levels in many research units today.

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1 Introduction

Many scientists have reportedly produced higher quality work in some research units than they have in others – the social environment has somehow been conducive to the quality of the research products (e.g. Blau, 1973; Pelz & Andrews, 1976; Long & McGinnis, 1981; Thagaard, 1991). Even Nobel Prize winners have in interviews stated that they have done better work in some settings, termed «evocative environments», than they have done elsewhere (Zuckerman, 1977). But how can we characterise these environments? In which way do they influence research quality? And how can this «better work» be described?

In general, the recent decades have seen an increasing interest in research quality, both from theoretical and practical perspectives. From the theoretical side, the concept of research quality has been elaborated and several studies have aimed to discover sources or determinants of «research performance» in individuals and organisations. From the practical side, research managers and policy-makers have been preoccupied with finding ways to «improve» and «prioritise» quality, and to organise and manage research units and systems for this purpose.

1.1 Problem

In this thesis, the central objective is to investigate the relationship between research quality and characteristics of the wider organisation in which the research work is carried out. The problem can broadly be defined this way:

> *How can the relationship between research quality and organisational characteristics be described?*

There are several previous investigations of the concept of research quality and how it can be elaborated further (e.g. Chase, 1970; Hemlin, 1991; Buchholz, 1995; Kaukonen, 1997; Andersen, 1997). Focus has mainly been on more or less in-depth specifications of good research, but the question of why some individuals or organisations produce better research than others, has barely been touched upon in this literature. On the other hand, many investigations have looked at research units or organisations to discover «determinants of performance» (e.g. Pelz & Andrews, 1976; Andrews, 1979a; Hare & Wyatt, 1988; Nagpaul & Gupta, 1989; Sing & Krishnaiah, 1989; Spangenberg, 1990a and b; Harris & Kaine, 1994; Asmervik *et al.*, 1995 and 1997; Bennich-Björkman, 1997). However, with only a few exceptions, these studies have used more or less rough quantitative measures of «performance» and have not tried to go deeply into the constituents of «good» versus «bad» or «high» versus «low» performance. In addition, the quantitative methodology that has been applied in the majority of these studies might have revealed a relationship between variables, but the processes underlying the relationships are poorly understood, as is their direction.

The present thesis aims to fill some of the «gap» between these two bodies of literature. I will elaborate the research quality concept and try to decompose it into several «sub-elements», and I will analyse the relationship between these elements and organisational characteristics, focusing on the processes by which these characteristics influence quality. As far as I know, this is the first investigation that combines an in-depth focus on research quality with an elaboration of organisational aspects. In addition, my organisation theory perspective – the organisation is seen as a «balance» or «maintenance of balance» between different «tensions», «paradoxes» or «dilemmas» – is relatively new, and has rarely been applied to studies of research units despite strong recommendations (for instance Foss Hansen, 1995; Dougherty, 1996).

1.1.1 Conception of research quality

Nature and society do not provide us with clear specifications of research quality. Fundamentally, I see definitions of good and bad research as being constituted by the many judgements of quality that are carried out connected with evaluations (of proposals, manuscripts, etc.) and not least in the daily work of scientists.[1] I assume that particularly senior scientists play a crucial role in determining good and bad research through citing or using others' research in their work and through the peer review processes that they participate in.

The question of «good research» has naturally been studied as long as humans have carried out research. The philosophy of science has dealt particularly with the validity of (different forms of) scientific inquiry, and the sociology of science and other fields have also provided input to the discussion about quality, for instance by specifying an «ethos» for science (e.g. Merton, [1942] 1973). Recent empirical investigations of research quality are rarely inspired by fundamental discussions about themes like «objectivity», «validity», «truth», «confirmation», «simplicity» and «rationality», maybe because these concepts are often seen as controversial and ambiguous (cf. Tranøy, 1986; Toulmin, 1992, Fuchs, 1997). I will elaborate briefly on such issues, but I will propose a decomposition of quality that is similar to the one found in other empirical studies (like Hemlin, 1991) where more «everyday» terms like «originality,» «solidity,» and «relevance» are used. My first main research proposal is that research quality can be divided into several more or less incommensurable elements, and that these elements together constitute major «tensions» in research work. This proposal will be developed in chapter two and illuminated empirically in chapter five.

1.1.2 Organisational perspective and level of analysis

On the organisational side, numerous theories, concepts, and «organisational paradigms» can be found in the literature, and the criteria for selecting a particular view are unclear and

[1] In the general parts of the thesis I use the term «science» (as well as «scientists», «scientific» etc.) in a broad sense more in line with the Norwegian «vitenskap», i.e. including social science, technology, and the humanities (although not everybody would include the latter two in the Norwegian concept either). This is done to avoid long phrases like «science, social science, technology and the humanities», and to achieve some variation in language instead of only referring to for instance «research», «researchers» and «research work.» Differences between fields of learning and disciplines are nevertheless a natural part of the thesis. When discussing such differences, I specify e.g. the «natural sciences».

debated (cf. Clegg & Hardy, 1996; also Pfeffer, 1982; Scott, 1992). My theoretical starting point is that research organisations can be characterised by *tensions* or «paradoxes» connected with certain aspects or dimensions. Some tensions that should be evident are for instance norms of elitism versus egalitarianism, responsibility/accountability versus freedom, and independence versus interaction in communication patterns and the formal organisation of work (see Pelz & Andrews, 1976; Foss Hansen, 1991 and 1995; Dougherty, 1996). My second main research proposal is that there are several such organisational tensions, and that they reflect inherent tensions in the quality criteria. This proposal will be specified further in chapter three and the first subchapters of chapters six through eleven, and dealt with empirically in chapters six through eleven.

The most relevant organisational dimensions will be drawn mainly from previous investigations of research unit or group performance, implying that more «macro-level variables» will not be much touched upon. Although for instance the impact of level and type of research funding will be elaborated, I do not *per se* investigate the overall structure of programmes, funding and control in the research system. Only a few factors have consistently been established as important to research performance: contacts/communication and the calibre of the research staff. Some investigations have pointed to a number of other (more or less) important characteristics: leaders and leadership, the organisational culture or climate, size of groups, financial and material resources, and the formal organisation of work, e.g. autonomy and the composition of research groups.

My analysis will take place at the *meso level* (cf. Nord & Fox, 1996). Organisations do not produce research; individuals do (alone or in collaboration), although they do so in a context (Weick, 1979; Fox, 1983). In my opinion, the importance of individuals will emerge by looking at other problems rather than studying characteristics of researchers by themselves (although I in general view individuals as one of the constituents of organisations, cf. Scott, 1992; also Pfeffer, 1982). Hence, I will not go deeply into individual-level variables like skills, experience, personality traits etc., and instead look at how some central characteristics (for instance creativity and motivation) influence, and are influenced by, the organisation.

1.1.3 Dynamic processes and intermediary variables

Much literature suggests that there is a two-way relationship between quality and organisational characteristics, a «dynamic reciprocal causality» (Nord & Fox, 1996). Many dynamic processes have been described in research organisations, e.g. that resource levels are affected by the quality (or impact, relevance, etc.) of previous research (see Merton, [1968] 1973; Blau, 1973; Cole & Cole, 1973; Pelz & Andrews, 1976; Latour & Woolgar, 1979; Katz & Allen, 1982; Kyvik, 1991; de Haan *et al.*, 1994; Kim & Lee, 1995). Research quality is not only the result of the efforts of individuals in a context, it also influences the researchers' motivation, the pride in what they do, and their relationship with others. It can be added that little is known about how research units evolve over time, particularly regarding the start-up of (subsequently) high quality units, although there is some indication that this can be tied to extraordinarily talented individuals (e.g. Zuckerman, 1977; Jacobsen, 1990; Bennich-Björkman, 1997).

In addition, I see differences between fields of learning (natural science, social science, medical science, technology and the humanities) and institutional settings[2] or sectors (university, institute, and industry) as central intermediary variables. Many investigations, both of research quality, research unit performance and individual «publication productivity», have found major differences between fields and between sectors (e.g. Allen, 1977; Cole, 1979; Hemlin, 1991, Kyvik, 1991; Martin & Skea, 1992; Kekäle, 1997). These dimensions are thus likely to be a fundamental source of systematic variation, as well as an explanation for variations in earlier findings, because many studies have gathered data from one discipline or institutional setting only. However, it is not clear from the literature whether there are common traits to research units regardless of such contexts. My third main research proposal is that the factors that influence quality elements, for instance originality, are very similar across different organisational and disciplinary settings. This proposal will be developed in the second half of chapter three and illuminated empirically in chapter twelve.

Finally, it should be added that the thesis also has a practical objective, as most of the earlier investigations in the area have had. A central aim has been to identify relevant characteristics to improve the management of research and to stimulate research units. In general, I view understanding of the meso level, the interface between the individual and the organisational environment, as fundamental to developing fruitful policies and management practices for research units. The practical objective has influenced both my analysis and the writing style throughout the monograph. Particularly in the empirical chapters (six through thirteen) I have had practising scientists in mind when writing, not only scholars in the «social studies of science» field.

1.2 Background – quality in a small country perspective

Reduced funds, more accountability for public expenditures, management trends and ever more group and equipment-based research activities are some of the underlying causes of an increased normative and improvement-oriented focus on research quality world-wide. Much of the concern about quality and its «determinants» has arisen in a research policy context, and there is a need for more scientific investigations of these problems. Quality is in many contexts more than a «neutral» label for good research – it often carries implications for resource allocation, control and other policy and strategy elements. Although everyone agrees that «good» (not «poor») research should be produced, definitions of quality and opinions on how it can be enhanced may differ widely.

Norway is a small nation, and despite its wealth, has to be regarded as a country on the scientific periphery. Less than one percent of the world's total R&D expenditure can be attributed to Norway. The country has four universities and a few colleges with university status, as well as a number of «state colleges» where some R&D work is carried out. The «institute sector» is larger than in many other countries – one third of the total R&D is

[2] The term «institution» is most often used as a synonym to university organisation. When I talk about «institutional differences», however, I refer to differences between *sectors*, i.e. universities, research institutes and industrial research units.

carried out in around 300 organisations classified as research institutes. Forty of these have more than 100 employees. Total R&D expenses in the institute sector are higher than in the university and college sector. Industry's share of the R&D work is lower in Norway than in most other countries, and there are few large companies.

For a small country with limited resources for R&D and a limited range of industries in which the research-based knowledge may be utilised, there is perhaps a particularly strong focus on «getting the most» out of the research funds. This is where the term «quality» enters the policy scene. In Norwegian research policy, two different foci on quality can be discerned.

First, there is a concern that internationally strong research activities should be promoted in select fields, for instance related to industrial clusters or perceived national areas of competence. The latest Norwegian parliamentary report on research names marine research, information- and communication technology, medical research and research in the intersection between energy and the environment, as «special challenges» and as «fields with particularly large potentials for creating economic value» in Norway (Stortingsmelding no. 39, 1998-99:85). Concrete measures have been established as part of such priorities, e.g. Research Council programmes within specific «strategic national areas» and scholarships to exceptionally talented researchers. Also universities have started to give priority to some fields to establish international «centres of excellence», which is seen as a key policy instrument for improving quality in Stortingsmelding no. 39.

Second, policy-makers (and others) have a strong interest in making the «run-of-the-mill» Norwegian research as good as possible. Making this concern explicit seems especially to be a feature of the more recent policy documents from the Ministry of Church, Education and Research, and the Research Council. For instance, the second most recent parliamentary report on research has a separate chapter on quality, mainly oriented towards general improvements of the Norwegian research system (Stortingsmelding no. 36, 1992-93: 101-110). In the most recent one, the issue of quality is a governing idea throughout the document. It is announced that «quality» to a larger extent will be given priority when public funds are allocated, and it is generally stated that «research of high quality shall be promoted and rewarded» (Stortingsmelding no. 39, 1998-99: 56). The former Minister of Church, Education and Research has accused Norwegian researchers of low ambitions and claimed that especially the universities need a change in research culture to improve quality (Hernes, 1986).

Although one can envisage tensions between the more «elitist» and/or «top-down» model implied in a concentration of resources in some fields, and the broader focus on quality from recent years, there is a clear view that both constitute necessary elements of research policy. The challenge is also very similar: to recognise research quality and to link it to environmental characteristics in a way that generates useful knowledge about how (and if) quality can be influenced. The roots of the present investigation can be found in the second most recent Norwegian parliamentary report on research (Stortingsmelding no. 36, 1992-93), where it was stated that (p. 105)

«As a basis for the further work on the promotion of quality, it would be interesting to have a scientific investigation of the specific factors that influence the research units to contribute good research. Although some of the central features of the good environments are known, there is little empirical material at hand about this.»

This thesis is intended as a contribution to that scientific investigation.

1.3 A history of quality improvements

Several questions arise out of the above quote. Is it really implied that, after a half or whole century of large-scale, organised research efforts, the factors that promote output quality are still not very well known? Or are the factors known, but have not been communicated well enough to the policy level? To answer these questions, a short historical overview is fruitful.

Before the 1960's, there was no explicit focus on R&D management and factors that promote good research. There was a steady growth in public funding for research at universities and in the institute sector, with «no strings attached», and it was often argued that «pure» research should have unrestricted autonomy (e.g. Bush, 1945; Polanyi, 1962). Still, a large share of the funds, in Norway as well as in the U.S. and other countries, had social objectives in mind, for instance related to health, energy and national defence. Also, the «linear model of innovation» (cf. Kline & Rosenberg, 1986) prevailed, both in the public and private sector. It was believed that investments in research would «pay off» eventually when research-based products, processes and advice reached the market, policy actors, health services and the population in general.

Universities, research institutes and R&D units of companies were thus mostly left to themselves, led by the units' most distinguished scientists. Even in industry, goals were set based principally on scientific criteria alone (Pelz, 1976), albeit within the frames of a company's current operations and future strategies (White, 1980). There was moreover a strong belief that the production of good research was rooted in eminent individuals and little else, which at a macro level then mostly led to concern about getting enough «talented people» to choose science as a career (cf. Merton, [1938] 1970). Finding that the research output was highly skewed both at the individual and aggregate levels, the first studies of the determinants of research performance thus focused on individual-level variables like IQ, work habits, demographic characteristics and so on (see Fox, 1983; Kyvik, 1991; Reitan, 1996).

Studies of science as a social institution had been carried out since just before the Second World War. A key figure in the early works was Robert K. Merton. Objects of study for Merton and his colleagues were for instance communication among scientists, the reward system and the norms of science. Still, the (natural) sciences were depicted as and believed to be an autonomous institution, where activities and decisions are based on rational, intra-scientific methods.

In the 1960's and 1970's literature appeared with a more normative focus on how research activities should be organised as well as administered. This literature reflected changes both in the environment of the research system, in the basic conception of science, and in the research system itself. Externally, the supply of brilliant scientists was smaller than the demand, especially in the U.S. in the 1960's, and private companies also started to worry about how to maximise the returns on R&D investments (White, 1980). In the public sector, where funding of research had shown a steady growth since the end of World War II, the growth rate decreased or even stopped completely (Ziman, 1994). Perhaps even more important for some of the early studies was that not-so-wealthy countries had started worrying about how to reap maximum benefits from limited scientific and technological research capabilities (de Hemptienne & Andrews, 1979). As a response, research *units* came into the spotlight, and investigations were carried out to explain differences in their output. The first major works focused broadly on the efficiency and productivity of research units (important are e.g. Pelz & Andrews, 1966 (2nd ed. 1976); Andrews, 1979a). The field R&D management was born at about the same time, centring on similar issues mainly in industrial settings only (Allen, 1977 is a good example).

Other issues also entered the policy scene during this time. Questions were raised about external criteria for selection of scientific areas of investigation, cf. Weinberg (1964/65) and the discussion in the journal *Minerva*.[3] An underlying trend was that policy (in general) to an increasing extent had become dependent upon advice based on scientific knowledge. Hence, policy-oriented or domain-based science was growing from the early 1960's, or from immediately after World War II if military R&D is included (Trist, 1972). This growth often took place in research institutes outside of the university sector.

In the 1980's and 90's, «innovation» came into focus, following a lot of theories on national and regional «competitiveness.» Here, successful implementation of knowledge in a market context (one possible definition of innovation) was pointed out as the most important determinant of economic success of nations and regions (a much cited and used work is Porter, 1990). It was often claimed that the significance of innovation for competition depends on its capacity to influence companies' existing resources, skills and knowledge (Abernathy & Clark, 1985; see also e.g. Teece, 1986). The fast-growing literature on innovation gained policy impact, and an important issue became how R&D could be more directly tied to needs in firms, business units and markets. Gradually, the view of innovation processes and knowledge production in general has changed as well (see e.g. Kline & Rosenberg, 1986; Gibbons *et al.*, 1994; Ziman, 1994; Etzkowitz & Webster, 1995; Etzkowitz & Leydesdorff, 1997). This has resulted in an even stronger focus on how to facilitate or improve co-operation, communication, research cultures, user involvement and related themes. Universities are now in many respects focused upon as «engines» in national and regional competitiveness (Gulbrandsen, 1997a). Although policy documents still uphold the cultural or intrinsic value of basic research, economic arguments most often prevail (as in Stortingsmelding no. 39, 1998-99).

Furthermore, in recent years the issue of quality management has reached R&D organisations, including universities. In the latter, quality management mostly concerns the education activities, but it is also touching research. The «quality movement» asserts that quality can be

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[3] See also chapter two.

enhanced through certain measures of quality control, assurance and improvement. Formal and explicit management of quality originated in Japanese corporations in the decades after the second world war, and it was developed there and brought to the Western world by a few well-known American «quality gurus» (most notably W. E. Deming). The adoption of quality management (of which there are various forms) to higher education has not been uncontroversial. Nevertheless, large numbers of practitioner-oriented articles discuss these themes, and there are journals devoted only to the issue of «quality in higher education» (cf. the journals *Quality and Assessment in Higher Education* and *Quality in Higher Education*, also recent volumes of e.g. *Higher Education Management* and others). The same can be said of the area «research evaluation», in which a number of articles and speciality journals can be found that not only deal with the systems level, but also the institutional level.

When it comes to the basic conception of research as an organised activity, Kuhn's ([1962] 1970) «revolutionary» work on scientific development must be mentioned. Asserting that science evolves in two phases, one termed «normal science» and the other «scientific revolutions», where an old «paradigm» is replaced by a new one in the latter, Kuhn claimed that there are no intrinsic «objective» scientific criteria on which a new paradigm can be judged. In many ways this highly influential monograph created a new view of science and laid the theoretical foundations for the study of social influences on the contents of science at all. Also, the study of Janik & Toulmin (1973) of turn-of-the-century Vienna gave a good account of how the intellectual macro-environment can stimulate the development of groundbreaking new ideas, not only in science, but also in the humanities and the arts. Recent literature with a more «constructivist» perspective promotes a new conception of science as well. Here, research activities are seen as (more or less) highly politicised where it is difficult to create clear boundaries between for instance claims and their context (see e.g. Latour, 1987; Jasanoff, 1990).

It can moreover be claimed that the basic organisation of research has changed also as a response to the intrinsic demands of science and its disciplines (Ziman, 1994). Conducting R&D in groups, which in itself is a 20th century phenomenon, has more and more become the normal state of affairs in many disciplines, especially in medicine, technology and the natural sciences (Lindbekk, 1969; Etzkowitz, 1992 and 1998). Studies of co-authorship of scientific papers also indicate that ever more research, in all disciplines and sectors, is made in collaboration between two or more individuals (see e.g. Hicks & Katz, 1996). The literature seems to indicate that these changes arise from the state of knowledge, the nature of problems, and other internal aspects of scientific fields. When science no longer is the (collective) result of many individual efforts, but rather group efforts, it obviously becomes more important to look at organisational factors and their influence.

Thus, studies of how and which organisational characteristics influence research performance are relatively new, reflecting changes in the research system, its environments and the basic conception of science. These studies have during the last three decades nevertheless revealed a cluster of factors that are somehow related to «high performance», to be discussed in chapter three.

To return to the questions posed above; we do seem to know (at least some of) the most important influences on research performance in general. However, policy debates concerning e.g. the size of research groups, where empirical results rarely seem to have been reviewed, indicate that there is a need to communicate these results better to the policy level. Furthermore, there is no recent survey of what we know in the field.[4] Hence, going through previous studies and pointing at shortages and relationships that seem well established, will be important in itself.

1.4 «Performance» and «quality»

A major shortcoming of previous studies is, as mentioned in 1.1, that they may have shown which factors are (more or less) highly correlated with performance, but they have rarely studied or given explanations of *how* these factors are related to performance. Are they for instance effects of performance rather than its cause? Even large-scale micro-level surveys, e.g. Pelz & Andrews (1976), Andrews (1979a) and Spangenberg *et al.* (1990b) seem relatively weak when it comes to explaining the underlying relationships and linking them to theory. I claim that one of the main reasons for the lack of focus on the direction of relationships and similar aspects in previous studies is the methodology that has been applied – especially how the performance/quality index has been constructed. Naturally, at the time when many of the previous studies were conducted, identifying the important factors was an essential aim since little was known then about the environment's effect on performance.

Most of the previous literature has used a single index of performance or quality. In the simplest studies, it has been based on bibliometric indicators alone, like publication and patent productivity or number of citations for publications. More elaborate approaches have included peer review judgements (albeit reported on numeric scales) of the output of the research units involved (or peer review of the units and their individual members themselves) in addition to bibliometric indicators. Consequently, earlier studies have mostly been designed to find the factors that correlate highly with, or that predict well, the performance, but not very well suited to explaining the underlying nature or even direction of the relationships. Moreover, very few studies have had a longitudinal design which is better suited to determining the direction of relationships (a much-cited exception is Long & McGinnis, 1981).

Performance/quality is in itself a very complex issue, and it might well be that an organisational factor could have a positive influence on some aspects of performance, e.g. originality, and display negative influence on other aspects, e.g. stringency. This point is indicated by Pelz & Andrews (1976) in the discussion of their results – there seems to be a certain amount of «creative tension» (cf. Kuhn, 1963) in the best research units: «Achievement often flourished in the presence of factors that seemed antithetical» (Pelz & Andrews, 1976:xv). These high-performing units displayed «contradictory» characteristics where factors of *security* and *challenge*, that seemed counter to each other, were both present.

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[4] The newest is Reitan (1996) which is primarily based on older review articles, although it includes a discussion of recent changes in views of the production of research knowledge.

A development towards giving more attention to performance criteria *per se* has been seen in many social sciences. For instance, in the area psychological testing for vocational purposes, several scholars have tried to come up with a clearer conceptualisation and decomposition of job performance and a more complex understanding of its determinants (cf. Anastasi & Urbina, 1997:495-6). This is not to say that earlier studies of research performance not have been preoccupied with their performance indices, on the contrary, but more or less all-encompassing indexes still seem to have been preferred. An exception is Andrews (1979a), defining «performance-effectiveness» as a multidimensional concept encompassing a variety of both quantitative and qualitative aspects. Still, this large work does to a very little extent discuss aspects of *quality* related to the research products, and chooses instead to focus on various facets of unit productivity like «training effectiveness», «social effectiveness» and «administrative effectiveness», in addition to the general index «recognition».

A fundamental assertion in the present study is that organisational factors do influence research quality. This is primarily evidenced by the many studies in the field that have found relationships between factors like communications structure, quality of leadership, quality of human resources, research/organisational culture etc., and the performance of research units. Still, as described above, there obviously is a two-way relationship as well as processes of «reinforcement» (e.g. good research units attract good researchers), and this will be looked more into in section 3.2.

The determination of research quality can be viewed as a process with two phases. In the first phase, a «claim» (or an «application» etc.) is produced, with certain characteristics that can be termed the research product's «intrinsic quality». The further fate of the product is determined in the second phase, where the claim or application is ignored or judged to be of little value, or used in practice or in other researchers' work. Peer review processes are central here, and much literature has focused on how «irrelevant» (i.e. not related to the intrinsic quality) factors influence peer review outcomes (e.g. NSF, 1996; NIH, 1996; Marshall, 1997; Cole, 1998). Despite the apparent influence of «irrelevant» factors in the final assessment of quality, I choose to focus mainly on the first phase. This means that I will investigate how the intrinsic quality of research products can be influenced by environmental characteristics. To some extent, however, the two phases will be related. A researcher's network may for instance both contribute to shaping the intrinsic quality of a claim, and determining the claim's later fate after it has been published.

1.5 Structure of the thesis

Chapter two starts with a specification of basic perspectives on *research quality* (2.1) and a brief discussion of the terms «research» and «quality» (2.2). I have also touched on some issues from the philosophy of science, e.g. «truth», «objectivity» and «rationality» (2.3). In the next section, a deepening of the concept «research quality» is found, based on some theory as well as on previous empirical investigations (2.4). The result is a model consisting of four factors – originality, solidity, scholarly relevance and external utility (2.5). A brief examination of quality indicators like number of scientific publications, number of citations etc., is found in 2.6. This is necessary because of the frequent use of such indicators in the literature. A short discussion of traditional methods of quality assurance and control in science is found in 2.7. Like all other chapters, this one ends with a brief summary and conclusions.

The topic of chapter three is the *organisational environment* of research work. First, in 3.1, a number of theoretical perspectives (from organisation theory and the «social studies of science» field) are sketched. From these, I develop the «tension» perspective used in the thesis, as well as define my level of analysis. In 3.2, I start by discussing whether the organisational environment has any influence on quality at all, and continue with explanations for variations in findings in earlier studies. The rest of 3.2 is a very brief summary of previous investigations of the influences on research performance. Relevant findings from previous studies will not be presented in full depth in this chapter. I have chosen to do this in later chapters (six through eleven), that centre on particular organisational aspects. The next subchapter (3.3) discusses dynamics – how research units and «stimulating» environments arise and evolve. In the following two sections (3.4 and 3.5), differences between disciplines and sectors are considered. The summary and conclusions in 3.6 also include the research model for the thesis.

Methodology, methods, data and analysis are the topics of chapter four. Basic considerations are discussed in 4.1 and 4.2, where the conclusion is that qualitative methodology and focused interviews as data collection method will be the best way to illuminate the thesis' problem given its objectives and basic research questions. In 4.3, the sample is presented, including selection criteria and sample distribution across sectors and disciplines. The interview guide is reviewed in 4.4, and the interviews in the ensuing part. Analysis of interview data, including questions of reliability and validity, is the main theme of the final subchapter (4.6).

In chapter five, which is the first chapter where empirical data from the present study are found, the *informants' descriptions of research quality* are presented. The model of quality that was developed in chapter three is assessed, and the contents of the four broad quality elements are considered in detail. In which way the quality concept varies across disciplines and sectors is also discussed.

Chapter six deals with *individual-level variables*. After a brief review in 6.1 of previous studies (as in all the subsequent empirical chapters), I describe my informants' specifications of «good researchers,» (6.2) focusing in particular on creativity (6.3) and motivation (6.4). In 6.5, individual-level variables are linked with the research quality elements to see whether some elements are more dependent upon personal traits and skills than others. The next four sub-chapters describe the interface between the individual and the organisation, looking closer at how the organisation can promote or restrain researchers' general potential, creativity, and motivation, as well as how researchers can be rewarded. Finally, 6.9 looks closer at recruitment.

Leaders and leadership are the topic of chapter seven. I have chosen to split the empirical part in two. In 7.2 I look at group leadership, and in 7.3 I discuss leadership at the level above (i.e. department or similar).

In chapter eight, various aspects of the *formal organisation of research work* are deliberated. I look closer at group work and project work in general (8.2), autonomy (8.3), diversity of people and tasks at the group and department levels (8.4, 8.5 and 8.6) and formal routines for quality control and assurance (8.7).

Size and resources are clustered together in chapter nine. The themes group size (9.2), department size (9.3), and financial/material resources (9.4) are elaborated further.

Chapter ten deals with *informal organisational characteristics*. Organisational culture and working climate are some of the key words here. In 10.2, I discuss how these aspects can influence quality, and in 10.3, I link informal characteristics to the question of organisational tension.

The large topic of *communication* is probed in chapter eleven. I distinguish between patterns of communication (11.2) and contents/type of communication (11.3). The analysis shows that there are major institutional differences in these aspects, and the dynamic and reciprocal nature of contacts is elaborated.

Finally, in chapter twelve, I connect the analyses of *research quality* with those of the *research organisation*. In 12.1, I discuss influences on each of the quality elements, and in 12.2, I try to define the «ideal» research unit. The tension framework is revisited in 12.3, and 12.4 is a summarising discussion of similarities and differences between fields of learning and between institutional settings. Implications for theory and policy/management are discussed in 12.5.

The interview guide and the introductory letter that was sent to the informants can be found in appendix A and B after the list of references.

2 Research quality

The theme of this chapter is *research quality* in itself. First, I discuss why this is an interesting object of study in 2.1. The next subchapter deals with the terms «research» and «quality.» In 2.3 I take different theoretical conceptions of «science» as a starting point, and in 2.4, previous empirical studies are reviewed, including a brief discussion of disciplinary and institutional differences. My own elaboration of research quality is presented in 2.5. Traditional «quality management» or «quality control» in science is the topic of 2.6, followed by a discussion of indicators like number of publications and citations in 2.7. The last section contains a brief summary and conclusions, including research questions for the empirical part of the thesis.

2.1 Why study research quality?

«Research quality» is a relatively new term that entered the world of science only during the last decades.[1] In many countries, quality indicators have been developed and new methods of quality control put into effect. «Quality», although positively laden like «beauty» and «freedom», is like these terms vague and relative and may hide controversies and conflicts connected with issues like goals and resource allocation (Kaukonen, 1997). All agree that «quality» is important, but not how it should be assessed. Current emphasis on «quality» may lead people to disregard the long traditions of quality control of academic research. Through various forms of peer review, manuscripts and research proposals are «certified» by fellow experts, with «quality» not a central term until recently (cf. Zuckerman & Merton, 1971; Chubin & Hackett, 1990; Burnham, 1992; Mazuzan, 1992).

It can be claimed that determining a research product's quality is a process with two phases. In the first phase, an individual or a group makes a research product, which has certain characteristics, an «intrinsic quality». This individual's or group's work may to a small or large extent be influenced by the «organisational setting», including leadership, organisation of work, culture, network of contacts and more. The product is then received by representatives of the greater research (or user) system in the second phase, where the (more or less) final quality is established eventually (or the work is ignored).

To improve «quality», research councils are trying to elaborate and standardise the criteria used for assessing proposals, and scientific journals are engaged in discussions on «bias» in peer review (see for example NSF, 1996; NIH, 1996; Marshall, 1997; Cole, 1998). These efforts may represent very different conceptions of research quality. The first processes

[1] A more comprehensive discussion of the literature that this chapter is based on is found in chapters two and three (pp. 16-48) of Gulbrandsen & Langfeldt (1997).

deliberately define the notion, while the latter ones often seem to take for granted that something like «pure and true research quality» exists, and that conflicting reviews must be caused by some kind of illegitimate bias, be it cognitive or based on author characteristics. An underlying value in discussions of «bias» often seems to be that the intrinsic quality should be the only characteristic by which a research work is assessed, and not the producer's fame, institutional affiliation, scholarly standing etc. (some authors do claim that «cognitive bias» is natural and legitimate on the «research frontier,» cf. Cole, 1992 and 1998).

I thus see the «working definition» of quality as being continuously maintained primarily by senior researchers, who decide which projects should get funded and manuscripts published. The high visibility of many senior researchers, especially those referred to as «eminent», may also have a large indirect influence. A research work that gets extensively used/cited by an already well-known individual, will probably receive more attention than it otherwise would (not least considering that much research is simply ignored; the majority of all scientific publications receives one or no citations at all). Those who judge (directly or indirectly) are furthermore most often researchers themselves, producing publications and other research products of their own. Hence, senior/eminent researchers should provide a good source both when it comes to probing the question of quality, and when one tries to determine the organisational and individual presuppositions of different aspects of quality.

Despite the current focus on quality and the quickly expanding number of articles and documents that invoke it, the concept as such is rarely given careful scrutiny. Many investigations within the field «social studies of science» have during the recent decades applied and developed a theoretical orientation that often is labelled «social constructivism». For authors who adhere to this framework, «research quality» is the result of a (more or less) political «game» played by researchers, users and other relevant actors. Although «strong» versions of constructivism often are rejected,[2] many accept the general assertion that research results and their evaluation are significantly influenced by the social setting of the research work (for instance Cole, 1992). Nevertheless, few constructivists will argue that this implies «normative relativism» – that «all research results are equally good» (Bijker, 1993). Instead, the argument is often that quality is determined by other processes (than by referring to more or less known «universal» criteria), but the nature of these processes seldom seems to be focused upon within this mainstream of science studies.

There are several reasons why research quality is an interesting subject to study. From a theoretical point of view, empirical studies of the meaning of «good research» are central to understanding the ideals and dilemmas of research communities. Such studies may also help expose internal conflicts and disciplinary differences in the bases of judgements of research. Regardless of the «epistemological stance» towards quality – if «good research» is the one that is moved from the frontier to the knowledge core of a field (Cole, 1992) or if it designates the claims that successfully are redefined from artefacts to facts (Latour, 1987) – how central researchers and other actors evaluate quality is central in any case. In my view, a «constructivist» perspective makes it even more important to study the problem of quality,

[2] See e.g. Sismondo (1993).

not less. From a practical point of view, a decomposition of the term into more tangible elements may contribute to more fruitful policy debates on how to improve the quality of research and what it means to give priority to quality. «Quality» is, as mentioned, central in recent policy documents, with frequent underlying implications for control, resource allocation and more. Research quality is also the starting point for looking at the research environment in this thesis – the «dependent variable» it can be termed.

2.2 On the terms «research» and «quality»

First, it should be noticed that the term «research» itself is not unambiguous. Even when the limitation to scientific/technological or scholarly research is taken for granted, it refers to an enormous range of activities, from literature analysis to nuclear physics, and to find a common thread in the activities can be difficult.[3]

2.2.1 Definitions of research

An important delimitation of the thesis is that I will look only at *research* work, not technological *development* or other related activities. In Norwegian universities, the majority of the work is described as basic research, based on the following definition from the Frascati Manual (developed for statistical purposes; Norwegian edition 1995):

> *«Basic research is experimental or theoretical work primarily undertaken to acquire new knowledge of the underlying foundations or phenomena and observable facts, with no particular application or use in view.»*

The R&D statistics that are published regularly in Norway (and in most other countries) furthermore reveal that the institute sector is relatively strongly oriented towards applied research, which is given this definition in the Frascati Manual:

> *«Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, primarily directed towards a specific practical aim or objective.»*

To some extent, applied research is found in the university sector as well, and to a larger scale in industry (see 3.5 for more on differences between institutional settings). In Norwegian industrial R&D laboratories, the majority of the work is labelled technical development, and informants from this sector should thus be selected with care. However, a certain overlapping between the activities must be expected, if the definitions are valid at all (cf. Kline & Rosenberg, 1986; Gibbons *et al.*, 1994).

2.2.2 Research and innovation

In general, it can be claimed that the industrial R&D units, and perhaps also many of the units we find in research institutes, are not created primarily to become good research units

[3] There is also a certain linguistic difference – the Norwegian term «forskning» is (more or less) only used in connection with originality-oriented scholarly activities, while the English «research» seems to have several usages (cf. «market research,» etc.). I will use the term in the stricter Norwegian sense.

in their own right (with main focus on development of the discipline). Their *raison d'être* is that they solve problems and otherwise directly or indirectly contribute to the company's or the contractor's competitiveness, revenues, etc. (see 3.5.2). Because a basic common denominator of all research work is the production of something *new*, it can be asserted that it is through *innovations* that the research units in industry and much of the institute sector make their contribution. «The end objective (…) is not R&D productivity, but R&D return: the profit earned on the R&D investment» (Foster, 1988:218). A short overview of the role of research in innovation thus seems necessary to see whether a research-only focus really is fruitful in the applied sectors.

The innovation literature does not grant a leading role to research.[4] On the contrary, it is often underlined that most innovations do not draw on research at all or on research results that are readily available (see e.g. Marquis, 1988; Kline & Rosenberg, 1986). In «normal» innovations, the main task of R&D is mostly problem-solving and to some extent idea-generation, but more fundamental research results may on the other hand spur radical innovations that can change or create whole businesses (cf. Abernathy & Clark, 1985). How advanced and intensive the knowledge-seeking activities are, will vary according to the phase of development of industries and technologies (Abernathy & Utterback, 1988, Foster, 1988).

Another main task for R&D in the applied sectors is to have a surveillance function. In-house advanced research allows the company or institute to «remain effectively plugged into the scientific network» (Rosenberg, 1990:171) which in turn makes it easier to precede or merely survive transitions based on radically new knowledge (Cooper & Schendel, 1976). Applied research (as opposed to development) in industry is mainly found in firms that follow a strategy of «first-to-market» or technological leadership, as well as in niche firms in advanced technologies (Maidique & Patch, 1988; Gemünden & Heydebreck, 1995). Basic industrial research is found in relatively few industries, e.g. biotechnology (Rosenberg, 1990).

Hence, I conclude that it still is meaningful to study research units in industry and the industry-oriented parts of the institute sector, without looking further into development work or other activities. To meet the requirements of the focus on research only in the thesis, informants from the commercial sector should be taken from technological leaders (mainly large firms) and advanced niche firms.

2.2.3 Quality conceptions

When discussing good research, researchers may provide different quality elements or criteria. But they may also have different views or understandings of the concept of quality as such. In the literature, basic views or understandings have been labelled for instance *excellence*, *fitness for/to purpose*, *zero mistakes*, and *value for money* (Harvey & Green, 1993; Doherty, 1994), and they should be well known from everyday life.[5]

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[4] A more thorough discussion of the role of research in innovation can be found in the unpublished paper «Hva slags rolle spiller forskning i innovasjon?» (Gulbrandsen, 1997b).

[5] See Gulbrandsen & Langfeldt (1997) pp. 19-22 for a more thorough discussion of quality concepts.

A «quality as excellence» view is expected to predominate in basic research, where quality is controlled by the scholars themselves, often without clear criteria for judgements (Ravetz, 1971). Here, one should be able to suggest a «scale» of quality corresponding to the stratified system of science, with famous «Nobel Prize class» researchers in the «most excellent» part of the scale (cf. Zuckerman, 1977; also Cole & Cole, 1973). In applied research, it can be anticipated that projects to a large extent will be assessed based on the demands and specifications of users, on the problem to be solved etc. (more «quality as fitness to purpose»), and research projects will rarely be measured against an «eternal» scale of excellence. This distinction is perhaps also evident between science on the one hand and technology on the other (see 3.4).

Thus, there is no simple and generally accepted «model» of quality. This makes the task of exploring quality in research more difficult. It also implies that, in practical situations where quality is to be measured, assured or improved, there may not be agreement on which understanding of quality to use as a base. Such disagreements are likely to be unspoken and unknown and might result in pseudo-disagreement in assessments.

2.3 Theoretical conceptions of «science»

Research quality is a vast subject, and relevant literature encompasses general philosophy and sociology of science, as well as more specific normative and empirical studies of the concept. Previous writings on for instance the organisation of research and characteristics of the research process may serve as starting points for discussing quality. Even the above definitions from the Frascati manual give some indications of quality elements and criteria – good research should somehow be «new» and result in «knowledge».

2.3.1 What is the purpose of science?

Even if «quality» has not been a central term, the nature and validity of scientific inquiry has of course been much discussed – it is for instance the primary subject of the philosophy of science. A brief overview of some of the central themes in this discipline can be fruitful before research quality is elaborated, not only to get insight into relevant quality criteria, but also to reveal controversies that should be reflected on in an empirical study of quality. Theories of knowledge, i.e. epistemological (and other philosophical) viewpoints may also inform *how* quality can be studied (mainly treated in chapter four). It can be added that traditionally, the philosophy of science has elaborated the *natural* sciences, not the social sciences, the humanities and the technological fields, that also (more or less) depend on activities that can be termed research. I shall return to these differences later.

(Natural) science can broadly be seen as the progressive improvement of the understanding of nature (Toulmin, 1992). Objectivity together with truth is often seen as the most precious epistemic value of modern science (Fuchs, 1997). In the words of Tranøy (1986), the fundamental norm or underlying rationale in science is the «optimisation of the truth or knowledge yields» (p. 145). Later in the same book this is elaborated as the «best possible combined satisfaction of demands for truth (or tenability) and demands for relevance» (p. 163). Through specification of some fundamental philosophical positions as well as some normative systems of science, values and concepts such as truth, objectivity, rationality and relevance will be elaborated below, to see if they constitute a useful starting point for looking at research quality.

2.3.2 Opposing epistemological views

The philosophy of science aims to shed light on elements of scientific inquiry (observations, arguments, etc.) and evaluate their validity. The boundary between the philosophy of science and the philosophical field of epistemology (theory of knowledge) is rather arbitrary. Because all science seeks to produce («good») knowledge, epistemological issues are central to understanding and elaborating the scientific purpose and activities. There is no universally accepted theory of knowledge, quite on the contrary.

Two opposing epistemological views can be discerned. At the one end, there is *realism*, which in a strict position underscores the factual basis of all scientific knowledge. Reality is seen as existing independent of our perception of it. All propositions in science aim to report a more or less comprehensive set of facts about nature and aspire to be an accurate and objective mirror of reality. Realists often use the success of humanity's mastery over nature based on scientific constructs as an argument why laws and theories must have some counterpart in the things themselves. Truth is seen as a relation of *correspondence* between a proposition and a state of affairs. Prediction is another common indicator of truth.

At the other end of the spectrum, one finds conventionalism or constructivism, resting on philosophical *idealism* – there is no reality independent of our perceptions. The strict view focuses on the constructive role of the scientists' own theory articulation. All but the most purely observational statements in science reflect the patterns by which the scientist shapes a conceptual picture of nature. For idealists, truth is often defined as *coherence* of propositions with one another to form a harmonious whole. Scope and simplicity are other commonly used criteria (not only by idealist, cf. e.g. the elaboration of the hypothetico-deductive methodology below). A few radical views rest on a relativist epistemology, in which truth and objectivity are seen as neither relevant nor possible even as ideals for scientific activities.

Finally, there is a wide range of intermediate views. One example is that the terms and concepts of science can be seen as the product of so many operations and constructions (logical or semantic) that questions about their «real existence» can be swept aside as «damaging metaphysical superstitions» (cf. Toulmin, 1992). Somewhat related to this is the opinion that science can be seen as a progressive selection process of «what works» (Knorr-Cetina, 1981): «The world is slowly moulded into shape in ever new ways through successive generations of (scientific) practice» (Knorr-Cetina, 1993: 560). In the social studies of science field, a number of investigators have proposed views that aim to incorporate many of the constructivists' empirical findings without ending up in a relativist epistemology (e.g. Cole, 1992; Sismondo, 1993; Fuchs, 1995). These and other realists (in one way or another) largely accept the claim from relativist studies that science is an important social enterprise: «What tends to make scientists work well is the training and the constraint and reward structure of the scientific community» (Couvalis, 1997:151).

2.3.3 «Truth» as a basic scientific value

Both the correspondence and coherence theories of truth have been strongly criticised. They require much additional specification – the correspondence theory demands for instance theories about reality (ontology), about our perceptions and the language in which we express them. It has been argued that «truth» cannot be permitted as a criterion for scientific theories, because it is claimed that no objective criteria exist to state that one set of theories is better than another (Kuhn, [1962] 1970, see also methodology discussion below). In many ways «truth» has disappeared as a relevant notion in science (Hagendijk, 1999), and Kuhn's term «paradigm» may be a good replacement, at least at a «theory system» level.

There are still philosophers (and presumably many others) who still prefer «truth» as a basic scientific norm. An example is Tranøy (1986), who does not use the term in an «absolute» or «positivist» sense. All scientific truths are limited and temporary and probably all researchers are aware that today's accepted theories or paradigms may/will be supplemented, revised or rejected in the future. The substitution of Newton's laws, which for more than two centuries by most were regarded as stating something profoundly «true» about nature, with Einstein's theory of relativity, is most likely a key incident in this respect in the history of science. In my opinion, «truth» is nevertheless most likely a poor quality specification, given its somewhat «absolute» or «old-fashioned realist» connotations.

2.3.4 «Objectivity» as a starting point for methodology

Truth and objectivity can be seen as two sides of the same coin – objectivity is the methodological guarantee or probability of truth or approximation to truth. It then follows naturally that the term «objectivity» is just as contested as «truth», and its meaning is probably even more broad or unclear. We can for instance distinguish between (Porter, 1995)

- «mechanical objectivity», which has to do with compliance to rules and calculations to exclude bias and personal preferences,
- «disciplinary objectivity», which is connected with the consensus of a scientific community (paradigm) and
- «absolute objectivity» (realism).

In day-to-day scientific work, the mechanical objectivity will be central. This term can also have several different meanings, for instance a capacity for impartiality and disinterestedness, or a characteristic of methods and rules of inquiry that reduces arbitrary and accidental forces (Fuchs, 1997). Frequently, the definition is negative – objectivity often refers to «the absence of individual, idiosyncratic, accidental, and contingent forces and circumstances» (*ibid.* p. 4). It has been argued that mechanical objectivity formally has little to do with «truth to nature» (Porter, 1995).

The last decades have seen many studies that from various viewpoints have criticised objectivity, and claimed that this is merely rhetoric or power, and/or that science cannot possibly be objective. One example is Barnes & Bloor (1982) and their «strong programme», which has a (type of) relativist epistemological standpoint. They assert that social location and social interests always play a crucial role in determining the acceptance of a scientific theory. Observation, experiment and reasoning may only play a role in delimiting the range of theories that are found acceptable. A central underlying assumption is that theories are underdetermined by data – any amount of data is logically compatible with a number of incompatible theories. The strong programme and its basic arguments and assumptions have been criticised frequently (over many pages by Couvalis, 1997), but the programme and other variants of relativism still have their proponents.

Despite or because of the criticism, some want to keep «objectivity» and give it new meaning (Fuchs, 1997), while others want to hold on to the term in its traditional meaning (Couvalis 1997). Fuchs wants to «rescue» objectivity from both «orthodox philosophy» (old-fashioned realists) and «standpoint epistemologies» (like the strong programme and feminist theories), and he ties the concept to the communication system in science. In this proposal, truth and objectivity symbolise «the unity of scientific practice in all of its actual diversity» (p. 17). The issue is obviously still controversial, and it has been claimed that objectivity is a sign of weakness, because it mainly is invoked when someone or something is under attack and needs legitimacy (Porter, 1995).

Although objectivity is disputed and ambiguous, it is nevertheless regarded by many as an ideal for contemporary research. «The notion of objectivity is maybe the most difficult and controversial, but it is at any rate common to regard unrestricted and purely subjective arbitrariness with open ground for sympathies and antipathies as incompatible with a scientific attitude» (Tranøy, 1986: 156). Evidently, objectivity does not come natural or easy, but demands hard, patient and thorough work, which furthermore may require a specific Ethos (e.g. Merton, [1942] 1973).

2.3.5 Fundamental methodologies in scientific work

The focus on methodological questions in the philosophy of science can be explained with the cumulative nature of research activities. Scientists cannot repeat much of other people's work – they have to be able to *trust* the results of others. The birth of «modern» science can be found in the intellectual Renaissance of the 16th and 17th centuries, when both Bacon and Descartes offered «manifestos,» intellectual programmes for a natural science. Largely inspired by Descartes, Newton devised in practice what has later been called the *hypothetico-deductive method*. Newton's *Principia Mathematica* is a prime example of a formal propositional system with a definite and essential logical structure. The system is called axiomatic because all symbols or entailments can be traced back to accepted axioms. It can be added that originally, the axiomatic system and methodology were invented by Aristotle, with Euclid's geometry as the most famous application.

This was developed further in the beginning of the 20th century, first largely by the so-called «logical positivists.» They saw theory construction as equivalent to the creation of systems in which groups of propositions are ideally set out in axiomatic form. The hypothetico-deductive method thus becomes a recipe for forging increasingly more comprehensive axiom systems. Particular propositions can then be used to *substantiate* the more general primitive propositions. Many debates have followed regarding this substantiation, which has been elaborated with terms like verification, confirmation, corroboration and falsification.

Positivism has in general been much criticised, with the strongest opposition from «idealist» viewpoints, which have questioned the possibility of identifying theoretically neutral observations that can substantiate or discredit alternative theories. Wittgenstein's theory of language as an instrument for the representation of facts is well known. A particularly influential example from the history of science is Kuhn ([1962] 1970), who claimed that there are no external criteria by which a «paradigm» (fundamental theoretical construct within which scientists work in a «normal science» phase) can be viewed as «better» than another. The start of a «scientific revolution», where a small number of scientists adopt a new paradigm in favour of the prevailing one, is based on a decision that «can only be made on faith» (*ibid.* p. 158). Kuhn's starting point is the above-mentioned transition from Newton's to Einstein's physics, and it can be added that Popper (1979) has a very different interpretation of the same transition. He sees all changes in scientific theories as rational or rationally reconstructable, insured by the participant's «intellectual honesty» and specifications of the data and circumstances under which scientists are ready to reject a theory or a hypothesis. Furthermore, Einstein's physics are by many regarded as both simpler and more experimentally satisfactory (Couvalis, 1997).

Although the grounds for substituting one theoretical system with another are not clear, the hypothetico-deductive methodology is still the central methodology of science. A fundamental criterion or value is that of *interdependence* (or *relationship*, *coherence*). If the coherence gets wider (explains more phenomena), more relationships are included and/or the interdependencies get clearer and more precise, we understand something «better» and may have better reasons for regarding a claim as «true» (cf. e.g. Walløe & Føllesdal, 1990). Both for the theoretical system as a whole and for the selection (or formulation) of individual hypotheses, *simplicity* is another central criterion. How this can be defined and why simple theories are more plausible than complex ones is treated in much literature, and I will not go deeper into it here. It can be added though, that a common criticism of simplicity (or the general methodological approach) is the *problem of induction*, often termed Hume's problem after the 18th century English empiricist philosopher. Hume claimed that predictions about unobserved behaviour of objects (like the sun rising) could not logically be proved true or even probable based on knowledge of past behaviour. This problem has not received a generally accepted solution, although for instance Popper (1979) suggested that all statements are theoretical and contain metaphysical elements – scientific laws cannot be derived from experience. Thus, hypotheses never get confirmed, but remain qualified guesswork or get rejected.

The *hermeneutic methodology* is the central one in the humanities and maybe the social sciences as well. Hermeneutics is often defined as the study of *interpretation* or *understanding* and how it can be achieved (Føllesdal & Walløe, 1990). This can be funded on a distinction where the purpose of the natural sciences is defined as explanation, while the purpose of the humanities and the social sciences is seen as understanding and interpretation. The distinction is somewhat oversimplified – it is for instance obvious that many social sciences seek to explain social phenomena. The type of explanation may differ between the fields and disciplines, however (cf. Elster, 1990).

Hermeneutic methodology has been elaborated in various ways, but the research process is in practice quite similar to the one devised by the hypothetico-deductive methodology. In the former, the researcher goes back and forth between different hypotheses, other propositions and the source material. This «hermeneutic circle» is reminiscent to the «research spiral» in the natural sciences, and it has been argued that hermeneutics in fact is the hypothetico-deductive methodology applied on «meaningful» material like texts, works of arts and human action (Føllesdal & Walløe, 1990). Others, for instance Habermas (1969), have argued that the natural sciences/medicine and the humanities/social sciences are methodologically fundamentally different (see also 3.4 on field and disciplinary differences).

2.3.6 «Rationality» as the common denominator of methodologies

The basic methodologies have all something to do with *rationality* (Tranøy, 1986): «We have only evidence for the truth of [a proposition] in rare borderline cases. Cognitive rationality is connected with *good reasons* for basic cognitive actions: accepting and rejecting, claiming and denying, seeking and criticising» (p. 160). What makes science rational, in Popper's (1963) view, is not any logical methodology to confirm or claim non-observables, but that scientific theories can be falsified. Hypotheses that are rejected advance science strongly.

Still, rationality is another much debated term, also when we leave out the transition from one «paradigm» to another. Some have asserted that arguments (following a «discovery») have to be justified, i.e. have a formal validity or explanatory power that justifies the scientist's accepting the conclusions as established (cf. Toulmin, 1992). This phase of justification is where the «rationality» in science is found. The opposite view claims that all phases of scientific investigation are strongly influenced by chance, guesswork, intuition etc., and that creativity plays a much greater role in theoretical achievement than rationality. Preoccupation with rationality («formalism») might thus impede creativity and the development of science, and a «romantic anti-rationalism» is preferred. Middle ways can be sketched – it is for instance evident that different disciplines and phases of scientific development imply large variations in the difficulties that face the investigators.

2.3.7 An abundance of methodological quality criteria?

The discussion above shows that there is a «high temperature» in much of the debate about notions like «truth», «objectivity» and «rationality». Although they have been and can be defined in moderate phrases, my response is that these controversial terms probably should be avoided in empirical questions about research quality (the respondents/informants may naturally use them).

In addition, the discussion has shown that «good» methods in science have been elaborated with a large number of different terms, and each of them can constitute a starting point for the specification of quality criteria or elements. Tranøy's (1986) in-depth and well-written discussion of science is a good example. In his suggested norm system, three basic methodological norms are derived from the perceived purpose of science (optimising yields of truth):

consistency, completeness and objectivity. These are used to elaborate no less than nine fundamental (sets of) norms:

- Truth/probability (with many sub-norms).
- Verifiability (testability, decidability), publicity, intersubjectivity.
- Consistency (contradiction-free), coherence (interdependence/relationship), order, system.
- Simplicity, economy (overview), completeness (comprehensiveness).
- Honesty, integrity, truthfulness.
- Openness, trust, publication.
- Impartiality, objectivity.
- Originality, imagination, creativity.
- Relevance, fruitfulness, «interest».

Some of these may be more relevant in particular disciplines and phases of scientific development, and aspects like replicability, verifiability and consistency are defined and elaborated differently from discipline to discipline (*ibid.*). For my purpose, there is a need for a general and perhaps more «everyday» expression that encompasses most or all of the methodological norms. In 2.5 below, I will suggest the term «solidity» for this purpose.

2.3.8 Core values: originality and relevance

Taken for granted in much of the literature on science is that problems, claims, results etc. should be new in one way or another. Science is a progressive or accumulating enterprise and a demand for originality is a necessary condition for renewal. An ideal of creativity or innovation shows that methodological demands never walk alone (Tranøy, 1986). Originality is a key norm in the literature on norm systems in science (Merton, [1957] 1973; Tranøy, 1986). Its further specification may depend on the discipline and its phase of development, e.g. Kuhn's ([1962] 1970) «normal» and «revolutionary» phases.

Many philosophers have also specified that science should have relevance, interest, importance and/or fruitfulness to/for other scientists (Føllesdal, 1990, Tranøy, 1986). Føllesdal claims that importance/relevance is a necessary ideal or demand for all research knowledge (in addition to objectivity). Also implicit in Merton's ([1942] 1973) norms of «universalism» and particularly «communalism» is that science is produced by a whole community. Thus, scientific results have to be interesting to others as well as be communicated to them.

Practical or social relevance is another possibly valid quality criterion or element, and the ultimate legitimacy of public support of science has to rest on its (at least eventual) utility for everyday life (Berger & Luckmann, 1966). Discussing philosophy of science may give the impression that theory building has been the central element of science the last centuries. Still, it has been shown that e.g. scientists in England in the 17th century chose areas and problems that were of practical economic or military concern (Merton, [1938] 1970). Many renowned scientists have been fundamentally inspired by a strong desire to «improve health» or by other practical aims, with Pasteur as perhaps the most well-known example. There may of course be phases (in scientific development and the attitudes of scientists) where external utility is more important. Furthermore, the innovation and competitive advantage literature that has expanded rapidly at least since the early 1980's, has often underscored that basic scientific research constitutes an economic advantage for many regions and nations (e.g. Porter, 1990). An «external utility» perspective on research is obvious in many policy documents and public programmes, for instance the EU framework programmes and the two most recent Norwegian parliamentary reports on research.

2.3.9 Philosophy and the organisation and study of science

Obviously, philosophical standpoints, epistemological views and/or fundamental normative systems in science (whether one uses Merton's ([1942] 1973) or Tranøy's (1986) model) also have implications for the organisation of scientific work (apart from the fact that the norms in themselves can be regarded as an informal organisational factor). For instance, norms related to openness and communality may indicate that certain types/levels of external communication should be striven for. Popper's falsification theory implies scientific freedom and democracy, because it cannot be predicted where the fruitful criticism will emerge. More generally, interpretations from the philosophy of science (which have been very diverse, as depicted above) have implied different practical procedures for testing and assessing the strength of rival concepts and hypotheses (Toulmin, 1992).

Furthermore, the basic view of science can to some extent influence the method by which science is studied and the aspects that are selected for investigation. For example, the relativism evident in Latour's most famous work (1987) is likely to have affected the choice of anthropological methodology and a strong focus on political aspects of social life among scientists (political aspects can naturally be interesting also seen with other epistemological starting points). Seeing the natural sciences as an autonomous institution where activities and decisions are based on rational, intra-scientific methods, Merton and colleagues did not focus on how social factors might influence the intellectual content of science.

It could be mentioned that my own view probably is quite close to a «moderate» or «subtle» form of realism (which e.g. can be seen underlying the proposals of Sismondo, 1993; see also Silverman, 1993). I do believe that at least a strong form of the opposite, be it called constructivism, conventionalism or idealism, makes it very difficult to explain why people are motivated to choose science as a career at all. Already Max Planck defended a «qualified realism», because without a belief in the enduring reality of external nature, all motives for theoretical improvements in science would vanish. Still, as I have aimed to show with the above discussion, scientists do select their representations, and obvious criteria of quality do not emerge easily (if at all) from nature or society. The focal point for an empirical study of research quality thus has to be the scientific community itself. When it comes to selecting organisational characteristics, I will be guided by previous studies of research performance and organisational theory (cf. chapter three).

This section has rendered us with two fundamental quality criteria or elements: originality and relevance (there can be several types and different specifications of both). However, most of the above review has centred on a third category of fundamental criteria linked with the methodology applied in research work. It has been seen that terms like «objectivity» and «rationality» are surrounded by much and hard discussion. Below, I will suggest a more «neutral» terminology for use in data collection.

2.4 Properties of good research from empirical studies

First, it can be mentioned that previous studies of research quality have rarely used philosophy of science and other literature on the fundamental purpose or constituent values of research activities as a starting point for developing models of research quality (e.g. Hemlin, 1991). Their terms have mainly been taken from empirical investigations of quality.

In explorations into the constituents of quality, we can see a spectrum ranging from simple two-factor models to complex multidimensional conceptual frameworks. An example of the former is Ravetz (1971). Here, research quality is decomposed into two criteria – *adequacy* and *value*, as well as four «classes» of quality, from «competent» to «immortal». When applied to particular cases, tacit judgements of adequacy and value are made which depend on one's intimate knowledge of the relevant field.

The framework described in Hemlin & Montgomery (1990) is an example of a complex model. Quality in this framework is seen as a combination of certain *attributes* and *aspects* of the research. Aspects are problem, method, theory, results, analysis and writing style, while correctness, novelty/originality, stringency, intra-scientific effects, extra-scientific effects, breadth and general utility are examples of attributes. It is asserted that some combinations of aspects and attributes correspond better with good research than others.

Prior empirical studies of the quality concept are mainly based on quantitative data. These include a Swedish survey of 224 university researchers, based on the framework developed in Hemlin & Montgomery (1990). Here the most frequently mentioned attributes of good research were novelty/originality, stringency and correctness (Hemlin, 1993). Extra-scientific relevance was mentioned before intra-scientific relevance in open questions, but not in closed questions. The most important combinations of aspects and attributes were said to be stringent and correct methods, and original and stringent problems. In a Finnish study among 205 researchers at six university departments, originality, practical utility and «methodical level» (reliability and validity) were most often referred to in open questions (Kaukonen, 1997). In closed questions, verisimilitude (probability for truth) ranked highest followed by originality and intra-scientific utility.

A study from Denmark where 788 (mainly social) scientists from universities and the institute sector responded, revealed the same picture (Andersen, 1997). Stringent argumentation and originality were attached the greatest significance. This study also concludes that Danish social scientists seem to put more weight on practical relevance than their Swedish counterparts do, even when the institute sector is left out. An American study, asking 105 natural scientists and 86 social scientists what is «essential for scientific writings in their discipline», gave the following criteria the highest ranking: logical stringency, research techniques that allow replication, clearness and precision in writing style, and originality (Chase, 1970). A publication's potential for practical utility was the criterion least referred to. In addition, some studies have more or less focused on originality alone (Buchholz, 1995; Dirk, 1999) (see 2.5.2).

The empirical studies of research quality find major similarities between research fields. An important conclusion in both the Swedish and the Finnish studies is that it is possible to define some basic dimensions of the research quality concept across all research fields. In one of the studies, the same aspects and attributes of quality were mentioned in all disciplines, although there is some variation in the importance different researchers attached to the criteria (Hemlin, 1993). Researchers in medical, natural and technical sciences asserted that external relevance is more important than researchers in the humanities and social sciences claimed. These, on the other hand, gave more weight to theoretical aspects. Precision and accuracy of results were found equally important in soft and hard sciences, which is said to be a little unexpected (*ibid.*). However, none of the empirical studies referred to above have studied the contents of terms like «stringency» and «accuracy». It can be claimed that these terms mean something else to the historian than to the mathematician, but this does not mean that they are more «important» in one discipline than another. Thus, looking more closely not only into the quality concept, but also at the almost equally complex notions that follow it, e.g. «originality» and «relevance», may prove essential to understanding disciplinary differences.

One study has shown that there are variations in quality conceptions within the social sciences, mostly connected with «practical relevance», but also to other quality criteria (Andersen, 1997). None of the empirical studies mentioned here have looked closely into differences internal to disciplines. The literature on peer review does indicate that quality is judged differently inside a research field (Cole *et al.*, 1978 and 1981; Ceci & Peters, 1982; Chubin & Hackett, 1990; Cicchetti, 1991; Travis & Collins, 1991). It could, however, be fruitful to distinguish between the research *frontier* and the *core of knowledge* in a field (Cole, 1992). At the frontier, there will be a large degree of quality disagreements in all fields. A study of research quality should still try to focus also on intra-disciplinary differences, for instance to see if there is more disagreement connected with some criteria than to others. A summary of some of the main investigations of research quality and their main specifications is found in table 2.1.

Table 2.1. Summary of quality specifications in earlier investigations.

Author(s)	Quality specifications
Chase (1970)	Originality, logical rigour, compatibility with disciplinary ethics, clarity and conciseness of writing style, theoretical significance, mathematical precision, pertinence to current research, replicability, coverage of literature, applicability to practical or applied problems
Ravetz (1971)	Two quality criteria: adequacy and value, four «classes» (competent, good, first class and immortal).
Hemlin & Montgomery (1990)	Main «attributes»: correctness, novelty, stringency, intra-scientific effects, extra-scientific effects, utility in general, breadth and competence.
Hemlin (1993)	Correctness, novelty, stringency, intra-scientific effects, extra-scientific effects, breadth, depth, productivity and international relations.
Buchholz (1995)	Originality decomposed as new theory, new area or phenomenon, extension of theory, refinement of theory and empirical knowledge; also appropriate methodology and external orientation.
Kaukonen (1997)	Novelty and originality, practical utility, methodical level, theoretical contribution, (good) research design, versatility and scope, verisimilitude, international visibility.
Andersen (1998)	Different aspects of practical utility and different motives for choice of research area (e.g. originality, basic research relevance, own interests).

2.5 A preliminary decomposition of research quality

Reviewing the literature mentioned above and trying to integrate the various quality criteria, I have ended up with four overall concepts or quality elements that describe different elements of good research: *Solidity*, *originality*, *scholarly/scientific relevance* and *practical/societal utility*. Initially, I see this decomposition as a compromise between the complex multidimensional models and the simple specifications with only two quality criteria.

2.5.1 Solidity

The concepts vary, especially for the solidity element, which includes such notions as infallibility, stringency, validity, reliability, correctness, truthfulness and consistency. In general, solid research is research that produces convincing results (strong validity or probability). This quality element will especially be tied to the research *methodology* that is used (e.g. data collection and methods for analysis), but also to theory and the account of or presentation of the work (for instance a stringent account in publications of the work that has been done).

A common way to emphasise solidity is to say that something is *scientific*. As was seen in 2.3 above, there are different answers in the literature as to what makes a piece of work scientific. In most cases, it can be claimed that solidity is a minimum demand for research work, not a great opportunity for excelling. A Swedish study of evaluations of applications in psychology for research council funding, found that «correctness» and «stringency» were often judged negatively in applications that were rejected (Hemlin *et al.*, 1995).

2.5.2 Originality

Originality is a key criterion in the literature on research quality, and it encompasses *novelty*, *innovation* (which also includes usefulness, cf. e.g. Van de Ven, 1986) and *creativity*. Prestigious awards like the Nobel prize are to a large extent awarded based on originality (Zuckerman, 1977). It has even been suggested that the term «quality» should be replaced with «creativity», because the latter is so central in research work (Premfors, 1986). Studies of creativity focus, however, not only on science, but also on, for instance, marketing, inventions and the arts. The results still seem to point in one direction: creativity flourishes under conditions of (much) freedom (see Sternberg, 1988; Taylor & Barron, 1963; also section 3.2).

The literature suggests that there are degrees of originality in science – from providing new theories and discovering new phenomena to improving current theory and giving more precise descriptions of known phenomena (Buchholz, 1995). Distinctions (in a «normal science» phase) can also be made between improving the fit between existing theory and observation, extending existing theory to new areas and collecting the concrete data required for the application and extension of existing theory (Kuhn, 1963). The concept is relative, i.e. originality is judged on basis of current knowledge, and by definition, a certain result is only regarded as novel once.[6]

Finally, it can be connected with different aspects of research like method, problem and theory. Dirk (1999) has developed and tested a model of originality where it is linked with either one of three aspects found in scientific papers: hypothesis, method and results, yielding eight possible combinations (all three new or all three previously published). 206 medical scientists rated their own articles according to this framework, and all combinations were used. The most frequent combination was new hypothesis, previously reported method, and new results. An interesting finding is that 13 percent of all articles were not judged as original in any of the aspects. Dirk argues that also these articles can have a scientific value through replicating others' work.

2.5.3 Scholarly relevance

Scholarly relevance is my term for what is most often called *intra-scientific relevance* or *value*. It states that the research should have some kind of interest or importance to other scholars or the discipline as such. One aspect is that research efforts should be *cumulative*, i.e. problem and theory require existing knowledge as a starting point, and results need to be discussed in relation to this knowledge. The basis of this aspect is the ideal that research is a systematic venture that fills knowledge gaps and ties results together to form overall theories. Another aspect is *generalisability* – the broader validity a project and its results have, the more research may the project be useful to.

In many cases, the original problem, solid results etc., of a research work, makes it interesting to others. Originality and solidity may nevertheless not be enough to determine a piece

[6] Much of the innovation literature does, however, underline that an innovation need not necessarily be «new to the world», a more *local* originality can be just as fruitful for the adopting firm (see Zaltman *et al.*, 1973; Van de Ven, 1986).

of work's scholarly relevance. In one way or another the research area, problem, methodology or results must be *interesting* to what other researchers in the same or adjoining fields are working on, most often implying a link to the research frontier. There is not necessarily agreement on the frontier as to what works are important, but in most disciplines some of them will make it to the knowledge core (Cole, 1992). The judgement process will determine the scholarly relevance, and the process can be heavily influenced by the field and scholarly standing of the one who makes the judgement (Travis & Collins, 1991).

2.5.4 Utility value

Practical/societal utility (frequently named external or extra-scientific relevance) is often referred to both in policy debates and in the literature, but rarely discussed in depth.[7] The term itself describes something that is of interest, importance or central to something else, and a distinction can be made between relevance, applicability/usability, application/use and utility (Vedung, 1994). Behind this distinction lies the implication that research can be highly relevant or applicable and yet not come to use, not necessarily as a result of factors intrinsic to the R&D unit.[8] As stated in 2.3.8 above, it can be argued that the «universe of science» has to be fundamentally justified by some kind of relevance to everyday life (Berger & Luckmann, 1966).

Some of the critical issues arising out of the utility concept are to whom or to what the research should be useful, how it should be assessed and the overall timeframe. It is often assumed that external relevance is a separate demand on research, in addition to (scientific) quality. This is frequently seen in research policy documents (e.g. Stortingsmelding 36, 92/93; Norges forskningsråd, 1996), where it is nevertheless underlined that both demands should be met. Researchers themselves (even in studies of the university sector), however, seem to regard external relevance as an integrated part of the quality concept (see Hemlin, 1991; Kaukonen, 1997; Andersen, 1997).

Although the Frascati Manual definition does not imply any external relevance criteria in basic research, the answers of researchers in empirical studies indicate that they frequently see at least a *potential* for such relevance in their work, which will also be the motive for basic research in industry (Rosenberg, 1990). Doing basic research in some disciplines can be a prerequisite for eyeing the possibilities for practical utility, which explains why some private industrial firms do it. In research activities that are more closely related to innovations, it should be expected that utility is more narrowly defined in terms of return on investment or similar concrete, measurable goals (Zettelmeyer & Hauser, 1995; also Van de Ven, 1986).

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[7] In Weinberg (1963) the distinction between «internal» and «external» criteria is somewhat different from here. Weinberg includes «scientific merit» among the «external criteria for scientific choice», as he thinks scientific merit should be judged by relevance to neighbouring fields. In my model such interdisciplinary relevance is part of scholarly relevance.

[8] As much of the innovation literature underlines, a technical success does not automatically lead to an economic success. The latter is determined by, broadly speaking, market forces (see Kline & Rosenberg, 1986:276; Abernathy & Clark, 1985).

2.5.5 The relationship between the quality elements

A central deficiency in prior empirical studies of research quality, and a major aim of this study, is to elaborate the various concepts and their relation to each other. Do researchers in the same and in different fields/sectors have a common understanding of such abstract concepts? There is in general little literature on the relation between them. A fundamental tension can be put forth between originality – breaking with tradition – and simultaneously taking account of tradition (Kuhn, 1963).

Well-known examples from the history of science suggest that the solidity criteria may not always be met satisfactorily for research of revolutionary originality. Pasteur did not publish results from experiments he had conducted that supported the «spontaneous generation-hypothesis» because he did not believe in the hypothesis himself (Collins & Pinch, 1993), thus violating norms related to «objectivity» (see Tranøy, 1986 and 2.3 above). The planning and the execution of Mendel's experiments were heavily influenced by his «desired» conclusions, but this does not seem to have diminished his place in the history of biology (see Hull, 1988:317-319). This may thus represent a tension between solidity and originality. The existence of an «ideology» of progress in Darwin's theory of evolution (see Gould, 1996; also 3.2.2) is an example of how external forces can influence scientific development, but it may also denote a difficult relationship between external relevance and solidity (Galileo would be another famous example). Tensions can furthermore be pictured between originality and the two types of relevance, because the latter may imply a «pull» in a more conformist and consequently less original direction.

2.6 «Quality control» or «quality management» in science

The assurance and control of quality has always been a central and self-evident part of scientific work:

> *«The social activity of science has another feature which makes it nearly unique among all sort of work: the social task of the maintenance of quality of the products seems to be accomplished with so little difficulty that the problem of quality control has received no more than a passing mention in any systematic discussion of science. (…) Assessments of quality are an everyday part of the scientist's work: any material that he is considering using in any way, must be judged for its quality in the relevant aspects.»* (Ravetz, 1971:273).

Peer review is the traditional formal mechanism of quality *control* in science, and it is especially found connected with publication. Seniors in the discipline and/or the speciality field will in most scientific journals control quality by selecting some manuscripts for publication and rejecting others. This system has long historical roots and is found in most journals with scientific ambitions (Zuckerman & Merton, 1971).

The growth of funding bodies like research councils has led to the development of a formal peer review system for judgements of research proposals as well. Although this primarily can be described as a way of allocating scarce resources, the system also implies a stronger focus on quality *assurance* as opposed to control. Ideally, the lowest quality research proposals will under this system not be funded at all, thus assuring that the mean or overall quality of the funded research is higher. Making sure that only the best graduates are able to get a career in R&D is another basic quality assurance mechanism in the systems of science and technology. Oaths made by «new» scientists have furthermore been used and promoted to assure quality, especially to reduce the occurrence of «fraud» (see e.g. Sechrest, 1987).[9]

Ravetz' (1971) assertion that the system of quality maintenance in science has received no more than a passing mention in discussions of science, no longer seems to hold. There have been (after Ravetz' book was published) many empirical studies of the peer review systems connected with manuscripts for publication (for instance Ceci & Peters, 1982; Daniel, 1993; Laband & Piette, 1994) and research proposals (e.g. Cole *et al.*, 1981; Travis & Collins, 1991). Many of these studies have been occupied with «bias» in peer review – the influence of factors that are thought irrelevant to the quality of the research product that is to be assessed (irrelevant factors are e.g. sex and institutional affiliation). The results often point to disagreement in judgements and the influence of irrelevant factors in peer review (see Langfeldt, 1998 for a discussion of this literature). Sonnert (1995) finds that about 59% of the variance in peer reviews of 42 biologists can be explained by publication productivity, the existence of solo-authored publications and graduate school prestige. It is suggested that «publication productivity could perhaps be viewed as the *baseline* for our raters' quality evaluations» (*ibid.* p. 49, emphasis in original).

These studies thus often seem oriented towards improvements of the peer review system through removing illegitimate bias, not towards the system's replacement. In general, to improve «quality», research councils are trying to elaborate and standardise the criteria used for assessing proposals, and scientific journals are engaged in discussions on bias in peer review.[10] These efforts may represent very different conceptions of research quality. The first processes deliberately define the notion, while the latter often seem to take for granted that there is something like «pure and true research quality» and that conflicting reviews must be caused by some kind of illegitimate bias (see also 4.1.2).

I have argued above that the working definition of quality itself, at least in basic science, is determined by senior researchers through e.g. selection of manuscripts for publication and awarding grants, and indirectly when the work of others is used or ignored. Still, the peer review system itself does not produce research results, and I will not go further into it here. Although the originality, relevance etc., of a research product ultimately will be determined by peers (and/or users), influenced by social factors and constrained by nature/society (see 3.1), I will focus on how the research organisation influences the «everyday» production of the results and their «intrinsic quality». My starting point will be the informants' definition of quality of research products.

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[9] Also Joseph Rotblatt, when accepting the Nobel Peace Prize on behalf of the «Pugwash» movement, promoted a «scientific oath» as a mechanism for both avoiding fraud and ensuring that science and technology come to a «good» or «ethical» use (cf. *Aftenposten* 11.12.95).

[10] See for example Marshall (1997), NSF (1996), NIH (1996), and Jama vol. 272 (1994), No. 2. More discussions on peer review are found in *Science, Technology and Human Values*, vol. 10 (1985), No. 3, and *The Behavioral and Brain Sciences* (1982), No. 5:187-255.

Finally, the growth of evaluations should be mentioned as a means of quality management (evaluations may naturally serve other purposes as well). Research evaluations, often of whole departments, institutes or disciplines, have become widespread during the last two decades. In such evaluations, for instance the national ratings of universities and university departments in the U.K. and the Netherlands, bibliometric indicators and analyses often play a role in addition to «site visits» or interviews by peers (cf. Foss Hansen & Jørgensen, 1995).

Generally, evaluators are often constructive, careful and focused on helping the organisation subject to evaluation with future improvements (Langfeldt, 1998). In a study of research evaluations in the Nordic countries, the researchers in the survey claimed the evaluations they had been subject to, had had almost no influence on quality but had been indirectly important in encouraging, contributing to self-reflection etc. (Luukonen, 1995). Another Nordic study based on evaluation documents and interviews found that evaluations were indeed used, but that their impacts rarely were dramatic (Luukonen & Ståhle, 1990).

Thus, there seems to have been a movement towards focus on quality *improvement*. Literature on quality management often describes the development of such management as going from focus on quality *control* to more weight on quality *assurance*, onwards to quality *improvement* and in the end often a kind of total quality management (cf. Barnett, 1992; Aune, 1993). Hence, the ever-increasing focus on the organisational environment of researchers (like in this thesis) can also be seen as a way of assuring and improving quality, additional to the long-existing system of quality control.

2.7 Quality indicators

In studies of researchers and research organisations, different indicators or indices of quality have been used. The most common ones have been the number of publications and the number of citations connected with (the publications of) a group or an individual, and the (quantified) opinions of peers. I will take a closer look at these three and consider their relation to «research quality» as discussed above. Of course, quality indicators can play an important role in a research policy context as well (see Foss Hansen & Jørgensen, 1995 for more on this). In addition, individual researchers may utilise more or less rough indicators (e.g. publication productivity and perceived prestige of journals) in their frequent informal judgements of quality.

2.7.1 Publication productivity

The simplest quantitative indicator of quality is a *productivity* measure – a count of the number of products that are completed by an individual, a group or a larger organisational unit in a certain period. In an academic setting this means counting the scientific publications. In more applied research units, patents, patent applications, prototypes, internal reports etc. have also been included (see e.g. Andrews, 1979a). There is a large body of literature on scientific productivity. The simplest methods and raw indicators are easy to criticise, for instance if co-authorship and the different types of publications (books, articles, etc.) have not been considered. Even a single type of publication, the scientific paper, may have a very varying information content even in the same discipline and journals (Seglen, 1996). However, more sophisticated approaches have been developed, where for instance a productivity index is developed which is adjusted for different types of publications, co-authorship and more (an example is Kyvik, 1991).

Although researchers themselves tend to dislike such a «simple» measure (in e.g. Jacobsen, 1990), many studies have shown high correlation between publication productivity and measures of quality. The scientists who publish the most papers are also in general the ones that receive the most citations, awards and favourable peer ratings. This is true also at the Nobel Prize winner level (Zuckerman, 1977). In a review of these studies, Kyvik (1991:24-27) concludes that a significant relationship between productivity in publishing and research quality is indicated in all fields of learning. The weakest relationship seems to be in the humanities, but here more research seems to be needed because only a few studies (partly with weak empirical evidence) have been carried out in these disciplines. Thus, the scientific productivity literature can be a valid and of course useful input to a study of organisational influences on research quality, especially in the university/basic research sector. Since the correlation between number of publications and other quality indicators varies and in general is not «perfect», however, some care must be taken when using this literature. Variations in findings may be explained by the different bibliometric indicators that have been applied.

Still, Kyvik asserts that it is not easy to separate pure qualitative criteria from productivity, stating that judgements by peers may also be influenced by the sheer quantity of publications of an individual or a group. This is evidenced by a study of U.S. biologists which found that 40% of the evaluators' judgements could be explained by annual productivity of the rated scientists (Sonnert, 1995). On the other hand, Andrews (1979b) claims that quantitative data (output counts) and more qualitative ratings by informed individuals provide different information about the performance of research units. «Some 'good' units may not be prolific producers, and (…) the copious work of some other units may be of only moderate or low quality» (*ibid.* p. 34). In the study, as in Pelz & Andrews (1976), there is a marked absence of relationships between the subjective appraisals and the objective outputs of the research units, leading to some scepticism about how useful quantitative output counts really are (see Bonmariage *et al.*, 1979 for an elaboration of this issue).

2.7.2 Citation counts

Number of citations is another quality indicator that has been widely used in the sociology of science, particularly following the build-up of the large databases *Science Citation Index* and *Social Science Citation Index*. This indicator also displays significant positive correlation with measures like prestige rankings, scientific prizes and peer reviews (see e.g. Narin, 1976).

The validity of citation studies has been questioned as well, particularly when these have been applied at the individual level (Martin & Irvine, 1983; Lindsey, 1989). Not only may high quality work receive few citations and low quality and/or highly controversial work receive many, but there are many (additional) sources of errors in citation studies (Seglen, 1992). It is evident that the motives for citation can be varied and complex (Sonnert, 1995).

There seems to be agreement that citations measure *impact* or *visibility* rather than «basic» or «intrinsic» quality of research (Martin & Irvine, 1983; Moed *et al.*, 1985; Sonnert, 1995).[11]

2.7.3 Peer ratings and combined indices

To overcome difficulties related to each of these bibliometric indicators of quality, studies of research groups and their environment most often combine several indicators, including ratings by peers. Large studies like Andrews (1979a), Nagpaul & Gupta (1989), Singh & Krishnaiah (1989) and Spangenberg *et al.* (1990b) use both number of publications/patents, citations, peer review ratings and other indicators to form their performance indices. Peer ratings based on Likert or semantic differential scales can also be called «quasi-quantitative» measures of research performance (Nagpaul, 1995).

A good example of a complex approach is Pelz & Andrews ([1966] 1976). Here, the performance indicator was based on both quantitative data and qualitative judgements. All respondents were asked to indicate their number of technical books, papers, patents and patent applications, and unpublished reports or manuscripts during the latest five-year period. Around 20% of all informants were furthermore asked to act as judges by giving an evaluation of their colleagues' contribution to general scientific and technical knowledge in the field, and of their overall usefulness in helping the organisation carry out its responsibilities. The performance measures were modified to remove systematic variation based on level of education, length of working experience etc., and skewness in the output distribution of papers, patents and reports.

The methodology of Andrews (1979a) is very similar. In this study, performance measures were constructed from both quantitative information, especially counts of the units' outputs, and more qualitative ratings. Outputs were e.g. books, articles, national and international patent applications, algorithms/drawings and similar products, internal reports, experimental prototypes and audio-visual materials. Unit heads, staff scientists and external evaluators were asked to rate units along many dimensions, including productiveness, innovativeness, R&D effectiveness, international reputation, demand for publications, usefulness, success in meeting quality requirements, success in meeting schedules, general contribution to science and technology and application of research results. All the «qualitative» ratings were thus «quantified» along certain scales. The different ratings and output counts were combined in various ways to form ten performance measures, termed published output, patents & prototypes, reports & algorithms, general contribution, recognition, social effectiveness, training effectiveness, administrative effectiveness, R&D effectiveness, applications effectiveness and general R&D effectiveness. Furthermore, adjustments were made to take into account the institutional/organisational and disciplinary setting, so that the measures would «reflect the performance of a unit *relative to the best available estimate of what might be expected for units of its type*» (Andrews, 1979b:45, emphasis in original).

[11] I will concentrate here on the organisational influences on the «basic» or «intrinsic» quality of research and not its impact. A gap between quality and impact is nevertheless of obvious policy concern, although measures to improve impact perhaps would be largely oriented towards the scientific communication system and hence different from overall attempts to improve the basic quality.

Allen (1977) applied a different, but still complex, method. He focused on information flows in technological R&D organisations, and studied «general problems» that several groups were working on simultaneously. This «parallel» or «twin projects» approach included measuring performance – e.g. by monitoring «subjective probability» of success along the life of a project – and a number of information consumption patterns with specially-designed survey tools.

A simpler approach is found in e.g. Harris & Kaine (1994), who used number of scientific articles adjusted for the researchers' own ratings of journal quality to study determinants of research performance among university economists. As mentioned, there is also a large number of investigations of «scientific productivity» where numbers of publications are not adjusted according to more individual judgements of the quality of publications, journals etc.

2.7.4 Quantitative indicators and quality

In general, the most attractive aspect of quantitative measures of quality is their objectivity and reliability (Foss Hansen & Jørgensen, 1995). It is their validity that can be questioned – do they really measure what they intend to (if they intend to measure something else than plain number of publications etc.)? Obviously not all publications are of the same quality.

From one theoretical viewpoint it has been argued for a «constant probability of success», i.e. relatively constant odds for a publication to make a significant contribution. Hence, many articles, books etc., indicate a larger proportion of high quality work. On the other hand, it has been claimed that researchers exercise some control over the number of publications that they produce. If there are relatively many «mass producers» creating a large volume of marginal material and relatively many «perfectionists» who produce a small number of very valuable publications, the validity of publication counts would be undermined (cf. Sonnert, 1995; also Cole & Cole, 1973). Sonnert's study of U.S. biologist confirms the «constant probability of success» theorem, and he finds, as mentioned above, that productivity is a good predictor of peer judgements. He concludes that publication counts can be the quality indicator of choice for many research purposes, but not necessarily for all.[12]

Foss Hansen & Jørgensen (1995) have examined a large number of indicators (e.g. journal impact factor, peer review along pre-determined dimensions and scales, scientific forecast and other «early warning systems», in addition to the indicators discussed above) to see whether they can be used in management and control of research activities. They conclude that although most of the indicators intend to measure or approximate quality, none of them accomplish this.

Finally, indicators like number of publications, number of citations and peer ratings along pre-determined scales and dimensions may display relatively high correlation with each other and with signs of quality (awards etc.), but they do not reflect *sub-elements* of quality like

[12] Sonnert finds for instance some evidence that women are «perfectionists» to a greater extent than men, and thus, publication counts may be biased in favour of men. I will not focus on differences between women and men in this thesis, assuming that both sexes are influenced in a similar way by the same environmental factors.

originality and relevance. If such sub-elements can be tied to different organisational characteristics, it can be claimed that studies based on a single index of quality, no matter how sophisticated, cannot capture e.g. organisational tensions based on inherent «conflicts» in the quality concept.

2.8 Conclusion

In the literature, we find no generally accepted theory of «quality», and there is much discussion about what research is and what makes a work scientific. The literature provides good reasons to claim that research quality can be divided into several sub-elements that each express very different characteristics of the research products. Still, highly different specifications have been suggested. Based on previous empirical and non-empirical investigations I have chosen to focus on four elements of quality: solidity, originality, scholarly relevance and external relevance. As a starting point, I see all major aspects of research quality across disciplines and sectors as being covered by these four, but this will of course be interesting to study empirically. A brief summary of my decomposition of research quality can be found in table 2.2 below.

Table 2.2. *A decomposition of research quality*

Quality «sub-element»	**Description/basis for exploration**
Solidity	Connected with how convincing the research is, expressed e.g. by validity, reliability, probability, stringency etc. Particularly related to the research methodology.
Originality	Key criterion in research work; one should be able to find types or degrees of originality.
Scholarly relevance	Can be deepened by the expressions cumulativity and generality, but how are these explicated further?
Utility value	Also called external relevance; both in practice and in the literature an abundance of different meanings can be put into these terms.

What we do not know, is how such quality elements are elaborated and specified in different disciplines and institutional settings, and if they all are relevant in all types of research work. We furthermore know little about the relationship between the elements, and we know next to nothing about how quality elements can be linked with the further organisational environment. Previous investigations have mainly centred either on research quality or on the organisational environment, and the research quality studies have furthermore been chiefly quantitative. The qualitative methodology and the focus on in-depth specification in the present thesis thus constitute a new perspective and fill a gap in the literature.

Although the term «quality» may be relatively new in common use in science, quality control has always formed a central part of scientific work. Nevertheless, the last decades have seen a development that can also be described by an increased weight on the assurance and improvement of quality, e.g. the now widespread carrying out of evaluations and focus on organisational prerequisites for good research. Indicators of quality have become much used outside of investigations of science, not only at the national/international policy level, but also at the institutional level. They can thus be regarded as a management tool by themselves. Such indicators measure aspects like quantity, productivity, visibility, activity and impact, but do not measure quality. Still, indicators tend to display high intercorrelation as well as have a strong relationship with more traditional quality measurement (peer review). Despite the weaknesses that have been pointed out, I do not see major problems with using results from previous investigations that have been based on rough quantitative indicators as a starting point for describing good research units. What none of these earlier studies indicate, however, is how research products and units score on the different sub-elements of quality.

We have seen that several studies of research quality have been carried out, most of them quantitative. What is lacking, is an in-depth elaboration of terms like originality and relevance, and a thorough understanding of the relationship between such elements. My first main research proposal is that quality can indeed be divided into sub-elements in this manner, and that there will be tension between them. This will be looked into in chapter five, along with the following research questions:

- Can we find diverging opinions on the nature and objective of research work and different conceptions of «quality» behind elaboration of research quality?
- Are there central criteria of good research that my four suggested elements do not cover?
- How are aspects and dimensions related to originality and solidity described?
- What is generally meant by «relevance», and is it fruitful to distinguish between «internal» and «external» relevance and make both of them demands in all types of research?

3 The organisational environment of research work

The topic of this chapter is the organisation(s) in which research is carried out. Although I see all research work as carried out by individuals (alone or in co-operation), they do so within a context. Organisational aspects of this context are elaborated below.

In 3.1, I describe some theoretical perspectives, both from organisation theory and from «social studies of science». I end up in a «tension» or «paradox» perspective, where research units are viewed as characterised by different «antithetical» or «dichotomous» aspects that need to be balanced. «Good research organisations» are described in 3.2. I argue that good research units are not just «accidental» clusters of individuals, that there are some common organisational characteristics unrelated to the present individuals in the unit. Furthermore, I elaborate how organisational aspects may influence quality, and I describe some central features in previous empirical investigations of research unit performance. The following subchapters deal with dynamic aspects of scientific work (3.3), disciplinary differences (3.4) and differences between institutional settings (3.5). A summarising discussion of the current knowledge about the constituents of good research units is found at the end of the chapter, resulting in a complete research model for the thesis (3.6).

3.1 Organisational perspectives and research work

In exploratory research, the role of the theoretical framework is typically to determine the concepts to be used both in elaborating the dependent variable, as well as accounting for differences in it (Blau, 1973). Furthermore, the framework will also indicate an order of priority among the factors that are being investigated (and implicitly also exclude some factors from the analysis). In addition to the elaboration of research quality in chapter two, organisation theory and results from earlier research on research unit performance will shape my research design and my interpretation of empirical results.

With very few exceptions, the previous investigations of science and scientists have rarely aimed at making general contributions to organisation theory (Blau, 1973 is an exception). In the field «social studies of science», organisational studies are furthermore lacking at the moment, at least if judged from the central journals in the field and the most recent *Handbook of Science and Technology Studies* (Jasanoff *et al.*, 1994). Laredo (1999) is the only large study since Andrews (1979a) that has connected judgements of outputs («research profiles») to organisational aspects.[1]

Although there are many cross- or transdisciplinary efforts, it can be claimed that a dividing line can be seen in the field connected with the objects of study that have been chosen. Many of the studies that originate in sociology and political science concentrate on basic research or «Science» (primarily as opposed to «Technology»), which means that empirical data mainly are collected from the university sector. On the other hand, industrial and other «applied» R&D organisations, and engineers/technology in general, have been the foci of management scientists. There can be good reasons for such a dividing line. The most important is probably that there seem to be major differences between the sectors in the way research is managed and organised (which is discussed in 3.5).

For policy purposes, the dividing line is not necessarily all that fruitful. Because of the different perspectives in the literature, comparisons across sectors can be difficult, and it is often hard to see «the total picture» of the research system. Some actors in the system, e.g. the Research Council of Norway, sponsor research both in universities, the institute sector and industry, and they would be interested in this total picture. Thus, for studies with a partially practical aim, like the present one, it will be important to include literature from «both sides». The dividing line in the field and the underlying dichotomies upon which it rests (e.g. science/technology, basic/applied, internal/external) have also been criticised from a scholarly point of view (for instance Bijker *et al.*, 1987).

3.1.1 An abundance of «organisational paradigms»

Turning to organisation theory, one's hope of finding simple and agreed upon specifications of organisations and their elements, and how these should be studied, vanishes quickly. There are very many different perspectives and no obvious criteria for selecting a specific model or «paradigm». Pfeffer (1982) has for instance described the domain of organisation theory as a «weed patch», full of «middle range theories» along with a number of more or less isolated concepts, measures, terms and «research paradigms». In the words of Clegg & Hardy (1996:3), reviewing the field: «Gone is the certainty, if it ever existed, about what organizations are; gone, too, is the certainty about how they should be studied, the place of the researcher, the role of methodology, the nature of theory.»

[1] It can be noted that many of the organisation theory scholars that I use in this chapter, more or less explicitly define themselves as «social constructivists» or «constructionists» (e.g. Weick, 1979; Pfeffer, 1982; Morgan, 1988), or are positive towards such a perspective (Scott, 1992; Clegg *et al.*, 1996). This does not mean that they are not preoccupied with «organisational effectiveness,» quality, or improvements in organising processes. These are central themes in this literature, although simple evaluation procedures (e.g. goal attainment), the belief in «objective» and «independent» quality criteria, and simple transitions from the descriptive to the normative are warned against. Constructivism can also be claimed to be the dominant theoretical perspective in the «social studies of science» field (at least from Jasanoff *et al.*, 1994 and two of the leading theoretical journals, *Social Studies of Science*, and *Science, Technology, and Human Values*). Here, however, aspects like «quality» and «organisational effectiveness» are rarely discussed at all in contemporary theoretically oriented work (Jasanoff *et al.*, 1994, is a good example). There are of course some exceptions, as will be seen throughout chapter three, but few of them with constructivist perspectives.

Some authors explicitly try to define what an organisation is (like Scott, 1992), while others avoid the question altogether (e.g. Mintzberg, 1983). Organisations can simply be viewed as mechanisms for achieving a large number of objectives, characterised by e.g. a certain internal hierarchy and division of tasks (Scott, 1992). The objectives are not necessarily clear and static, however, and the organisation may produce a number of unanticipated effects and engage in many activities that are not necessarily related to the objectives in any way. This leads Scott to present several alternative definitions, based on other perceptions of organisations. It is obvious that organisations look very different, depending on the «paradigm», the «frame» (Bolman & Deal, 1984) or the theories through which they are viewed.

Behind many reviews of organisation theory (e.g. Pfeffer, 1982; Morgan, 1988; Scott, 1992; Clegg *et al.*, 1996) seems to be the opinion that organisational perspectives have progressively become more complex and improved. From viewing organisations as simple, mechanistic structures, as «machines» (Morgan, 1988), theory has «progressed» to including for instance political, symbolic and other cultural aspects, as well as dynamic and sophisticated relations between individuals and their surroundings. This development has been based on or preceded by e.g. ideas in which organisations are perceived not as isolated units (but rather as «open») (Scott, 1992), new perspectives on action that are less «rational» (Pfeffer, 1982), and changes in psychology towards investigations of «contextual matters» (Nord & Fox, 1996).

3.1.2 Elaborating organisational paradigms

Scott (1992) distinguishes between views of organisations as *rational systems*, *natural systems* and *open systems*. Within each of these views, one can furthermore discern between levels of analysis, for instance the «social psychological level» and the «macro level». The rational view places great emphasis on control – the determination of the behaviour of one group by another. The focus is mainly on formal organisational variables, the «normative structure», most often ignoring aspects like the larger social, cultural and technological context. Such aspects are on the other hand central in the natural systems perspective. A main assumption behind this view is that the formal structure (including goals) is often overshadowed by the «behavioural structure». Other processes are vital, and these are often oriented at «system goals», survival being the most prominent one.

The open systems view questions the distinction between the organisation and the environment, claiming that the definition of the boundary often seems arbitrary and should vary with the purpose for considering the organisation. It is stressed that all organisations must secure a continuous supply of resources, including people, from their environment. A central assumption is that interorganisational relationships may be a more important source of capacity and capability than internal features such as «size» and «technology» (Clegg & Hardy, 1996). In this perspective, a shift is furthermore often made from an attention to structure to an attention to process (cf. Weick, 1979). Processes can be related to communication, training and socialisation, accumulation of resources etc.

Quite similar to Scott's «rational» and «natural» views, Pfeffer (1982) advances two dimensions to distinguish between different theories of organisations. The first is the perspective on action taken, i.e.

- if action is seen as rational or at least «boundedly» rational, purposive and goal directed, or
- action is externally constrained or environmentally determined, or
- action is emergent from, and in, social processes.

Behind this distinction, different fundamental views of human behaviour can be found. The two first perspectives on action can be described as stimulus-response views, centring on preferences, values, goals etc., or on environmental conditions that produce the behaviour, respectively. Pfeffer mainly advocates the third perspective, which rejects the stimulus-response «paradigm» altogether, arguing for the importance of «the unfolding process» in understanding action. This could imply that one should not exclude the «research process» when aiming at elaborating how research quality can be influenced (see also Weick, 1979). Pfeffer's second distinction is related to the level of analysis, which is dealt with below.

Scott (1992) describes «professional organisations» like R&D units as some of the most elaborate and intricate organisational arrangements that have been devised, due to high orders of uncertainty and complexity. Scott distinguishes between two types of professional organisations – those that are autonomous and those that are «heteronomous». This distinction is very similar to Mintzberg's (1983) elaboration of the professional bureaucracy and the adhocracy (see 3.5 for an elaboration). The autonomous professional organisations, of which universities and hospitals are prime examples, grant the professional employees considerable responsibility for defining and implementing goals, setting performance standards and maintaining them. In the heteronomous types, employees are subordinated an administrative framework, and the amount of autonomy is smaller. Scott states that this organisational form often is exemplified by applied research institutes and R&D departments of industrial companies. It is claimed that both these types of organisations offer many opportunities and challenges, but at the same time impose great pressures and requirements on the individuals. Hence, forms of «tension» seem to be built into the organisational design. Furthermore, the employees of these professional organisations have a «dual membership» – their external professional network may provide more important rewards, routines and other inputs and processes than their formal employer (Mintzberg, 1983). It seems necessary to have an «open» view of organisations to capture this central feature.

In the field «social studies of science» (or «research on research»), two different basic perspectives on how research can be influenced and controlled can be discerned, termed *internalism* and *externalism* (Foss Hansen, 1988). These are very similar to the views of organisations as open or closed systems (cf. Scott, 1992). The idea or basic premise behind internalism is that the development of science is autonomous, i.e. independent of the development in the rest of society. Foss Hansen distinguishes between the following internalist sub-perspectives:

- *Bureaucracy*, stating that senior or «elite» researchers influence the work of junior researchers through authority, hierarchy and by controlling systems for rewards and funding (cf. Blau, 1973; Cole & Cole, 1973).

- *Market*, asserting that the research system best can be seen as a market where information (research results etc.) is exchanged for e.g. «recognition», «credit» and/or funding opportunities (see Hagstrom, 1965; Bourdieu, 1975; Latour & Woolgar, 1979).
- *Democracy*, where focus is on the tradition of freedom for research, on the internal democratic structure of research institutions and on the institutions' relatively high level of autonomy (e.g. Wyller, 1991).
- *Norms*, considering fundamental norms of science to be the most influential factor on its development (cf. for instance Merton, [1942] 1973, Mitroff, 1974 – the latter verges on externalism, for instance through its «counter-norm» of self-interest).
- *Dialogue*, claiming that the most important source of control are networks of researchers that can be found in disciplines (examples are Crane, 1972; Collins, 1985).

Some of these can relatively easily be fit into a rational/natural framework, with the first two perspectives in the above list closest to the rational end. Sub-perspectives under externalism are not that easily discernible. In general, though, this perspective upholds a two-way relationship between science and society. The relevant networks that influence the development of science stretch outside the scientific world, to economic and political actors (Knorr-Cetina, 1981), who on the other hand also are influenced by the scholarly development. Differences between disciplines in this respect are often underlined (cf. Whitley, 1984), and policy recommendations call for diversity (Cheng & McKinley, 1983). Almost all the internalist literature describes basic research only, while the externalist perspective also takes e.g. high-tech fields as a starting point (for example «artificial intelligence» in Ahrweiler, 1997).

Foss Hansen (1988) argues that although externalist views have been fruitful, this does not mean that internalist perspectives are irrelevant. Although each of them does seem to give only a partial view of management and control in science, a combination may yield a fruitful description of the complex interplay of different control mechanisms in the everyday life of researchers. A Danish study of one research institute and four university departments found that all the internalist control mechanisms could be recognised in each of the organisations (cf. Foss Hansen, 1988: 69-91). It is concluded that although the internalist models are essential for comprehension, they should be supplemented with externalist models «if an overall understanding is desired» (*ibid.* p. 91). For this study, an implication could be that for instance communication and collaboration with actors outside of the scientific communities should be touched upon.

Earlier studies of science and scientists can also be categorised using other organisational frameworks, e.g. Morgan (1988) or Bolman & Deal (1984). The latter distinguishes between several «frames» or approaches of looking at organisations and management – for instance the «structural approach», the «human resource approach» and political and symbolic frames. Works on the norms of science could then be placed in the symbolic frame, while e.g. Latour (1987) could be labelled as a «political» point of view, seeing researchers as political, even «Machiavellian» (Sismondo, 1993) actors in a «warlike» environment. However, the message from Bolman & Deal (and that of Morgan, 1988) is similar to Foss Hansen's: It is necessary to gather a combination of factors from different perspectives in order to get a more total picture of organisations.

Thus, although adopting an organisational paradigm gives an indication as to which elements and processes are central (and which are not), the literature also recommends using several perspectives simultaneously. Multi-paradigm perspectives often look at a broad selection of organisational elements. For instance, Clegg *et al.* (1996) deals with strategy, leadership, decision-making, cognition, groups, individuals in organisations, communications, technology, innovation, organisational learning, diversity, the environment and globalisation. Pfeffer (1982) views organisations as physical structures, relational networks and a number of demographic processes. Scott (1992) elaborates e.g. environments, dynamic processes, social boundaries, technology, size and structure, goals and organisational effectiveness with the rational/natural/open systems framework. It can be seen that some issues are common to these perspectives, like communication, resources and physical facilities, and how the work force is put together.

3.1.3 Level of analysis

The level of analysis may inform further some relevant aspects of organisations. As stated in the introduction, I am not trying to discover why or how some individuals create good research, but why and how they seem to do better work in some organisations than in others. In other words, I am not focusing on organisations like universities, research institutes or groups *per se*, but rather on what makes individuals perform better in some of them. Furthermore, I do not see social conditions as «given», with a one-way influence on people's behavious. Obviously, social conditions are not simple exogenous variables, but somewhat or largely constituted by the (mix of) individuals in research units. I see individuals as «semi-autonomous» and as important contributors to and interpreters of their environments (cf. Weick, 1979), and I thus see the «meso» level of analysis as appropriate for the present study. This is elaborated below.

The level of analysis is the second dimension in Pfeffer's (1982) categorisation of organisational theories. He distinguishes between a macro level, where the organisation is seen primarily as a single unit, and a micro level that focuses on smaller social units (coalitions, groups and other sub-units). This broad dividing line can be drawn also in the social studies of science field. Macro studies for instance focus on the characteristics and development of science «in total» or of whole disciplines (examples are Merton, [1938] 1970; Price, 1965). Micro investigations centre on the other hand on small units – groups and/or individuals, and the characteristics of and influences on research work at this «floor» level. It can be added that in general, «internal» and relatively autonomous small groups have become very common in all types of work, particularly for tasks requiring some degree of innovation/-creativity (see e.g. Shulman, 1996), increasing the need for more micro perspectives.

Pfeffer (1982) claims that there are two issues of importance when considering the unit and level of analysis issue. The first is methodological and involves selecting a level or unit that is appropriate, given the propositions that are being examined. The second is more a «matter of taste and philosophy», where dependent variables and theoretical processes are selected, based on the assumption that one level is more productive than others in generating useful and important theories. Both these issues imply that I focus on individuals and their surroundings, given my definition of research quality as an intrinsic characteristic of the research «products» (cf. chapter two), and that these products are made by individuals or individuals in co-operation. In addition, Pfeffer states that one should define units of analysis that are sufficiently inclusive to capture variation of interest. For this purpose, I include fields of learning (natural sciences, social sciences etc.) and institutional settings as intermediary variables.

Still, it is not necessarily obvious what is referred to with the broad term «micro». At this level, we can again find different perspectives or paradigms. Pfeffer (1982) for instance discusses the «individualist-structuralist controversy», involving «fundamental epistemological beliefs» about the nature of human interaction and social structure. Nord & Fox (1996) talk about a variant of the «nature versus nurture» debate. They argue that a change has taken place in organisational studies concerning assumptions about the appropriate «primary level of analysis» from the individual (psychological) level to the *meso* level: «Emphasis has shifted from viewing individuals independently of context to consideration of the interplay between individuals and their contexts» (p. 148). The term «context» is elaborated with attributes of the physical and social systems in which individuals exist. Interplay is a key word, implying that neither the role of the environment nor the importance of the individual is exaggerated, but that there is a «dynamic reciprocal causality».

Nord & Fox argue strongly that «insufficient attention» has been given to contextual matters in organisation studies, where the main framework in «primary level» studies has been psychological, with major themes like personality and individual differences, job attitudes and career variables, and motivation. Such aspects have also been studied intensively to explain differences in scientific productivity and performance (see Fox, 1983; Kyvik, 1991; Reitan, 1996). Although good scientists may be given certain common personality traits (Stein, 1963; Jackson & Rushton, 1987), few studies have managed to present a clear connection between research performance and individual abilities and other psychological characteristics (cf. Bayer & Folger, 1966; Cole & Cole, 1973; Andrews, 1976; Kyvik, 1991). The reason could be methodological: abilities are not likely to be as unevenly distributed as performance, thus making it difficult to come up with significant correlation coefficients. However, it is also suggested that environmental factors have to be present for individual abilities to be transformed into a creative and productive output (Pelz & Andrews, 1976).

My own focus on the meso level does of course not mean that researchers are not important to research quality. Nevertheless, I believe that the importance of the individuals will emerge by looking at other problems, rather than by studying characteristics of the researchers by themselves. Following Weick (1979), I also assume that a good understanding of behaviour and influences at the meso level is necessary in order to develop policy and strategy for research at a macro level.

To elaborate somewhat, Weick asserts that organisations do not behave. People behave, and organisations and organisational processes can only be understood by considering the interactions among people. He discusses the *process of organising*, introducing «the double interact» as a new fundamental unit for organisational analysis. His view is not that individuals have features that help them know their environment objectively, but rather that individuals act, and then respond to and try to make sense of what they have done. Through this, individuals actively create the environments they respond to. Organising is seen as the process of developing stable patterns of interaction, which serves to remove some of the «equivocality» (ambiguity) from the interaction process. Thus, organising is oriented at establishing a workable level of certainty. Dealing with equivocality or ambiguity in general requires efficient «communication-behaviour cycles.» Hence, (internal) communication is seen as a central process in organisations.

Finally, it can be mentioned that although my analysis will be oriented mainly at the meso level, the *unit* of analysis is not necessarily given. The question of the «basic unit» in research work has been widely discussed (see e.g. Premfors, 1986). In my opinion, this will probably vary between disciplines and sectors, particularly based on the degree of teamwork and the degree of project work (matrix structure). Since I intend to look closer at several fields and sectors, I will not specify further any unit of analysis (team, project, department, laboratory etc.), but rather let this be a minor point of study.

3.1.4 The organisation as «tension» or «paradox»

We have seen that there are different perspectives or «paradigms» in the realm of organisation theory, all stating that some organisational elements and processes are more important than others. Many authors have argued that empirical investigations need to incorporate several frameworks or views in order to capture a more complete picture of organisations (e.g. Bolman & Deal, 1984; Morgan, 1988; Foss Hansen, 1991). Each perspective may give a logically coherent but still insufficient view of organisational elements and processes. Multiple frameworks are thus needed to capture ambiguous, inconsistent, paradoxical and dichotomous aspects.

Foss Hansen (1995) has taken this a step further and proposed a «paradox perspective» in which the inconsistencies and paradoxes of organisations are defined as their central element. She argues that all organisations can be characterised by contradictory traits, e.g. concerning tasks, processes and structures. These contradictions are elaborated as *tensions* that «keep organisations breathing and alive» (p. 41) because they «release energy» and thus improve performance. It is claimed that «organisational effectiveness» in fact rests largely on the ability to maintain and manage the balance in relevant dichotomous dimensions. Hence, research evaluations should for instance look for the existence of paradoxes and the ability of the organisation to sustain them. Foss Hansen provides three examples of tensions in research organisations: norms of elitism versus norms of egalitarianism, international versus local integration and renewal versus the maintenance of current paradigms and problems. She underlines that the perspective seems fruitful both to get an improved understanding of organisations and to suggest methods for improving quality.

A matching framework is proposed by Dougherty (1996). Here, tension is the key word for understanding how innovation is organised. As was seen in chapter two, there are many similarities between research work and innovation (research can e.g. be seen as part of the innovation process). Dougherty distinguishes between four main types of tension: inside versus outside, old versus new, strategic determination (top-down) versus strategic emergence (bottom-up) and responsibility versus freedom. Innovation (or R&D) typically implies a focus on outside orientations, originality, emergent strategies, and freedom, while the rest of the organisation may be better served by an orientation towards the opposite. It is indicated that tensions stem from the activities themselves, but the theme is not elaborated much further. The dilemma of «creative destruction» and stability versus change is also well known from the general innovation literature (cf. Zaltman *et al.*, 1973; Abernathy & Clark, 1985).

Similar to Foss Hansen (1995), Dougherty (1996) underlines that tensions cannot be eliminated: «These tensions must be balanced throughout the organization, because the activities of innovation extend beyond a project, and are inextricably bound up with the organization as a whole.» To «balance» or «accommodate» tension is seen as crucial to facilitate innovation. Weick (1979) suggests that even if the objective of the organising process is to reduce ambiguity, some ambiguous features have to remain to make the organisation able to survive the transition to a new and different future.

Tension can furthermore be linked with theory on «organisational learning», because learning is seen as disorganising and increasing variety, while organising implies forgetting and reducing variety (Weick & Westley, 1996). It is claimed that these two opposites should be connected (i.e. maintaining the tension), and that a focus on informal organisational aspects is necessary to accomplish this. Tolerance of ambiguity and paradox, albeit difficult to achieve, is seen as a key factor behind organisational renewal (see Birkelund, undated for an elaboration). It can be mentioned that it has been found that eminent scientists frequently work simultaneously with alternative methodologies, competing hypotheses, conflicting theories etc., compared to «run-of-the-mill scientists», thus maintaining a kind of tension at the individual level (e.g. Zuckerman & Cole, 1994).

An interesting parallel can be made to micro-level investigations of influences on motivation. Herzberg *et al.* (1993) claims that the motivation to work is affected by two types of factors – «hygiene» and «motivation». The former may make the worker less «demotivated» or «dissatisfied», but do not by themselves contribute in a positive way. Examples are salary, physical working conditions and the relationship to colleagues. Motivational factors, on the other hand, contribute directly and positively to motivation/satisfaction, and their influence will be greater if the necessary hygiene factors are present. Herzberg and his colleagues mention the work itself, recognition and responsibility as examples of motivational factors. The authors furthermore assert that these will be more important the higher the work/educational level of the personnel. Hence, such «inner factors» should be central in an R&D context. A central claim is that the two types of factors influencing motivation are independent of each other, and that any individual's motivation thus can be explained by «a paradox of two dynamics» (p. xvii). Although Herzberg and colleagues seem to have a relatively simple view of action as environmentally constrained or determined, the distinction between «hygiene» and «motivational» factors can be fruitful when trying to explore the relationship between individuals and their surroundings. It can be added that the basic perspective in Herzberg *et al.* is that of «human relations management», and its central assumption is that motivation (or «morale» in some studies) is central to performance and that this motivation is influenced in various ways by social factors. This has been corroborated in several investigations of researchers and research units (e.g. Knorr *et al.*, 1979b; Hare & Wyatt, 1988).

Thus, organisations can be characterised by tension along various dimensions or connected with certain aspects. Some dimensions/aspects can be external versus internal orientation, freedom versus responsibility and egalitarianism versus elitism. The essence of a tension or paradox perspective is that one «side» cannot (and/or should not) be selected at the expense of the other, but that a balance between opposing characteristics can lead to innovation and learning (see Birkelund, undated). Although I do not wish to contribute primarily to organisation theory, the tension perspective is new and interesting and a call for theoretical and empirical work has been made (Foss Hansen, 1995). Furthermore, tensions are often defined in terms of abstract categories («egalitarianism versus elitism»), and it will be interesting to study how (and if) this is experienced in the daily life of researchers.

3.1.5 Tension in research units

A tension/paradox perspective is consistent with earlier findings in empirical studies of research units – good research organisations seem to be characterised by many such ambiguous aspects. In the words of Kuhn (1963:342), «The ability to support a tension that can occasionally become almost unbearable is one of the prime requisites for the very best sort of scientific research.» This seems particularly oriented towards originality in research work; Kuhn names the phenomenon «creative tensions».

Pelz & Andrews (1976) adopt that expression and discuss factors of «challenge» and «security» that together constitute creative tensions. They assert that all organisational aspects of research units may have a stabilising and destabilising side, and that both have to be present in order to create an environment that makes the individuals perform their best. In their empirical study[2], performance was found highest under conditions that seemed «antithetical», e.g. simultaneous high levels of autonomy and dependency upon others (*ibid.* p. xv):

> *«It seemed reasonable to say that the scientists and engineers of our study were more effective when they experienced a 'creative tension' between sources of stability or security on the one hand and sources of disruption or challenge on the other.»*

Some of the most distinct tensions were related to time use – the researchers' distribution of «technical time» (time spent on non-administrative tasks) across five different technical activities (basic and applied research, development and improvements and technical service) – and communication. Pelz & Andrews found that the highest performers in all types of settings devoted a relatively large share of their time to other activities than what could be described as the main goal of their laboratory or organisational unit. Effective scientists did not spend their time in basic science or in «the world of application» alone. For instance, «even in laboratories devoted to pure research the best performers carried out four functions; they did not concentrate on research alone, but spent some time on development or service functions» (p. xviii). If Ph.D.'s or assistant scientists tried to do all five types of R&D activities, performance dropped, whereas engineers flourished under such conditions. Pelz &

[2] This is another of the largest studies in the field, both in terms of size and influence. Data were collected from 1,311 scientists and engineers at universities, in government research institutes and in industrial R&D laboratories. They come from a broad range of fields and disciplines, but none from the humanities and only a small share from the social sciences (and only in the university sector).

Andrews discuss seven broader tensions surrounding research units: science versus application, independence versus interaction, specialisation versus breadth, autonomy versus external demands, influence on others versus control by others, intellectual harmony versus intellectual conflict and young versus old (e.g. related to group age).

One implication of balancing security and challenge could be that university departments/-research groups can be described as «nice places to work» without necessarily making high quality research products (Jacobsen, 1990). Having a good and friendly working climate contributes to a feeling of security among the researchers, but does not provide the challenge necessary to produce very good research. It has also been found that groups with high autonomy but little external pressure perform poorly, while groups with an equivalent level of autonomy and much pressure or with strong group-internal norms of innovation and change, perform well (Kim & Lee, 1995). It is perhaps typical that the literature that gives a more «ideal» picture of good research units focuses almost exclusively on challenge factors – e.g. Asmervik *et al.* (1995), who depict good research units as «dynamic, demanding and courageous».

Separating factors in this way may for instance explain why few studies fail to find a significant relationship between resources and performance (see chapter nine). A certain level of (economic/material) resources may be necessary to be able to do good work, but does not in itself contribute to high performance – this is a «hygiene factor» in the terminology of Herzberg *et al.* (1993). Thus, it can be asserted that a certain minimum of human, time-related and financial resources, as well as possibilities of interaction with colleagues and other relevant actors, is necessary to be able to create good research at all. Time to carry out research, a friendly (or maybe at least non-hostile) working climate and the right equipment will not, however, automatically lead to research quality. Other factors influence how good the performance will be, e.g. a strong dedication to research, pleasure of carrying out the actual research work and interaction with challenging colleagues. In addition, following the arguments of Herzberg *et al.*, a low salary, relatively low standards of facilities and equipment, an unfriendly working climate etc., could make the individual researchers more dissatisfied, but would not necessarily lead to reduced motivation.

From the literature, the institute sector seems surrounded by particularly high levels of tension (Mathisen, 1989). Mathisen argues that institutes need to develop a «third alternative», balancing forces that pull them in academic and in market directions. Focus on strategic research and new forms of recognition and dialogue («hybrid communities») are some of the arrangements that are suggested for balancing tension.

Finally, I would like to comment on the somewhat «normative» underpinnings in many specifications of tension (including mine above). For instance, Foss Hansen (1995) argues that tensions and organisational paradoxes are good because they «release energy» and stimulate individuals. However, it is not necessarily certain that all types of scientific personnel feel comfortable in such organisations. Pelz (1967) found that high-performing researchers seek out units where the levels of both security and challenge are high. It could be claimed that some individuals and research units want less tension because they do not aim to become «eminent» or internationally leading. I will return to the question of tensions at the end of

3.2, after looking closer at the organisational aspects that have been found central to research performance in previous investigations.

3.2 The good research organisation

Two basic questions need to be addressed before turning to specific organisational aspects. Is it at all relevant to talk about good research organisations, or are they nothing more than an accidental clustering of extraordinarily talented individuals? Furthermore, can it really be claimed that organisational/social aspects can influence research *quality*, the very intellectual heart of scientific activities? These two questions are elaborated in 3.2.1 and 3.2.2.

3.2.1 Do good research organisations exist?

The literature on publication productivity has firmly established that the overall rate of scientific productivity is low, and that it is highly skewed (see Fox, 1983 and Kyvik, 1991 for a review). Since the correlation between number of publications and measures of quality is generally high (cf. chapter two), it can be claimed that also the research quality is highly variable. A Danish interview study furthermore found that there is a large variation in how «good» or «supportive» the informants' own department was perceived. This variation does not follow institutional or disciplinary boundaries, i.e. there may be «good» and «bad» groups or departments in all disciplines and institutions (Jacobsen, 1990).

However, although both the research quality and the «quality» of the environment seem to be very variable, and many studies have shown high correlation between different organisational variables and research performance, the nature of the relationship has been questioned, not least in the productivity literature. «Does the institutional affiliation affect the productivity of an individual, or is it the productive individual who is attracted by these institutions?» Kyvik (1991:142) asks.

Fox (1983:292), in a review of the publication productivity literature, concludes, «Recent investigations point to the stronger causal effect on location upon productivity (rather than vice versa).» The investigations that Fox points to, are two longitudinal studies by Long (1978) and Long & McGinnis (1981). Here, it is shown that the initial appointment of scientists (after their doctoral degree) has an impact upon later productivity, which in turn affects the prestige of the second location (Long, 1978). Publication is especially depressed by taking a job in four-year colleges and non-academic settings, and fostered by working at a research university (Long & McGinnis, 1981). Although this may be explained by barriers towards publication in other settings than research universities, this cannot be the full explanation, because the authors find that it takes three years for the changes to take effect.

Blau (1973) found that the «colleague climate» displayed a pronounced influence on the research involvement of individuals, independent of the individual's own training and institutional conditions. He stated that when one's colleagues have good research skills, they give advice when needed. Such processes of exchange constitute not only a reward mechanism, but also a form of group pressure to engage in advanced research, because failing to do so will deprive the individual of fundamental social rewards. A similar process was found in poor research units, where «opposite normative pressures» stifle research interests – the long and difficult research process is not rewarded with social approval, but rather ridiculed with phrases like «publish or perish». Thagaard (1991) found the same in Norwegian universities. Some scientists are «opportunity-limited» or simply «isolated» in poor environments. It can be added that not all those in «good environments» had high publication rates. The researchers in good units who neither carried out leadership functions like team building, resource gathering, recruiting etc., nor focused on building networks to other institutions and countries, did not publish much more than moderately motivated researchers in poor units.

Still, the reasons why the organisational environment influences research performance and publication productivity, are not well understood (Fox, 1983:293, emphasis in original):

> *«While research has garnered support for departmental or institutional prestige as a determinant of productivity through publication, the shortcoming of these investigations lies in their failure to explain* how *prestigious departments and units foster, and minor institutions discourage, publication. Hence, the literature has failed to specify the extent to which major (that is, prestigious) departments and institutions promote productivity through available time, through research assistantship, or through a favourable reward structure.»*

The nature of the relationship between individual and environmental variables is also discussed by Pelz & Andrews (1976). They found that scientists and engineers who saw their most important colleagues (excluding supervisors and assistants) rather frequently, tended to perform better. They ponder whether it may not be the other way around – that high performers are sought out more often by their colleagues, and conclude (p. 52):

> *«When we found that the positive relationship between colleague contacts and performance appeared even after we had taken into account differences in experience, in supervisory status, and in which person originated the contacts, then it looked as if contacts did enhance performance – at least sometimes.»*

Exchange and communication among colleagues and associates is also the one variable that Fox (1983) finds emerging with some consistency from the productivity literature, and it is central in Blau's (1973) specifications. Even Nobel Prize winners, who can be expected to be very motivated and skilled, state that they have done better work in some settings than in others (Zuckerman, 1977:172):

> *«Do social contexts of scientific research affect its scientific quality or significance even though they do not affect the timing of the [Nobel] prize? Next to nothing is know about the ways in which particular universities or laboratories promote intellectual achievement over and above what would have been the case were the same individuals working elsewhere. (…) Accounts of (…) 'evocative environments' often take note of the presence of several generations of distinguished and promising scientists rather than just one generation. They also note the presence of intensive interaction and competition.»*

The quotations from the Nobel Prize winners seem to indicate that they have benefited from close collaboration with colleagues and the «research culture» that such an environment signifies. Still, one-fourth of the (future) prize-winners did not work in elite universities or research institutes. Zuckerman states that they have «enlarged» their environment and contributed much to forging the research culture and the collaborative patterns. Thus, there is not a one-way relationship. Kyvik (1991), finding that international communication is the best general predictor of research productivity (excluding individual characteristics as age and rank) in a sample of 1,585 Norwegian university scientists, also sketches a reciprocal relationship. Individuals need to be aware of research done elsewhere and aware of scientific networks to establish external communication, «but visibility and attractiveness are equally important for the possibility of establishing close research relationships» (*ibid.* p. 137). Pelz (1967:xxvi) arrives at the same conclusion:

> *«My own speculation is that a feedback loop exists. Usually a high performer has not only ability but also personality traits of curiosity and confidence. He is attracted to diverse problems and to contact with colleagues (a source of challenge) and at the same time insists on freedom and a voice in decisions (conditions of security.) He thus exposes himself to conditions which in turn stimulate him to achieve. If this is the case, might lower achievers surround themselves with a similar climate and so enhance their own performance? I believe they can.»*

Blau (1973) sketches a reinforcing process as well, because good researchers are attracted to good universities. They benefit from an excellent collegial climate and become better and/or more productive scholars than they otherwise would be, thereby helping to «perpetuate the university's tradition of scholarship and preserve its reputation» (p. 241). Thagaard (1991) describes a process where a good environment, a high individual dedication to research work and high «organisational activity» (e.g. building teams and networks) become mutually reinforcing. She stresses that the organisation and network contexts might be particularly central in the early years of a scientist's career.

Thus, the evidence cited above indicates that all researchers, no matter how talented and experienced, can benefit from being in a «good» research organisation and experience difficulties in a «bad» one. Consequently, enhancing one or several individuals' performance by improving the «research climate» seems possible. There is nevertheless a need for more evidence and a focus on feedback loops and other dynamic processes (see 3.3).

3.2.2 «Social» or «external» influences on quality – basic views

What does it mean that the organisation can influence «quality»? Does it mean that Watson and Crick's model of DNA would not be the same, given a different social environment? If so, what would be likely to constitute the major differences? And how diverging would they be? Or would Watson and Crick never have presented a model of DNA at all or maybe later, or would a similar model have been presented by somebody else?

At a macro level, it is uncontroversial to claim that social factors influence what can be described as aspects of «quality», and in that mild sense adopt a «constructivist» approach. It has for instance long been established that the «rate of advance» in particular fields can be influenced by the number of talented people that select science as a career (Merton, [1938] 1970, see also Cole, 1992). A more micro-oriented approach would be looking at the «foci of attention», i.e. the specific areas and problems that researchers choose to focus on. Again, already Merton ([1938] 1970) showed how the foci of attention of seventeenth-century British scientists were influenced by the demands of society. Even when it comes to the intellectual substance of research work, it seems no longer controversial to assert that it too is influenced by social factors (Cole, 1992; Sismondo, 1993). Macro-social processes contributed for instance to the theories of the physicist William Thompson (Lord Kelvin) (Sismondo, 1993, discussing Wise, 1988). Also Darwin's theory of evolution was influenced by an idea of «progress» that Darwin «the member of society» believed in, even though Darwin «the scientist» was sceptical and found little empirical support for the idea that progress was a central aspect of the evolution of life on earth (Gould, 1996).

A current controversy, however, is whether one regards the cognitive content of science as being more or less *solely* determined by social variables or not. The position that scientific representations «construct» or constitute their natural objects has been termed «radical constructivism» (Sismondo, 1993). This point of view – nature and society have very little influence, or none at all, on the cognitive content of science – is expressed by some social constructivists (e.g. Collins, 1985; Latour, 1987; Woolgar, 1988). Others have criticised the relativism behind or following from this perspective, promoting the need for a new position that accepts many of the constructivists' findings but without adopting the relativist epistemological stance (Cole, 1992). The controversy also seems to be related to the nature of the construction process. Berger & Luckmann (1966) can be said to represent a «mild» view here, where the social construction of reality is described as a relatively non-political and fundamental process in all social life. Scientific representations can in this framework be said to be part of our «subjective reality», and Berger & Luckmann discuss the interplay between social factors and nature in their last chapter. The «radical» view, e.g. found in Latour (1987), sees the process as little but a political struggle.

Hence, it must be legitimate to claim that organisational factors can influence the intellectual content of research work, although the extent of the influence is much debated. What interests me is finding *how* social factors influence research quality, using scientists' own explications of good and bad research as a starting point. Although this research design will allow me to touch upon the question of how society and nature influence or restrain the intellectual contents of research work, if at all, I do not wish to make this a major point of study. But the explication of quality criteria, their weight and determinants does naturally provide a starting point for discussing success and failure in science (although I doubt that active scientists will promote strong relativist viewpoints). Some epistemological issues are also discussed in chapter four on data and methods.

3.2.3 Previous studies of organisational variables – general features and explanations for variations in findings

Most of the previous studies of organisational influences on research performance have used quantitative methods. Large studies, several of them sponsored by UNESCO, have examined research groups in many different disciplines, most often in different sectors, and often in various countries as well (e.g. Pelz & Andrews, 1976; Andrews, 1979a; Nagpaul & Gupta, 1989; Singh & Krishnaiah, 1989; Kyvik, 1991). A few larger studies have been oriented towards a single field of learning only, most notably Allen (1977), with main focus on R&D units in technology. Smaller investigations have mostly concentrated on a single discipline in one country, for instance Spangenberg *et al.* (1990b) (Dutch clinical research units), Spangenberg *et al.* (1990a) (economics research units in Dutch universities) and Harris & Kaine (1994) (Australian university economists). There are few examples of qualitative studies that specifically have addressed organisational influences on research quality, these being Asmervik *et al.* (1995 and 1997) and Bennich-Björkman (1997).

The results from previous investigations are not very uniform, and what one study finds central to performance, is described as not so important by another. In addition, it is evident that there are many relationships and hypotheses at the organisational level that we do not know much about or do not understand well enough. It is clear that productivity and performance varies much between individuals and research units. In a review of the literature on individual scientific productivity, Fox (1992) concludes that we know «precious little» about the causes of the tremendous variation. Although factors like abilities and motivations display some importance, these characteristics «do not exist in a social vacuum and such factors alone do not account for publication productivity» (*ibid.* p. 109).

Many explanations for varying findings can be put forward, that also indicate some of the most important problems when it comes to comparing results. Investigations have been carried out in different sectors, disciplines and countries. Some multinational studies indicate that the processes through which research performance is affected by the organisational environment are similar in all countries (Andrews, 1979a)[3]. The sector or institutional setting (university, government institute, industry), however, seems to constitute a major distinction in the way research work is organised and influenced (e.g. Cole, 1979). Significant disciplinary differences are also to be expected, at least in the university sector. Dynamic processes play a role as well. It has for instance been found that type and level of communication changes as research units grow older (Katz & Allen, 1982), and cumulative advantage and reinforcement processes can lead to very large differences between units over time, although they initially may have been very similar. The characteristics of the few units and individuals that benefit from cumulative advantage could be distinctive. I assume that dynamic processes and characteristics of different fields and institutional settings are the main explanations for variation, and they are the themes of sections 3.3, 3.4, and 3.5.

There are furthermore variations in the foci of attention of individual studies. Some divide research units into high performers and low performers and study the differences between them; others try to correlate organisational variables/indices with performance measures. Some again try to describe the characteristics of only the very best researchers and their environments[4]. Organisational variables are (naturally) not defined and measured uniformly; even a simple variable like the size of research units is operationalised in many different

[3] This study encompasses approximately 200 research units from each of six countries (Austria, Belgium, Finland, Hungary, Poland and Sweden), totalling 1,222 units. More than 11,000 questionnaires were completed by different types of unit members, and in terms of data this is probably the largest study ever undertaken in this area. Furthermore, few investigations have been as broad as this one with data from academic settings, «co-operative institutes,» and «productive enterprises» (mainly private industry) and a large number of disciplines. However, there are no units from the humanities and few from the social sciences.

[4] It can be added that for practical purposes, one should perhaps centre on the «middle ground» researchers and their environments. Nothing needs to be done with the most eminent and little can be done to affect the lowest performers, but «the scientists in the middle who offer a good deal but do not benefit from cumulative advantage may be an effective target for efforts to increase both opportunity and productivity in science» (Fox 1983:299).

ways. More complex aspects, like «organisational culture», are looked upon very differently (and are as mentioned not included in many studies).

Another reason for variations in findings and a general problem with previous studies could be the different performance indicators that have been constructed. Some have used the surveyed researchers' (Likert-scale) judgements of their own unit, others have used a count of publications and/or citations, while several of the largest studies have made one or several performance indices based on a variety of quantitative and «quasi-quantitative» (e.g. peer review along pre-determined dimensions reported on Likert or semantic scales) data. These measures may naturally display varying relationships to the organisational environment, although the correlation between different performance measures generally is good (see 2.7).

It must be added that it is of course not (necessarily) «wrong» that results from previous studies point in different directions. There probably are several ways in which a research unit can be good, and no research organisation is uniformly strong in all aspects (see e.g. Andrews, 1979a; Spangenberg, 1990b; Kim & Lee, 1995; Asmervik *et al.*, 1997). The literature cautions others not to apply too strict «ideal» or «utopian» views of research organisations. This is in fact one of the main conclusions of Andrews (1979a) (quote from de Hemptienne & Andrews, 1979:11, emphasis in original):

> *«Several considerations converge to suggest that one should* not expect *massively strong relationships (and should be highly suspicious of any that appear) between any single characteristic of research units and performance: (1) The effectiveness of research units is almost certainly determined by* many *factors; hence no one factor by itself will account for a large part of the variation between units in effectiveness.»*

The results confirm that research performance is a multidimensional concept and that units that rate highly on some criteria may not necessarily rate highly on other criteria as well. Hence, «if one wants to understand and/or enhance the performance of R & D units, one has to be clear about the particular aspects of performance that are of primary concern» (*ibid.* p. 10). In addition, it does not seem sufficient to focus on just a few organisational characteristics to understand the relationship with quality.

3.2.4 Determinants of research performance in earlier investigations

I have chosen not to go into detail concerning the results of previous studies in this chapter, but rather discuss these in-depth in later empirical parts of the thesis. Here, I will only briefly describe the main factors that have been studied and/or found important to research performance. For a thorough and critical review of these investigations, see chapters six through eleven. It can be added that the discussion of organisation theory in 3.1 pointed to a number of characteristics that are relevant, for instance cultural aspects, leadership, communication, technology, individuals, diversity and dynamic processes related to e.g. learning (Weick, 1979; Pfeffer, 1982; Scott, 1992; Clegg *et al.*, 1996).

12 broad determinants of research performance emerge with at least some support from the literature. For most of them, the question of causality is not easy to answer. Are for instance numerous international contacts the result of good research, or the cause of it? The answer

is probably complex, and may vary for instance with the category and experience of the personnel, and with the phase in the research unit's life cycle.

Internal communication is described as important in almost all empirical studies. «Internal» refers to communication between the research unit members. The unit can be a project (temporary group), formal group, section, department, institute or company (in some cases).

High levels of *external communication* are a fundamental characteristic of good research units, particularly in universities and other basic research settings. In non-U.S. studies, it is often specified that *international communication* is the central type. Technological and applied units (and some others) seem to benefit from cross-disciplinary contacts.

Human resources are unanimously regarded as vital in good research units, mainly meaning that the researchers should be «good» and that there should be «enough» of them (i.e. a «sufficient level» of human resources). Good researchers are characterised by high motivation for or dedication to research work, which might e.g. influence how the organisational environment is perceived in general. Highly motivated researchers are frequently more pleased with their resources, collegial climate etc., than not-so-motivated researchers, regardless of «objective» levels of resources and quality of working climate. A few studies have looked into the complex interplay between individual motivation, creativity, and organisational factors, finding that the environment may both facilitate and prevent abilities from being «released». The centrality of individual-level variables has led some authors to discuss recruitment and similar issues.

Time resources have been found related to research performance in few studies only. The individual time to research only seems to matter in disciplines where there is an extraordinary pressure on the researchers, e.g. in clinical medicine where it is often expected that scientists also should devote some time to treatment of patients.

Hardly any investigation finds a significant relationship between research performance and the level of the *financial/material resources*. In addition, the researchers' perception of the sufficiency of the resources again seems to matter more than «objective» levels. Still, it is evident that a certain minimum level of resources is necessary to do research at all, and expensive equipment is central at least in some disciplines and settings.

The importance of the *size* of research units is somewhat unclear, for instance how this variable affects performance, if at all. Still, at least in some disciplines a minimum size has been found at the group level, and some evidence exists that there are negative effects when groups become too large, particularly if the leader is inexperienced.

Diversity of people is described as beneficial in some of the largest studies that have been carried out. The highest-performing research units have a certain distribution across different backgrounds, age groups, experience etc.

A related finding is that *diversity of tasks* is a frequent characteristic of good research organisations. In these, the researchers do not spend their time in basic (or applied) research alone, but carry out a number of different scholarly activities (development, technical service, education, training etc.).

Autonomy is a complicated aspect. Most high-performing research units have a relatively high level of autonomy, e.g. defined as the unit's degree of influence on the selection of projects and problems. It is difficult to envisage creativity without it. At the same time, the highest levels of autonomy have often been tied to low-rated university departments. It seems that the effects of autonomy are the most positive if there simultaneously is some degree of external pressure, a strong organisational culture focused on innovation and/or high levels of external communication.

Formal routines for quality assurance and control have not been much investigated. I mention it here because researchers tend to mention for instance formalised and systematic discussions as a means of improving quality. In addition, the last decades have seen a continuous increase in research evaluations as well as a stronger call for «rewarding» the best scientists and units.

Leadership is described as significant to performance in some investigations, and not very important in others. Various types of leadership (e.g. «supportive» versus «directive») have been elaborated and tied to aspects like task uncertainty and changes in the research unit environment.

Finally, several investigations have pointed to the *working climate* and/or the *organisational culture* as a central (frequently indirect) determinant of performance. Tensions are often described in connection with this aspect, for instance that good research units have a supportive and friendly working climate, coupled with strong norms of innovation and productivity and/or a shared vision of being «among the best» internationally.

In the interview guide (cf. chapter four) and in the empirical chapters, I have chosen to cluster these twelve dimensions. This results in six groups of organisational factors, as shown in table 3.1. In the table, I have also added some possible tensions that may be experienced «within» and «between» the factors. These can be considered more detailed research questions (cf. chapters six through eleven).

Table 3.1. *Organisational aspects and possible tensions*

Organisational aspect	**Tensions**
Human resources (chapter six) Creativity and motivation Link with the organisation Recruitment and rewards	Elitism versus egalitarianism in recruitment and rewards? Breadth versus depth in skills/experience? Theoretical versus practical orientation?
Leaders and leadership (chapter seven) Group level, department level	Supportive versus directive leadership? Top-down versus bottom-up control?
Formal organisational factors (chapter eight) Diversity (people, tasks) Autonomy Formal routines	Heterogeneity versus homogeneity? Narrow specialisation versus working on several tasks/projects simultaneously? Intellectual companionship versus conflict?
Size and resources (chapter nine) Group size, department size Material/financial resources	Economies of scale/stability versus small-size flexibility?
Informal organisational aspects (chapter ten) Working climate Organisational culture	Social support versus pressure for e.g. innovation and productivity? Collaboration versus competition?
Communication (chapter eleven) External, international Internal, cross-disciplinary	High degree of interaction versus autonomy and independence? User contacts versus scientific contacts?

In later chapters, I will go into more detail as to what we know and what we do not know concerning each of these organisational aspects. It should be added, however, that little is understood in general about how and why individuals do better work in some organisational units than in others. Furthermore, the relationship between organisational aspects is not very clear. Leadership may for instance not be important to research performance, but may have a large influence on the development of a fruitful organisational culture/working climate. Finally, a tension perspective has not been applied to investigations of research work since Pelz & Andrews (1976). Why and how tensions create «energy» or performance and how they can be maintained or balanced, are important questions for study.

3.3 The dynamics of research units

Research units and environments are not static. They may produce «better» or «poorer» results as they age, and environments can become more or less «stimulating». No research setting, be it good or not good, has existed forever. Differences in duration and reputation inevitably lead to questions of how units emerge and develop, and the processes behind «positive» and «negative» developments.

3.3.1 How do good research units emerge?

There is not much literature about the *emergence* of good research units. Several studies, for instance Zuckerman's (1977) investigation of Nobel Prize winners, indicate that the starting point of a fruitful research environment is an extremely talented individual successful in establishing a reputation that helps attract funding and other good researchers, including talented graduate students. The four highest-rated departments in Jacobsen's (1990) study were all characterised by having had extraordinarily qualified and popular «department builders» with excellent reputations both professionally and socially. Jacobsen suggests that it may be impossible to establish a very good research environment without an eminent researcher with certain personal properties. All «high quality» university departments in Bennich-Björkman's (1997) investigation had visible leaders with a strong commitment both to research and administrative work. These key people had to a large degree initiated organisational change and influenced the «excellence» culture that was found in the departments.

Some well-known examples exist of attempts at attracting eminent or extraordinarily talented researchers. Such a policy has been carried out in universities, e.g. the «Steeples of Excellence» policy at Stanford University, and in private companies (Hall, 1997 gives examples from small biotechnology firms). Common to such initiatives seems to be a combination of a high degree of freedom for the researchers and relatively substantial resources to carry out research projects. It has been suggested that new and inexperienced R&D units in industry, or in other locations where user-centredness is a prime feature of the activities, should outsource long-range projects to universities or independent centres in the beginning. As learning takes place, the limit of what the unit can do internally is stretched (Trist, 1972).

A recent study of «labs» (single groups or clusters of groups in universities and government institutes) in human genetics in several European countries, found that the labs have very different «profiles» (Laredo, 1999). Some have strong «scientific involvement» and others strong «socio-economic involvement». There were also labs that tried to do both or had no distinguishable profile (see 3.5). Because institutional setting, funding, facilities and other variables were not obviously related to profile, it is hypothesised that strategic choices made in initial phases are crucial, setting the units in trajectories that are very difficult to change.

3.3.2 Research performance and group age

Several studies show a decline in performance as R&D groups age. This has been called the «Not Invented Here Syndrome» because it is supposed that stable groups have a tendency to see themselves as «experts» and to believe they have a monopoly on knowledge in their area of specialisation (Katz & Allen, 1982).

Pelz & Andrews (1976) found a curvilinear relationship between group age and performance, with a peak at around four to five years. Older groups were in general less competitive and less communicative than young ones, and the authors speculate that this is the cause of the decline. However, some older groups managed to continue to achieve, and these groups in most ways «behaved like young groups», i.e. were able to maintain high levels of interaction and competition. A certain amount of intra-group «intellectual rivalry» had developed among the «old» high performers.

Similar results have come out of a survey among professionals organised in project teams in a large corporate R&D facility (Katz & Allen, 1982). Here, performance was found to increase steadily until mean tenure reached one and a half years, and decline clearly set in by the fourth or fifth year. Decline operated independently of the age of project team members and of type of project. Teams furthermore performed best if they had not been completely stable, but when tenures were too widely dispersed, performance was also low. The performance differences were accounted for by reduction in communication. For distinct types of groups the most important form of communication had decayed – research-oriented groups showed a decline in communication with external colleagues, while development groups communicated less with other members in the organisation. Katz & Allen emphasise that the reduction in communication *per se* does not lead to lower performance. Instead,

> *«a decline in performance is more likely to stem from a project team's tendency to ignore and become increasingly isolated from sources that provide more critical kinds of evaluation, information and feedback.» (p. 304).*

Thus, in the language of Pelz & Andrews (1976), groups (and their individual members) try to reduce stress and uncertainty, but the consequence may be too much focus on factors of security instead of challenge. Groups and units seem to be less likely to expose themselves to more «stressful» factors of challenge as they age; an effect that was also seen at the individual level. In other words, maintaining tension over time may be a very difficult task.

Other investigators talk about «groupthink» (reluctance to accept new ideas and approaches both from group members and external actors) at the unit level, and find that this has a negative effect on performance (Kim & Lee, 1995). Katz & Allen (1982) assert that communication and subsequent performance can be influenced strongly by recruitment and staffing decisions. Specifically, new group members have an energising and destabilising function that contributes in a positive way. It is not clear whether effectiveness can be maintained without new team members.

Research groups with stable employment may consequently find themselves in dilemma as they age. Initially, «cohesiveness» is beneficial to performance (Pelz & Andrews, 1976), but after a while, «groupthink» may begin to show itself, which could lead to a decline in quality and productivity unless the working climate changes to become more competitive and critical. More temporary staff is not necessarily the best solution to the problem. Although this can lead to an influx of new ideas and techniques, it may also lead to more short term and less curiosity-driven research, as well as have negative effects on the recruitment of talented young researchers (Senker, 1999). It should finally be added that some studies have found no relationship between age and performance. In a thorough review of a large number of studies, Cohen (1991) concludes that management based on simple notions of age probably will do more harm than good.

3.3.3 Underlying processes of change

The *cumulative advantage theory* is the most important explanation for performance or quality differences between individuals, groups or environments. This theory focuses on feedback processes, and asserts that differences cannot be explained by the talent of individuals, group members or a single event alone, but rather by a sequence of events. For instance, initial appointment or feedback may have a major impact upon later productivity and feedback, and in turn upon the prestige of the next appointment and the subsequent productivity (see e.g. Merton, [1968] 1973; Cole & Cole, 1973; Latour & Woolgar, 1979; Fox, 1983; Merton, 1988; Kyvik, 1991; de Haan *et al.*, 1994). Each event leads to outcomes that strengthen or weaken the competitive advantages between groups. Minor initial variation may thus lead to substantial differences over time.

Fox (1983) distinguishes between cumulative advantage and *reinforcement*, the latter referring to behaviourist principles or processes whereby rewarded activities are continued and not rewarded ones are discontinued. The notion as such is taken from animal experiments in laboratory settings, and Fox underlines that the social context of scientific productivity is much more complex. Reinforcement (positive) can exist without accumulation of advantage, but it is not likely that cumulative advantage can occur without some kind of prior positive reinforcement. Some scholars have focused especially on how performance and resources form a mutually reinforcing cycle (Latour & Woolgar, 1979).

Merton ([1968] 1973) first presented the cumulative advantage hypothesis under the heading «The Matthew Effect», alluding to the gospel of St. Matthew (13.12 and 25.29). This effect implies an accrual of recognition to scientists of considerable repute, and lesser recognition to those of limited repute. Eminent scientists are particularly favoured – both in collaboration and multiple discovery disproportionate credit is given to the already eminent. Merton thus seems to indicate that the process of cumulative advantage has negative effects, that it is non-meritocratic.

Later scholars have described the process in other terms. Cole & Cole (1973), who also talk about cumulative advantage connected with publication productivity, view the process in a more positive light as contributing to the goals of science. The most creative researchers are encouraged to continue to publish, while the less creative researchers have their energy diverted to other activities, i.e. cumulative advantage is connected with a process of reinforcement. It has been asserted that the theory has been empirically confirmed, and that the discussion has centred on whether the process is meritocratic or not (Merton, 1988).

Although much of the literature has focused on accumulation of advantage at the individual, it is evident that a similar effect can be seen at the group, department and institutional level, where the most prestigious centres, departments etc., attract a disproportionate share of resources. Eminent scientists attract talented and ambitious young scholars (Zuckerman, 1977) as well as other distinguished scientists, who in turn contribute to improving e.g. the collegial climate of the organisational unit (Blau, 1973).

However, it is difficult to test quantitative hypotheses of reinforcement and cumulative advantage. Data on the particular resource levels of scientists have rarely been available (Fox, 1983), and it is difficult to untangle the effects of for instance native abilities (Kyvik, 1991). It is furthermore not easy to distinguish between cumulative advantage processes and reinforcement. Tests of the hypotheses have been carried out using citation counts, which have several methodological problems (see chapter two), although citations naturally can be said to be an important feedback mechanism in many cases. In addition, not all studies have found evidence of such feedback processes, for instance Mittermeir & Knorr (1979) based on data from Andrews (1979a). It can also be mentioned that the «cumulative advantage» and related topics literature has no references to more general organisational change/organisational learning studies and theories.

Finally, all studies that have confirmed the hypotheses have focused on the university sector or on basic research alone (noteworthy, Mittermeir & Knorr who did not find evidence of accumulation of advantage processes, used data also from other institutional settings). It is thus unclear whether and how feedback processes occur in industry and (applied) research institutes where perhaps recognition and particularly publication are less central aspects.

Still, several investigations have corroborated the existence of processes of cumulative advantage and reinforcement in basic research (see reviews in Fox 1983:295-7 and Kyvik 1991:108-12). It is nevertheless difficult to find a mathematical model describing the accumulation of advantage process. Studying publication productivity, Kyvik (1991) found evidence of neither an additive nor of a multiplicative model. His data instead point towards what he calls a «pragmatic» interpretation of the theory – that the most rewarded and resourceful scientists are the most productive, without any assumptions of a widening gap between the more and less productive over time.[5] There are forces that restrain a too high concentration of resources and inequalities, although these forces have not been subject to much investigation (Merton, 1988). The decline in group performance due to loss of tension as described in 3.3.2 could perhaps be such a («subconscious») force. A study of Dutch «Centres of Excellence» in the social sciences concludes that accumulation of advantage is not just related to the (external) reward system, but also to structural conditions internal to the research units, particularly the units' communication networks (de Haan *et al.*, 1994). An important general limitation of the cumulative advantage theory is that it is very unlikely that all scientists start their career with aims to become eminent, which does seem to be a premise of this theory (Kyvik, 1991).

In conclusion to this section, it can be asserted that a static view of research units is insufficient to grasp how organisational factors and quality may be linked. Research units emerge, grow and may decline as a result of internal changes, for instance related to the ageing process or as a result of different types/levels of feedback from the larger professional environment. Small differences between researchers and research units in talent, resources etc., may give rise to much greater differences in performance after consecutive events that reinforce behaviour and increase/decrease competitive advantage. Hence, «quality» is not simply the result of a good research unit's work, but it is also an influence on the unit's characteristics. Not only may good research result in a unit getting more resources, improved contact networks etc., but quality also affects the individual researchers' pride in what they do and their desire to continue.

[5] Kyvik calls this a pragmatic interpretation because it is not consistent with the internal logic of the theory.

3.4 Disciplinary differences

In general, it can be stated that «research examining multidisciplinary samples of faculty (…) ought to assess whether disciplinary[6] characteristics, such as level of consensus or pure vs. applied orientations, can account for variables of primary substantive interest» (Braxton & Hargens, 1996:36). There has been a tradition within the sociology of science of viewing science as a single sub-culture with well-defined norms and value structures that describe both cognitive and social aspects of research work (Cole, 1979). A good example is Merton's discussion of the normative «ethos of science» ([1942] 1973). Many have challenged both the cognitive and social sides of this view. The work of Kuhn ([1962] 1970) has been particularly influential, asserting that the «paradigm» is the central mechanism in the development of a scientific speciality. Others have followed and argued that specialities are loosely bound social units (Crane, 1972). Investigations have been carried out focusing solely on disciplinary differences (e.g. Becher, 1989).

According to Jacobsen (1990), a basic distinction can be drawn in the philosophy of science, where it has been argued that there are fundamental (epistemological) differences between the fields of learning (Habermas, 1969). On the other hand, it has also been claimed that science and the research process are fundamentally the same regardless of discipline or speciality (Popper, 1979; see also the discussion about «what is science?» in 2.2). Some have, based on empirical evidence, argued that the distinction is only meaningful in the university sector (Cole, 1979).

Many studies have found differences between specialities, disciplines and fields of learning, for instance connected with publication behaviour, dependency on physical resources, descriptions of good research, academic leadership, graduate education etc. (see Crane, 1972; Biglan, 1973b; Blume & Sinclair, 1973; Kolb, 1988; Kyvik, 1991; Martin & Skea, 1992; Hemlin, 1993; Kekäle, 1997; Smeby, 2000). It can still be that there are basic common features to all research specialities distinguishing them from marketing, accounting and other professional cultures and activities. A discussion of differences between research disciplines is nevertheless necessary in a study of good research environments. Much of the other relevant literature touches upon such differences, as indicated in section 3.2 (and 2.4 regarding research quality). In addition, a large number of studies have only gathered data from a single discipline or speciality. To go through some of the investigations of disciplinary differences may thus be helpful in assessing the validity of previous findings.

3.4.1 Cognitive differences

In the literature, one can find specifications of both *cognitive* (e.g. Zuckerman & Merton, 1972; Biglan, 1973a) and *social* (for instance Kekäle, 1997) differences, or both (Kolb, 1988;

[6] Following common usage in the field, I see the humanities, technology, natural sciences, medicine and social sciences as different «fields of learning.» Disciplines are found at the level below (the prime example being university departments), e.g. sociology, political science and psychology are disciplines in the field of learning termed the social sciences. It can be added that some authors have questioned the existence of «global» characteristics of disciplines, proposing the research speciality or other disciplinary segments as the appropriate unit of analysis (cf. Braxton & Hargens, 1996:21).

Becher, 1989; Braxton & Hargens, 1996). Classifications of disciplines do not emerge as very different whether one uses cognitive or social dimensions (Becher, 1989). According to some authors, cognitive differences explain social differences; others take the opposite stance, while e.g. Braxton & Hargens (1996) have argued that «complicated systems of reciprocal causation [might] link consensus, disciplinary social structures, and research technologies» (p. 38). Both dimensions are interesting with this thesis' focus on both research quality and organisational aspects. Although the social/cognitive distinction may be problematic, I use it here as a starting point for discussing the literature.

The most commonly applied cognitive framework is perhaps that of Biglan (1973a and b), who distinguishes between *hard* and *soft* (and pure and applied) disciplines. The natural and medical sciences and the technological disciplines are often referred to as hard, while the social sciences and the humanities are labelled soft. This traditional distinction can relatively easily be connected with Kuhn's ([1962] 1970) paradigm theory (Biglan, 1973b). In the hard disciplines, a single paradigm can be found upon which the researchers agree and that «regulates» possible problems and methods (in this way Kuhn's theory is largely social). Focus will be on causality and universal laws, and these disciplines have a well-structured theory and a high degree of cumulativity. Such characteristics are mainly missing in soft disciplines, where there will not exist any paradigm (or agreement about it).[7] More disagreement over quality issues should thus be expected here. Zuckerman (1977) points to the remarkable unanimity in the awarding of Nobel prizes in medicine, physics, and chemistry.

A similar division has been developed by Zuckerman & Merton (1972), who argue that disciplines or specialities vary according to their degree of «codification». This concept refers to the extent to which empirical knowledge is consolidated into concise and interdependent theoretical formulations. The medical and natural sciences are the most codified, the humanities are placed at the other end of the scale and the social sciences can be found somewhere in the middle. This has been tested using citation data, and Zuckerman & Merton found that the more codified the field, the more recent were the publications referred to in general. They furthermore assert that «the comprehensive and more precise theoretical structures of the more codified fields (…) provide more clearly defined criteria for assessing the importance of new problems, new data, and newly proposed solutions» (p. 303).

This point can, however, be objected to. Cole (1992) distinguishes between the *core of knowledge* and the *frontier* in a discipline or field. He suggests and finds some empirical support for the assertion that at the frontier there will be a high degree of disagreement about quality regardless of field. No assessment criteria are readily available for the «newest» research works. In this framework, the mere existence of a (more or less) universally accepted knowledge core can mark a difference between fields and disciplines. A higher degree of codification may also imply that criteria for «promoting» a piece of work to the knowledge core are more obvious.

[7] I will not go further into Kuhn and the long discussions his *Structure of Scientific Revolutions* has aroused, not least on what the central notion «paradigm» really denotes. Much of the criticism and the threads in the discussion have later been commented by Kuhn himself (1977).

Literature on disciplinary differences often includes at least one dimension in addition to soft/hard, most frequently a scale ranging from *pure* to *applied* based on the discipline's orientation towards practical problems (as in Biglan, 1973a and b). This is not the same as the distinction between basic and applied research – applied disciplines are more or less completely based on practical problems. Examples are nursing, education, and several technological and business economics disciplines.

Several scholars have described a main distinction or dichotomy between science on the one hand and technology on the other that seems closely related to distinctions between pure and applied fields. Scientific methodology can be said to be developed to search for knowledge under an ethos of e.g. truth (or verisimilitude), universalism and generality, with excellence as the ideal, evidenced by the sharp stratification of science and the attention given to prestigious awards like the Nobel Prize. In contrast, technology answers to a logic of «context appropriateness», and optimality or even development of «satisfactory» solutions has been described as the ultimate goal (Mitcham, 1994). It can be claimed that the conception of quality as «excellence» (see 2.2) will dominate in science, while a «fitness for purpose» view is more in line with the logic or epistemology of technology.

Not only may this involve a distinction between philosophy of science and philosophy of technology (*ibid.*), without the latter being viewed as «applied science», (this view is in general rejected now, for instance by Bijker *et al.*, 1987). It also implies that one should distinguish sharply between scientists and engineers (people working in technological fields). Allen (1977) has made this point the strongest, asserting that neglecting differences between scientists and engineers would almost be the same as lumping «physicians with fishermen». Much social science literature commits this error, Allen claims, and the consequences are confusing results and lack of applicability of the results in practical situations.

Combining the dimensions, Biglan (1973a) has developed a classification matrix based on the hard/soft and pure/applied distinctions (and life system/non-life system, but this dimension seems less important). For a discussion of this classification, see also Kolb (1988) and Becher (1989). Braxton & Hargens (1996) claim that the concepts behind the cognitive taxonomies, particularly the dimensions hard vs. soft (Biglan, 1973a) and degree of codification (Zuckerman & Merton, 1972) may be referring to phenomena that are either closely related or simply the same. They propose the term *consensus* as a common denominator, asserting that degree of consensus constitutes the equivocal basis for disciplinary differences.

3.4.2 Social differences

When it comes to social differences, the taxonomy of Becher (1989) should be mentioned. In addition to using a cognitive dimension, Becher places 12 disciplines according to a «social dimension» based on a «rural-urban»-scale and a «divergence-convergence» scale. The latter is grounded on the degree of professional and social fragmentation and identity. This classification is thus more based on «external» characteristics like agreement in judgements and disciplinary values, less on the contents of the research, which can be said to constitute the basis of the cognitive dimension. However, most disciplines will be classified in a similar way, with the hard sciences at the convergent end of the scale. Some exceptions can nevertheless be mentioned. The soft discipline economics is placed among the most convergent by Becher,[8] while mechanical engineering is described as one of the most divergent. Later studies have been based on Becher's framework and focused for instance on different leadership cultures in academic departments (Kekäle, 1997).

A number of investigations have focused on differences in the organisation of work, resource levels etc., between disciplines. Allen (1977) has elaborated (natural) scientists vs. engineers (technologists). He asserts that the two groups are different when it comes to goals, attitudes and (sub)culture, communication patterns and other professional activities, and response to rewards. Scientists regard the publication of results and professional autonomy as important goals, but these are among the least valued goals of engineers. Reading scientific literature and maintaining external professional networks are important to scientists. Engineers, on the other hand, keep abreast in their field by close co-operation with colleagues in their own organisation, thus displaying a more «local» communication pattern. An exception is the «technological gatekeeper», who peruses external contacts including vendors and customers (that rarely form part of scientists' networks), and read refereed technical journals significantly more than other engineers. It is asserted that (*ibid.* p. 46)

> *«Despite all the discussion of informal contact and invisible colleges among scientists (and scientists do make extensive use of personal contacts), it is the engineer who is more dependent upon colleagues. The difference between communication behavior of scientists and engineers is not simply quantitative, however. The persons contacted by scientists are very different from those contacted by engineers.»*

Both scientists and engineers desire career advances, but for the latter advancement is tied to activities within the company or research institute. Advancement for the former is dependent upon established reputation and recognition received from outside the institute or company (see e.g. Omta *et al.*, 1994; also market models of science, for instance Hagstrom, 1965; Latour & Woolgar, 1979). Most engineers are employed by bureaucratic organisations that control their pay, promotions and largely their prestige in society (Allen, 1977). Yet another difference is connected with publication, where it is claimed that there is «nothing wrong with publishing non-original material in engineering. The first goal of engineering publication is to inform, not to stake out claims» (*ibid.* p. 78).

Even so, the distinction between science and technology might not be as clear as the above assertions express. There is also variation among scientific and technological disciplines, and Allen himself admits, «there very probably are some technologies that are more closely connected with science than others» (p. 57). Other scholars have chosen to focus on the similarities between science and technology, often using the notion «technoscience» (e.g. Latour, 1987; Callon, 1987). It has been argued that both science and technology are socially constructed cultures whose common boundary is a matter of social negotiation that represents no underlying distinction (Pinch & Bijker, 1987). Using another expression, it is claimed that science and technology form a «seamless web» (Bijker *et al.*, 1987). The labels are seen as imprecise and failing to capture the complexities of the entities named. In part, science can be

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[8] In some countries, economics would probably not be regarded as a soft discipline, especially if research groups in economics work within the same theoretical and maybe also methodological frameworks.

looked upon as knowledge about technology, and technology as embodied knowledge, and some scientists develop technology while some engineers conduct research in ways usually associated with scientists (Hughes, 1987). The message from this body of literature is that the exceptions to dichotomy-based rules are so extensive that the dichotomy itself does not always make much sense in studies of scientists and engineers and the work they do.

Looking more broadly at social disciplinary differences, one of the strongest and most uniform findings is that the degree of teamwork (and co-authorship of publications) varies much between fields (see e.g. Biglan, 1973b; Kyvik, 1991). Still, there is evidence that teamwork increasingly is the norm in all fields (Hicks & Katz, 1996). Research in groups and preferences of working closely with colleagues are most common in hard fields, while the humanities and to some extent the social sciences still seem to follow what can be termed an «academic individualism» (Trist, 1972). However, a study of psychology departments at three Scandinavian universities finds that the degree of teamwork also varies strongly between these departments (Schmidt, 1996). The differences can be explained by for instance varying links to the external environment and research users, differing rules of promotion and dissimilar «research cultures».

Teamwork is furthermore favoured more in applied than in pure fields (Biglan, 1973b). Researchers in pure fields also have preference for research work, while academics in applied fields like engineering and education have a high degree of liking for different service activities (*ibid.*). Correspondingly, contacts with the international research community are more important to those in pure than those in applied fields (Martin & Skea, 1992). Many of the differences described in the literature follow from the nature of the activities within each discipline or speciality, e.g. the finding that mathematicians attach much less weight to the importance of a technical support staff than physicists do (*ibid.*). In hard fields (or fields with a high degree of consensus), one can furthermore find larger departments, stronger focus on research as opposed to teaching, more resources (particularly from external sources), and a greater concentration of scholarly talent than in soft fields (cf. Braxton & Hargens, 1996).

A study of the publishing activities of Norwegian university faculty confirmed earlier findings. Researchers in medicine and the natural sciences produce more international publications, but less books and popular science publications, than their colleagues in the humanities and social sciences do (Kyvik, 1991). Kyvik explains the differences by referring to e.g. Kuhn ([1962] 1970) and Zuckerman & Merton (1972), i.e. by pointing to dissimilarities in paradigmatic status, communication language, degree of predictability and more. In a study of Danish university researchers, Jacobsen (1990) found some variation between researchers in social science, natural science and the humanities, particularly regarding the importance of physical resources and size. Still, Jacobsen finds that the similarities are the most striking:

> *«Perceptions of research, types of research, the view of how research should be controlled, desire for cross-disciplinary work, the quality of the research environments, the interplay between research and teaching etc., seem basically to be spread evenly or in a comparable way between the three different fields of learning.»* (p. 120, translated from Danish).

The largest study of research units that has been carried out does not support a detailed distinction between disciplines or fields (Cole, 1979). Clustering analyses reveal that most of the variance in research orientations, research output and patterns of influence, can be explained by institutional settings (see 3.5 below). Differences between «subgroups of the same discipline but differing organizations (…) are considerably greater than the distances separating subgroups of differing disciplines but the same organization» (*ibid.* p. 383). Consistent and significant disciplinary differences are found only in the university sector, where three main clusters are described. These are «exact and natural sciences», «medical and social sciences» and «academic applied sciences and technology». The main difference is found related to research orientation. Professional recognition is stressed in the first group, while social effectiveness is more emphasised than recognition *per se* in the medical and social sciences. In the applied sciences and in technology, applications are stressed in addition to recognition. There are few differences related to patterns of influence and research output. Scientific significance is the dominant force in the selection of research themes, and published written material the main form of output, in all three academic clusters.

Few other studies have focused on more than one sector, and from Cole (1979) it seems natural to maintain that sector differences are much clearer than disciplinary differences in descriptions of research performance and its determinants. Allen (1977) asserts that most engineers are employed by private companies or government applied research institutes, while most scientists work in academia. The differences between science and technology or scientists and engineers, as sketched above, may thus more be a function of varying institutional settings than of disciplinary/field differences *per se* (the two can of course be related). Sector variation will be described in more detail in 3.5 below.

To conclude briefly, dissimilarities between specialities, disciplines and fields of learning are likely to be found when one looks at the organisation of research activities, but systematically and significantly only in the university sector (or government institutes oriented towards basic research). When the purpose is the study of influences on research performance, it furthermore seems acceptable to use a relatively rough classification. Still, differences cannot be ignored, and it is not possible to study a small number of disciplines and fields if one wants to achieve analytically generalisable results. Various theoretical explanations for disciplinary differences, both cognitive and social, have been put forward. When investigating such theoretical frameworks empirically (with dimensions like soft/hard, convergent/divergent etc.), the resulting distinctions between disciplines are often relatively similar, although some disciplines tend to receive varying placements. However, several investigations also suggest that some underlying mechanisms, e.g. how creativity can be influenced, are common to all fields of learning. Hence, a study of organisational influences on research quality must be watchful of such common traits, and it seems necessary to adopt a «dual perspective» that focuses both on similarities and differences.

Since my investigation to some extent focuses both on cognitive aspects (research quality) and social aspects (organisational characteristics), the links that emerge between the two should be of interest also to scholars who investigate disciplinary differences. In table 3.2, I have tried to summarise some of the central differences. Note that this is a very simple table (where e.g. the pure vs. applied dimension has been left out), and there are of course differences within both hard and soft fields. In my selection of data sources, I have tried to select two probably different disciplines within each field of learning (cf. chapter four).

Table 3.2. *Summary of disciplinary differences. Sources: Zuckerman & Merton (1972), Biglan (1973a and b), Allen (1977), Becher (1989), (Kyvik, 1991), Cole (1992), Braxton & Hargens (1996).*

Hard fields	Soft fields
Natural science, medical science, technology	Social science, the humanities
(Relatively) high degree of codification	Lower degree of codification
Higher degree of scholarly consensus, less scholarly fragmentation	Lower degree of consensus and more scholarly fragmentation or divergence
More teamwork, «urban» research culture	More individualistic research and publication, «rural» research culture
Higher resource levels, more external resources	Lower resource levels
Relatively stronger weight on research	Relatively stronger weight on teaching
Higher agreement or more unified view of quality?	Less agreement on what constitutes good research?

3.5 Sector differences

Differences between sectors (institutional settings) have only to a small extent been an issue in previous studies of research quality and research organisation. One reason is the mentioned sub-disciplinary specialisation – roughly speaking, sociologists and some other social scientists have looked at basic research and at universities, while management scientists have looked at industrial R&D and at innovation. Research institutes seem more or less split between the two, often depending on the institutes' orientation towards fundamental or industrially relevant research. A few cross-disciplinary studies have included research groups from all sectors (most notably Pelz & Andrews, 1976; phase two of Allen, 1977; and some of the countries studied in Andrews, 1979a; the first two do not, however, discuss sector differences to any considerable degree).

A vast majority of the investigations have furthermore been concerned only with academic scientists and their work (Cole, 1979).[9] Cole has argued that the image portrayed in the writings of much of the influential «Merton school» corresponds to the *academic* scientists committed to publication alone. Still, investigators have also found that researchers and research managers in all institutional settings tend to use (or did so some decades ago) the academic environment as a point of reference when discussing the atmosphere in their own organisation (Kaplan, 1963).

Empirical studies nevertheless find that the institutional/organisational setting constitutes a major dimension when describing differences in the orientation, influences and outputs of research work. In general, «research units of a different scientific discipline, but operating within the same type of institution, are more closely associated than research units of the

[9] Literature reviews (e.g. Fox, 1983; Reitan, 1996; also Kyvik, 1991) and knowledge from more recent studies indicate that this still seems to be the case.

same scientific discipline but differing organisational affiliation» (Cole, 1979:381). Whereas disciplines only vary systematically and significantly with respect to research orientations (cf. 3.4.2), sector differences are also found related to research outputs and research influences. Public R&D units are often more influenced by external actors, less influenced by the organisational leadership, and more open and less bureaucratic than are private sector units (Bozeman & Loveless, 1987). Academic and industrial R&D units are even described as «antipodal» (Cole, 1979, also Allen, 1977). Descriptive analyses of research in different institutional settings also talk of opposites and major differences (e.g. Trist, 1972). It has been claimed that research settings are subcultures with differing organisational characteristics, standards of performance, norms, creativity criteria and definitions of innovation, incentive systems and patterns of conflict (Marcson, 1972).

In this section I shall first characterise the three sectors that usually are depicted in the literature and are the most relevant in a Norwegian context – universities (in 3.5.1), industry (3.5.2) and the (mainly government-associated) institute sector (3.5.3). In 3.5.4 the characteristics of the three sectors are summed up and contrasted in a table. This section also includes a short discussion of the relevance of confining the discussion to three distinct organisational settings.

3.5.1 The university sector

Broadly speaking, universities are committed to training and to the advancement of knowledge along disciplinary lines. Hence, teaching, publication and professional recognition are the primary concerns of the faculty (cf. e.g. Hagstrom, 1965; Trist, 1972, Marcson, 1972; Blau, 1973). University scholars most often have educational as well as administrative tasks, which frequently leads to a concern about whether there is enough time for research. However, most empirical studies have failed to confirm the significance of this factor to research performance (for instance Pelz & Andrews, 1976; Andrews, 1979a).

Universities have been described as «professional bureaucracies» (Mintzberg, 1983) where duly trained and «indoctrinated» professionals are hired for the «operating core». «Standardisation of skills» (only people with certain formal backgrounds are considered for positions) is the primary co-ordinating mechanism. The professionals often seek collective (or democratic) control of the administrative decisions that affect them, and power is mainly based on expertise (Blau, 1973). Mintzberg (1983) claims that many universities have an inflexible organisational structure. They adapt slowly to new environments and are full of conflicts of power between professionals.

Problems of co-ordination and innovation are often seen by the outside society as consequences of lack of external control: «So they do the obvious: try to control the work with (…) direct supervision, standardization of work processes, or standardization of outputs» (*ibid.* p. 210). However, such controls are badly suited to professional work and may only lead to frustration and poor performance. If the professionals are incompetent, no external rules can make them competent, Mintzberg asserts. Externally defined plans and rules can impede the competent professionals from providing their services efficiently. This seems to be a good description of the conflicts surrounding e.g. «managerialism», «accountability» and new forms of «management by objectives» that for instance have been introduced at Norwegian universities.

Despite changes that can be described in the system of management and control, not least in Norway (cf. Kyvik & Larsen, 1993), control and alterations are still vested in the faculty. University research is furthermore largely carried out in small groups with relatively low need for expensive equipment, but there are significant disciplinary differences. Most of the discussion of disciplinary differences in 3.4 is relevant for the academic setting only.

Needs of theory and method are the central sources of research problems, and scientific significance or scholarly relevance can be used to describe the research orientation (Trist, 1972; Cole, 1979). Basic research demands the highest degree of autonomy, and it has been argued that «pure» research should have unrestricted autonomy (Polanyi, 1962).[10] It is furthermore very difficult to envisage fundamental research taking place without a certain amount of internal funds (Trist, 1972).

Disciplinary networks that are external and most often international constitute loosely bound social units that may function as sources of research ideas, critique and inspiration, and recognition and reward (Crane, 1972; Blau, 1973). Although all researchers have a «dual membership» – they are not just employees of a university, institute or company, but normally also active «members» of a scientific/technical discipline – university scholars should show the highest degree of commitment towards the discipline as opposed to the institution by which they are employed (Pelz, 1963; Blau, 1973; Allen, 1977). The university research culture can be described as cosmopolitan, and because the social system of science is highly stratified with the «most excellent», «Nobel-prize class» scholars at the top (see e.g. Cole & Cole, 1973; Zuckerman, 1977), it can also be said to be excellence-driven (instead of utility-driven).

3.5.2 Research in industry

At the opposite end of the spectrum one finds industrial R&D. Here, focus is on long- or short-term economic or other returns to the company, and the company goals are often the same as the researchers' own, particularly for engineers (Allen, 1977). Research priorities are typically set by market conditions, the needs of users, as well as by a more long-term or strategic/tactical concern with updating and renewing the firm's core knowledge and basic product lines (Marcson, 1972; Trist, 1972; also Hamel & Prahalad, 1990). Teece (1986) has argued, «If an innovating firm does not target its R&D resources towards new products and processes which it can commercialize advantageously relative to potential imitators and/or followers, then it is unlikely to profit from its investment in R&D. (…) The R&D investment decision cannot be divorced from the strategic analysis of markets and industries, and the firm's position within them» (p. 301).

[10] This has been a recurring theme the last decade in feature articles written by university scientists in Norwegian newspapers like *Aftenposten* and *Dagbladet*.

Hence, stress is placed on practical value, cost-efficiency and on potential payoffs. Publications and professional recognition are not very central, and publications are eschewed in favour of internal reports, prototypes and patents (Cole, 1979). Various service activities are common in this sector's R&D organisations (Trist, 1972). Industrial engineers carry out very many different professional tasks (Allen, 1977; Andrews, 1979a), and it has been argued that industrial scientists have particularly many roles to fill (Stein, 1963).

Firm-internal communication has been established as the most important determinant of performance (Allen, 1977; Allen & Katz, 1982), and indicates a more *local* culture (Roth, 1988). Scanning and transmission of relevant outside information are done by a few individuals, termed *technological gatekeepers* (Allen, 1977). Projects are carried out in larger groups, and the closer one gets to the development end of the R&D spectrum, the more expensive the projects get (Stolte-Heiskanen, 1979; Omta *et al.*, 1994; Laredo, 1999). Management plays a crucial role in the operations of the research units, including the selection of research themes (Cole, 1979). Still, it is common that industrial research organisations provide, on a formal basis, some «free time» for the individual scientists – they are allowed to do their own research during perhaps five to fifteen percent of the company time (Kaplan, 1963). This free time is typically used for small-scale tests of new ideas, and thus comprises a sifting mechanism before ideas are turned into project proposals.

Some authors talk about different «tiers» of the R&D mission in industrial laboratories, e.g. exploring the tools of the future, creating the tools and pioneering the use of the tools (Zettelmeyer & Hauser, 1995). The laboratory interfaces with business units that use the tools routinely, and with universities and basic research laboratories, that «lay the foundations». A central claim is that each tier is characterised by distinct quality focus, time horizon and organising principle. Balancing short-term survival with long term viability is the major challenge of R&D management in industry (Tushman & Moore, 1988), and «any organisational structure (…) implies a short-term vs. long-term trade-off» (Zettelmeyer & Hauser, 1995:6). Since the institute sector in Norway also conducts much applied research, it can also be interesting to see if the work sharing (if such a thing exists) between the sectors can be found along the distinction between such tiers.

In general, research activities in industry are carried out in large firms (see e.g. Dosi, 1988) and in small «hi-tech» firms, with some of the most basic activities concentrated in small companies in biotechnology/pharmaceuticals etc. (cf. Rosenberg, 1990). The strategy of giving resources and freedom to young researchers believed to be very talented, as discussed in 3.3, now seems to be a characteristic of some small biotechnology businesses (see Hall, 1997). Informants from industry should thus be selected from firms at both ends of the size spectrum.

3.5.3 The institute sector

Research institutes that neither are part of a university nor of the commercial sector can in general be expected to fall somewhere in between the characteristics of university and industry research, as described in the preceding paragraphs. Most units in government institutes will exhibit an influence and a research orientation profile that to a greater extent resembles units in industry than in academia (Cole, 1979). Institute researchers may experience tension between market demand (for contract research, etc.) and desire for scholarly recognition and competence development (Mathisen, 1989). For this reason, some institutes have aimed to «train» their main customers to make them support more long-term and high-risk research, and thereby to get a continuous dialogue with key users (*ibid.*).

Institutes are often domain-based, i.e. oriented towards a major problem area (Trist, 1972). Research activities often play a supportive part and are expected to help further one or more socially or politically determined programmes (Marcson, 1972). Thus, the research on issues of social concern that leads towards practical applications is stressed, and the weight given to scientific significance in the choice of research themes is quite low (Cole, 1979). There are often strong internal norms of «user relevance», particularly in organisations working in technological and/or natural science disciplines (e.g. Foss Hansen, 1991). In some sense the problems that institutes take up are more applied than those from the university sector, and more general than those in industry/user-centred organisations, although the basic/applied dichotomy is not well suited to distinguish between sectors (Trist, 1972). Hence, institutes need a measure of basic support/funding. Primary forms of research output are articles and patents published or registered within the country, and internal reports (Cole, 1979).

The organisational structure is often more hierarchical and than in universities (Marcson, 1972), although some domain-based and application-oriented centres are indeed found inside of universities, which of course complicates the sector distinction (Trist, 1972). Research institutes have been described as something between «professional bureaucracies» (see the discussion of the university above) and «adhocracies» (Foss Hansen, 1991). The latter term refers to one of Mintzberg's (1983) five basic structures, and is typically a flexible project-oriented organisation with little standardisation of any kind. Multi-disciplinary teams are common, and innovation is often seen as the primary purpose of the organisation. Thus, adhocracies can be found both in the research institute sector and in the R&D divisions of industrial firms. Advanced technical facilities that require sophisticated skills in the support staff are particularly suited for this organisational form. The main problem with the adhocracy is that it is fluid and ambiguous, and thus is a highly politicised organisational configuration. The channelling of conflicts towards productive ends is seen as a central management task, and control often occurs through informal processes (Foss Hansen, 1991).

Furthermore, the cost of communication is high, and the organisation is often poorly suited to doing the routine work that often accumulates with success and/or ageing (Mintzberg, 1983). The role played by the organisation's leaders is quite high compared to academia (Cole, 1979). Some authors have described that the organisation may generate tension for scientists who wish to set their own research priorities, adopt unorthodox working patterns or pursue a problem beyond the requirements of the larger programme within which it has been conceived (Marcson, 1972). A study of medical researchers in U.S. government institutes found that it seemed possible to combine motivation for doing good basic science and creating social utility (Pelz, 1967), although this could of course also be due to the link between medical research and public health.

An in-depth case study of four Norwegian institutes found that successful institutes were moving in a «trajectory» between the «extreme» values «academic nostalgia» and «commercial nihilism» (Mathisen, 1989). Some of their characteristics were a reward policy that balances market success and academic reputation, focus on «strategic research» and hybrid communities and communication, i.e. maintaining links with both universities and users. It is stressed that upholding networks to both users and the academic community is very difficult and that research council funding constitutes a counterweight to the funding from user groups.

More recently it has been found that research institutes increasingly are managed in ways similar to private firms, although their culture, mission and organisational status remain rooted in the primacy of their scientific expertise (Turpin & Deville, 1995). Both scientists and research managers show strong support for the organised management of research «in the present situation», and there seems to be little destructive tension left between «scientific excellence» and «external relevance». Instead a new tension has emerged between «managed science» and the commercial values of the market, the latter built on the value of generating financial returns. Thus, at least in this case (the CICERO institute in Australia), a new culture has arisen incorporating values of both industrial relevance and scientific excellence, implying that the task for research managers is to be many things at the same time: «scientist, administrator and inspiring entrepreneur». Although the tension between an informal «university-like» system of management and control and a formal «business-like» one seems to be the strongest in research institutes, it is not unlikely that such a tension also can be found in university departments and industrial laboratories.

3.5.4 Contrasting sector differences – are the boundaries clear?

The characteristics of research activities and organisation in universities, industry, and the institute sector are summed up in table 3.3.

Table 3.3. *Summary of differences between sectors. Sources: Stein (1963); Marcson (1972); Trist (1972); Pelz & Andrews (1976); Allen (1977); Cole (1979); Stolte-Heiskanen, 1979; Bozeman & Loveless (1987); Tushman & Moore (1988); Katz & Allen (1988); Roth (1988); Omta et al. (1994); Laredo (1999).*

Characteristics	**Academic research units**	**Research institutes**	**Industrial research units**
Overall pattern	Discipline-based	Domain-based	Profession-based
Problem sources	Needs of theory and method	«Field» or «domain» needs, contractors	Specific client needs
Problem level	Abstract	Generic	Concrete
Quality focus	Scientific significance, originality	Societal relevance, applications	User relevance, practical returns
Activity mix	Research/teaching	Research/application	Research/service
Disciplinary mix	Single	Interrelated	Multiple
Communication	Focus on external communication with other researchers, «invisible colleges»	Communication both with other researchers externally and internally, and user organisations	Focus on intra-organisational communication with researchers, practitioners, and managers
Culture	Cosmopolitan, focus on excellence	More local	Local, focus on practical value
Main output	Articles, books	Reports, patents, technical data, lectures to practitioners	Internal reports, patents, prototypes
Rewards	Professional recognition, «breaking new ground»	Domain and/or societal problem-solving	Solving practical problems, improved situation for company
Resources	Not very costly research (with exceptions)	Everything from small projects to multinational «Big Science» operations	The more applied, the more expensive the projects get and more people are involved

All I have written about differences between the three sectors does represent an oversimplified picture. External relevance is important to many university researchers[11] (Hemlin, 1991; Andersen, 1997), and promoting the economic utilisation of research has become a part of the basic mission for many universities (Gulbrandsen, 1995; Etzkowitz & Leydesdorff, 1997). There are growing numbers of entrepreneurial university scientists that have commercial interests, having started high-tech firms and patented research results (Etzkowitz, 1998), which also may add to the blurring between sectors. Quite a few private firms carry out activities characterised as basic research (Rosenberg, 1990), and it is not uncommon for industry researchers to have part-time positions at a university. In some kinds of knowledge production, there is no clear distinction between basic and applied research at all (Gibbons *et*

[11] This is of course also due to the broadness of the external relevance concept, as discussed in chapter two.

al., 1994). The line that was drawn between scientists and engineers in the previous section also applies – both types of researchers work in industry, and to some extent in the two other sectors as well. New organisations that cross traditional boundaries have also been established, e.g. «science parks» (see for instance Gulbrandsen, 1997a).

A study of «human genetics» in Europe found that «labs» in this field differed significantly in their overall «profile» (Laredo, 1999)[12]. Some had a strict «scientific involvement» only, while others had exclusively a «socio-economic involvement». One third of the labs were oriented in both these directions, while around one fifth had no «marked involvement». All types of labs were found in all the studied selected settings (universities, government institutes and university hospitals). In a broader analysis of public research systems in Europe, it is claimed that the boundary between universities and mission-based government institutes is becoming increasingly blurred (Senker, 1999). In Norway, the institute sector is larger than in many other countries and in general described as belonging somewhere between the university sector and industry (as outlined above). However, the sheer number and size of institutes in Norway indicate that indistinct boundaries could be found in «both directions» (universities and industry).

Furthermore, there is variation within the same institutional setting. Universities can be large or small, research-oriented or not, and differences as described in table 3.3 can also be envisaged between «major» and «minor» universities. Similar differences in e.g. size and focus are evident in the institute sector and industry as well. The R&D units of private firms can for instance be very university-like or organised in the same way as other functions in the firm (Kaplan, 1963).

Behind some of the perspectives in the sociology of science and other fields seems to be an assertion that the academic organisation of research work is the «natural» mode, and that researchers would suffer some kind of «strain» if working in other organisations and under deviant conditions (Cole, 1979). Studies of differences between institutional settings have not found evidence of such strain. Inner motivation is very important in all sectors, although the rewards may be different. Pelz (1963) finds that researchers consciously have selected their institutional setting based on their preference for certain types of problems, ways of working, rewards etc. Authors have warned that because of this, organisational changes (e.g. making a university more «market-oriented» or an applied institute more «university-like») may not work, because researchers have chosen to work in certain settings based on traditional/existing characteristics (Cole, 1979).

Finally, it must be added that studying sector differences often is described as very difficult (e.g. Bozeman & Loveless, 1987). Differences between e.g. university research and industrial research may not simply be a result of an abstraction termed «the institutional environment», but rather stem from differences in relevant disciplines, distinct research technologies, types and levels of funding, size and age of units etc. However, it can also be claimed that these in fact are likely to be main variables distinguishing between sectors, and «sector» *per se* has

[12] Almost 400 questionnaires were completed for the analysis, making this one of the largest investigations in the field since Andrews (1979a).

been found to have «staying power» as a relevant concept accounting for differences between research units (*ibid.*).

To conclude, major differences between sectors are likely to be found, both in descriptions of good research (particularly how external relevance is defined) and which organisational factors are regarded as important to high quality research. However, there may also be clear *differences within sectors*, depending on the mission and scope of the institutions and along disciplinary and industrial dividing lines, and a certain amount of *overlap* between sectors. Because much of the literature only describes differences between universities and industry, it will furthermore be interesting to see where in the spectrum the institute sector can be placed, although it in general can be expected to display characteristics that lie between those of the two other sectors.

3.6 Conclusion – research model for the thesis

In this chapter, we have looked closer at the organisations in which research work is carried out. We have seen that there is no generally accepted theory of organisations. On the contrary, the field «organisation studies» has been compared to a «weed patch», and the criteria for selecting a certain perspective/method are unclear and disputed (see e.g. Pfeffer, 1982; Scott, 1992; Clegg *et al.*, 1996). Contemporary views of organisations stress that they are complex entities with unclear boundaries to the individual-level and to the environment. Several authors maintain that it is necessary to combine different perspectives in order to get a more «complete» picture of organisations (for instance Bolman & Deal, 1984; Morgan, 1988). A few characteristics are common to almost all perspectives. Organisations consist of individuals working within a certain formal and informal structure, communicating with each other and the «environment» and utilising various types of resources and technology.

In this thesis, I have developed a framework where *tension* is a fundamental notion for understanding organisations. Such a view has also been termed a «paradox perspective», because a central claim is that organisations can be characterised by aspects that seem antithetical, ambiguous, inconsistent, or dichotomous (Foss Hansen, 1995; Dougherty, 1996; Weick & Westley, 1996; Birkelund, undated). Some of the tensions that have been discussed related to research units are elitism versus egalitarianism, strategic determination (top-down) versus strategic emergence (bottom-up), freedom versus responsibility and basic versus applied research focus (see Pelz, 1967; Pelz & Andrews, 1976; Andrews, 1979a; Foss Hansen, 1995; Dougherty, 1996). A common claim in the literature is that tensions need to be «balanced» or «maintained» if the organisation is to be innovative and productive over time. My second main research proposal (following the one that was developed in chapter two) is that research organisations can be characterised by a number of such tensions, and that these can be tied to conflicting criteria for research quality.

I will focus on the *meso* level. I am not trying to discover why or how some individuals create good research, but why they seem to do better research in some organisations than in others. Emphasis will be on the interplay between individuals and their «contexts», e.g. through gaining access to researchers' own specifications of organisational aspects and their different effects. I assume that the meso level is the most productive in generating useful and important theories about the relationship between research quality and organisational factors.

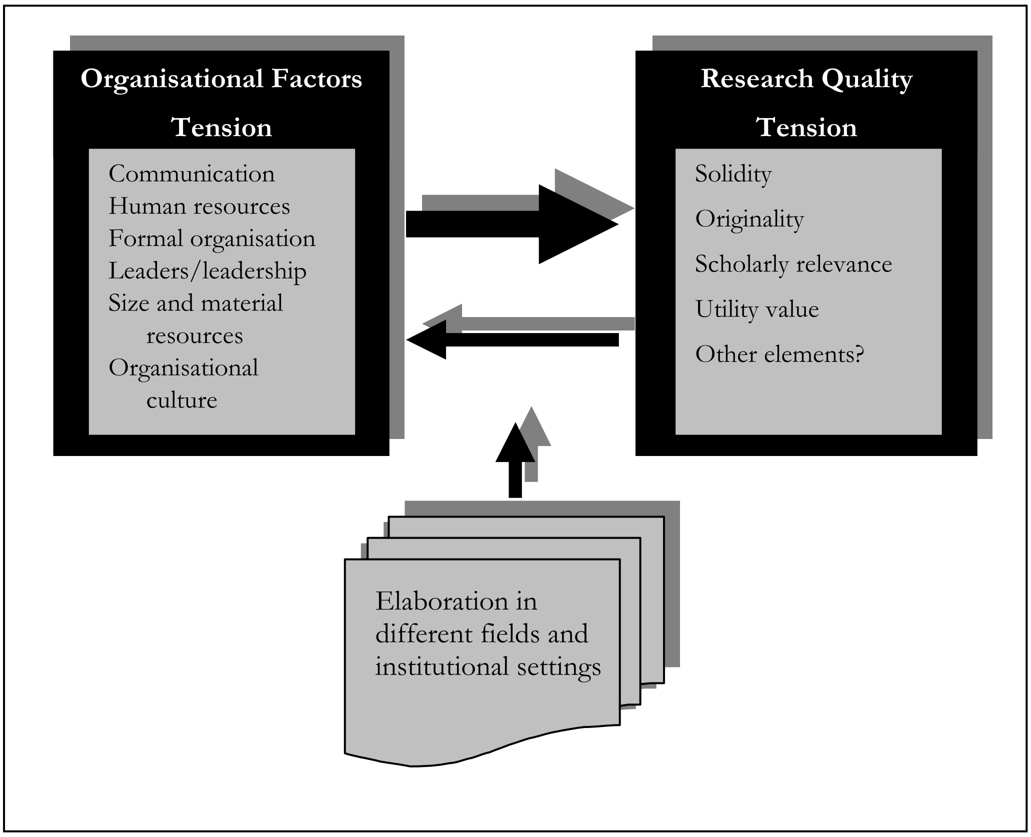
In this chapter, I have also gone briefly through earlier studies of «research unit performance» to find those aspects or characteristics that seem the most relevant. The results are not concordant – there is considerable disagreement as to what factors are the most central to performance. I have chosen to cluster previously found «determinants» of performance into six groups: individual-level variables, leaders and leadership, formal organisational aspects, size and resources, informal organisational aspects, and communication. Only the first and last of these have consistently emerged as very important. Concrete mechanisms of influence and the direction of relationships have rarely been focused upon. Are e.g. some communication patters a *result* of high performance, or its *cause*? *How* does for instance a certain organisational climate affect performance? As mentioned in the introduction, there are few links in the «research unit» literature with in-depth studies of research quality, and this thesis is intended as a contribution to filling that gap. More concrete research questions, for instance tying the six clusters of organisational aspects to the tension framework, and a more thorough discussion of earlier studies, can be found in chapters six to eleven.

The uncertainty about the direction of relationships is also related to certain dynamic processes that have been found in science. One of these is that group performance seems to deteriorate with time, often explained by a gradual reduction of «creative tensions» (Pelz & Andrews, 1976; Katz & Allen, 1982). Several authors have furthermore tried to explain large differences in productivity and performance with processes of «reinforcement» and «accumulation of advantage». These theories, supported by much empirical evidence, suggest that no or very small initial differences between individuals and between units lead to very large differences later, the reason being that those who are successful at an early stage, sustain their motivation and may gather more resources. What is still unclear, however, is how good research units emerge in the first place. Some data indicate that a leading research unit cannot be established without one or several extraordinarily talented individuals. In any case, it is evident that there is a two-way relationship between quality and research units. Quality is not simply the result of individuals in a context. The production of good (or not good) research influences both this context, the individuals and they way they perceive their surroundings. Achievement is a major source of motivation and of perceiving opportunities rather than threats in the organisational environment.

Finally, there are two central dimensions, or intermediary variables, for understanding differences in how quality is elaborated and influenced: field/discipline and institutional setting (sector). Many studies have found important cognitive and/or social differences between fields and between disciplines. Some evidence suggests that the differences are only systematic and relevant in the university sector, however, and that a rough classification (e.g. talking about natural science, social science, etc.) seems to be acceptable, at least for my focus. The sector or institutional setting (university, institute and industry) seems a more fundamental dimension concerning differences in how research is organised and which quality criteria are the most important. Still, it can be added that few studies have incorporated data from different institutional settings. A majority of earlier work has concentrated on the university sector. An interesting point for study is whether the organisational aspects or tensions that influence a certain research quality element are similar across disciplinary and institutional settings. A few studies indicate that this may be the case. Thus, my third main research proposal is that the *mechanisms* through which the quality of the research products is affected by organisational factors, basically are the same across fields and sectors. Communication with users may for instance be conducive to utility value in all research settings. Varying importance of user communication might thus reflect differences in the importance or type of utility value in disciplines and sectors.

Taken together with the decomposition of research quality put forward in chapter two, a research model for the thesis can be constructed. This is shown in figure 3.1.

Figure 3.1. *Research model of the thesis.*



The large arrow in the figure denotes the main point of study of the thesis - how organisational factors are thought to influence research quality. The small arrow signifies the two-way relationship between quality and organisational factors, which will be focused upon to some degree. As discussed above, the production of good research at one point in time may result in a unit getting more resources, improved communication networks etc., later on (accumulation of advantage). Quality research may also have an effect on the culture of a research unit, on its members' dedication and motivation, and more.

A basic premise behind the model is naturally that there is a relationship at all between quality and organisational factors. Good research units must have more in common than being an accidental clustering of talented individuals. This is primarily evidenced by the many previous studies that have found correlation between different organisational aspects and various indices of performance. Even Nobel Prize winners, considered a scientific «ultra-elite», have reportedly done better work in some organisational environments than in others (cf. Zuckerman, 1977).

Finally, my three main research proposals can be repeated:

- Research quality can be divided into four more or less incommensurable elements – originality, solidity, scholarly relevance and utility value (external relevance) – and these elements together constitute major tensions in research work.
    - Can we find diverging opinions on the nature and objective of research work and different «conceptions of quality» behind elaboration of research quality?
    - Are there central criteria of good research that are not covered by my four suggested elements?
    - How are aspects and dimensions related to originality and solidity described?
    - What is generally meant by «relevance», and is it fruitful to distinguish between «internal» and «external» relevance and make both of them demands in all types of research?
- Research organisations can be characterised by a number of organisational tensions, reflecting conflicting demands in the quality criteria.
- The organisational factors that influence quality elements, or the mechanisms that link quality with the organisation, are similar across fields and institutional settings.

More specified research questions or proposals for the last two will be elaborated in chapters six through twelve.

4 Methodology, method, data and analysis

This chapter consists of six main sections. Basic methodological considerations are discussed in 4.1, while the method for data collection is deliberated in 4.2. In 4.3 the sample is described, including the sampling procedure and the matter of representativity. The interview guide is presented in 4.4, and 4.5 deals with the carrying out of the interviews. Data analysis is the topic of 4.6, including questions of language use, reliability, validity and audiences.

4.1 Basic methodological considerations

The objective of this study is to examine the relationship between the organisational environment of research work and the quality of the research products. As discussed in chapters two and three, there are no generally accepted theories of organisations, quality or science. In addition, I have for instance pointed at lacking specification and elaboration of complex terms like «relevance» and «originality» in earlier empirical studies of research quality. There is a strong need for more in-depth exploratory investigation of this theme, to which the present thesis is intended as a contribution.

Furthermore, most previous empirical investigations of influences on research quality have constructed «productivity» indices or other types of (quantitative) performance measures. These indicators have a number of problems, and it has been questioned whether they at all are able to capture the essential aspects of research quality. Although previous investigations have pointed to a number of common traits of good research units, there is nevertheless a lack of in-depth understanding of *how* the organisation can affect the intrinsic quality of the research product. Such processes are a main emphasis of this thesis. Thus, the present study to large extent has *exploratory* purposes, focusing on complex relationships between individuals, their organisational surroundings and the quality of the work they do.

4.1.1 Quantitative and qualitative methodology

In empirical social science, it can be claimed that the researcher has a main choice of qualitative or quantitative methodology (or a combination of the two). Quantitative studies are often critical towards qualitative studies and vice versa (cf. Denzin & Lincoln, 1994). The two «schools» are furthermore often tied to different epistemological beliefs. Quantitative methodology has been tied to «positivism» or «simple» forms of realism, while qualitative methodology is linked with various forms of «constructivism» or «interpretative social science» (Silverman, 1993; see also 4.1.2 below).

Still, I do not see these two as polar opposites, and it is worth noting that an increasing number of scholars utilise both methodologies in their research. In fact, it has been argued that the «schools» do not offer any worthwhile descriptions of major alternatives of sociological research at all: «There are no principal grounds to be either qualitative or quantitative in approach. It all depends upon what you are trying to do» (Silverman, 1993:22). The same applies to the data resulting from either approach: «Neither kind of data is intrinsically better than the other; everything depends on the method of analysis» (*ibid.* p. 106).

Also Stablein (1996) has argued against the «quantitative/qualitative divide». He claims that the distinction is «a binary opposition that hides a more complex, non-dichotomous, and non-hierarchical distinction» (p. 515). Numerical representations are for instance not members of a single class, and they often represent non-numbers of the type «I agree strongly with this statement.» Labelling «everything else» to the non-numerical is also a poor starting point for defining qualitative data. Some authors have developed methodological distinction on the qualitative side, e.g. «grounded theory methodology» (cf. Strauss & Corbin, 1994; and 4.2 below). Instead of qualitative data, Stablein (1996) develops the notion of «ethno-data» (which includes for instance different types of interviews and observation strategies), which aim to depict empirical reality as it is experienced by the (organisational) participants.

Traditionally, qualitative methodology has been treated as relatively «minor» to be used only (if at all) in early or exploratory phases of a study, «before the serious sampling and counting begins» (Silverman, 1993:20). Qualitative interviews, observation, textual analysis etc. have been seen as appropriate in exploratory or descriptive investigations and/or when one knows little about the subject for study. Silverman argues that both quantitative and qualitative approaches can be relevant in all phases of an investigation, but that they are tailored towards different objectives.

Qualitative methodology is oriented at explicating the subject's interpretation of social reality, to understand how people understand their worlds and how they create and share meanings of their lives and activities. The need for this type of research arises out of a desire to understand complex social phenomena (Yin, 1984). The approach is not primarily oriented at categorising and classifying, but at figuring out what events mean, how people adapt and how they view what has happened to them (Rubin & Rubin, 1995). There «is not one reality out there to be measured; objects and events are understood by different people differently, and those perceptions are the reality – or realities – that social science should focus on» (*ibid.* p. 35). It can be claimed that behind all qualitative research is at least a mild form of social constructivism (as expressed e.g. by Berger & Luckmann, 1966). Behind the growth of such approaches lies the «doubt that any theory or method has a universal and general claim to authoritative knowledge» (Denzin & Lincoln, 1994:2).

Quantitative approaches, on the other hand, are oriented at collecting comparable data (most often in numerical form). The researcher is rarely interested in the subjects' own concepts and interpretations, but uses her or his pre-determined categories to get information about certain factors. These are most often analysed statistically to uncover differences or co-variation among important variables in the phenomenon under study. Hence, the quantitative researcher develops concepts and categories *ex ante*, while the «ethno-researcher's» organisational reality is full of constructs and meanings «to be discovered» (Stablein, 1996).

Unlike qualitative methodology, which implies the gathering of (relatively) much data about few subjects, quantitative approaches aim for precision. To achieve this mirroring of the variation of the relevant phenomenon, (relatively) little data is gathered about many subjects, mainly selected as representative of a larger population (Yin, 1984). Experiments and surveys with closed questions are preferred. In addition to assuming that (at least some of) the researcher's own concepts are relevant, the main representational assumptions behind quantitative research (e.g. Likert scales) are that the respondents are truthful, understand the items, are able to make the required judgement and are able to translate the judgement to the response format (Stablein, 1996).

Although it can be claimed that the epistemological boundary is irrelevant or indistinct (qualitative studies may e.g. look for aspects of an independent reality), it is, as stated above, evident that the two methodologies are tailored for studies with different objectives. The choice of methodological approach should thus be based on a judgement of its perceived usefulness for achieving a research project's purpose (Silverman, 1993). Quantitative studies are effective in determining the frequency of phenomena and the strength of relationships, while qualitative investigations aim for exploring phenomena in-depth and for looking at the direction and the characteristics of relationships between variables and contexts. It is obvious from the elaboration of my objective above that this thesis will benefit the most from a qualitative approach. Particularly my focus on in-depth elaboration of research quality and underlying concepts like «originality» and «relevance» requires qualitative input from researchers. It is often argued that quantitative researchers seldom manage to capture subjects' perspectives and specifications because they rely on more remote, inferential empirical materials (Denzin & Lincoln, 1994).

My focus on organisational aspects and on the processes that link them to research quality is also exploratory, aiming for «analytical generalisation» (Yin, 1984) through the development of theory that can help us understand the complex relationship between quality and the research organisation. A common critique of quantitative methodology is that it is atheoretical, and many of the investigations of research unit performance have been criticised for not trying to contribute to developing theory (Foss Hansen, 1988). It has been argued that qualitative research can (Hammersley & Atkinson, 1983):

- provide broader versions of theory than simply a relationship between variables, because a theory must include elaboration on mechanisms or processes that generate these relationships, and
- allow for effective and economical theory development.

I will elaborate what I mean by «theory» in 4.2 after discussing method for data collection. The main critique against qualitative methodology has been that the data it yields seem unreliable, «anecdotical» and not objective (Denzin & Lincoln, 1994). I will return to this critique in subchapter 4.6 where I discuss the status and the analysis of qualitative data.

4.1.2 Realism, idealism and choice of methodology

It can be fruitful to elaborate somewhat on epistemological issues related to the study of research quality and its organisational influences. A possible basic view of good research is the assertion that there are quality standards/criteria independent of what researchers define as good. Such a view is based on philosophical *realism* – reality is independent of our understanding of it. A realist conception of research quality has different consequences if research evaluators «know» the standards or not. If independent standards are easily acknowledgeable, evaluation will be unproblematic. However, the literature on peer review (e.g. Ceci & Peters, 1982; Chubin & Hackett, 1990; Cole *et al.*, 1981 and 1978; Travis & Collins, 1991) and knowledge of controversies in connection with research evaluations (Luukonen, 1995), do not give good arguments for the existence of independent standards. On the other hand, if such standards are not obvious to evaluators, quality assessments may be wrong, i.e. there may be a gap between what good research *is* and what good research is *perceived* to be.

Another basic view is *idealism*, implying that what is good (and poor) research is determined by the scientific community and possibly by other authoritative actors. Different types of peer review processes will thus be central to both definition and judgements of quality. Realist and idealist views of research quality do not necessarily exclude each other. They can be combined by saying that some elements or criteria are (more) realistic aspects of good research, for instance consistency and thoroughness, while others are constituted through assessment processes, e.g. originality and relevance.

The basic view of research quality will determine how the questions «What is good research and what are its determinants/influences?» should be explored. Idealism involves seeking answers in opinions of leading researchers, concrete evaluations and review processes. This is the focus of most of the recent literature on good research. The most extensive study has tested a framework of aspects and attributes both on researchers' opinions and on concrete assessments of quality connected with project applications and candidates for professorial positions (Hemlin *et al.* 1994, Montgomery & Hemlin, 1991; cf. chapter two). From realism, on the other hand, one could try to bring to light «eternal» standards and norms for good research. A «test» against independent standards is difficult, but for instance Tranøy (1986) approaches the problem from a philosophical angle and seeks universal, constitutive norms for good research, which implies a more «realist» view of quality. A realist standpoint could of course also use interviews, surveys etc., assuming that the resulting data and the analysis of them aggregate to give a good approximation to an external, independent reality. As I have argued in chapter two, I see research quality as being more or less completely defined by the judgements of research works (and to some extent individuals, units etc.) that is carried out in various circumstances, mainly by senior or «leading» researchers. This can be termed a more idealist epistemological standpoint, although I in general would favour an in-between view (see the discussion of a «subtle form of realism» in 4.6).

4.2 Methods

Silverman (1993) argues that the method should be selected based on its perceived fit with theory, hypotheses/research questions/propositions and methodology. Still, he maintains that common methods in qualitative research – observation, interviews, transcripts and textual analysis – also can be used in quantitative studies. However, these techniques take on a different meaning within a quantitative framework, e.g. checking the accuracy of categories, using fixed-choice interviews to get particular data and for preliminary work.

In qualitative research, observation is oriented at cultural understanding, textual analysis is done to understand participants' categories, transcripts are studied to understand how participants organise their talk (e.g. in patient-doctor relationships) and interviews are used to explore specific issues or the general «reality» of the subjects. One can furthermore distinguish between different types of interviews, for instance cultural (oriented at revealing value standards, shared understanding, rules of behaviour) and topical ones (focused on more specific phenomena, events and processes) (Rubin & Rubin, 1995; Merton *et al.*, 1990).

I have developed a comprehensive theoretical framework in chapters two and three, for instance by decomposing research quality into different «sub-elements» and by elaborating organisational tension and different organisational aspects found important in previous studies. From this I have put forward three main research proposals and a number of specific research questions, which should imply data collection based on semi-structured or «focused» interviews (Rubin & Rubin, 1995; Merton *et al.*, 1990). Nord & Fox (1996) argue that interviews are highly appropriate in micro and meso level organisational studies, because «a person's static traits are not of central interest; more crucial are the person's goals and self-perceived competencies that influence how he/she interprets particular situations» (p. 156). The fit between focused interviews and my propositions are elaborated below.

4.2.1 Explicating the tacit dimension

Common to many of the research questions and the three proposals I have put forward, is a focus on explicating what is most likely tacit knowledge about good research, and also about how it can be influenced. It has been claimed that an important problem for empirical studies of research quality, is that judgements of research probably to a large extent are conducted based on tacit knowledge (Ravetz, 1971). It can be difficult to operationalise the basis of professional quality assessments or to put it into concrete terms, perhaps not least for the most experienced evaluators. The more established and routine something is, the more difficult it may be to explicate and explain it. Tacit elements of the basis for assessments leave room for both hidden and fictitious disagreement. Different meanings can be put into the same concepts and also similar meanings into different concepts. There is no standard operationalisation of notions like solidity, relevance and originality.

The same point applies to how research quality is influenced, i.e. the systems of beliefs that underlie action, the prototypes from which actions are derived and procedural prescriptions for action, which in sum can be termed an organisation's or individual's «theory of action» (Argyris & Schön, 1996). This theory can further be distinguished into the two sub-components «espoused theory» and «theory-in-use». The former refers to the theory of action which is advanced (e.g. in an interview setting) to explain or justify a given pattern of activity. Theory-in-use, on the other hand, is implicit in the performance of activities. Although this component is largely tacit, it has been argued that the theory-in-use can be made more explicit through reflection, observation, historical studies, etc. (*ibid.*). I also claim that the espoused theory, what interviews tell you «directly», is relevant. In chapter three I described that it is e.g. the resource levels as perceived by the individual that are important to performance and motivation, not the actual levels (see Stolte-Heiskanen, 1979; also Knorr *et al.*, 1979b; Visart, 1979). Hence, I claim that the researchers' espoused theory and subjective opinions have a value of their own, not just when compared to others' accounts to find similarities and differences (see also the discussion of the status of interview data in 4.6). It can be added that most organisational tension/paradox perspectives emanate from an interpretative paradigm where the main empirical input (or seen as the only way to gain access to such aspects of organisations) is how participants define and experience tension and paradox (see 3.1.4, also Birkelund, undated).

Explicating tacit knowledge about research quality will therefore be an important part of exploring different quality elements and their origins. Thus, I have not carried out a comprehensive survey to determine the share of researchers that attach weight to different quality aspects. Instead, I have chosen to use focused interviews with mostly open-ended questions. The respondents have been encouraged to go thoroughly into the themes, give examples and problematise quality aspects and their determinants from their own disciplinary context.

Focused, yet open-ended interviews have many advantages compared to surveys by mail. The quality of the data should be very much improved when an interviewer can ask follow-up questions and is able to focus the attention on the subtle and ambiguous that would be lost in a questionnaire. This way it is easier to go deeper into central and complex issues, and the informants can use their own words e.g. when describing properties of good research. Furthermore, researchers are critical, intelligent and most often loaded with work. It can therefore be expected that a questionnaire sent by mail would be completed without the necessary reflection about complex issues, or yield a low response rate. The main disadvantage of personal interviews is that they are resource-intensive – the sample will be smaller and it may thus be more difficult to generalise findings (cf. 4.3).

Focused interviews are as mentioned preferred to more open-ended «cultural interviews» when the researcher has specific questions in mind. Earlier investigations have yielded some central concepts related to research quality (cf. chapter two) and some important organisational characteristics of good research units (cf. chapter three). Hence, I see focused interviews as appropriate to be able to verify (or falsify) earlier findings. Despite the difficulties with many of the previous studies of e.g. research performance, it would not be very fruitful to dismiss their categories and concepts completely. More structured interviews could thus lead to improved theory in the field.

4.2.2 Grounded theory

Using the interview data, I will form explanations and theories that are based on the details, evidence and examples from the interviews. This has been called *grounded theories*, which «explain what is happening in the terms of those involved in a situation» (Rubin & Rubin, 1995:4). Thus, a theory in this sense is not the formulation of some discovered aspect of a preexisting reality «out there» (Strauss & Corbin, 1994). Theories are interpretations and therefore fallible, but judgements can of course be made about their soundness or probable usefulness (cf. 4.6 where validity and reliability are discussed). It can be added that theories are constantly being changed, updated and outdated: «Theorists are not gods, but men and women living in certain eras, immersed in certain societies» (*ibid.* p. 279).

To elaborate somewhat, «theory consists of *plausible* relationships proposed among *concepts* and *sets of concepts*. (…) Without concepts, there can be no propositions, and thus no cumulative scientific (systematically theoretical) knowledge based on these plausible but testable propositions» (*ibid.* p. 278). As in almost all qualitative research, the relationships are presented in «discursive» form, embedded in a thick context of descriptive and conceptual writing.

Some of the concepts in this study are e.g. diversity, motivation, and recognition, as elaborated both by the literature and my informants. Tension is a central concept throughout the thesis; it is put forward based on some of the literature, but refined and specified through my empirical analysis. I have gone to the empirical material in search of particular concepts, but also to develop them, test them and look for contrary evidence, a method that has been compared to a «fishing expedition» (Blau, 1973:46). Thus, theory is something that «evolves during actual research, and it does this through continuous interplay between analysis and data collection» (Strauss & Corbin, 1994:273).

4.3 The sample

In this study an empirical course has been chosen – I have collected data from senior researchers to determine their opinions on research quality and how quality is influenced by organisational factors. The empirical analysis is based on ideas and categories from previous empirical studies and to some extent from theoretical discussions of universal norms for good research as well as perspectives from organisation theory. The data collecting method (intensive interviews) and the sample selection (leading/central researchers) are founded in perspectives from the sociology of science that mainly assumes an idealist view of research quality. What is meant by solid, relevant and original research is defined by the scientific community (and sometimes by others) in a continuous process. More solid methods are developed, and criteria of originality and relevance are updated as new knowledge gains credibility and sub-disciplines evolve.

What constitutes good and bad research is communicated through different kinds of «disciplinary socialisation», for instance methodology courses, supervision by seniors, feedback on manuscripts from journal referees and other «trial and error» processes. It is therefore the opinions of central researchers in each discipline that are of interest to a study of research quality and its determinants. These researchers can be defined as those who have important roles in evaluations of project proposals, manuscripts and applicants for research positions, and who are responsible for the training of researchers. Through such activities, good and bad research is implicitly defined.[1]

I have selected central researchers and research groups in two different disciplines, perceived to be quite unlike each other, in all fields of knowledge, i.e. in the humanities, social sciences, technology, natural sciences and medicine. In the social sciences, for instance, sociology and economics have been chosen. These two disciplines are classified as different by Becher (1989); sociology as «divergent» and economics as «convergent» (cf. 3.4).

In total, 64 researchers in a broad selection of disciplines have been interviewed: biomedicine, biotechnology, chemistry, clinical medicine, economics, engineering cybernetics, French, mathematics, philosophy and sociology. The selection in the university sector has to a large extent determined the research groups/organisations of interest in other institutions, because I (as far as possible) wanted to interview researchers in the same disciplines across sectors. However, the disciplines do change character somewhat in the applied sectors. Researchers in the applied end of the spectre often identify themselves just as much with their often cross-disciplinary research areas as with their original discipline.[2] The number of respondents is distributed as shown in table 4.1.

Table 4.1. *Sample distribution across sectors, disciplines and fields of learning.*

Discipline Sector	*Philo-sophy*	*French*	*Mathe-matics*	*Che-mistry*	*Biotech nology*	*Cyber-netics*	*Socio-logy*	*Econo-mics*	*Bio-med.*	*Clin. med.*	**Sum**
University	3	3	3	3	3	3	3	3	3	3	**30**
Institute			3	3	1	3	3	3	3	3	**22**
Industry			2	5		1		3		1	**12**
Sum	**3**	**3**	**8**	**11**	**4**	**7**	**6**	**9**	**6**	**7**	**64**
Sum fields	**6**		**19**		**11**		**15**		**13**		

Five of the 64 interviewees are women (the five come from all fields except the social sciences). The youngest respondents were in their mid-thirties and the oldest was 71 (in 1996).

[1] «Users» may naturally also be among those who define good and bad research in a number of fields. Because the aim of the present study is to elaborate the characteristics of good *research* units, I have not used data from users in the analysis.

[2] In addition, it can be claimed e.g. chemistry (with basis in natural science departments) and chemical engineering (with basis in technology departments) are completely different disciplines (see section 3.4; also Mitcham, 1994). Rosenberg (1991:339) writes among other things about «the emergence of chemical engineering as a unique discipline, not reducible to 'applied chemistry'». I have termed both of them chemistry in table 4.1, although some of these informants could have been moved to the «technology» cell. Due to the small number of respondents, I have not compared fields of learning in industrial R&D laboratories, however.

The mean age of the sample is approximately 47 years. The respondents from industry are the youngest (mean 43 years), and those from the universities the oldest (mean age 51 years).

4.3.1 Sampling procedure

Selection criteria varied depending on the available information. To find «eminent» researchers, I started out by looking at nomination for or receipt of distinctions/research prizes (NAVF's prize for outstanding research, NTNF's honorary prize and the research prize of the University of Oslo). I also looked at scientific publishing (I had access to databases from the Institute for Scientific Information, ISI), evaluation tasks, position/seniority and general reputation. For selection of informants from the university sector, this in most cases was sufficient. A few of the respondents were selected based on recommendations from the first person interviewed in the discipline. In the institute sector, and particularly in industry, I usually did not have a more extensive basis for choosing respondents than position/seniority and the recommendations of the institution's R&D executive. In addition, I scrutinised annual reports/brochures and information on the World Wide Web. I also used data from ISI – a colleague had recently compiled a list of Norwegian private firms with publications in international scientific journals.

From the information that the interviews have provided about the respondents' role in different kinds of professional reviews, I feel confident that the target group has been reached: central seniors in their fields and sectors. Also in industry and partly the institute sector, the informants stressed that their unit, institute or laboratory, had strong visions of being among the leading within their field, in Norway or internationally. I claim that all of the respondents come from nationally leading research units, but not necessarily internationally leading.

In one case, the interviewee turned out to be a former researcher who now mainly worked with administrative tasks. All the others were active researchers. The respondents represent two universities, eight research institutes and four industrial/consultancy companies, based in four different Norwegian cities. Two industrial researchers, both working in chemical engineering and both in group leader positions, had an advanced engineering degree (the Norwegian degree «sivilingeniør»), while the rest of the sample had doctoral degrees.

Essentially, three researchers have been interviewed (most often within the same department) in each field and sector. The exceptions are primarily philosophy and French, where only the university sector is represented, and sociology, where there is no research in the commercial sector. Because some companies and/or individuals turned down the interview inquiries (because of workload or «company policy»), it was difficult to get respondents from industry, particularly in medicine and biotechnology.

4.3.2 Representativity

It is obvious from the discussion above, without any reference to R&D statistics, that my informants are not representative of the Norwegian research community. For instance, in the private sector, the informants come from four firms, all among the leading within their industries, and two of them are among the largest and the most international companies in the country. Although a large share of Norwegian industrial research is carried out by such firms, the majority of the ones involved in R&D most likely is different from those in my sample. In addition, almost all informants have doctoral degrees – they are in this respect a minority in the Norwegian research community – and they have been selected largely based on seniority and perceived centrality in judgements of quality.

However, in qualitative studies cases are rarely selected at random, but because they allow access to certain perspectives more than others (see for instance Silverman, 1993). To ensure «representativity», several propositions are made in the methodology literature: the investigator can compare her or his cases to similar investigations of other cases or of the larger population, co-ordinate several studies of the same problem or generalise in terms of theories. Particularly the latter strategy is elaborated. It has been argued that case studies and other qualitative investigations are not representative (or generalisable) the way large surveys are (statistical generalisation), but rather that one achieves «analytical generalisation» through the depth and quality of the analysis (e.g. Yin, 1984).

Qualitative studies are thus seen as generalisable to theoretical propositions and not to populations or universes. «Theoretical propositions» do not imply that qualitative studies have no practical relevance. They seek to generalise insights about the pattern of a situation that may have relevance for the understanding of a similar pattern elsewhere (Morgan, 1997). Through specifying a theoretical framework, research proposals and a number of research questions, I have tried to achieve such an analytical generalisation. Still, I must add that I believe much more research is needed before my conclusions (and e.g. the tension framework) can be regarded as «general» or «airtight». Morgan has argued that generalisability rests in the resonance and relevance of the data «as constructed by the reader» (p. 305). I will discuss the «audiences» of the thesis in 4.6.4.

I nevertheless believe it is necessary to comment on some more specific issues related to the representativity of my sample. First, it is clear from table 4.1 that the university sector is over-represented – almost half the informants are university professors – which may pose a challenge for comparisons across institutional settings. However, I have often combined the institute sector and industry in the analysis, mainly because the answers from these informants in many cases were very similar. The two groups «informants from basic research units» and «informants from applied research units» are almost equal in size (30 versus 34). Also, the more theoretical literature categorises research institutes and industrial R&D laboratories as similar types of organisations (Mintzberg, 1983; Scott, 1992, see chapter three). Although the informants from industry cannot be viewed as representative of industrial researchers in general, they do pose an interesting counterpart to the answers from the university sector in many of the thesis' research themes.

More serious is the bias in the interview material towards seniors' perspectives and views. I have argued that senior researchers are the central ones when studying research quality. Still, this investigation has another important purpose: to characterise «good research units» or how organisational characteristics can be linked with research quality. For this purpose, the opinions and experiences of e.g. junior researchers, not-so eminent scientists etc., have a definite value (e.g. «unit heads» and «staff scientists» gave significantly different answers in Andrews, 1979a). In a sense, I have «picked the winners», and their perspectives may for instance have a bias towards «concentration of resources», increased differences in resource allocation and other policy measures that can contribute to accumulation of advantage effects that not necessarily will benefit the quality of the Norwegian research community as a whole. I see this as a major methodological weakness with the present study, and I believe that later studies will have to focus more on «whole» research units. I should nevertheless like to add that it is also clear from the interview material that all the informants have been juniors at one time and most often have a deep sympathy for the juniors in the system, as evidenced by the many comments to be analysed in later chapters. Most of the scientists in the sample have also seen many different research units throughout their career, both «good» ones and «bad» ones, and their experiences in this respect are of course valuable.

Finally, it can be stated that both the disciplines and the sectors that have been studied are distinguished by a high degree of diversity, and most respondents can only be said to be representative of specialities or sub-fields (if «representative» at all). In many disciplines there are, in addition to often large numbers of sub-disciplines, different «professional traditions» and «schools of thought» that can have divergent views of what constitutes good research and perhaps also of the origins of good research. The informants have been asked to elaborate such intra-disciplinary differences to give a picture of possible differences of quality opinions (although the researchers' own professional standing may influence these comments). Furthermore, in industry there are large differences between for instance well established versus young technology/research, between size of companies etc. The general implication is that much care must be taken in the comparison of answers across disciplines and sectors, especially the former.

4.4 The interview guide

Although the interviews mainly were carried out with all questions in a pre-determined order, I will use the expression «interview guide» rather than «interview schedule» (cf. Newell, 1993), because of the open-ended nature of the questions and the many follow-ups and probings. Three persons conducted the interviews (more on inter-researcher reliability in 4.6.3). During autumn 1995 we had several discussions where my guide drafts were refined and a common understanding of the purpose of each question was developed. Care was also taken, for instance, to make the questions as «neutral» and non-leading as possible. Three seniors at the Norwegian Institute for Studies in Research and Higher Education also provided feedback on a late draft.

The result was a relatively standardised guide with questions meant to be asked in a predetermined order. An English translation of the guide can be found in Appendix A. All but one question were open-ended because of the complex issues to be discussed and because the relevant dimensions often were not known (cf. Merton *et al.*, 1990; Newell, 1993). In the guide, probes were often listed to help the interviewer with follow-up inquiries.

A test interview was carried out at the end of January 1996. This led to very few changes in the guide, and ordinary interviewing therefore started from February 1996. There still was a continuous discussion about formulations and results. The university sector was completed first, and some formulations in the guide were changed before it was applied to the institute and commercial sectors (by mainly adding «development» and «technical service» in some questions, and substituting «study» for «project» a few places).[3]

It is important to note that the interview guide functioned as the starting point for the interviews; additional probing questions were often posed to get the respondents to go deeper, make things clearer etc. We particularly tried to do that when we received «simple», unclear and/or «standard» answers. In some cases, the wording of questions was slightly changed, for instance if a question was not understood or if the respondent used words/formulations that it was natural to continue using. Some of the questions that seem general in the guide were also asked with a more direct basis in the researchers' own activities and previous answers. As a preparation for the interviews, we frequently read annual reports and other material about the research groups/departments, to become more acquainted with the discipline, the environment etc. This sometimes made some specific questions possible, for instance about ISO 9000 certification of a research organisation's quality system.

All respondents received a written inquiry, where an overview of the interview topics was added. The inquiry and the topic sheet can be found in Appendix B. Only general formulations were used in the overview of topics to prevent the respondents from becoming committed to certain expressions that were not their own (e.g. originality, solidity, relevance). Some of the interviewees had made notes and put keywords on the topic overview, while others excused themselves for not having had the time to look at it.

In retrospect, having read more literature and started a preliminary analysis of the data, I can see that the interview guide could have been different. Although all questions were meaningful to some informants, I would now have liked to add some other themes, particularly a stronger focus on dynamic processes, tension and political aspects of research organisations. This being said, the main separation of the interview guide into «good research» and «good research units» worked well. Although some issues were not touched to the extent I now believe they should have been, I still have comprehensive data from sixty-four researchers, elaborating research quality and its influences, and organisational aspects of research units.

4.5 The interviews

As can be seen from the interview guide, the interviews consisted mainly of two distinct parts. In the first part, the informants were queried about their research activities and their opinions on «good» and «bad» research and on various quality judgements. A question about the research process led to the second part, where the research unit or organisation was in focus. Still, many of the organisational questions referred to the elaboration of quality, and the informants were also asked how quality elements could be «promoted» and «restrained» by the organisational environment during the first part of the interviews.

[3] Most of the respondents from industry were asked a few additional questions about scientific publishing.

With one exception, all interviews took place in the researchers' office or a seminar room at their place of work. The shortest interview lasted for about 55 minutes, while the longest progressed for three and a half hours. Mean interview time was just short of two hours, with a standard deviation of 28 minutes. The interviews lasted a little shorter in industry than in the other two sectors. There are also differences (although not significant) between disciplines, with slightly shorter interviews in clinical medicine and mathematics than the rest, and slightly longer ones in biotechnology, chemistry and sociology. In my opinion, this is due to characteristics of the individual respondents – some talked very much or spent much time answering the questions, while others only had a limited amount of time for the interview or gave quick and/or concise answers.

We were well received by most respondents. Many of them expressed that they found the interview theme exciting and important, and they were interested in talking about their own field and their opinions on research quality and its determinants. However, three informants were very negative. They gave quick, one-syllable answers and were unwilling to elaborate their own statements. One of these (a professor of medicine) expressed that such a study was «nonsense». The two other negative interviewees answered the questions very briefly and instead took the opportunity to vent anger and frustration connected with «bureaucratisation», the Research Council, research administrators and others. These three did answer some of the questions in a useful way, especially those about good and bad research in their own field, but they are excluded from the analysis of many other themes.

Some of the questions were perceived as very difficult and required that the respondents reflected on complicated issues, previous answers etc. If the informant was stuck, we tried to give cues, often based on earlier responses («You said something about…» and «What about … that you mentioned»). We largely tried to make the interview flowing and conversation-like and the discussion as frank as possible. Questions were frequently answered earlier than «expected». As a rule, we would let the respondent finish the response and perhaps drop the theme (or probe deeper) later in the interview. Still, in many interviews the succession of questions seemed natural. In most interviews, it was successful to first talk about elements of research quality, and then proceed to talk about the determinants of these elements. At least the answers seemed to be less vague e.g. when the question posed was «what can promote and restrain originality/relevance etc.» instead of «what can promote and restrain good research». Not all researchers were able to answer questions related to organisational characteristics, in most cases because words like «leadership», «organisation» and «organisational culture» gave no (or mainly negative) associations (this will be further discussed in chapters six through eleven where these questions are elaborated). We tried to be as open as possible towards the informants' perspectives and terms, a prerequisite for doing good interviews (Rubin & Rubin, 1995).

It has been argued that interviewers may have an advantage compared with more traditional survey researchers, because the former can make «verifying probes» and other follow-up questions that enhance the reliability and validity of the study (Morgan, 1997). There was probing connected with almost all questions, and this was found very important, for instance to get the informants to define the (often relatively standard) expressions that they used. As with the original questions, we tried to make this follow-up questioning as neutral as possible. Probing has been described as a «key interviewing skill» (Fielding, 1993:140). All three interviewers benefited from having assisted in several previous interview studies.

We did not experience that the informants refused to answer questions completely, but some would not (and some could not) come up with concrete examples of good/bad/relevant/original etc. research in their field. Still, they were generally speaking more reluctant in giving «negative» examples. In a few cases the respondent underlined that he/she did not want to be quoted (or asked to have his/her anonymity confirmed). This was connected with negative experiences with the Research Council and/or other important contractors.

4.6 Data analysis

In qualitative studies, the main issue is not the recruitment of the sample, the format of the interviews etc., but the quality of the data analysis (e.g. Yin, 1984). All data are representations, but what do they represent? According to Stablein (1996), they must represent «empirical things», and these «things» are our ideas about empirical «reality». A successful representation process provides data that scholars can interpret and analyse in ways that increase their shared understanding of an empirical reality (*ibid.* p. 512). My interview transcripts and notes are not the organisations and opinions on research quality of the 64 interviewees, but symbols that I have attempted to analyse to present, hopefully, an insightful description of research organisation and research quality.

The nature of interview data has been much discussed. What is the validity of people's statements in semi-structured, open-ended interviews? What people say in interview settings does not have a stable relationship with what they do in naturally occurring situations. This is of course not only a critique towards interviews, but towards all types of research relying on respondents' language or even interpretation of other's categories.

Two problems in particular have been widely discussed (see Silverman, 1993; also Denzin & Lincoln, 1994). First, many researchers who have used interviews, seem to have a tendency to select field data to fit an «ideal» conception (or preconception) of the phenomenon. Second, interview researchers have been accused of selecting conspicuous field data because it is exotic, at the expense of less dramatic but perhaps more indicative data. Both of these problems lead to texts that are «anecdotal», i.e. a contention is put forth, and brief pieces of conversation are subsequently added to provide evidence for it. «Unreliable», «impressionistic», and «not objective» are other terms used by opponents of qualitative research (cf. Denzin & Lincoln, 1994).

Regarding objectivity, it is evident that «the depth of understanding required to do qualitative interviewing makes it difficult for qualitative researchers to remain value free or neutral toward the issues raised» (Rubin & Rubin, 1995:12). The authors argue that neutrality or objectivity probably is not a legitimate goal in qualitative research. Apart from being labelled impossible, neutrality is also seen as a barrier towards attaining the empathy necessary to do good interviews and thus get access to the world of the interviewee. A middle road is proposed – a moderate degree of empathy that allows the researcher also to focus on «negative things». Hence, qualitative researchers often aim for balance rather than neutrality. It can be repeated that a number of studies have found that e.g. «subjective resource levels» display a stronger correlation with performance than objective measures of resources (cf. Stolte-Heiskanen, 1979; also Visart, 1979; Knorr-Cetina *et al.*, 1979a; Harris & Kaine, 1994).

For Silverman (1993), the solution to avoiding «anecdotal» studies is to not theorise «too much» in advance (it might be seen as «suspicious»), to examine «deviant cases», to include typical answers even if they are not too «eloquent» and to do «simple counting» where possible. Rubin & Rubin (1995) argue that «qualitative interviews should sort out what is unique and what may be common while staying close to real examples» (p. 39). Such means of improving reliability and validity are the theme of this subchapter.

Stablein (1996) upholds «fidelity» as the main criterion of data quality. Two-way correspondence between representations and the empirical world can only be assured if the representation in one way or the other matches the «native» viewpoint. Some researchers discuss this in terms of reliability and validity, claiming that there is «nothing special» in qualitative research (e.g. Yin, 1984). A «trade-off» between reliability and validity is often stressed (Stablein, 1996). Others deny the acceptability of such criteria and propose for example credibility, transferability, dependability and confirmability as substitutes (e.g. Guba & Lincoln, 1994). Handbooks of qualitative research usually devote several chapters to the discussion of such criteria (e.g. Denzin & Lincoln, 1994). In the discussion below, I will mainly follow Silverman (1993), who claims that reliability and validity are the two central concepts in any discussion of rigour in scientific research. It should nevertheless be noted that the relevance of these terms in qualitative research is contested.

In 4.6.1, I discuss a fundamental issue – the status of «language use» in qualitative research. Language is no longer seen as a neutral medium for the transmission of information. Validity is the theme in 4.6.2, reliability in 4.6.3 and the question of «audiences» in 4.6.4.

4.6.1 Language use in interviews

Silverman (1993) and Fielding (1993) describe three different analytic stances towards interview data. These are:

- *Positivism*, where interview data «are regarded as giving access to 'facts' of the social world. They are treated as accounts whose sense derives from their correspondence to a factual reality» (*ibid.* p. 150). Standardised interviewing approaches are preferred.
- *Symbolic interactionism*, the supporters of which regard the research interview as any other social interaction, i.e. one has to understand the context in which the data were produced to understand the data. Validity is ensured when a deep and mutual understanding between interviewer and respondent has been found, and interviews should consequently be unstructured and open-ended.
- *Ethnomethodology*, where the interview is regarded as a «happening» – an interviewer and a respondent strive to construct something that can be recognised as an interview. The data deriving from it are thus regarded as a «topic», not as a «resource».

It can neither be said that these positions do not overlap, nor that they are the only positions that can be described. Particularly Silverman (1993) stresses that the boundaries between them are very indistinct. Furthermore, one position cannot be described as «better» than the other two, but in pure form they are linked with different perspectives of the social world (Fielding, 1993). The basis of this study is a mixture of the first two (with a stronger emphasis on symbolic interactionism), as can be seen from the relatively standardised yet open-ended interview guide. Still, one has to be aware of how the data production context (the interview as a type of social interaction) can influence the data. Of special interest here is the respondents' use of language not only to depict the «world», but also to do specific tasks in the world.

Language is by many no longer considered as a neutral medium for the transmission of different kinds of information, attitudes etc. (Wooffitt, 1993). Instead, language (both in written texts and in oral communication) has systematic properties and serves specific functions, which can have important implications for the validity and reliability of investigations that are based on participants' accounts. In a study of a scientific dispute in biochemistry, Gilbert & Mulkay (1984) found that scientists employ two distinct linguistic repertoires, both in texts and conversations. The *empiricist repertoire* «portrays scientists' actions and beliefs as following unproblematically and inescapably from the empirical characteristics of an impersonal natural world» (*ibid.* p. 56). This repertoire is most often used to describe a piece of work that the speaker/author agrees with. If the speaker does not agree, however, he or she is likely to use the *contingency repertoire*, which «enables speakers to depict professional actions and beliefs as being significantly influenced by variable factors outside the realm of empirical (…) phenomena» (*ibid.* p. 57). Some authors have found the same in other contexts, for instance that scientists are likely to use the empiricist repertoire when describing research evaluations that are «positive» for themselves, and the contingency repertoire connected with «negative» evaluations (Luukkonen, 1995).

The same distinction can be found outside the realm of science. For instance, high technology development groups that are successful, often talk about supreme technical characteristics, while teams whose activities are shut off search for «outside explanations, excuses, and scapegoats upon which to blame the decision» (Katz, 1994:7). Some authors are thus very sceptical towards using participants' accounts as a basis for analysing social life. The goal of making an analysis of social life based on interpretations by participants «is made unattainable by participants' ability to engage in the creative use of language» (Gilbert & Mulkay, 1984:8).

How relevant is this for the present study? The dichotomy of language use presented above seems to pertain especially to controversies and conflicts – scientific disputes (Gilbert & Mulkay 1984) and controversial research evaluations (Luukkonen 1995), and Woofitt's (1993) example is taken from accounts of a violent clash between police and punks. My interview guide does not bring up any themes that seem highly controversial, although the question concerning different «schools of thought» perhaps could be regarded as a bit «touchy». However, I find that my informants mostly aimed at a «neutral» or «tolerant» position when describing individuals and groups with a view fundamentally different from their own. Although the researchers' own approach was preferred (naturally), opposing theories or methods were often described as alternatives that also may yield original or useful data or applications (but probably less efficiently).

One question was specifically aimed at revealing differences between the empiricist and the contingency repertoires of scientific discourse. The respondents were asked who they saw as the best research group in their field. A hypothesis was that when this question was asked in an informal way and in an informal part of the whole interview setting, the answers would be dominated by rough and quite «social» explanations, in the line of, «I think it's A's group, he's a nice fellow who really produces interesting stuff.» Subsequently, the researchers were asked whether these were criteria that they would use in an official evaluation of research groups. Official criteria were expected to be different and more empiricist, like, «The group at AAA really has a large production of original and reliable data in that sub-area.» This hypothesis must be rejected based on my interview data – almost all respondents gave perfectly «rational» explanations to the first question that they also would use officially.[4]

Many of the respondents experienced trouble with specifying what they perceive as good research and which criteria they use in different judgements. This does not seem to be due to any reluctance in using the contingency repertoire, but rather that judgements to a large extent are based on tacit knowledge and have much to do with intuition. An «I know it when I see it» component of quality seems ever present. Descriptions of bad research were mainly done in an empiricist repertoire. «They have drawn too wide conclusions» and «The work of others has been uncritically copied» are examples of how poor quality research was characterised. These explanations may also, of course, be regarded as «publicly acceptable» grounds for judgement, without necessarily being the «real» ones. Still, I do not see the rare use of the contingency repertoire by my informants as an indication that I have not dug «deep» enough, but rather as a sign that the linguistic repertoires may not be as antithetical as e.g. described by Gilbert & Mulkay (1984).

I have the general impression that very few answers were produced with strong political or strategic intent. For instance, few respondents tried to create too positive a picture of the possible external relevance and utility of his or her discipline, and many are very frank about the problems of the peer review system, although they mostly are even more critical towards other evaluative procedures. Another example is that many of the informants claim that resources and material rewards are of very little importance to research quality. While other investigators have found evidence of a «ritualistic» referring to the necessity of more funds (e.g. Martin & Skea, 1992), this is not evident in my study. In addition, there are few extreme case formulations («always», «never» etc.), which would have been more common if the informants' intentions have not been oriented mainly towards a «balanced» description of «reality» (cf. Woofitt, 1993 p. 298).

In other words, a dichotomy between two repertoires of scientists' discourse or a sharp division between the two «worlds» of science exemplified by the classical «Mertonian» ideal (see

[4] The answers would probably have been quite different if we had asked who the informants saw as the worst group in their field. In this case, however, it would not be unlikely that the worst group actually would be «best» described in the contingency repertoire.

for instance Merton, [1942] 1973) and the Machiavellian war zone of Latour (1987), is not likely to be very fruitful or effective. I do not think it is productive or relevant to separate sharply between rhetoric and ideology, on the one hand, and «real» attitudes and motivations on the other. My basic assumption in this respect is the same as Mathisen's (1994:147): «the researchers are shaped by their own language use» and «their motives are influenced by the vocabulary they employ» (see also the discussion of Argyris & Schön's distinction between «espoused» theory and «theory-in-use» in 4.2.1). Hence, I generally do not see the informants' ability to engage in creative use of language as a very serious threat to the validity and reliability of the present investigation.

4.6.2 Validity

In this investigation, the fundamental question of validity (and to some extent, reliability) can be stated this way: «Can we believe the researchers?» Are the quality criteria they talk about the ones that they would apply in a concrete judgement of a research work, a proposal or an applicant for a position? When they discuss e.g. influences on originality, are these factors that in a practical situation really would promote or restrain how original a piece of research turns out? It can be repeated that the largest study ever undertaken of influences on research performance actually found that researchers' (subjective) perceptions of for instance resources and communication were better predictors of performance than more «objective» indicators (cf. Stolte-Heiskanen, 1979; Visart, 1979). «Subjective» and «objective» indicators furthermore displayed only a weak relationship with each other, leading Visart to conclude that «perceptual measures may be more relevant in human sociology than countable measures and lend themselves better to generalization» (p. 249).

Following Glassner & Loughlin (1987, described in Silverman, 1993:99-101), I see my interview responses both as culturally or contextually defined narratives and as possible factual statements. Thus, when one of my informants talks about «freedom» as the central influence on originality, I take this to suggest two findings:

- The informant has made use of a culturally prevalent way of understanding and talking about this topic.
- We have some evidence that freedom is a precondition for originality in research work.

Taking interviewees' responses as (partly) factual statements this way can be based on a number of claims regarding how «rapport» or «understanding» is established with the subjects (Silverman, 1993). Three of the most central claims are that I was accepted by the informants, tried to show a genuine interest in understanding their views and opinions, and guaranteed confidentiality. Behind this «interactionist approach» is a fundamental tension or doubt as to whether interviews are purely «symbolic interactions» or express underlying external realities.

Thus, I do not treat my subjects' responses simply as true or false reports on reality, but rather as displays of perspectives, mechanisms, processes and moral forms. Silverman claims that the purpose of the investigation influences whether local narrative or potentially true reports are seen from interview data. He also indicates that following up both issues can be possible (but difficult), as I have sketched above. Thus, I will investigate how the researchers themselves describe «good» and «bad» research organisations and their constituents (more local narrative), as well as treat this as an indication of or approximation to some processes between organisational aspects and research quality that may operate more independent of contexts and individuals. Still, I find it somewhat difficult to look for a «true» attitude or sentiment of an informant. In my opinion, tension, ambivalence, ambiguity and context-dependent sentiments are common conditions and do not display any «faults» in interview settings.

This approach is also very similar to the one proposed by Hammersley (1990), who suggests that qualitative researchers apply a «subtle form of realism» to be able to address the issue of validity. In this view, validity is identified with confidence in knowledge but not with certainty. Reality is assumed independent of the claims researchers make about it, and reality is always viewed through particular perspectives. Accounts thus represent reality but do not produce or reproduce it. A key issue for the researcher is to convince the reader that the evidence is plausible and credible.

Two of the traditional means of ensuring plausibility and credibility have been «data triangulation» and «respondent validation» (see for instance Yin, 1984). The first method implies comparing different kinds of data and methods to see if they corroborate each other. Respondent validation means that the findings are taken back to the subjects for comments and verification. Both of these have been much criticised (cf. Silverman, 1993: 156-160). Triangulation, for instance, by counterpoising different contexts, «ignores the context-bound and skilful character of social interaction and assumes that members are 'cultural dopes' who need a sociologist to dispel their illusions» (*ibid.* p. 158). Respondent validation may generate further data but is probably a poor technique for insuring validity in interview studies.

Instead of these techniques, Silverman proposes two other ways of ensuring validity and reliability: counting and tabulation, and investigation of deviant cases. Limiting or deviant cases are particularly valuable in the illumination of consistent features of social life. The inclusion of both «rules» and «exceptions» in the analysis can contribute both to explicating common sense (or tacit knowledge) and yield unusual insights (e.g.Yin, 1984). Exploration of each new case, informant, situation etc., is done to see if they fit, how they may fit and how they may not fit (Strauss & Corbin, 1994). This is one of the main differences between qualitative and quantitative work. «While survey researchers may be satisfied with explaining 99 per cent of the variance in their samples, case-study researchers must pursue every single instance in order to refine their analysis» (Silverman, 1993:169).

In the empirical part of the thesis (chapters five through twelve), the reader will see that I make some propositions based on earlier studies concerning a certain issue and then go through the informants' statements on the same theme. Whenever possible, I try to do simple counting (in some instances tabulation), and if there are counter-examples regarding a claim, I always try to include quotes representing this view. In my opinion, «exceptions» to a «rule» are important; I do not believe in universal social laws, and exceptions are central to understanding the social lives of researchers. Thus, I have often used a couple of quotes that confirm or represent a certain claim, relationship or pattern, followed by quotes representing exceptions, and then I have returned to the literature and my propositions and modified them. This can also be termed pattern-matching and explanation-building (cf. Yin, 1984), i.e. techniques to improve validity where the researcher continuously seeks rival explanations and possibilities, convergence in the evidence, and the context in which particular propositions were made by informants.

A similar process is described in grounded theory methodology, which I discussed in 4.2.2 to show how this approach could benefit the validity of a qualitative study. Strauss & Corbin (1994) assert that qualitative researchers within this framework should have a «theoretical sensitivity» – through scrutiny of the literature and similar cases, the «continuing conversation with the data» is improved. In the words of Morgan (1997), validity can be improved by emphasising «the importance of seeking confirmations, refutations, and reformulations throughout the course of a research project» (p. 307). Hence, the knowledge I have generated is context based (on the «reality» of a small sample of Norwegian senior researchers), and claims to any universal or broad-based validity are naturally very problematic. Still, I do see my conclusions as valid for the Norwegian research community, and probably for similar communities in other countries as well (cf. also the discussion of «representativity» in 4.3.2).

Validity can (and should) be improved in later studies, though. Regarding research quality, one possibility would be to take the conclusions and categories from this investigation and apply them to actual judgements of research, e.g. connected with proposals, publications or recruitment. When it comes to the organisation of research work, I believe that future investigations will have to focus on whole research units with a broad (and not exclusively quantitative) view of performance, and maybe try to compare units within different settings (or «good» and «bad» units in similar institutional and disciplinary settings).

A few additional comments regarding validity can be made. «Construct validity» is particularly difficult in qualitative research, i.e. the degree to which the theory (e.g. «research quality») can be operationalised into meaningful terms. It might be claimed that I have tried to address this aspect by taking my decomposition of research quality to researchers in different disciplines and sectors, asking them both to criticise and further elaborate the decomposition. In this sense, I have used «multiple sources of evidence», recommended by e.g. Yin (1984) to insure construct validity.

Internal validity is much discussed in experimental and quasi-experimental research, where a number of «threats» to validity are identified, often dealing with «spurious» effects. This is yet another complex issue in qualitative research. It is difficult to «prove» a relationship between the «independent variable» (the research organisation) and the «dependent variable» (the quality of the research products). In investigations like the present, internal validity may rest upon how well the author is able to sketch the processes through which one variable influences another, after going through all the information concerning a certain issue and comparing with previous results.

When it comes to disciplinary and sector differences, I have tried to be careful in drawing conclusions. It is difficult to claim that these are the «real» cause behind differences in the informants' statements. I only talk about such differences when all (more or less) relevant answers from one set of informants (e.g. from industry or from a particular discipline) are distinct from other answers. Naturally, these conclusions must also be seen as tentative, pending further research.

In general, my interviews are more abstract than such where informants are asked about a certain incident, piece of work etc. Although we strove to make the informants link their answers to concrete research products and research organisations, this was not always possible. Some responses are therefore relatively «ideal» or «abstract». This also makes it more difficult to say whether actual influences on research quality have been investigated (again, see the distinction between espoused theory and theory-in-use in 4.1.1). The strength of the approach is of course that I have gained access to many senior researchers' experiences.

A related problem is that informants may be more inclined to mention factors of security rather than challenge – only «one side» of a tension (see Pelz & Andrews, 1976) – when talking about determinants of research performance. As discussed in chapter three, at least some investigators have concluded that for instance good research groups not necessarily have the best «working climates». A related validity problem is that some respondents had a tendency to label everything as «important». Whenever a new organisational factor was introduced in the interview, they exclaimed, «that is very important too». Some informants also contradicted themselves. A university professor exclaimed at the beginning of the interview that the distinction between basic research, applied research and development was very easy to make in his technological field. Nine questions later, discussing a slightly different issue, the professor said that a clear distinction between activities was almost impossible to make.[5] Such problems are probably common in many investigations based on peoples' accounts, and the problems would perhaps be greater with a more structured interview (or mail survey). Comparison of my findings to those where another methodology/measurement of quality has been applied is as mentioned an important validity test. It can be added that I have tried to present short excerpts from all the interviews in the discussion below and not just quote the most eloquent (or controversial etc.) informants.

4.6.3 Reliability

Reliability is another complex issue in interview studies. Some of the analysis techniques I have sketched under validity and language use may help ensure reliability (e.g. the investigation of deviant cases). Yin (1984) argues that the general way of approaching the reliability problem is to make as many steps as possible as operational as possible. In the present study, this has implied a highly structured interview guide, similar wording in questions asked to different researchers and interview transcripts that have been transferred into a computerised data base (see below)

According to Silverman (1993), the traditional way to ensure reliability of interview data has been through pre-testing of interview schedules, training of interviewers, use of fixed-choice

[5] Both these statements may naturally be valid, given a different context for defining research activities. Such contradictions nevertheless pose special problems in the analysis of interview data, and the context is not always obvious.

answers and inter-rater checks on the coding of answers to open-ended questions. This approach has been linked with a «naive positivist epistemology», but Silverman argues that pre-testing and comparative analysis still are helpful in unstructured and open-ended interviews. As mentioned above, the interview guide was tested on several colleagues and on a medical scientist at another institute.

Furthermore, standardised methods for writing field notes and preparing transcripts can improve reliability. All the interviews were taped, except two where there was trouble with the tape recorder, but in these cases this was evident before the interview started so that the interviewer was able to take more complete notes. The interviews have been written out based on the recordings and the notes following standard procedures (non-verbal responses etc. have often been mentioned in the notes and are commented in brackets or with special characters). I have transcribed most of the interviews myself, thereby obtaining a good overview of the material.

I have found the verbatim transcription important; not only to give a fuller picture than what could be seen from the notes, but also to yield more reliable answers. An interesting phenomenon in this respect was that «yes» often ended up as «no». Many informants immediately answered yes to most questions, but when they were asked why and also to reflect upon the question, they ended up responding closer to no than yes. The first answer was often the only one recorded in the interviewer's notes. An example is that the question «Is there an optimal size of research groups in your field?» very often yielded a quick «yes» as response. When asked to elaborate and to think about their own work experience, many ended up by stating that size is not really important to quality after all. This shows the strength of personal and not too structured interviews, especially when compared with mail surveys or structured interviews carried out by non-professionals, and the importance of probing. That interview subjects «change their responses to seemingly factual responses» following probes by the interviewer is often the case (Silverman, 1993:99). For a discussion of «tactical answers», see the elaboration on language use in 4.6.1.

The computer programme NUD•IST (Non-numerical Unstructured Data • Indexing Searching and Testing) has been used in the analysis. In the programme, the interview transcripts were coded based on discipline, sector, question number and central themes across questions (e.g. «originality and creativity», «resources and equipment» and «norms and research culture»). My basic process for analysis of a certain issue (for example the importance of the research unit size) was as follows: First I took printouts of all the answers to the question(s) that addressed that issue in particular. After that I searched on the computer through all the remaining answers in all interviews for relevant key words (e.g. size, large, small, big, quantity, magnitude etc.), and again printed out all findings (including the text immediately before and after the key word hit). I then read through the answers, marked the most relevant text and discarded irrelevant paragraphs. The answers were summarised on large sheets of paper divided into disciplines and sectors, and I made notes of good or typical/representative quotes, exceptions and more. Finally, from this I constructed a general description and analysis of the answers (cf. chapter six to twelve).

Another problem related to both validity and credibility of interpretation is that all the interviews were carried out in Norwegian, while the quotes have been translated into English in this thesis. Although I feel «secure» in the use of both languages, I obviously cannot disregard that some meanings and interpretations may be slightly changed after translation.

In some sense, the reliability of the study has been tested already, since three people carried out the interviewing. I see the inter-researcher reliability as relatively high – the interviews do not differ to any considerable extent when it comes to length, probing and focus (of course, some informants were more able to or interested in answering some questions than others were). Still, other investigators may have ended up with at least slightly different responses. There are many ways to talk about quality and organisations, without any common theory or generally accepted and unambiguously interpreted phrases.

Reliability also rests with the (implicit) definitions of relevant concepts. A study of the relationship between research quality and organisational factors at a macro level, for instance in a national/system perspective, would probably look at other aspects than what the present investigation has done. A macro level study might focus more on the international dimension of quality and on resources as a prerequisite for establishing good research units.

Finally, much of the literature on qualitative interviews emphasises that reliability is closely related to what or whom the interviewer is seen as a representative for (e.g. Rubin & Rubin, 1995; also Silverman, 1993). In most cases, I claim that the other interviewers and I were perceived as independent researchers (colleagues even) and/or a doctoral student in my case. I have the impression that in the interviews that did not turn out very well (cf. 4.5), the interviewer was perceived more as a representative of the Research Council and other (in these cases unpopular) institutions.

4.6.4 Audiences

As mentioned above, I claim that the validity and relevance of the present study is not independent of the audience (see for instance Stablein, 1996). Readers are interpreters, and reading is an active, sense-making process. For instance Morgan (1997) describes the goal of qualitative studies of organisation and management as rendering «the rich texture of a situation in a way that will allow *the reader* to gain some experience of the situation and understand the patterns and processes involved so that he or she may use them as key insights or key learnings that may have relevance in understanding similar situations in other contexts» (p. 305, emphasis added). Hence, (external) validity is shaped by the reading. «Each reader will bring a context of meaning and interpretation to an account or text, and will interpret it accordingly. This interpretation or 'reading' may or may not be commensurate with what the writer intended» (Altheide & Johnson, 1994:496). Yin (1984) also talks about audiences and that different readers will have different interests.

To achieve my purpose – an exploration of the relationship between research quality and the organisation of research work – I have selected and interpreted theory and data for my perceived audiences. When writing this thesis, I have of course had the «traditional» groups in mind: the doctoral judgement committee and scholars within the field («research on research»). I have also aimed at presenting my findings, and the theory, so that researchers in other fields should be able to gain something from it. Particularly in the empirical chapters concerning organisational aspects, I have tried to mix many different quotes from my informants with my analysis and overview of previous studies. I have also aimed to make the theory sections readable to non-specialists by not taking too many terms from organisation studies and «research on research» for granted. Instead, I have e.g. tried to elaborate the different meanings of concepts like «leadership» and «organisational culture». The reader will (hopefully) see that I am trying to enhance the generalisability of my study by blending several messages at once: messages about good research, messages about how researchers interpret their organisational environments as opportunities and constraints, messages about the patterns in which these organisational characteristics are thought to influence quality within and across different settings and finally messages about how researchers, research managers and policy-makers may improve research quality by focusing on organisational aspects.

4.7 Conclusion

To conclude briefly, I have selected a qualitative method based on the exploratory purpose of the investigation and the nature of my object of study (research quality and research organisations). A semi-structured interview guide was made and a sample of senior researchers was selected, based on two assumptions. First, research quality is largely a tacit concept, and explicating the tacit dimension requires a not too structured gathering of data. Second, I assume that research quality is in fact defined by central researchers in each field through decision-making related to publications, new projects and new appointments. An interview guide was made that aimed at touching on all central issues identified in the literature, but with room for flexibility and much probing and many follow-up questions.

My analytical approach follows long traditions in the social sciences. I shall look for broad similarities and differences in the statements of researchers asked to talk about research quality and its determinants. The similarities and differences are initially taken at «face value» (cf. Woofitt, 1993:303), i.e. seen as a (more or less good) reflection of the motivations and actions of researchers. I will then construct a more generalised «version» of research quality and its relationship to organisational factors, and these analytical conclusions are discussed in the final chapter of the thesis.

It is common in doctoral theses to comment on what could have been improved in the study and what other scholars can do to get better knowledge of the problem under investigations. Like probably most doctoral students, I should have liked to have some more data – more interviews – and I wish I had read more literature before I made the interview guide, which would have resulted in the removal of some questions and the inclusion of others. I would specifically like to mention that the organisational factors in focus mainly are selected based on previous quantitative investigations of «research performance» or «publication productivity». These studies have most often looked at characteristics that are relatively easily countable or quantifiable (and their results rarely manage to explain a large share of the variance in performance). Teodorescu (2000) may be a good and recent example. Here, more than 11,000 university scientists were surveyed to find correlates of publication productivity, but the questionnaire included no items regarding informal organisational aspects, leadership and more. My investigation would probably have benefited from a more thorough specification of the «tension» framework before the interviewing was started (the framework was developed later).

The present study could of course also have been carried out differently – for instance by focusing on actual judgements of research quality e.g. connected with evaluations of research units/institutes carried out by the Research Council. I could also have tried to get third party (more objective) data on organisational aspects of the units involved. Still, as I have argued throughout this and the previous chapter, several earlier investigations have shown that research performance is better explained by participants' subjective opinions about their organisational environment, rather than more objective measures of the same aspects.

As I see it, the main weakness of the study stems from its dual objective – to elaborate both good research and good research organisations. The sample selection method, as described above, was primarily based on the assumption that research quality is constituted by the various assessments carried out by the (well-known) seniors working in a scientific speciality. However, research units also consist of juniors, not-so-eminent seniors, support staff etc., who may have other perspectives on how the quality of the products they make can be improved and restrained. The elaboration of the organisational side would probably be somewhat different if these other research unit members were represented. Hence, although it is interesting to create a link between the quality literature and the organisation literature, the specification of organisational factors and processes in this investigation may be biased towards the perspectives of senior/eminent researchers.

Still, I will claim that I have carried out my investigation in accord with «good scientific practice» of qualitative studies such like present one. The problems I have sketched in this chapter connected with such issues as representativity, validity and reliability are also found in other investigations with similar methodology and method. Improvements, e.g. increased reliability and external validity, can of course be achieved through later studies of research quality and organisational factors, using the categories, terms and results of this investigation. However, as I have argued in all the previous chapters, one of the main problems in the field has been the lack of understanding of the direction of relationships and the processes by which the organisation influences research quality, even though there has been no shortage of quantitative studies. In my opinion, there is still a need of in-depth qualitative studies, for instance oriented at a particular sector, discipline or research unit «as a whole».

5 The informants' description of research quality

In his chapter, the informants' elaboration on research quality is the central topic.[1] I present some findings related to the researchers' basic and general perception of research and quality in 5.1, including a brief comment on whether they connect their criteria and elements to characteristics of research products, processes, environments or individual researchers. In 5.2, I describe the sample's reaction to the quality decomposition presented in chapter two, and I briefly outline their specification of the different sub-elements. This is further detailed in the next two sections within the frames of sector (5.3) and field/disciplinary (5.4) differences. In 5.5, I have chosen to focus on the complex and often controversial notions of internal and external relevance. I investigate the tacitness that seems implicit in the judgement of intra-scientific relevance, and the abundance of meanings that can be baked into the external relevance concept. Some concluding comments are made in 5.6. Here, I also return to the first main research proposal, which was developed in chapter two.

5.1 Research activities and quality conceptions

As described in chapters two and three, my first research question regarding research quality was: «Can we find diverging opinions on the nature and objective of research work, and different conceptions of 'quality' behind elaboration of research quality?» In the interviews, a number of interesting specifications of the terms «research» and «quality» can be read directly and indirectly in the transcripts.

5.1.1 Basic and/or applied research?

All respondents were asked to relate their own research to the concepts basic research, applied research and development/other classifications. From this, it is natural to conclude that the sharing of research work between sectors in Norway seems clear. Basic research takes place in the university sector and to some extent in the institute sector (where it was particularly stressed by the informants from sociology and medicine).[2] The closer you get to the commercial sector, the more applied the activities get. Thus, systematic variation connected with institutional setting will also designate differences between basic and applied research.

Even so, particularly the sociologists, but also individual respondents from other disciplines, expressed that the distinction between basic and applied research is unclear. A majority of

[1] A more thorough analysis of this theme can be found in Gulbrandsen & Langfeldt (1997:55-131).

[2] To repeat, the informants come from biomedical research, biotechnology, chemistry, clinical medicine, economics, engineering cybernetics, French language, mathematics, philosophy and sociology.

the researchers in engineering cybernetics found the concepts difficult to apply, for instance because «the same project can jump from pure mathematics to practical and technical matters connected with e.g. measurement and computer programming» (university professor). A few respondents seemed to define the research as applied or basic if it is connected with an external contractor or not, and two industry researchers defined «applied research» as the application of new results from the university and institute sectors.

The distinction between basic and applied research among the other informants does not seem to be based on the activities' purpose (as implied by the Frascati Manual, 1995). It is rather based on an individual perception of the *degree of theoretical content* in the activities, which is relative. Many respondents from the natural sciences and technology underlined that what may be defined as a practically oriented research project by university researchers can be perceived as a basic research project by for instance industry researchers or R&D users. Especially some of the cybernetics researchers emphasised that the perceptions of «basic» and «applied» may differ widely between university and industry personnel. One implication of the at least slightly different perceptions of what research is and should be is that quality also may be defined differently, given a «mild» or «strict» definition. This pertains especially to applied research and whether a rather immediate and concrete utility value should be asked of the activities. It must be added that for a large majority of the researchers, the terms «basic» and «applied» research were meaningful and easily elaborated.

I do not develop these themes further or return to them in later chapters. Although a common reference or basis among researchers may be desirable, e.g. to get more homogeneous views and judgements of quality, it is probably unrealistic. Not only quality, but also the meaning of the word *research*, is in many ways defined by the scientific community (and others) in a continuous process. It should be added that the respondents whose work mainly consisted of development were asked to answer on behalf of the research activities that they carried out.

5.1.2 Quality conceptions

A basic view of quality as «excellence» dominates among the informants. One scientist said that 90 percent of all research is not particularly good, while another claimed that 90 percent of what is published is trivial. Many expressed that only a tiny share of research works *really* is good, and their examples of quality were often taken from famous names in the history of science. In applied research and particularly in industry, where utility value frequently is a central criterion, good research was said to satisfy certain demands and specifications (of users or the employer). This view of quality as «fitness to purpose» seems to come in here *in addition to* the «excellence»-conception.

In the institute sector, around half of the informants expressed that their institute desires «useful» research that is tailored to meet the demands of external actors, something that may conflict with what the researcher wants to do (for instance to maintain a link with the research front in the field). In other words, the scientists in this sector can experience a tension between their employer's basic view of quality and their own. Apart from this, the combination of «excellence» and «fitness to purpose» seems relatively free of tensions. The interview material indicates that some basic demands have to be fulfilled if the work is to be seriously judged as research at all, while other elements contribute to the work's location on a scale of excellence. In addition, the period of judgement can be very different. There may be relatively concrete demands to individual studies/projects based on scholarly or external needs, but when looking back a decade or two later, most informants will rate the studies/-projects and refer to «the best» in a discussion of quality.

5.1.3 What is «good research» connected with?

The answers to open questions about the characteristics of good and bad research were both short and long, concrete and abstract. Some informants had written lists of criteria in advance, while a few claimed that it is practically impossible to answer such a general question about quality. Although a large majority connected «quality» with a research product (publication, application, individual project), it is interesting to note that a fair share responded with criteria that can be tied either to the research process, the environment or the individual researcher. There were no clear distinctions between sectors and disciplines in *how* people answered. The following is a brief summary of key words (all as answers to the question «What characterises good research in your field?»):

- **Product (directly on contents):** Original, useful, tenable, solid, targeted, thorough, innovative, creative, replicable, valid, controllable, reliable and many more.
- **Product (not directly on contents):** Publishable or published internationally, cited, implemented in a technical-economic context, integrated with other studies in the same organisation, contributing to product development etc.
- **Process:** Understanding of user needs, keeping a high level of ambition, creating good contacts internationally, working internationally, independent research process, process characterised by intensity, determination, curiosity, eagerness, good planning and more.
- **Environment:** Has guest scientists, good international reputation, extensive publishing, recognition in industry and/or other R&D institutions, creative environment, good infrastructure and resources to follow up interesting problems that emerge.
- **Person:** Creative, persistent, critical, participates at leading conferences, does not work alone but is well integrated in a larger group, has co-operation skills, high ethical standards, journalistic skills, is wise, deep thinking, highly dedicated and motivated, able to see things in a wider perspective etc.

This range of answers shows that many researchers do not distinguish clearly between characteristics of research product, process, environment and individual. The final product may be so closely linked with the person, process and organisation that produced it, that it is natural to see their characteristics together. On the question of poor quality research, the most common response was that «it is the opposite». Especially a lack of solidity and originality was mentioned as typical of research that is not good. More informants mentioned a lack of originality as a characteristic of poor quality than they mentioned originality as a criterion for good research. Some expressed that research products can be good only in a few respects, but be of poor quality in an «indefinite number of ways».

5.2 The four-element decomposition of quality

In chapter two, a simple decomposition of research quality was developed based on previous empirical studies and some non-empirical normative literature. Quality was divided into four sub-elements: solidity, originality, scholarly relevance and utility value.

5.2.1 Comments on the decomposition

All informants were asked if these four elements captured what they perceived as the essentials of good research in their field. Almost all (59 out of 64) said that this seemed like a good or fairly good division, and they had relatively few problems with fitting their own expressions into this framework. The reactions varied from lukewarm «that's an OK division, I guess» to «this fits very well», «these are good and important elements» and «perfect». Five of the respondents were negative and felt that other «models» would be better. A philosopher was of the opinion that all elements «lost something» of the total notion of quality, especially the «dialogical» element. Two university professors, from engineering cybernetics and chemistry, did not like the model, but could not offer alternatives that they felt were better. An industrial researcher in chemistry thought that good research was much better described as scientific quality (very much the same characteristic I have labelled solidity) plus utility value and «level of ambition». Finally, a biotechnology researcher from the institute sector felt that external utility value plus internal «increase of competence» constituted a better division of quality.

Among the 59 other informants who were (more or less) neutral or positive, the decomposition of quality into the four sub-elements was perceived as tidy and general. The latter was seen as both advantageous and disadvantageous – some said that such a general specification is good as a «rule of thumb», «vision» or «mission statement» for the research venture, while others pointed out that more detailed criteria and specifications are necessary for practical purposes. Since chapter two was based largely on studies of basic research, it is perhaps a little surprising that the model was quite well received in the applied sectors. Nevertheless, I have the impression that the university researchers saw it more as their «duty» to answer in a critical manner, while the informants in industry and institutes more quickly stated, «this looks fine to me». There are no systematic differences between disciplines and fields in how the model was received.

Still, many of the neutral/positive informants commented on the elements. It was commonly underlined that one should not place too strong originality demands on research work, and that utility value should not be a criterion for all research. Several also claimed that solidity had to be elaborated because the notion was too general to make good sense, and that originality should be split in two to distinguish between «academic» originality and new applications. These and other remarks have been taken into account in the presentation of results below. Eleven informants said that there are important characteristics of good research that are not covered by my four elements:

- Two believed that the critical function of research (i.e. social criticism) is not evident from the elements (I treat this under utility value/external relevance).

- One researcher felt that ethical questions were not well enough covered (ethical questions are discussed under solidity (honesty/integrity) and external relevance).
- To «come deeper into the problems» and «give a more basic understanding» was mentioned by two (I claim that this is covered by the distinction below between radical and incremental originality, and by scholarly relevance/generality).
- Characteristics related to the *mediation* or *publication* of the research were pointed out by six informants (one from each of philosophy and chemistry, two from each of sociology and economics). These asserted that the presentation of the research (one called it «mediation effectiveness») in itself contributes to its being good or not. Especially in the soft sciences, it was said that exceptionally well-written books and articles are judged more favourably than those that are not but otherwise may e.g. contain similar empirical data (I categorise this under solidity related to substantiation of claims and conclusions). Many other respondents, not least in the hard sciences, underlined the importance of writing well (and including good tables, pictures etc.) for the reader to be able to «perceive what has really been done» and «understand what is new in this work». But the research in itself is not necessarily low quality if the article in which it is described is not good, although the quality may be more difficult to determine then (and badly written manuscripts are returned for improvement).

With these last specifications, all informants deepened the quality elements. They were asked to give examples of good and bad research within each element, to explain what distinguishes solid (original, etc.) examples from those that are not and to suggest how this feature can be influenced by the wider research environment. The results are outlined in the following paragraphs, and elaborated in the sections on sector and field/disciplinary differences.

5.2.2 A common denominator of quality

In general, the answers to open-ended and both highly specified and unspecified questions show that good research has *three* necessary overall criteria: (1) solidity, (2) originality and (3) scholarly relevance *or* some form of social or practical utility. These criteria may be described as minimum demands or ideal demands – based on the minimum characteristics which research must have in order to be perceived as good, or on the characteristics that we ideally think research should have. The minimum demands for good research are, in short, that it must reveal something that we did not know completely before, it must not be trivial and it must be substantiated in some way. The *ideal demands*, on the other hand, are considerably higher. Ideally, we want research to say something new in a revolutionary sense, which will have great effects for the discipline or praxis, and with solid evidence – that it contributes with definitive new understanding of central phenomena or problems in an absolutely convincing and tenable way.[3]

[3] It should be note that this distinction does not seem related to Kuhn's ([1962] 1970) phases of «normal science» and «scientific revolutions». The «ideal demands» are just as applicable to a «normal science» phase. Informants who have given concrete examples of good research, often talk about the best works of the most eminent within their field at the present time, but these have not necessarily induced a «paradigm shift».

These various elements received different weight in different disciplines. The contents of the terms were not as dependent on disciplines as one might expect, though. The interview material easily allows a *general* elaboration of the four terms – to extract a sort of «common denominator» across the studied disciplines:

Solid research is characterised by well-founded assertions and conclusions, and can be furthered by integrity, good academic credentials in the field, thoroughness and patience. This aspect of the concept of quality includes thorough documentation and data of good quality, internal consistency and coherence between assertions, critical attitudes, factual interpretations, and an impartial, stringent and clear presentation. For most, the concept incorporates ethical judgements, especially related to avoiding fraud.

Originality includes theoretical or «academic» novelty and the original application of theories/methods to practical problems. Examples of more «radical» novelty are development of new theories or methods, discovery of phenomena or to explain them in a scientific manner for the first time. We find more «incremental» originality connected with the further development of existing theories or methods, combination of prior knowledge in a new way, or the use of (improved) theories/methods on known or new problems.

Scholarly relevance (or importance) especially takes the form of cumulativity or generality. Cumulativity is understood both as filling of holes in previous research, contribution to the research forefront and preparation for future research, for example, by generation of new hypotheses or opening of new research areas. Generality includes broad (cross-)disciplinary importance or consequences, the discovery of important and general principles, or the development of research «tools» or methods (of general interest).

Practical or societal utility can be defined related to possible broad and long-term effects on sectors (health, environment, culture or economy), and all potential users. The concept is also used by many for short-term and direct effects in the form of concrete applications for specific user groups, and the direct impact of the research on e.g. the economy or the environment. Short-term or direct utility is not regarded as a necessary quality criterion in basic research, although some basic researchers are inspired by practical problems or future possibilities of solving such problems. The more we move into the applied sector, the more we find that practical utility is the central criterion of quality, usually defined as the concrete results (products, cost reductions etc.) which the research has contributed to.

The informants underlined that the very best research works most often are judged favourably within all elements or they score particularly well in originality. Middle-range research may score well in one respect and poorly in some other respects, or may be judged moderately well on all criteria. From the interviews, I have the impression that solidity and to some extent originality frequently are assessed based on well-established disciplinary norms, while the two types of relevance are more «dynamic» criteria, changing faster and closely related to the larger scientific community or groups outside of the research units (mainly users).

5.2.3 Tensions between the quality elements

The relations between the four elements of good research are not unproblematic. The elements partly overlap or depend on each other, but may also conflict with each other. Several interviewees were concerned about elaborating on such matters. An often-mentioned dilemma is experienced between solidity and originality. Systematic work and a thorough and long training contribute to solid results, but may hamper creativity, and thus reduce originality. Many also stated that some researchers are much more creative «by nature», while others are thorough and patient, and that people rarely combine these two features (see chapter six for a further discussion of individual-level variables).

Originality and scholarly relevance may both presuppose each other and conflict with each other. Research which is scholarly relevant by discovering general principles, filling holes in the stock of knowledge or opening new areas, is by definition also original. However, scholarly relevance may also be judged in a narrower sense, based upon contemporary research trends. The research community does not always value the originality that implies breaking with prevailing traditions. The relation between originality and scholarly relevance thus depends on how scholarly relevance is defined.

Also, the relation between originality and utility has more than one side. On the one hand, several informants emphasised that the potential utility is proportional to the degree of originality. A mathematician with relations to both university and institute sectors thought, «Originality and utility most often are positively correlated, and the best researchers often are successful both in academia and industry.» On the other hand, many informants claimed that unoriginal research can be far more useful than original research. For example, «yet another survey on living conditions» can be important and useful, but is not especially original (and perhaps not even regarded as «research» in the stricter German and Scandinavian sense of the word). The negative relation seems particularly connected with short-term utility. This was expressed in two different ways. Some emphasised that the less original research projects are, the less future utility may be expected. Others said that demands for short-term utility result in less original research.

In the same way, there was said to be an animosity between concrete utility and scholarly importance: utility will increase with the «narrowness» of the problems that are focused upon, while general results and overall perspectives will be more interesting to other researchers. Focus on extra-scientific utility may therefore reduce the scholarly value of the results, and vice versa.[4] Another case of tension between utility and scholarly relevance was mentioned by two medical researchers. They gave examples of experiments that yielded small effects on a certain variable in the research subject (e.g. 5-10 percent). Effects of such a magnitude are most often written off as measurement errors, and scientists rarely bother to communicate the results explicitly to users or follow the experiments up with further investigations. However, many industries (both informants mentioned the food industry as an

[4] There are, however, differences between fields. In cybernetics there appears to be a positive relation between non-scientific utility and scientific importance – very successful applications are often scholarly interesting.

example) would be very interested in identifying substances that can produce small changes in the output of a product, because the companies' operating margins often are very tight.

On the other hand, the relation between solidity and utility seemed far less problematic. Several interviewees mentioned that in order for research to score on practical utility, it must be solid. For instance, scientists in industry stressed that solid research is a prerequisite for successful industrial implementation. Some informants problematised the relation between solidity and utility, though. A few social scientists asserted that some users of social science in public administration etc. may find the results of non-solid research much more useful than the results of solid research, provided the non-solid research gave the conclusions they *wanted*. One medical scientist also thought that too hard demands for solidity may hinder utility. He claimed that competing firms might use unrealistic solidity requirements to prevent new competing drugs from reaching the market and thus be able to block any «social utility» of the new product.

5.2.4 Using the quality elements in assessments

When looking back and describing the best research in their fields, the informants used something close to ideal demands. Books or whole research projects (e.g. as communicated in a number of articles) were often mentioned as examples. The demands were much closer to minimum demands in discussions of manuscript reviews, where e.g. originality criteria often were lowered to «nothing very similar should have been done before». Fewer than ten of the researchers described peer review of (scholarly) journal manuscripts as an easy task; the rest claimed that this is very or quite difficult. The «real» originality and the relevance to the journal's audience were most frequently mentioned as problematic aspects, but some also said that «understanding at all what has been done» can be a problem. In some cases, the reason was that the author of the manuscript had «a poor knowledge of English».

Reviewing manuscripts outside one's speciality was frequently upheld as the most difficult task, and the interviews indicate that this is quite common. It seems that there is little or no formal training of reviewers, and that selection criteria provided by journals are not widespread. Some informants asserted that «consciousness raising» and more or less specified «check lists» could be fruitful and reduce the «random» factors in such judgements. Others said that defining more specified criteria than e.g. originality, solidity etc. would be very difficult, have no impact on the judgements or lead to some good research being rejected.

Proposals for new research projects are judged along similar criteria, closer to the minimum than to the ideal end of the quality scale. Still, many informants underlined that it is more difficult to judge the relevance of a problem/idea than to judge concrete results. For most respondents, characteristics of the individual or the research unit behind the project become central in the assessment, especially in the institute sector. Some claimed that «many can write a fairly good proposal, but that does not mean they have persistence and talent to go through with it» (chemist, institute). If this often is the case, it can be claimed that blind reviews of proposals can lead to more reviewer disagreement (which may not necessarily be «bad», given that variations in quality judgements are legitimate).

In judgements connected with hiring senior researchers, the criteria become stricter again and include the total history of the applicants. Publications are very important, even in the applied sectors. A basic difference, however, is that personal interviews were said to affect the outcome of the hiring decision to a large degree in the applied sectors. In the universities, interviews are often related to «trial lectures» (oriented at testing «teaching skills») and have a more ritual character.

5.3 Sector differences

The interview material reveals a clear division between the university sector on the one hand and the institute and industrial sectors on the other. The distinction concerns to whom and for what the research should be important or interesting. Scholarly relevance is mainly a criterion in the university sector, while utility value/external relevance is emphasised by industrial and institute scientists. The concept «scholarly relevance» did in fact not give any associations (other than practical utility) to informants from industry. In the institute sector, several interviewees did not consider scholarly relevance a relevant criterion for applied research (sociologists were the clearest exception). However, some of the informants from this sector were concerned with cross-disciplinary relevance.

The focus on practical relevance in the institute sector and particularly in industry generally entails shorter time horizons. Research projects typically last for 1-3 years and should lead to implementation of new activities, increased revenue or other forms of concrete utility value immediately after conclusion. Again, the social sciences were an exception, where the utility of research can come about many years after completion of projects. Still, some research projects in industry, e.g. the development of new chemical processes, may bring about a continuous R&D effort during up to 15 years, before they start to «pay back», a time horizon for practical utility also often found in the university sector. All the informants from industry maintained that university research can be good without having a practical utility value. This will come eventually, and they asserted that one or several decades may pass before for instance a potentially useful new theory comes to concrete use. Thus, it seems the «linear model of innovation» is not dead; it still designates a distinct kind of innovation.

The «relevance division» between the sectors can also be read out of the descriptions of originality. In basic research, theoretical/academic originality was pointed out, while some kind of practical novelty was important in industry and the institute sector. Several respondents also asserted that the more applied research gets, the less original will it be. Looking at solidity, the most important distinction between sectors is that theory and methods were mentioned as important by the same number of university researchers, while research methods were given much more weight than theory was in the other two sectors.

Furthermore, the sector distinction manifests itself when it comes to the relations between the quality elements. Many informants claimed that demands on university research for external relevance will make it less original. On the other hand, several researchers in the institute sector and industry asserted that demands for scholarly relevance may be problematic, because the most useful problems often are «narrow» and «local». To some extent, however, the institute sector appears to be caught in the middle, experiencing demands for both scholarly and external relevance. As mentioned above, several institute researchers expressed a tension between their organisation's demand for utility and «income-generation», and the researchers' own desire for scholarly development (which for the majority would require scientific publication).

Despite the clear difference in research quality focus, there does not seem to be very much tension between the sectors. The division of research labour seems to be understood and agreed upon, and informants gave many examples of well-functioning cross-sector collaboration. A few industrial researchers accused some university researchers of working on matters that «never will be useful» (e.g. extremely expensive methods), but more were worried that university research turns out less original because «professors are too occupied with getting a large number of publications» instead of «taking chances». Similarly, a few university scientists (with extensive industry co-operation) claimed that many industrial companies have too short-term a focus and consequently are unable to put new basic research findings into practical use. The few tensions expressed thus seem to concern «violations» of the division of research labour that create gaps (or overlap) in the research system.

Finally, it has to be remarked that in previous empirical studies, most of which with focus only on university/basic research, extra-scientific relevance has been viewed as important by at least some university researchers. This is confirmed by the present study as well. Most university researchers in the sample asserted that practical relevance *may* be a relevant quality criterion, that *potential* relevance is always or frequently sought after, or that they themselves from time to time carried out very practically oriented R&D work. What the above discussion of sector differences has concluded, however, is that external relevance is not a *necessary* criterion for basic research (as opposed to applied). Most of the informants, including many from industry and the institute sector, furthermore asserted that demands for a too narrow, «monetary» relevance could be harmful, particularly to the originality of the research.

5.4 Field and disciplinary differences

The differences between fields and disciplines are not as distinct as between sectors. In all fields, characteristics mentioned as properties of good research fell under all four elements. In order to find distinctions we need to look more closely at what researchers include in each of the quality concepts. Because of the limited number of informants in each discipline, the tentative nature of this section is emphasised, as it was in chapter four.

5.4.1 Solidity

Main disciplinary differences are found when one looks at solidity. We find that the emphasis on good literature studies, corroboration of assertions and thorough and clear argumentation, is somewhat larger in the humanities than in the other fields. The two social science disciplines studied differed in their emphasis on solid methods-oriented or solid theory-oriented studies. The sociologists emphasised for instance thorough design, overall perspectives, good training in theory and a thorough theoretical discussion, while the economists were concerned about well-specified models, internal logic and consistency, testability, thorough fault tracing and being up to date on research methods.

The solidity demand was basic or obvious in mathematics. Replicability and producing solid mathematical evidence were for instance taken for granted. Scientists in experimental disciplines such as chemistry, medicine and biotechnology stressed the possibility (for others) to replicate or test the results as an important criterion. In addition, the informants in biotechnology used expressions like «carefully reasoned experiments» and «unambiguous results». Biomedical researchers talked about good controls and high quality of photographic documentation, whereas chemists were concerned with internal consistency and «checking the systems». Clinically oriented researchers emphasised solid data. Researchers in engineering cybernetics mentioned successful industrial implementation as an important indicator of solid research. Non-solid research would fail in the implementation phase, they asserted, a point that also was mentioned by most industrial scientists, particularly chemists.

Thus, these differences are intuitively understood as depending on the characteristics of the research in the disciplines studied – humanists focus on good arguments, economists on well-specified models, mathematicians on adequate or elegant mathematical evidence, and so on. Because of the use of different research methods in fields and disciplines, the solidity demands will vary accordingly, although solidity in general can be said to concern the extent of conviction in the conclusions, common to all fields. When elaborating on solidity criteria, the informants largely used a vocabulary that seemed tailored to their particular discipline.

The greater emphasis on replicability in for instance chemistry and medicine can be explained by the importance of causality and universal laws in the natural and medical sciences. The focus on theory and «reading the classics» in the humanities and sociology may furthermore be explained by the pre-paradigmatic nature of these fields (Kuhn, [1962] 1970), and supports previous findings (e.g. Hemlin, 1991). Economics does not fit into this category (although often regarded as a «soft science»), perhaps because of the level of theory in this discipline, as well as its «convergent» nature, i.e. the existence of a common identity and the low extent of scholarly and social fragmentation (Becher, 1989). The difference between the two social science disciplines also confirms earlier findings (Andersen, 1997).

Another explanation for the finding of differences connected with solidity in particular, is that ideal demands in many situations are the focus of quality questions. Minimum demands are more taken for granted and may therefore not be mentioned (but are often stressed in negative reviews, though, cf. Hemlin *et al.*, 1995). What is considered a minimum demand in one field may be ideal in another, e.g. what is seen as a minimum level of evidence in mathematics may be an ideal demand in other disciplines. The latter disciplines would thus emphasise such demands to a greater extent when describing good research.

5.4.2 Originality

Originality was perceived as very important in all disciplines studied. The only field really differing from the rest was cybernetics, where originality strongly oriented towards (practical) applications was emphasised regardless of sector. Otherwise, there were no specific differences in the type of originality stressed in the various disciplines.

There seems to be a pattern in the degree of consensus when originality is being judged, though. Informants from natural, medical and technical sciences and economics more frequently expressed a high level of agreement in such judgements than informants from other disciplines. Again, this finding can be explained with Becher (1989). In the «harder» sciences and convergent disciplines with a well-established body of theory, including economics, assessing originality can be expected to be easier. It is asserted, though, that this depends highly on the assessor's intimate and up-to-date knowledge of the special field in question. As mentioned, the fact that a large majority of informants stated that judgement of manuscripts for publication always is difficult, supports Cole's (1992) distinction between the research frontier and the core. However, different levels of agreement, indicated by the interview data, could imply that the research frontier is not equally uniform in all disciplines.

In disciplines like philosophy and sociology, we also found researchers who said that research may be «too original» and that there may be a «narrow line between the genius and the madman». In most of these cases, the informants added that originality detached or isolated from scholarly tradition, often gets «too wild» and fails to display «critical originality».

The central type of originality (radical/incremental, practical/theoretical) seems to differ according to the «phase of development» of the discipline or speciality. In e.g. engineering cybernetics, it was stated that after a major theoretical contribution, researchers would be occupied with applying the new theory to practical areas, developing methodology etc. After a while (from a few years to several decades) another central theoretical contribution would emerge, leading to a new phase oriented towards practical applications. Several informants from other disciplines gave similar descriptions of the knowledge production process. It may be that the same field can have both a basic disciplinary and an applied trans- or cross-disciplinary knowledge production, albeit at different points in time (cf. Gibbons *et al.*, 1994).

5.4.3 Scholarly relevance

Scholarly relevance was specified in numerous ways, and, to some degree, disparate aspects of scholarly relevance were emphasised in different disciplines. However, we found that generality and cumulativity had broad support as criteria across disciplines even if they were specified differently. The humanities were the only disciplines *not* concerned with generality, which may be explained by their being more ideographic – explanations of phenomena need not (to the same degree) be general (see e.g. Føllesdal & Walløe, 1990).

Researchers in the humanities and social sciences were far more familiar with and generally more concerned about scholarly relevance as such. A majority of the informants in these fields mentioned factors pertaining to this element in their answers to the open introductory questions. It may be that less preoccupation with causality and universal laws in these disciplines lead to a stronger need for focusing on «scholarly relevance». In other disciplines, such factors were less central and some informants had difficulties in understanding the concept of scholarly relevance. Particularly in chemistry, clinical medicine and cybernetics some informants understood little else by the term than that the research should be related to the field, or they did not separate intra-scientific relevance from extra-scientific relevance.

5.4.4 External utility

Focus on different kinds of utility varied as expected by what can be called the fundamental purpose of research activities in the various fields. Humanists mentioned general culture values (in philosophy specifically the intrinsic value of increased understanding and «seeing things clearer»), the social scientists general understanding of society and input to policy-making. In the remaining disciplines, various sector aims were mentioned: to solve practical, technical and environmental problems and to «improve health». In addition, the intrinsic value of increased understanding of nature was stressed, and that such understanding eventually «always has practical potentials». In chemistry and cybernetics (and partly also in applied sectors in other disciplines) market success was an additional criterion.

As mentioned, the social scientists differ as mentioned from other informants in not setting solid or good research as a necessary premise for external utility – some «users» may find research useful for their (political) purposes regardless of its being «selective» or even «incorrect».[5] In other cases plain «consultant work» (e.g. writing up what is already known about a certain problem) may be far more useful for certain users than a good research project.

Scientists in cybernetics appear to be considerably different from their colleagues in other disciplines in their strong emphasis on utility. Here, a practical and direct form of utility was the central element of quality, regardless of sector. In general, the discipline of engineering cybernetics is different from the rest in many other respects as well, largely due to its strong focus on application (individual research projects may still include e.g. «pure mathematics» and theoretical modelling). In some ways, the interviewees from cybernetics sketch more of a «Mode 2» knowledge production (cf. Gibbons *et al.* 1994). They tell of projects that are cross- or trans-disciplinary, have difficulties in using the terms basic and applied research and development, and in general describe knowledge as being produced in the context of application.

It is noteworthy that although traditional notions like basic and applied research were not thought applicable to activities in cybernetics research, there still seems to be a relatively well-established sharing of work load between sectors. It was claimed that «theoretically oriented» researchers would find work at a university, while individuals preoccupied with utility value would take positions in industry or at a research institute. One could ask why the other technological discipline in the sample does not stand out in this way as well. A probable explanation is that biotechnology is special in being closer to the natural sciences than most other technological disciplines, a point stated by all the sample's representatives from biotechnology. Still, the informants from engineering cybernetics indicated that research in their field «always» had been conducted this way – that there is no «new» or recently emerged mode of knowledge production. It could be that the Mode 2 of Gibbons *et al.* mainly is a description of how most technological research is carried out, and this may be spreading to non-technological disciplines.

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[5] I had a strong impression that most of these informants did not appreciate this effect. A few directly expressed that some researchers are too easily «bought» by users or contractors, and that this is unethical.

5.5 The problematic relevance concepts

As discussed above, to define or elaborate «relevance» (both internal and external) was a very difficult task for the informants, much more so than to discuss solidity and originality. Because relevance is a much-used term, both in studies of research and in policy contexts, it can be interesting and useful to try to go deeper into this complex notion.

5.5.1 Challenging the tacitness of «scholarly relevance»

The interview material clearly points to scholarly relevance as the most tacit component of research judgements. What is a valuable and important contribution to a research field? The informants had problems in specifying general rules or criteria for such judgements. In the comparison of research projects, a crucial query is which questions and problems are the most important. Many highly competent researchers had difficulties with explaining or elaborating why research is judged as important and interesting or not. As mentioned, the views of those who provided an answer also differed considerably: research may be interesting and relevant because many others are concerned with the same problems or because no prior research has been done in that area. It may be valuable because it provides research methods that open up new areas for research, it discovers general mechanisms, it generates new hypotheses or simply solves unanswered puzzles.

However, the interviews also indicate that the kind of criteria mentioned by the informants cannot (always) suffice for a conclusive answer to questions of scholarly relevance. Responses differed considerably *within* disciplines, and in general, the informants considered the issue rather complex. It involves questions like, what will prove valuable for future progress? Which are at the moment considered the most «pressing» problems? In what context and on what scale is generality judged? According to whose knowledge or what speciality is cumulativity judged? In addition to general rules and criteria, assessments of scholarly relevance may be influenced by the evaluators' conception of what their peers consider «hot» or interesting, what kind of research the evaluators themselves are concerned with and other more or less vague criteria of what is important to the field. It may be that a substantial part of actual judgements of scholarly relevance that cannot be covered by such terms as cumulativity and generality.

Competing schools can be among the factors that contribute to differences in assessments of scholarly relevance. We asked the informants about the existence of competing «schools of thought» within their fields. Such schools were mentioned in all disciplines, most often related to differing methodological preferences (except in the soft sciences where some more fundamental differences were described, as expected, e.g. between «quantitative» and «qualitative» research in sociology). Many hard scientists for instance talked about a «generation gap» between older researchers trained in mathematical modelling and younger ones focusing on computer simulation. Competing schools were most often described in an «empiricist repertoire» (cf. Gilbert & Mulkay, 1984; also section 4.6) as other «paths» to the same goal (albeit less effective than the informants' own choice). Still, some added that it could be difficult for e.g. a mathematically oriented scientist to «appreciate» well enough investigations that had been carried out with a computer simulation-based methodology.

To challenge the tacitness of judgements of scholarly relevance has particular interest for the part of the literature on peer review concerned with «cognitive bias» that results from the scholarly standing of the evaluator. An often-cited study on peer review by Cole *et al.* (1981) concluded that differing assessments from different experts were due to «real and legitimate differences of opinion among experts» about what good science is or should be. Others have been concerned that the scholarly standing of reviewers unduly influences the outcome of reviews (cf. Mahoney, 1977; Travis & Collins, 1991). Thus, the question is whether the influence of scholarly standing on peer judgements means particularism or legitimate scholarly disagreements. From my point of view, the answer depends on the criteria behind the judgements of scholarly relevance. As long as a substantial part of these criteria are tacit, the question remains unanswered.

If we suppose that the more tacit and complex the evaluation, the higher the potential for bias, then scholarly relevance is an obvious cause of biased judgements. In addition, one may claim that my interview material presents an idealised account of criteria by which scholarly relevance is judged. It may be that more particularistic criteria consciously are left out of informants' accounts. On the other hand, the material also includes accounts of «negative» ways of judging scholarly relevance. Several informants warned against ways of defining scholarly relevance that result in exclusion of what is not «fashionable», mainstream or conservative research. Noteworthy the criteria warned against are those that may be more conclusive than criteria of generality, originality and the like. In any case, there is evidently an inherent tension in this relevance concept – following the mainstream versus more «esoteric» attempts (that may become mainstream later).

5.5.2 The extensive utility concept

What I have called utility, often referred to as external or extra-scientific relevance, is both a complex and extensive concept. An informant stated that «all research will be useful eventually», while another asserted that it is positive and natural that «90 percent of all research is without practical utility». Both these respondents come from medicine, and the difference in these statements seems to rest on different understandings of the utility concept. In general, it is difficult to explicate a common core in the utility concept from the interviews. One important reason is of course that practical utility is defined (at least to some extent) by research-external users, who have not been interviewed.

In the literature, one can find distinctions between (external) relevance, applicability/usability, application/use and utility (Vedung 1994). We did not make such distinctions in the interviews. Nor did the informants, and terms like «relevance» and «utility» were more or less used interchangeably by them, although the latter for some referred more to «economic» utility. One way of going further into the concepts is to look at such utility *domains*. A majority connected external relevance to questions of the nation's or firm's economic position. Other domains were as mentioned the environment, health and social and cultural issues. Many disciplines are relevant across several domains, although single projects seem to be tied to a distinct purpose. In medicine, some informants asserted that economic issues, like the price of a medical treatment, are important to consider next to health aims. Several researchers worried that research funding bodies looked too much at the economic domain.

External relevance and its synonyms were moreover used concerning both *potential* and *actual* utility value. Potentially useful research implies that somebody (normally not the researchers) must do something (substantial) with the research results in order to appropriate benefits from them. Actual utility value refers to projects that are closely tied to the demands and specifications of a user, who thus will benefit from the project immediately after the results are at hand. This distinction is a good split of utility criteria of basic and applied research – indeed, several informants seemed to base their definition of basic versus applied research on to which degree a project is tied to a user's concrete needs. Accordingly, to increase the utility value, the informants from universities said that one should focus on improved mediation of research results, whereas the institute sector and industry would try to increase user participation in the earliest phases of the research.

Some informants asserted that the definition of external relevance should be narrow and thus imply concrete benefits in the short term. In this way, external relevance will not be demanded of basic research and it simultaneously will be clearer what is referred to for activities where external relevance is an important criterion. Another advantage is that one does not have to try to measure or assess «potential utility» in any way, an exercise deemed futile by most informants. Even for the most applied research projects, utility is difficult to measure. Some of the industrial researchers expressed frustration over having to use much R&D resources to assess economic benefits *ex ante*, instead of relying more on their own «gut feeling» and on previous, promising results, when making «go decisions» for R&D projects.

The difference between potential and actual utility can also be seen concerning the *user groups* that the informants specified. In the universities, it was common to refer to broad terms like «the general population», «industry» and other scientific disciplines. In the institute sector and industry, users were more specified, and it was common to communicate directly with end users. Very few informants (less than five) stated that users are able to assess the quality of the research, but most underlined that users are fully able to, and perhaps the only ones that should, assess external relevance. Some informants (particularly in biotechnology and medicine) asserted that the users not always are able to see what will be most useful to them, though, possibly related to the low-tech profile of the relevant industries in Norway.

Ethical issues also emanate connected with external relevance. Many informants were preoccupied with how (and by whom) the research is used, and ethical questions can arise during contract research for competing firms. Moreover, many of the social scientists asserted that their disciplines have a moral responsibility to conduct research that is relevant to the weak groups in society that do not have the funds or apparatus to initiate research themselves.

In conclusion, the controversies and uncertainties that often seem connected with «external relevance» may in some cases result from a lack of specification of the concept. Thus, further specifications in the form of e.g. utility domain, time frame (degree of actual/potential utility) and user groups, might be appropriate. In other cases, conflicts may arise out of a too narrow definition of relevance that focuses only on economic benefits and/or a relatively short time frame. Conflicts are nevertheless not necessarily bad. Particularly researchers in the institute sector asserted that good research that is both useful and interesting to other researchers may come out of a («balanced») tension between the two types of relevance.

5.6 Discussion

This part of the study shows that it is possible to elaborate the concept of research quality in such a way that most researchers, across sectors and disciplines, will agree with the overall criteria. The deconstruction of «research quality» into solidity, originality, scholarly relevance and societal/practical utility has also proven useful in exposing underlying tensions in the concept. The most central specifications (in *italics*) and tensions are summarised in table 5.1.

Table 5.1. *Specifications of research quality and quality tensions.*

Quality elements	Solidity	Originality	Scholarly relevance	Practical utility
Solidity	*Well-founded claims/-conclusions; good documentation and data; consistency and coherence; factual interpretations; impartiality, stringency, clearness, avoiding fraud*	Systematic work vs. creativity; creative researchers vs. those that are more «thorough» or «patient»	No tensions sketched (unless the research work is extraordinarily original, it has to be solid to be relevant to others)	No tensions sketched (solidity is seen as a precondition of practical utility)
Originality		*Theoretical/academic novelty or originality related to practical problems; incremental versus radical originality*	Following the major research trends vs. breaking with tradition (although original research often is relevant to others)	Short-term utility vs. more «radical» originality (which requires long-term focus)
Scholarly relevance			*Cumulativity (filling holes/other contributions, opening new areas) and generality (e.g. general principles, research tools and methods)*	Focus on broad or general problems (scholarly relevant) vs. «narrow» or «local» problems (potentially useful)
Practical utility				*Long-term and short-term (immediate); specific users or more broadly defined social sectors (health, economy, environment)*

Disciplinary differences found in prior studies are mainly confirmed. Research quality ideals and dilemmas seem more fundamentally dependent on the *institutional affiliation* (university research versus sector and industry research) of the researcher than on the discipline, though. The main distinction lies in the weight put on intra-scientific and extra-scientific relevance. At universities, focus is mainly on scholarly relevance and merely a potential for external utility, if regarded as important at all. External utility, on the other hand, is the main quality criterion for industrial research. Which «side» the institute sector belongs to, seems to depend on characteristics of the discipline and not least the special history and environment of each institute. To a certain degree, however, some institute researchers seem to be «caught in the middle» between what they view as almost incompatible demands for both intra-scientific interest and external utility.

Furthermore, the interview material displays considerable variations *within* each field of learning, and within specialities in these fields, in how the elements of research quality are elaborated and in the kind of importance assigned to them. There is ample room for disagreements in peers' judgements of research quality. Thus, cognitive and other «personal» preferences are important, but so are «intrinsic» characteristics of the research products. We have seen that the researchers claim there is huge variation in originality, solidity etc., between different research works. The wider context can also influence quality criteria (and their use), for instance, the kind of product to be assessed (proposal, manuscript etc.) and the type and purpose of the assessment (e.g. formal evaluation or collegial advice).

The informants were somewhat negative to the possible development of more concrete evaluation criteria for their fields to increase consensus in assessments. They warned against elaborate guidelines that do not allow enough room for discretion. More detailed criteria for good research can be worked out within disciplines, it is asserted, but a substantial degree of discretion cannot be avoided. There will always be a subjective element in judgements on research quality, particularly when weight is given to the various criteria and overall conclusions are made. Several informants thought that, if at all, *only* the minimum demands may be operationalised, such that outstanding and more «exceptional» research cannot be covered by detailed quality criteria.

To «give priority to» quality is a strong policy dimension in many countries, not least small ones with limited resources and frequent demands for concentration of research resources. This is perhaps reflected by the many studies of quality originating in the Nordic countries. Here, the discussions of quality may have much stronger and direct implications for resource allocation than in larger countries with a broader scientific base. Steps to improve quality can be taken towards the review system (of proposals, people, manuscripts), as a few of the informants indicate. Some researchers stated that a general model, like the one proposed in this thesis, may function well as a «mission statement» or starting point for concrete improvements of both quality reviews and research units. Another strategy is to focus on the research units to improve the «intrinsic» quality of research. This will be dealt with in the following chapters.

Four research questions or propositions concerning research quality were specified in chapter two, and they have been discussed throughout this chapter. The following is a brief review and summary:

Can we find diverging opinions on the nature and objective of research work and different «conceptions of quality» behind elaboration of research quality? What is meant by «research» (or e.g. «applied research») varies between scientists, which may be a reason for different specifications of good research. There seems to be more agreement on conceptions of quality. A single research work/project has to satisfy certain specific and/or minimum demands to be «good», while research works in the long run are judged more along a scale of «excellence».

Are there central criteria of good research that are not covered by my four proposed elements? Eleven informants indicated this. I have tried to incorporate their suggestions (e.g. critical attitudes and ethical questions) into the discussion of the four elements above. The probably most difficult aspect to incorporate into my decomposition is a research work's *mediation quality* (how well it is written, maybe also how and where it is published). This was particularly mentioned by scientists from soft fields.

How are aspects and dimensions related to originality and solidity described? In originality, two dimensions clearly emerge from the interviews: incremental versus radical and theoretical versus practical novelty. This can vary between settings (discipline and sector), but also with the phase of development of a research field. Only a few informants used the word «solidity» in open questions – the vocabulary regarding this aspect seems closely related to the nature of work and the specific methods applied in each field.

What is generally meant with «relevance», and is it fruitful to distinguish between «internal» and «external» relevance and make both of them demands in all types of research? Relevance is obviously a difficult term, and that there may be tensions between what is relevant to users and to other researchers, and between what is relevant in the short and in the long run. Still, it seems natural to maintain a distinction between internal and external relevance, although only the latter made sense to many of the applied researchers. External relevance or utility can be an appropriate demand to basic research, given a broad definition, but not given a more short-term and purely «economic» definition.

I finally claim that the first main research proposal of the present study – that research quality can be divided into four more or less incommensurable elements, and that these elements together constitute major tensions in research work – is confirmed, but only partly confirmed. There is obviously tension between quality aspects, and we have seen that a decomposition into four elements (less than e.g. Hemlin & Montgomery, 1990; more than e.g. Ravetz, 1971) worked quite well for a large majority of the informants. However, it is evident that all decompositions, also the one I have proposed and elaborated, lose a «facet» or an «aspect» of research quality.

Even after long interviews with experienced researchers who were prepared to talk about quality, a tacit and largely «personal» factor remains that is not covered by originality, relevance etc. Good research is something that one «feels» or «experiences» as much as «analyses», and many informants concluded long attempts at explications with the (often somewhat resigned) phrase «you know good research when you see it». Individual preferences were expressed, for instance, in sentences like «personally, I put much weight on originality», and «methodological contributions are most valued by me, but not necessarily by others». This tacit and highly subjective component should probably be regarded as a legitimate and integrated part of research quality that nevertheless escapes decomposition and, to some extent, elaboration.

6 Individuals in research units

The elaboration of the organisation starts with the individual. Previous investigations of individual-level variables and their relationship to research performance are discussed briefly in 6.1. The rest of the chapter deals with my own empirical data. A very short discussion of «good researchers» is found in 6.2, followed by analyses of creativity and motivation in 6.3 and 6.4. In 6.5, I connect the individual to research quality to see if some quality elements are more dependent upon characteristics of researchers than others. The next three sub-chapters deal in various ways with how individuals are influenced by the organisational environment: how the «potential» in researchers can be «released» (6.6), how creativity can be restrained or promoted (6.7) and what types of rewards may be efficient (6.8). Finally, 6.9 deals with the recruitment of research personnel.

6.1 Previous investigations of good researchers

Many types of individual-level variables have been studied to explain large performance differences between researchers. Fox (1983) distinguishes between investigations of psychological characteristics, work habits, and demographic characteristics. These will be discussed below, followed by a brief elaboration on recruitment.

6.1.1 Psychological characteristics

One perspective in the psychological studies has been called the «sacred spark» theory (Cole & Cole, 1973) because of its focus on strong individual motivation, dedication or «inner compulsion» to carry out research, even in the absence of external rewards. That the «best» or most eminent researchers are a highly motivated group, has been confirmed in several studies (e.g. Merton, [1968] 1973, Pelz & Andrews, 1976; Harris & Kaine, 1994; also Andrews, 1979c, where motivation is seen as a characteristic of the research unit as a whole). High performers are much more dedicated to research work than to teaching and other activities (Blau, 1973; Blackburn *et al.*, 1978; Harris & Kaine, 1994). Still, they rarely spend all their time in the world of research (or development), but carry out different R&D activities (Pelz & Andrews, 1976; Asmervik *et al.*, 1997; see 7.3).

Studies of creativity in general have also focused on «inner motivation» (see for instance Bennich-Björkman & Rothstein, 1991). A lot of notions that are used to describe good research environments, express originality in one way or another – creative, brave, imaginative people and units willing to take risks, produce original/creative research results (see e.g. Asmervik *et al.*, 1995). Many studies of creativity have been carried out from a psychological perspective (cf. Taylor & Barron, 1963; Sternberg, 1988). The research on creativity can have a starting point both at the individual or organisational level, as well as have a product, process or domain perspective. Usually studies are not limited to scientific creativity, but also connected with for instance marketing/advertising, inventions and innovations, and the arts (music, literature, etc.).

There seems to be agreement that all types of creativity are results of interaction between domains, social networks and problems, and that the creative individual is but one of several necessary components in a long lasting process (Tardif & Sternberg, 1988). Confirming the main result of Pelz & Andrews (1976), and thereby implying the central position of creativity/originality in research, Tardif & Sternberg found that creativity does always involve some kind of *tension*. Such tensions can be envisaged in the process (stick to traditions or enter unknown ground), in the ideas as such, as well as «in the constant battle between unorganized chaos and the drive to higher levels of organization and efficiency within the individual, or the society at large» (*ibid.* p. 431). More disagreement in the psychological studies is related to the significance of «sudden insight» (individuals being «struck by lightning»), how random the creative process is and whether creativity is commonly available or only seen in special individuals in special contexts (with Edison, Freud and Einstein as frequent examples)[1]. In general, inner motivation is regarded as central to creativity: «People will be most creative when they feel motivated primarily by the interest, enjoyment, satisfaction and the challenge of the work itself – not by external pressures» (Hennessey & Amabile, 1988:11).

Hennessey & Amabile have conducted many studies that show a strong positive relationship between social/environmental factors and the type of motivation that people have. These and other studies have found that expectations of or promises of monetary or other tangible rewards in most cases will reduce the individual's inner motivation for the activity. It is not the reward in itself that functions this way, but rather the significance of making one's activities subject to a form of external control. This provides an explanation for the finding of Spangenberg *et al.* (1990b) that expectancy of financial rewards has a negative influence on research performance. Similar negative effects on inner motivation and creativity have been found connected with supervision, time limits and evaluation (Hennessey & Amabile, 1988). However, a few studies have shown that some individuals manage to view rewards as an additional motivational factor. Good role models seem to be necessary if for people to maintain inner motivation during varying circumstances (see Hennessey & Amabile p. 17-35, for a discussion of these studies). It can be mentioned that Nobel laureates view socialisation during advanced apprenticeship (most often with an eminent scientist as mentor) as decisive in e.g. the transmission of standards of achievement (Zuckerman, 1977).

Hence, the conclusion is that not only is inner motivation essential to creativity, but also that promises of rewards in almost all cases will be detrimental to motivation and creativity (Hennesey & Amabile, 1988). «Threats» of upcoming evaluations have for instance been shown to undermine creativity in R&D laboratories (Amabile *et al.*, 1990). However, similar forms of pressure can have positive effects if they arise from the intellectual problem itself (Amabile, 1988). Still, some studies have found that there are large variations between

[1] There is a clear parallel here to the different basic views of quality (e.g. «quality as excellence» and «quality as fitness to purpose»), cf. chapter two.

individuals (and even within individuals' careers) in what rewards that are expected and how these influence productivity (Tien & Blackburn, 1996).

As will be seen in 8.3, several studies have shown a positive relationship between autonomy/freedom and research performance. Freedom or autonomy thus seems to be an organisational prerequisite for creativity or originality. It can also be added that the researchers' inner motivation influences how the environment is perceived. Less motivated individuals are more likely to see constraints and problematic aspects in their environment than those with high inner commitment to research (cf. for instance Harris & Kaine, 1994). Finally, motivation can be tied to other issues than creativity. An example is Andrews (1979c), who postulated and found a strong link between motivation and hard work/persistence.

Bailey (1994) surveyed university researchers on their «commitment», by which was implied both inner motivation to add to the stock of scientific knowledge or to solve social/economic problems, and motivation based more on external tangible rewards. Two results stand out. First, job security and promotion were relatively unimportant and second, the personal satisfaction gained from research was attached a «very high level of importance». Intrinsic motivation was much more central to commitment than any kind of extrinsic reward, but professional recognition was also essential to many. As expected, extrinsic rewards like job security and promotion were relatively more important to staff in positions without tenure.

In general, investigations have failed to show significant relations between number of publications, number of citations and innovativeness, and indicators of researchers' *abilities*, for instance IQ (Bayer & Folger, 1966; Cole & Cole, 1973; Andrews, 1976) and grades from upper secondary school (Kyvik, 1991). Because scientists are a highly select group of people, it is much harder to obtain significant correlation coefficients. This is perhaps the most straightforward explanation of the results, and in general one of the most problematic aspects of the literature that studies individual characteristics in search of explanations for performance differences – abilities and traits are not likely to be as unevenly distributed as productivity/performance (Fox, 1983).

Even tests of creative abilities have failed to correlate with «R&D innovativeness» as judged by peers (Pelz & Andrews, 1976). A follow-up study confirmed these results and pointed out four environmental factors that have to be present simultaneously if a creative ability is to be transformed into an innovative output (Andrews, 1976). The four factors were high degree of responsibility for initiating new activities, power to hire a research assistant, no interference from administrative superior and high stability of employment. R&D organisations may thus have a «security dilemma» – the autonomy that promotes security and creativity could and should lead to risky ideas that on the other hand may elicit organisational responses that undermine autonomy and security. The studies clearly point to the necessity of viewing social and personal factors together. This is a general problem with studies of individual-level variables; personality traits do not exist in a vacuum, but are affected by the social environment in various ways (*ibid.*).

Another perspective in the psychological studies of determinants of research performance is more oriented towards «stamina» or the capacity to work hard in the pursuit of long-term goals. A relationship has been confirmed here: high performers are absorbed, involved and highly identified with their work (Pelz & Andrews, 1976), and they work longer hours than the medium and low performers (Harris & Kaine, 1994).

Yet another perspective in the psychological studies of researchers has concentrated on the cognitive, emotional and perceptual styles of scientists. Reitan (1996) and Fox (1983) state that these studies have reported that productive scientists show high ego strength, personal dominance, preference for precision and exactness, strong control of impulse and a preoccupation with ideas and things rather than people (see also Stein, 1963; Jackson & Rushton, 1987). They also have a capacity to play with ideas and recombine familiar concepts, as well as a high tolerance for ambiguity and abstraction. In addition, scientists are able to write convincing texts and good at «translating others' interests» (Latour, 1987).

Investigations of the biographical backgrounds of scientists reveal yet another common set of background variables: «Eminent and productive scientists show marked autonomy, independence, and self-sufficiency early in their lives» (Fox, 1983:287). Creative industrial researchers are described as more distant from their parents, more cautious and realistic, and more autonomous than the less creative (Stein, 1963). However, Pelz & Andrews (1976) found that the high performers also showed the highest degrees of collaboration, constituting a counterpart to their autonomy and independence.

6.1.2 Work habits

Regarding *work habits* (which of course are related to cognitive and perceptual styles), Hargens (1978) found that disciplines differ in their level of «predictability» or «routine», both in time and compared with other disciplines. High performers adapt their work habits to these levels, so that for instance working on several problems simultaneously affects productivity in a positive way in disciplines with much routine work or predictability. Pelz & Andrews (1976) concluded that diversified tasks, e.g. several areas of specialisation, were conducive to performance both for young and old scientists, as well as for those with Ph.D.s and those without. Andrews (1979c) found the same at the unit level.

Simon (1974) studied work habits of «most outstanding» scholars, finding a similar pattern. They worked on several problems at a time, devoted early mornings to their writing and spent vast amounts of time on their work. Hard work and a simultaneous study of several related problems or sub-areas also characterised the high performing cluster in Harris & Kaine (1994), in addition to very conscious career choices – the best researchers selected projects that they felt certain would further their academic career.

Zuckerman & Cole (1994) studied «research strategies», particularly criteria of problem choice, based on interviews with both «eminent» and «other» scientists in physics, biology, mathematics, psychology and economics. The eminent scientists typically thought «long and hard about what constitutes a good problem and how to recognize one when it comes along» (p. 395). Problems were selected primarily because of their significance (personal and communal), feasibility and duration. Several had a rule of thumb saying that anomalies often are sources of interesting and important problems. They also tended to avoid problems that were being pursued actively by others, and they worked on an array of problems simultaneously – questions related to the main one, multiple aspects of the same questions or different methods. The «rank-and-file» scientists were generally more modest in their definitions of problems worth studying. In some sense they used the same criteria, but in a less stringent and ambitious way. They worked on one problem at a time, and they did not invest an enormous effort in choosing the sites and materials with which they would carry out the research, as the eminent did. This fits well with the description of scientists given in Latour & Woolgar (1979) and Latour (1987). Still, Fox (1983) gives a word of caution on the results pertaining to work habits. The causal relationship is uncertain; particular practices may be a function of productivity or quality and not the other way around.

6.1.3 Demographic characteristics

Many scholars have looked to demographic characteristics when searching for explanations of performance differences. The three variables age, rank and sex have been much studied. Several investigations have found a curvilinear relationship between age and publication productivity, while others suggest a bimodal connection with two peaks (Reitan, 1996). The precise relationship is, however, generally difficult to establish because of methodological complexities (Creswell, 1985), and questions have been raised whether a decline that appears in any mean across scientists is largely attributable to «shooting stars» – high producers who decline sharply after reaching an early peak (Hammel, 1980, quoted in Fox, 1983). There are furthermore great differences between disciplines, which can be explained if developments are more or less rapid in various fields (Kyvik, 1991). Reinforcement processes (see 3.3) can also explain productivity decreases with increasing age, but are probably less suited to explaining disciplinary differences. Still, the literature points to very different reasons for decline in productivity with age (Fox, 1983).

Kyvik (1991) hypothesises that although researchers in the humanities, social science and medicine remain productive when they get older, they may not be as creative as they were in their younger days and thus produce work of lower quality. The productivity studies are naturally not suited to investigating such hypotheses. A side effect of declining productivity (or quality) with age may be that older scientists resist the innovative work of younger scientists, and thereby impeding the scientific or technological development. This effect has been refuted in empirical studies (Levin *et al.*, 1995).

Fewer investigations have been carried out of the relationship between academic rank and research performance. Still, Blackburn *et al.* (1978) and Knorr *et al.* (1979a) have both found that rank is a better predictor of publication productivity than age is. In Kyvik's (1991) study of Norwegian tenured university personnel, academic rank was the best determinant of productivity in all fields except the natural sciences (where age and international contact were relatively more important). Explanations can be tied to time use, resources and the scientific networks at the different levels of the academic hierarchy. The causality question is nevertheless very unclear for this variable: is productivity determined by rank, or is achieving a higher rank a result of publishing a lot of articles, etc.?

Finally, several studies have shown that women publish less than men do (for an extensive review see Kyvik, 1991:186-224; also Kyvik & Teigen, 1996). Many explanations have been put forth, but the underlying causes are not clear. The data of Kyvik (1991) point to caring responsibilities for small children as a more important cause than previous studies do; this is also one of the few data sets with possibilities for distinguishing between the effect of having children in general and of having children below a certain age. However, it has been claimed that studies of publication productivity may be biased against women. Sonnert (1995) finds that women may be more «perfectionist», i.e. they publish smaller amounts of very valuable material, in their publication behaviour, «which would bias a performance measure based on publication counts against them» (p. 52). The later years have seen a gradual increase in the share of women at all levels of the research system in Norway. How this will affect performance and gender-based performance differences is not discussed further in the present study.

6.1.4 Recruitment

Few studies have looked at what makes a research unit attractive to prospective employees. Blau (1973) found that salary is the central explanation for recruitment of senior faculty. This does not mean that financial rewards override other considerations or that good researchers accept otherwise unsatisfactory jobs if they are highly paid. Instead, at least in the U.S. system, the best scholars «are rarely confronted with extreme choices of this kind, since their academic reputations govern how many academic institutions with desirable working conditions are interested in them and thus the salary they can command. As a result, faculty members with superior reputations can get higher salaries without having to sacrifice the intrinsic advantages of positions in good universities» (p. 81). It is probably not like this in the university sector (and maybe research institutes as well) in Norway, where the salaries are more or less equal in all institutions.

Blau furthermore argues that high salaries have a «snowball effect» because they not only attract better scholars, but consequently create a «colleague climate» that further stimulates scholarly activity. He also found that recruitment was improved if the academic work was more specialised and advanced. It can be added that Jones & Sullivan (1994) found that the professional «reputation» of a research organisation is a central determinant of recruitment. The most important correlation of reputation was «innovative climate», i.e. researchers appreciate getting opportunities to do creative work.

Senker (1999) argues that recruitment of junior personnel has become more difficult the last decade in Europe, due to an increase in temporary work contracts. This makes many of the talented junior researchers look for positions elsewhere. Little is known about other formal rewards such as prizes and promotion. In general, I assume that this does not affect research quality significantly. This is supported by Blau (1973), who found that promotion based on performance does not motivate researchers not already inclined to engage in research.

6.1.5 Short summary

Several investigations, representing a variety of perspectives, have pointed to characteristics of individual researchers as determinants of scientific performance or publication productivity. «Inner motivation», including a strong dedication to research work, seems to be the most central variable. The literature suggests that it is unlikely for an individual to produce much or very good research without it and that dedicated and motivated employees are an essential feature of good research organisations. Creativity or originality in particular seems to rest much on inner motivation, but so does persistence or stamina. Although little can be done to improve such motivation, scholars have found that many types of environmental control may be detrimental to it. Some also claim that motivation influences the individual's perception of the quality of the environment.

Few studies have managed to present a clear connection between research performance and individual abilities. The reason could be methodological. Abilities are not likely to be as unevenly distributed as performance, making it difficult to come up with significant correlation coefficients. However, it is also suggested that certain environmental factors have to be present for individual abilities to be transformed into a creative and productive output, for instance responsibility for initiating new activities and no interference from administrative superiors. A general finding is that the most eminent work longer hours than the more «average» researchers do. Few detailed studies of work habits have been done, and they point out stringent and ambitious criteria for choice of problems and research equipment, as characteristics of the best researchers. Still, it is not obvious if some work habits are a cause of scientific performance, or if high performance induces certain patterns of working.

Investigations of demographic variables most often find a connection between age and productivity (or rank and productivity), but different relationships (bimodal, curvilinear) are found, and a number of explanations have been put forward. It seems safe to assert that the environmental factors that influence research performance in one age group or career level may differ from the factors that are important in other groups.

Finally, it should be pointed out that discussing factors at the individual level *per se* is not necessarily fruitful or relevant. Not only do individual characteristics to some extent constitute the working environment (including perceptions of it), but work habits, abilities, motivation and more do not exist in a vacuum. On the contrary – to define the boundary between individual characteristics and features of the social environment can be difficult (Fox, 1992:105):

> *«Fundamentally, it is difficult to separate the performance of individual scientists (or scholars) from their social and organizational context (…). Work is done within organizational policies and procedures. It relies upon the co-operation of others. It requires human and material resources. Further, the scope and complexity of research and the use of advanced technology in science, in particular, have heightened reliance upon facilities, funds, apparatus and teamwork.»*

The professional reputation of a research unit is most likely central in its ability to attract good personnel, particularly when few possibilities of offering significantly higher salaries than other units exist. Little is known about rewards like promotion, but it has been argued that talented young scientists may select alternative careers if the prospect of a long-term position is poor.

I have tried to condense the above into four main research questions or propositions, to be elaborated in the rest of the chapter:

- Good researchers may or may not have certain traits in common. Still, individual characteristics obviously do not exist in a vacuum but are embedded in social contexts.
- It is difficult to make strong claims about the link between individual characteristics and sub-elements of research quality. From the creativity literature, it is natural to propose that originality will be tied closely to the individual. Creativity is essential in research work, and many studies conclude that creativity is easy to destroy but hard to promote.
- Inner motivation resulting from scientific curiosity, the joy of doing research work etc., is most likely more central than external motivation resulting from rewards outside the work itself, although scientific recognition may be important.
- Rewards like salary and promotion are not attached much weight by eminent scientists, but they may mean more to young researchers and to those in temporary or non-tenured positions. Recruitment can be linked with vicious and virtuous circles (reinforcement effects). In simple words: good researchers attract other good researchers.

6.2 A brief description of good researchers

The informants were asked what they would accentuate when hiring senior researchers for their unit. They were also questioned about general characteristics of good researchers, as well as urged to elaborate on what they saw as the special features of creative researchers. It is difficult to go into much detail about individual characteristics, partly because the answers varied much. A clear picture of the «good scientist» does not emerge from the data. Many of the informants stated that researchers, even the most eminent ones, are very different. For instance, a mathematician from industry said, «It's difficult to say something generally. People have so different backgrounds, personalities and roles.»

The respondents mentioned a lot of different personality traits, skills, abilities and competencies. A broad selection of terms and phrases was used. Most of the researchers talked about motivation, dedication and underlying characteristics like curiosity, scholarly ambitions and interests, and a more general «thirst for knowledge». An economics professor for instance said, «It's so important to think it's fun, that you are genuinely interested in doing this research. You can't look upon it as any other job. You need ambitions to be able to last many years.» This seems to be a basic trait for people to become and/or remain researchers at all (motivation will be elaborated more closely in 6.4 below).

General social skills and communication abilities were also frequently mentioned as basic characteristics of good researchers. An economist working in industry stated, «Social competencies mean a lot, (…) many of the good scientists are good at taking the floor and discussing matters in larger surroundings, in large forums.» A sociology professor said that good researchers are distinguished by very good «communication skills and a pleasure in communicating *per se*».

Furthermore, good researchers were often described with terms like «bright», «clever», «analytically sharp», «intelligent» etc. However, several of the informants were sceptical about judging potential post-docs and doctoral students on their grades, because these were not seen as an adequate reflection of the necessary skills and traits. The point was elaborated by a chemistry professor: «It doesn't necessarily mean very much that you graduate with the best grades in the world. Very often we see that the grades don't mean much, it's more those skills that are very complex, the ability to do something to an idea and the will and capability of getting through it all.» Creativity was most the frequently mentioned as an aspect that could not be read out of a university diploma: «Grades are definitely not the only important aspect [*talks about doctoral students*]. (…) Of course, good grades are a nice starting point, but not enough to become a good scientist. On the contrary, I would say in some cases. (…) The two or three best of my graduate students were too much 'A4' [*standard size sheet of paper*] to become good scientists» (biotechnology professor).

Some informants were concerned about elaborating on the question of in-depth knowledge versus broad and general knowledge. All of those who discussed this matter claimed that eminent scientists have both. You cannot become a good researcher without going deeply into a speciality, but a broader outlook is nevertheless regarded as necessary. Some of the informants from technology and industry claimed that a knowledge of practical applications and use of research is indispensable to become a capable scientist/engineer, but others saw this more as «nice but not necessary» (chemist, industry). A few added that good researchers often have interests outside of research, for instance in the arts (music, literature, etc.). This was described as a potential source of creativity as well as a fruitful way of relaxing.

Extreme workloads were also mentioned by many of the researchers. A philosophy professor said that good researchers are «quite different, but they all work very intensely». This was not only seen as a choice that good researchers make (and that not so good ones do not make), but was also linked with individual traits: «Energy and persistence are very important. The best researchers manage to have a colossal work load and they have no leisure time at all» (medical researcher, institute). Less than five of the informants discussed work habits or strategies in more detail – for instance, related to problem and methodology choices. A philosophy professor stated that working on several problems simultaneously is quite common, and added that the best «almost always have a combination of attitudes and strategies – they are interested both in depth and in breadth, and they have a liking for both the fashionable and the most basic perspectives».

Some more particular specifications can be mentioned. A medical professor maintained that the best scientists do not «compromise when it comes to quality. They have a very high standard of work that they follow in every project and publication.» To produce few but particularly high quality publications was seen as an ideal by two professors (and several others were negative towards «mass producers»). Three of the informants from the soft sciences said that to be a good researcher has to do with maturity. Some researchers are able to achieve a higher degree of professional maturity than others, it was claimed. A professor of French language thought for a long time about characteristics of good researchers, and finally stated, «I believe it's the ability to pose a question as neutrally as possible.»

In general, much of the image of the «good scientist» that emerges from the literature is confirmed by my data. Good scientists are highly motivated (e.g. Blau, 1973; Pelz & Andrews, 1976; Fox, 1983; Jackson & Rushton, 1987), they have immense workloads (for instance

Harris & Kaine, 1994) and they often work on several problems/methods and tasks simultaneously (e.g. Pelz & Andrews, 1976; Zuckerman & Cole, 1994). Perhaps the most unexpected finding, at least judging from the literature reviewed above, is the many strong claims made about communication skills and «general social skills». Earlier studies often portray good scientists as not very preoccupied with people and not necessarily equipped with good interpersonal skills (see Stein, 1963; Fox, 1983; Jackson & Rushton, 1987; Reitan, 1996). My informants clearly saw the «ideal scientist» as different. One reason could be that the growth in group work and other types of collaboration has increased the need for researchers that are good not only at the research work *per se*.

6.3 Creative researchers

Because creativity seems fundamental in scientific work, the informants were asked a specific question about this. More than half of them claimed that creative researchers have nothing in common, and did not want to elaborate further. A chemist from the institute sector specified: «I don't think you'd recognise them from behind. (…) They belong to all groups in society, all kinds of backgrounds.» Another institute researcher, from mathematics, problematised the question: «I can't elaborate it – but this also has to do with your own ability to recognise creativity. Sometimes you're just not able to see it.»

Still, from the detailed answers I received, some typical traits of creative researchers emerge. They are «by nature a little more difficult to control than others» (mathematician, industry), and they have «an unusually high level of energy» and productivity. An intense work effort was often elaborated, for example by a biotechnology professor: «They're very difficult to describe, but I believe that they are extremely preoccupied with what they're doing. They have problems and puzzles in their subconscious for a long time, they ponder while they're skiing and things like that, they quite simply give it priority in their minds.»

A recurrent specification was the term *imagination*, often coupled with other traits: «Imagination, but combined with knowledge, and maybe audacity; some audacious people are extremely creative» (professor, engineering cybernetics). *Openness* to other fields, domains and ideas was another frequent comment, for instance from a mathematics professor: «There's often a connection between being open and being creative. (…) It's a bit like Espen Askeladden [*famous figure from Norwegian folk tales*], you gather something here and you gather something there, and maybe you'll find some use for it in the future.» This means that creative researchers are often not seen as very structured: «They're ill-structured, and they easily transfer knowledge from one area to another» (economist, institute).

However, this does not mean that creative researchers are not knowledgeable. On the contrary, the most common specification of all was that creativity is based on an extremely broad and/or in-depth knowledge of the relevant speciality. A cybernetics engineer from the institute sector said, «A very profound and good understanding of your field is necessary to be creative. I used to believe that these messy heads were creative, but I guess that these people often don't connect at all.» A mathematician stated, «They're a heterogeneous group, (…) but I think a deep understanding of problems is a precondition of originality.» Creativity is thus not seen as «random» or «accidental»: «Sometimes just before you fall asleep at night, something occurs to you. But that's always based on the knowledge that you already have» (medical scientist, institute). «I like this idea about lateral thinking, that you have the ability to extrapolate from seemingly totally irrelevant things. Creativity in today's complexity depends upon good previous knowledge. Creative ideas don't strike as lightning just in any individual» (medical professor).

Some more atypical comments can be mentioned. An institute researcher from clinical medicine said, «I could point to a characteristic that rarely is put much weight on these days, and that's depression. I believe there are many more creative people among the depressed than among the happy psychopaths.» This statement constitutes a contrast to the many positive images of creative scientists as energetic, highly visible professionals. A few maintained that creativity alone is insufficient to become a good researcher. A chemistry professor said, «Creativity isn't enough, you need the will to test out the ideas.» Another professor, from clinical medicine, made a similar point. He said that fruitfully creative scientists «manage to *create* something. They don't just have an idea, but they're also able to implement it fully.»

Most of the informants explicitly or implicitly stated that creativity mainly is a «given» characteristic of certain people – something that you are born with or that is made possible in early childhood. Still, a few claimed that it is possible to learn how to be more creative, for instance by attempting to be open towards new ideas. A scientist from a basic biomedical institute said, «I believe it can be learnt, but it's an individual process. (…) You have to be aware of it [that new things might occur] and try to be open and say to yourself that now I have to think innovatively.» How the organisation can influence an individual's potential for becoming a good scientist and for being creative, is elaborated further below.

Finally, it should be underlined that not all (good) scientists are creative. Several of the informants stated that creativity often is in short supply in research units. Some good scientists may be characterised by for example thoroughness, patience and other traits, but they are not necessarily creative in addition to that. It was frequently added that this is another argument for diversity in research units (groups, departments, laboratories) – you need to have at least some creative people, but not all personnel need come up with new ideas.

The results confirm the centrality of creative abilities in research and that these are very difficult to learn or to improve (e.g. Jackson & Rushton, 1987; Tardif & Sternberg, 1988; Hennessey & Amabile, 1988). Creative researchers combine knowledge from different areas and think about their work and work-related puzzles almost constantly, which fits some of the descriptions in Taylor & Barron (1963). My informants particularly underlined the necessity of having very much knowledge for creativity. They did not exclude the much-debated «bolt of lightning» or «Eureka» experience (cf. Tardif & Sternberg, 1988), but those answering the question all connected this sudden insight to a previous long (and often unconscious) process of pondering and knowledge appropriation.

6.4 Motivation

It is obvious from the answers that motivation has an internal and an external side. For instance, a mathematician from the institute sector said, «Internal and external aspects play a role, most people depend upon both. Curiosity and recognition are the most important.»

6.4.1 Internal motivational factors

Almost all the informants mentioned inner motivation, dedication, curiosity, compulsion etc. as characteristics of researchers (particularly the good ones). A philosopher said that philosophy is «a possession. You ask yourself questions that you after a while discover are of a philosophical nature, and then you just [continue] doing it.» A mathematician from industry talked about «the joy of formulating and solving problems», while a professor of the same discipline stated that «nobody would have bothered to do mathematics research if they didn't enjoy it, at least I've never seen it». It can be seen that this inner drive to do research not only is a characteristic of the university personnel. Inner motivation plays a role in all sectors and disciplines, although there probably are differences regarding the contribution one wants to make (see below). Another industrial example is a chemist who claimed that motivation is based on «a genuine interest in the scientific field, it's as simple as that.»

A medical researcher from the institute sector elaborated how this commitment influences your whole life: «I guess it's that you become committed yourself and think [the work is] interesting. You're very excited about the next day, you want the night to be over as soon as possible so that you can run down and see the results in the counter machine.» Many other institute researchers talked about several types of inner motivation. A mathematician for instance said that good scientists have «an inner drive and a great personal satisfaction in solving the professional problems, as well as the possibilities for publishing it and doing something useful for others.»

Hence, a number of researchers have an «inner drive» towards utility value and applied science. This is most evident in the institute sector and industry, as well as in the discipline engineering cybernetics. A professor of the latter said that good researchers experience «an inner drive towards utility, that the research ultimately will come to some kind of practical use, a potential of applying the results in industry and otherwise for the best of society, for instance through medical applications». Still, even in this discipline there are differences, as elaborated by an institute researcher: «I believe the primary motivation is to be useful, to solve real problems and to become a good professional. Those who want to become good professionals and go to this institute are most often *more* oriented at utility than those who remain at the university.» A medical scientist from the institute sector talked about utility as well, stating, «I am so naive that I think it's the desire to achieve something. [*Interviewer: to make the vaccine that saves the world?*] Well, maybe not the *whole* world, but…»

An inner drive towards non-scientific ends was familiar to the soft sciences too. For instance, a sociologist from the institute sector maintained that «social idealism instead of strong scholarly interests is typical of [the motivation of] many social scientists». It is furthermore evident that motivation for utility has an effect on the work effort similar to a «basic scientific curiosity». An industrial scientist told, «we've had three people in the unit who've worked quite intensely all this autumn because they've wanted to succeed in the project [*which was described as highly practical*]. There's been a lot of late night work without pay.» It can again be added that many upheld both internal and external motivational factors. A chemistry researcher from industry said that good researchers are characterised by «the joy and desire related to developing new chemical products and achieving professional recognition».

6.4.2 External motivational factors

The external motivational aspects also have a «scientific» and a «non-scientific» side. In addition, a few of the informants mentioned pay and other tangible rewards as motivational factors. Some of the researchers discussed mainly recognition (not «dedication» or «inner drive»), for instance an industrial chemist who said, «A lot of it has to do with recognition, and that can have different meanings. Recognition among professional colleagues or satisfaction through seeing the utility value, that your results are used by somebody else.» Hence, it is natural to distinguish between recognition by peers and recognition by users. Furthermore, it can be claimed, in the words of a chemistry professor, that «for all people, no matter what kind of job you have, it's important to get some recognition for your work».

Recognition by peers was mainly mentioned in the university sector and can be claimed a fundamental element of basic research. A philosopher said, «it means very much to get the interest of others, recognition. It means a lot more that one I hold highly in professional regard is interested and positive towards something I've written than to get a salary increase or whatever.» All those who made this point stressed that it is the recognition in the *international* scientific community that counts. A chemistry professor said that motivation results from showing «that you're able to achieve results that others see as essential, to present this at scientific conferences where others are interested. So to get status internationally, that clearly is a significant matter.» Still, some also added that recognition is not enough – you also need to have an interest in the field as such: «people here radiate, or the tears flow when they don't get their articles accepted in the top journals, so that's a reward. But I'm not sure if it's strong enough to make you want to write another. You have to think that the work is fun and interesting and enjoyable in itself» (professor, clinical medicine).

In applied fields and institutions, recognition and feedback from users were often seen as essential ingredients in researchers' motivation. This can be tied to the «inner drive» towards utility value as depicted above. A chemist in industry elaborated it this way: «to have fun, (…) and to have contact with the customer and to get feedback and see that what you've done is appreciated and utilised, I believe that's very motivating. The worst is to sit and do a job and write a report and then nothing happens.» Hence, the «motivation process» – inner drive followed by recognition from other relevant actors – seems very similar both in basic and user-oriented research. In the latter, however, the researchers are rarely pleased with only producing publications. A biotechnology researcher from the institute sector underlined that «publications are not interesting unless you plan an academic career.»

A few other «external» motivational factors were mentioned. Two institute researchers mentioned salary when they discussed motivation. One of them, from economics, said, «You need to believe the work is fun, is interesting. But I would never have done this on miserable pay, you have to be able to live like people with a similar professional background.» Thus, pay may make some otherwise motivated researchers look for jobs elsewhere: «You don't have to be ahead of all others, but if you don't have comparable salary levels you lose a lot of talented people» (cybernetics engineer). Increases in salary and payment levels in general are discussed below in the section on rewards. Finally, a chemistry researcher in the institute sector discussed travels: «I travel a lot and that's an important motivational factor for me. If I hadn't had that opportunity I would probably have found something else to do.» Although nobody else mentioned this in particular as an influence on motivation, many informants discussed sabbaticals, international collaboration etc. (see chapter eleven).

6.4.3 Internal, external or both?

The discussion above shows that it is often difficult to separate «internal» from «external» factors, although the distinction made sense to the informants. Most of the researchers mentioned both when they discussed motivation. For instance, a philosopher maintained that motivation stems from «the desire to understand things, in wide perspectives, clear understanding. (…) And there may also be a fair share of ambition among good philosophers, the desire to become a star and to be recognised in a narrow, highly qualified group.» Other informants made similar points: «it's curiosity, and the potential for recognition and honour and fame through one's publications» (sociology, institute), «recognition among colleagues, and curiosity» (economics professor) and «it's the interest in mathematics, and maybe also the possible international prestige» (mathematics professor).

Most of the researchers elaborated both internal and external factors, while a few claimed that individuals mainly are influenced by one type of factors. For example, a chemistry researcher from the institute sector said, «For some, it's curiosity, for others it's to work together on an invention with a clear objective. For some, the career potentials are very important.» It can be added that recognition, although it naturally is defined as an external motivational factor, for the informants is tied to the quality of the research work itself. That the recognition should be «deserved» is taken for granted.

We have seen that inner motivation is very important in both basic and applied research, but that the drive in the latter type of work is stronger towards solving practical problems. This confirms that researchers, at least to some extent, choose their workplace/sector based on the type of professional work they prefer (e.g. Cole, 1979). It can be noted that (external) recognition was stressed more in this study than in Bailey (1994), but that some said that this again is closely tied to inner motivation. Behind this claim is perhaps the fact that the informants saw publishing research results as essential – «good research is not made for the desk drawer» one of them said. Inner motivation and recognition obviously form mutually reinforcing cycles. Researchers who do not get recognition for their work (regardless of its quality) will get dissatisfied and most often lose their motivation for doing research eventually (see Herzberg *et al.*, 1993). In other words, a «reinforcement» interpretation of the «Matthew effect» (Merton, [1968] 1973) is supported (see Fox, 1983). This does not exclude the accumulation of advantage interpretation – that those who receive recognition also gradually will get improved working conditions.

6.5 Individual factors and the quality elements

In several parts of the interview, the informants elaborated on quality elements and how these can be related to different individual and organisational factors. They were also asked to what extent they thought individual-level aspects alone determined the quality elements. The skills and competencies of the researchers are obviously judged as very important. Still, there is *something* the environment can do to influence quality. This point was underlined to various degrees by most of the informants. In the weak end of the scale, a sociology professor stated that «They [the quality elements] are all very dependent upon the individual. The culture you're in may affect all the quality elements, but they're nevertheless mainly determined by individual factors.» A cybernetics engineer in industry was a little more positive towards organisational possibilities for influencing quality: «All are very dependent upon the individuals, but all can also to some extent be influenced or assured by the organisation.» Only a few of the informants were markedly more positive than this. Thus, it is natural to claim tentatively that there are definitely limits to what the organisation can do to affect research quality. Questions of recruiting and possibly motivating/inspiring the individuals were nevertheless seen as central.

6.5.1 Originality

When we turn to the quality elements (cf. chapters two and five), originality was most strongly tied to individual-level aspects. The most typical response was: «Originality is very much determined by the individual researcher. The other quality aspects may to a larger extent depend upon the research *group* and the research *management*» (clinical medicine, institute). Originality was tied to terms like creativity (naturally), enthusiasm, and inspiration.

As mentioned above, most of the informants maintained that creativity is a given trait, while a few claimed that it to some extent can be learned. A mathematician in industry said, «You may be able to learn some creativity, but I really think that originality follows the individual. All the rest you should be able to learn or be told, although some people are more thorough by nature.» Others talked about how the organisation can influence the potential for creativity in individuals: «Originality is not so easy to learn. But you can easily imagine a climate that stimulates originality and another one that kills it. It may be easier to kill than to stimulate» (clinical medicine, institute).

6.5.2 Solidity

Regarding solidity, the sample can be split in two almost equally large groups. Around half of the informants tied solidity mainly to individual characteristics, while the other half claimed that it can be corrected or significantly influenced by the organisation. In the latter group, we for instance find a mathematician from industry: «Solidity can to a certain extent be learned and/or quality assured by the environment, that's why, among other things, we have a doctoral education.» Many informants compared solidity to originality. A sociologist from a research institute said, «solidity is easier to learn than the innovative», while a professor of the same discipline maintained, «Solidity is chiefly what we can correct through the doctoral training, (…) but there's not much more we can do. We can't create originality through structured training, originality will always be scarce.»

Those who connected solidity to individual characteristics often elaborated it with terms like persistence, thoroughness, integrity, knowledge, competence and experience. Solid researchers are «perfectionists» it was sometimes stressed. A cybernetics engineer from the institute sector upheld the non-routinised nature of research work as the main reason for the individuals' importance, «I believe solidity is closely tied to the individual. Of course you can have routines and all that, but since so much of the work we do is new and not routinised, very much depends on the individual who has to do the job properly.» A chemist from industry made a similar point, stating that you need to be able to trust what a researcher has done. He elaborated, «It is difficult to check everything a researcher has done, so again we need some kind of personal ethics, attitudes that have to do with honesty and integrity.»

6.5.3 Relevance

Scholarly relevance and utility value were much less tied to the individual researchers. The most frequent comment was that scientists can (or should) be told by others what is relevant, and/or that these quality aspects can relatively easily be promoted by the group or broader organisation of research (e.g. funding sources). A few informants claimed that relevance can be learned (as opposed to creativity and thoroughness), for instance a sociologist from the institute sector who said, «Scholarly relevance is possible to learn in the sense that you can learn techniques to familiarise yourself with what others are doing in the field.»

Still, it is evident (as was seen above related to motivation) that some researchers are more preoccupied with relevance, particularly external relevance, than others. An institute mathematician stated, «Scholarly relevance and utility value also depend on the individual, but more as a result of the interests you have than your abilities and competence.» Thus, it can to some extent be claimed that relevance is influenced by individual characteristics like (type of) motivation and professional interests. A sociologist elaborated a distinction between external and internal relevance: «It's easier to have a nose for what the politicians want [than what the scientific community wants], it's much clearer.»

6.5.4 The interface between the individuals and the organisation

We have seen that most of the informants connected originality to personal characteristics, and around half of them made a similar claim regarding solidity (albeit to other traits). The two types of relevance can more easily be assured by the group, wider organisation or even the research system, but to some extent these quality elements also depend on the interests and experience of the researchers. This could thus be an argument in favour of heterogeneous or diverse groups (see also chapter eight).

Nevertheless, we have also seen that there are ways for the organisation to influence quality. Creativity can be «restrained», «killed» or even «promoted», and solidity can be influenced by for instance routines and training (or the lack thereof). The organisation's role when it comes to «releasing the potential» in researchers and in promoting/restraining creativity and motivation, are the topics of the next subchapters.

6.6 Releasing the potential in researchers

«It's obvious that groups and departments release the potential in researchers, but I can't elaborate it more than that,» an economics professor stated. Good scientists are «easily killed», a medical professor stated metaphorically, while a professor of engineering cybernetics stressed that capabilities can be «both cultivated or killed». On the other hand, it was also claimed that «those who have a potential will have no problems in releasing it in a good research unit» (basic biomedicine, institute). To have «a good and stimulating working climate» in general may assure that the individuals' capacities are transformed into good research. Many informants specified the relationship further and mentioned processes related to stimulating young researchers, international contacts and acquiring good projects.

6.6.1 Taking care of the young: time, patience and feedback

When discussing what can be done with promising young researchers, many mentioned a combination of security and challenge. The young should be given time and possibility for long-term concentrated work, but at the same time receive challenging and autonomous professional tasks and continuous feedback on what they do. A sociologist from a research institute said that you should «give people possibilities and autonomy. Our structure here, where people most often start out as research assistants, may give people too subordinate tasks.» A cybernetics engineer from the same sector maintained, «Young people need to be allowed to concentrate within an area. They shouldn't have to jump too much from one area to the next. They don't become good researchers by doing that, although they may get a pretty good overview of things.» The doctoral study period and the years following it was by many seen as a time when the individual mainly builds up competence within a speciality. For some, this was also a question of resources. Doctoral students need to get «enough freedom and enough resources», professors from both hard and soft sciences stressed.

Many were slightly or even highly critical towards their own department or institution. For instance, a chemist from the institute sector said, «In our system, (…) you either become good or you don't become good, and it's mainly up to *you*.» This scientist wanted much more personal follow-up and stimulation, particularly oriented at the young. Here and in some other respects a tension can be seen between the seniors' need for autonomy and little «bureaucracy» (few formal rules and routines) and the juniors' frequent need for regular contact and constructive criticism.

It was unanimously underlined that autonomy and patience have to be coupled with feedback in order to be effective. A philosopher said, «You should give the young people who come to the discipline stimuli and time, read their stuff and encourage them, but still give them feedback.» It is interesting to note that this was stressed the most in disciplines where group work is not the norm, and the point was frequently made regarding all researchers, not only the young. It is probable that feedback and stimulation occurs more «automatically» in more formalised group settings than in soft fields with a more individualistic research venture. It was often added that critique and demands should not be too harsh. A sociologist from the institute sector stated that he had «seen several examples where people have broken down in organisations that run over them. You have to make demands, but with good will, you need good will in training, not the rough feedback and style that seniors often have towards each other.» A professor of the same discipline elaborated that the feedback needs to be as good as possible and that not all seniors may have the appropriate competencies to do so. He added, «Criticism and inspiration has positive effects, and here the unit can do much with its weaknesses for instance through establishing external contacts.»

6.6.2 International contacts

The issue of external, most often international, contacts was specified by many informants, particularly those working with fundamental research. «You need to include people in teams, preferably working towards international networks, from a very early stage,» a medical professor maintained. A chemistry professor underlined that all external experience is beneficial: «They [the young scientists] should be exposed to other units. One should for instance avoid inbreeding and stay-at-homes. They should be exposed to international groups, preferably stay abroad but at least stay at other labs.» Sabbaticals were clearly preferred to international conferences, and two professors (from mathematics and chemistry) stated that you may need to promise talented young researchers tenured positions to make them return.

International contacts were frequently linked with resources (this is elaborated further in chapter eleven). For instance, a chemistry professor said, «Mobility is important here [for releasing individuals' potential]; that you get travel opportunities. And that has a lot to do with financial resources.» To have some «money for travels and meetings» (clinical medicine, institute) was seen as important and relatively often lacking.

6.6.3 Good projects

In the applied institutions, projects were more frequently elaborated than international contacts. An economist working in industry stated, «You need competence development outside of the projects, and then of course you need to acquire exciting and good projects inside which you can develop.» For many of the applied researchers, competence development occurs chiefly through the work they do for others. Another economist said, «Our main strategy is to train people through the projects that they have. Of course, you can send people to seminars, stays elsewhere and such things, but the effects are often a bit limited. The most important contribution has to be the projects that we actually carry out.»

«Good projects» did not only refer to qualities of the projects as such, but also to aspects like continuity and consistency within an area. A biotechnology researcher from an institute said, «In the long run it's important to have adequate continuity and a continuous stream of contracts in an area to build competence.» A mathematician from the same sector underlined that it is beneficial that young people also take part in defining problems and in acquiring new research projects, because «people are very loyal and motivated if they've participated in defining the project».

6.6.4 Other organisational influences on individuals' capacities and capabilities

Some other influences should be mentioned. Three of the informants talked about various leadership elements. Two of these (both medical professors) stressed the importance of the supervisor in guiding promising young scientists. One of them, from a clinical speciality, maintained that «you learn to become a good scientist by your supervisor». The other, from basic biomedical research, simply stated that you need an inspiring and enthusiastic supervisor in order to become a good scientist. A chemist in industry said that researchers often become leaders without necessarily having the best social qualifications for the tasks, but that critical self-examination within the unit could be a way to avoid such problems.

A scientist working in a clinical research institute wanted a shift in the institute's policies to make it easier for the personnel to change jobs temporarily in periods of low motivation or morale. He elaborated, «People sometimes tire of what they do but can't switch because of the uncertainty. So I believe that you could do much good by reorganising the structure of positions here, so that people very easily could go on leave for two, three or four years. To work elsewhere and then return.» Another clinical medical scientist, from a university, wanted a change in the research fellows' social position through better pay and working conditions, to ensure that promising young people are motivated to do scientific work. This remark was also made by many other informants related to recruitment (see below).

We have seen that there are lost of suggestions when it comes to «releasing the potential» in researchers, particularly the young. A combination of «challenge» and «security» is generally preferred (cf. Pelz & Andrews, 1976). Young scientists need much time and shielding from activities other than their research, but at the same time they need critical feedback and exposure to the international scientific community. In the applied sectors, long-term projects and governing ideas behind successions of projects were often stressed.

6.7 Influences on creativity

A question was also asked about how the organisation can promote or restrain creativity. This subject was touched upon in many other parts of the interview as well (see for instance chapter twelve where quality elements are tied to organisational aspects). From the answers, it evidently is easier to restrain than to promote creativity, and there are various ways of doing that. A few did not think creativity could be influenced directly at all, e.g. a chemistry professor who simply stated, «I think it's something you're born with, so you influence it through recruitment.» In the positive end of the scale, several talked about freedom or autonomy, and cultural aspects, as beneficial to creativity.

6.7.1 Restraining creativity: bureaucracy, poorly managed programmes and poor leaders

«Bureaucracy» in its popular sense was often described as destructive. A medical scientist from a clinical institute for instance said, «The standard way of killing all creativity nowadays is this modern management, where you have to complete forms with goals and sub-goals and plans for just about everything.» The source of such bureaucracy was often described as external to the institution, or at the department level and above: «At the department level one technique of ruining creativity is to swamp people with bureaucratic trivialities» (chemistry professor). Too «strong» or «top-down» control was frequently mentioned as an aspect of a «bureaucratic» organisation. A few added that reduced creativity rarely is intended. For instance, a professor of engineering cybernetics stated, «a tight and inflexible organisation surely restrains it, and I think that in many R&D organisations, restrained creativity is an unintended consequence of other things.» Needs/rights of students and university employees in general may be a source of rules and routines that have negative effects on creativity.

Related to this are several comments made about programmes in the Research Council of Norway. A few were negative towards programmes generally, for instance a medical professor who stated, «You restrain creativity if you force people into externally defined frames like these Research Council programmes.» Others were critical towards the way some of the programmes are managed and controlled, for instance the way project proposals are judged: «You can at least restrain creativity. If you put too much weight on user interests and if accidental housewives from Toga (…) are going to sit and judge what's good research in these programmes, you restrain it. I've seen a couple of programmes where there are people [in the assessment committee] who obviously are incompetent about the research and all the methodological aspects» (economics, industry).

Poor leaders/leadership was mentioned by around ten informants. An economist from the institute sector said, «The conservative seniors that oppose all new ideas can very easily destroy creativity.» Regarding creativity, poor leaders are those who are too «authoritarian», «unpredictable» or «conservative» both in organisational and scholarly matters. «Shifty and unpredictable leadership is occasionally worse than authoritarian,» a medical professor exclaimed. However, another medical scientist (institute) claimed that leaders often face a dilemma because «young and inexperienced researchers often have poor ideas». Encouraging the young may be difficult to combine with what this informant regarded as necessary criticism of poor ideas. It can finally be mentioned that two scientists discussed negative effects of «too hard internal competition.» This may be bad for creativity (and quality in general) because «you keep things hidden from others, you're afraid to make a fool of yourself» (mathematics, institute).

6.7.2 Promoting creativity: freedom, culture, time and communication

Organisational aspects that promote creativity are largely the opposite of what was described above. To most of the informants, freedom or autonomy is the antithesis of «bureaucracy» and top-down control: «You have to provide people with freedom, you can't be voted down every time you propose something new» (medical scientist, institute).

This was often tied to the organisational culture and the working climate, which preferably should be *open* and *tolerant*. An economics professor stated, «The organisation can't be too dogmatic, it has to be open to new ideas,» and a sociologist (institute) said that the central element is «tolerance – you get so easily pushed down by formal demands and these things». Tolerance was mainly tied to being able to do «stupid» things, which was seen as a precondition for creativity by many. An economist from industry said, «It's (…) trust and encouragement and so on. One must be allowed to act a bit stupid, (…) or rather to try the opposite of what's common without being regarded as stupid.» The same was specified by a chemist in the institute sector: «If people feel insecure, unsafe, they won't be creative. You need tolerance and generosity.» This implies that lack of tolerance can be negative: «What may restrain [creativity] is the fear of making a fool of yourselves. You should always remember people for the best they did and not for the blunders they've made, and judge them on their best work» (economics professor).

Time was also mentioned by a considerable share of respondents, not least in the applied sectors where researchers often get tied up in projects with very specific goals and methods. A chemist in industry said, «You should leave some slack to be able to test out new ideas. If you can't test out new ideas all creativity will be killed.» The same argument was stated by a chemist in another company, who underlined, «I don't think creativity can be learned, but I think it's important that you have the right conditions, that you at least have the time to be creative.» The «right conditions» were elaborated with for example how much of the individuals' time should be «free», i.e. not allocated to any specific projects. Some basic researchers also made this point. A few informants suggested communication as beneficial to creativity. «You need active professional discussions to promote creativity,» a sociology professor maintained. A mathematics professor elaborated, «It has to do with communication – to have good seminars and lunchtime discussions about big problems, not details.»

6.7.3 Is the organisation actually important to creativity?

As indicated above, some of the informants were sceptical as to whether the organisation can influence creativity at all. For instance, a sociology professor said, «I believe that the unit may promote it somewhat, although creativity is largely dependent upon the individual. The effect of the organisation is limited, because you get shaped by role models early in your career. This tends to last and is often very difficult to change.» Another sociology professor thought that one should not focus too much on creativity. «I'm not sure what can be done, but I would like to say that you can't sacrifice solidity and other quality aspects to get originality.»

A chemistry professor stated that some people manage to be creative in extremely bad circumstances. To him, this did not imply that one should not try to promote creativity, but that the most creative and motivated scientists are able to flourish in almost any organisational environment. This was not indicated by any of the other informants. It should finally be mentioned that the answers are strikingly similar across sectors and disciplines. The processes by which creativity is influenced can thus be claimed to be the same in all settings, and the few variations seem to rest on differences in type and centrality of originality as a quality criterion.

These findings support somewhat the claim that creativity is more easy to destroy than to improve (cf. Hennessey & Amabile, 1988). It is still obvious that some organisational aspects like freedom (or autonomy, responsibility) and sufficient time often are seen as necessary for the transfer of creative abilities into creative research products, similar to the results of Andrews (1976). In fact, it may be difficult to distinguish clearly between individual and organisational aspects, given the close relationship between creativity, motivation and recognition from others, and the fact that creativity can be killed by the formal organisation of research work and by leaders of research units.

6.8 Rewards

To some extent, the question of rewards to increase the motivation of researchers has already been answered. It is probable that recognition from peers and/or users is the most important reward. The joy of doing research work can also be seen as a «reward» in itself: «Recognition, freedom, pay are not very important, fascination [with the work] is much more important [to motivation]» (professor, engineering cybernetics). In this subchapter, I discuss the informants' view of other rewards. Overall working conditions, promotion, pay, prizes and other formal «feedback mechanisms» were elaborated during the interviews.

However, it must first be mentioned that several informants thought that the question of rewards to sustain or increase motivation was somewhat meaningless. «Rewards don't matter, it's the inner motivation that counts!» a mathematics professor exclaimed. The point was probably made the strongest by a philosopher, who stated, «If you're not motivated, you can't be a researcher.» Still, although it can be asserted that «researchers are very motivated, their motivation normally is very high» (chemist, industry), most informants said that some researchers may have lower motivation or experience periods with low morale and dissatisfaction with their work.

6.8.1 Overall working conditions

The most frequently mentioned reward or means of increasing motivation was challenging projects and tasks for the researchers. «You have to give researchers challenges and let them have personal development. You should focus on [long-term] building of competencies,» a medical scientist in industry said. He wanted a plan for each individual to help ensure a string of interesting projects. Many made similar points. «You have to work to get projects about topics that people are interested in,» a sociologist (institute) said, while a mathematician in industry stated, «You need a fit between interests and projects one is set to do.» To some, finding the right projects was also a question of resources. A French language professor said the Research Council had made important initiatives: «You need to take care of the talents, stimulate them. The Research Council does it by earmarking certain funds so that people at least get a project and the breadth required to become a professional researcher.»

Time and freedom were mentioned in this respect as well. A mathematician from the institute sector maintained that a certain degree of freedom probably is more important than salary and possibilities for promotion. A mathematician from industry said, «Time is always a bottle-neck, and to find time to do research can be a problem even at the university.» His large company had recently established a «reward program» oriented at university researchers in fields relevant to its core areas of business. A group of scientists selected professors judged to have done particularly interesting work, and «bought them out» of all teaching obligations for some years.

The creation of «good working conditions» in general was proposed by a few. This referred both to the organisational climate and to satisfactory resource levels. A medical scientist (institute) remarked, «You need to ensure that people get the equipment they need, can participate at the most important meetings and present their stuff. That's a minimum.» A philosopher said that it would be motivating if at least one unit in Norway is internationally famous for good work. That would constitute «something to strive for» for researchers in within the unit and elsewhere.

6.8.2 Promotion

Only a few informants mentioned promotion as a relevant reward. A sociologist from the institute sector stated, «It could be a problem that people have to work many years to be promoted compared with alternative careers; it's demotivating to have so uncertain prospects for the future. A research organisation is surely not the only exciting place to work.» An industrial scientist talked about a specific career ladder for workers who desire promotion but do not want to have more administrative tasks. «In this firm we have something called the professional ladder where you are promoted in the hierarchy to advisor and specialist and further with still a purely professional position. I assume some researchers are motivated by this type of promotion instead of more time or pay.»

Finally, two of the medical professors claimed that career possibilities were interesting to many of the young scientists. One of them maintained that lots of people «look at the possibilities of getting a tenured position, and this possibility unfortunately is tiny these days». Thus, promotion is not very central in itself, but researchers may be dissatisfied when their prospects seem very poor compared with those of the same professional background with careers that would have been relevant for the researchers too.

6.8.3 Pay

Many informants were concerned with elaborating various elements related to pay, although the general message is that pay is not very important to good researchers. As in previous studies (e.g. Herzberg *et al.*, 1993), salary differences perceived unfair seem to be of more concern than salary levels *per se*. When relative differences increase, dissatisfaction sets in: «Pay is not important, (…) but it's important that you feel that it is satisfactory compared with what you would receive in other firms and other types of positions, especially as your competence and responsibilities increase» (mathematics, industry).

Nevertheless, a few informants did state that pay can be important. A medical scientist in industry said, «Pay could mean something but in this company the salaries are good [so it doesn't mean anything to me].» He did not want to exclude the possibility that some had chosen an industrial rather than an academic career partly due to salary differences, although he claimed for himself that his career choice was based on a desire to do «something useful». Pay seems to be the most important when there are alternatives for doing advanced professional (non-R&D) work in industry. In my sample, engineering cybernetics is the only discipline where this largely seems to be the case. A professor stated, «To some extent the salary matters. Contract research makes it possible to give the professors a decent salary. I could never have defended my work load to my family without the extra income from the contracts. I have also lost a lot of very talented people to industry because of the low pay here [at the university].» An institute researcher in the same discipline said, «Professionally there are many workplaces that are challenging to for instance doctoral students, so we can't have a much lower level than what they are being offered in industry or else we won't be able to recruit those we want.» A few of the researchers in other fields also mentioned the existence of interesting and advanced professional alternatives in non-scientific workplaces, particularly for those with an «inner drive» towards applied research/utility. A mathematician in the institute sector maintained that the gap between researchers and those choosing alternative careers had been swelling the last decade. Due to increased dissatisfaction among the researchers, he postulated, «Maybe the culture in research units is changing so that salaries will become increasingly more important. We may have to raise the salaries over time.»

Future recruitment was the argument made by almost all the informants in favour of higher pay: «I don't think more pay would be motivating, but it's evident that some people have left research work because they needed money. (…) And it's not obvious that those who did were the least suited ones for scientific work» (economics, industry). Several underlined that it is no secret that research work is relatively poorly paid, so that those who are «particularly preoccupied with salary are probably selected away early» (chemistry professor). Some informants indicated that those with the highest potentials for becoming good researchers, i.e. those with high inner motivation, choose a scientific career despite the salary outlooks. Still, nobody excluded the possibility of low salaries making science as a vocation less attractive to those who may become good scientists in the future.

When it comes to rewarding today's scientists, most of the informants did not think that increases in pay would have any effect. «Of course nobody would say no to more pay, but I don't think it would increase the motivation much among the researchers,» an economist from industry stated. A colleague in the same company said, «People aren't very preoccupied with salary. They may want a larger computer and stuff like that, but it's really unimportant compared with having good working conditions and a feeling that you're appreciated.»

A few researchers elaborated differentiated pay – that those who have done a particularly good job get a (higher) salary raise compared with others. «Differentiated pay may be motivating to some,» a chemistry professor maintained, and an institute researcher in the same discipline was positive to this type of reward, which had been discussed in his institute. A colleague of his added many words of warning: «This is a minefield. To demotivate one person to motivate another is a bad trade. All the reward systems you make must have effects that are acceptable to everyone. (…) It's not so important what people earn, but mercy on us all if this other one with the same degree as you [gets more], (…) then 5,000 kroner is a lot of money!» A mathematician from the same sector was also rather in doubt about this type of reward: «Differentiated pay is on its way, I think, and it could be the source of numerous conflicts.» Hence, it is evident that research organisations (still) are very egalitarian, making it difficult to establish highly differentiated reward systems.[2]

6.8.4 Other formal reward mechanisms

Some of the informants from the university sector wanted reward systems that to a larger extent identify the good researchers/works and give them recognition in one form or another, for instance in the form of increased resources for assistants or projects and less teaching obligations. A sociologist said, «I think that you have to get some kind of reward for international publishing and emphasise it more. Not necessarily punish others, but reward in particular those who publish internationally.» In industry, several discussed such mechanisms. A mathematician told, «We just awarded a research prize [internally], 150,000 kroner and a picture by a famous Norwegian painter. I think that at least was an inspiration!»

Recognition for publishing need not be linked with pay, resources, teaching etc. Celebrating a colleague's article in a renowned journal with a cake was mentioned by two informants. A mathematics professor said, «The applause of the masses is an important motivational factor. You should tell people when they have done good work. And then there's the satisfaction of seeing it in print.» Some researchers may have done good work without receiving appropriate recognition from peers or users. In these cases, there may be a role to play for the institute/department, although the role could be difficult: «You need to give people feedback and praise. And we need to be better at it than everybody else is. [But we're not, and] I think it has to do with the Norwegian way of being» (chemistry, institute). Three other respondents from applied units stated that «internal praise» is essential to motivation. This supports the finding of Mathisen (1989) – research institutes need to develop mechanisms for recognition between traditional academic recognition and user satisfaction.

Other mechanisms were also mentioned. A sociologist (institute) wanted a system through which the researchers are helped complete publications, as he had seen lots of interesting results only «made for the desk drawer». An economist from the same sector made the same point, and he wanted better opportunities for publication of scientific articles. This may be a particular challenge in institutes, where projects often are regarded as finished when a report has been published in the internal series.

A chemist in industry, who described a strong «inner drive» towards utility value, wanted improved communication between users and researchers to increase motivation. The point was elaborated further by a mathematician in another company: «You need to put the problems into a larger framework to give people insight into the complete objectives and an understanding of their role and that they can contribute with something.» This is the classic argument in the «human relations» approach to management aimed for instance at reducing workers' «alienation» (see e.g. Herzberg *et al.*, 1993).

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[2] It could of course be argued that the Matthew effect, as described in chapter three, is an extremely differentiated reward mechanism – a small minority of the researchers get a huge share of all scientific recognition, while a majority hardly receives recognition at all for the research work they do.

6.8.5 Macro-level variables

As a final comment, it can be mentioned that five of the informants elaborated features of the whole research system (or society in general). Most of them (all but one from medicine) talked about funding and were dissatisfied with perceived low levels of funding for research in Norway, compared with other countries. A medical scientist in industry suggested that to increase motivation among researchers, «Maybe you could spend more money in general [in Norway] on research. You could dismiss the Research Council and hand all the money to researchers!» A researcher at a basic biomedical institute said, «I think that the respect society shows science and scientists is very important. Obviously, the last year's lack of priority to research (…) can give negative attitudes, which may influence the creative process, the self-respect and the recruitment.»

As a brief conclusion, it can be said that the question of rewards is a highly complex one – there are many types of rewards and different needs for them among scientists. As a means of increasing motivation, factors of «challenge» (e.g. professionally challenging tasks) seem to be much more efficient than factors of «security» (for instance pay and promotion). It is obvious that people become less motivated without factors of challenge (cf. Pelz & Andrews, 1976) and that personal satisfaction from doing research (including professional recognition) is the most central reward for the best researchers (also found by Bailey, 1994).

Increased «security» (like a tenured position) is expected as a result of good research, but it is not likely to result in increased motivation. Lack of such job security may be a source of dissatisfaction, however. This may explain the dissatisfaction in research units in the Nordic countries that have had positive evaluations, which still did not bring e.g. increased resource levels (Luukonen, 1995). The organisation may have a role to play in striving to acquire challenging projects and in recognising good work, particularly when recognition is slow or absent from peers or users, particularly in applied settings (confirming Mathisen, 1989). It can finally be added that for young researchers with alternative career possibilities (who may not be less talented and motivated than those who do not consider alternatives to a scientific career), pay and promotion (or a secure position) can be a deciding factor (as found by Senker, 1999). Some of my informants furthermore claimed that pay (or more differentiated pay/higher salary differences) probably will become more important in the future.

6.9 Recruitment of good researchers

The question of recruitment received many long comments. This is obviously seen as a central policy (and sometimes practical) problem that needs to be addressed. In the discussion below, I have partly distinguished between sectors, because the recruitment challenges seem to differ between universities on the one hand and research institutes and industry on the other. Active recruiting and self-reinforcement, which researchers from all institutional settings elaborated, will also be treated.

6.9.1 The university sector: education/training, resources and making people stay

Around two-thirds of the informants from universities talked about education/training when they discussed recruitment. To guarantee recruitment of new researchers, a necessary basis is «to have students, and to encourage the bright ones» (philosopher). Continuity was stressed, «to have a constant influx of new personnel and students» (chemist). Furthermore, «The doctoral education is important. You need to create good working conditions for those with special talents. Send them out internationally» (economist). Another economist stressed, «You have to have good teaching and take good care of the recruits. (…) It's probably a bit more difficult here where things are a bit individualistic. So we do see from time to time that we miss out on talents.» Also others underlined that one has «to include the doctoral students in research activities and support them very much» (chemist), or you risk that the most talented research fellows choose alternative careers when they have finished their degree. An economics professor also saw the opposite problem – that some doctoral students get a research job too easily, without having had to prove their scientific abilities and motivation: «There is a danger in the Norwegian system that many get a tenured position immediately after their doctoral degree. It may lead to a poor choice of career.» To spot the talents and secure resources and projects to enable them to develop and later get tenured positions were points particularly underlined by the humanists.

The international dimension in doctoral training was important to many of the informants. A philosopher formulated the challenge in the following way: «In Norway, we don't have many possibilities for attracting people from other countries, so we have to try to take care of the ones we have. Give [the talents] scholarships, feedback. Stimulate them to go to very good departments abroad and hope they return.» To consider to industry, hospitals or other places for candidates was rarely seen as an option for the basic researchers, exemplified with the words of a medical professor: «You need to give people opportunities and get them going right after completing their [doctoral] education. You have to start early with science. You can't be somewhere else for ten years and then come back to the research unit. (…) It's important to get started right after the dissertation while you're still enthusiastic.»

A few comments were also made concerning education at lower levels. For instance, a French language professor said, «You should take good care of the teaching from the undergraduate level on (…) so that the students get interested in the topics at an early stage.» Others wanted focus on the initial phases of the school system: «You should teach philosophy in secondary education so that people get a very early feedback on their interests and abilities, both those that are good and those that aren't good enough,» a philosopher maintained. Three informants from natural sciences were worried about the future recruitment to their disciplines due to a general decrease in interest in science in the public. A mathematics professor elaborated, «As a dean I saw that we had a lot of trouble with the reforms in secondary education and the place of the natural sciences. (…) We want more probability calculations and more statistics because we're interested in an exciting form of maths that can ignite people early. You have to get [the natural sciences] well into the education at the primary level and it can't be standardised and sterile teaching. But I'm afraid it goes from bad to worse.»

Resources were also frequently referred to as means of recruiting: «Everything from salaries to equipment is important» (biotechnology professor). Others, particularly the humanists and medical scientists, discussed the problem of having resources for positions, to be able to hire «the talents» as research fellows, post-docs, assistant professors etc. A medical professor asserted, «It's more important to restrain the departures than to assure the supply. At present we don't have positions to offer, we have very few mechanisms to keep the talented research fellows.» Another professor from a clinical speciality made the same point: «You have to have these intermediary positions that allow people to stay in the research unit. We have good research fellows, brilliant scientists who have completed [their doctoral degree] and have a hard time [because it's extremely difficult to stay].» This seems to be a particular problem in medical sciences, and was mentioned by almost all informants from that field. Lack of basic resources makes it possible to offer only temporary positions, frustrating young scientists and making them choose other types of work. The problem was also described in other disciplines: «It's important to have associate professors to take over when the full professors retire. In this department, there's nobody to take the place of some of the oldest scientists. I have tried to make sure that nobody will notice it when I leave. Just consider – at sixty I am the youngest person with a tenured position in the department!» (biotechnology professor).

A final problem mentioned by some university informants, was the difficulty in making people move from Oslo to other Norwegian universities. The problem was elaborated by a sociology professor: «The best we can do is to underline that we have quite good working conditions and a quite good professional unit. (…) We compete when it comes to getting people out of the Oslo area and nobody succeeds in that. What is particular for Norway is the low level of mobility between the universities. It's one of the few countries with a system that makes it unrealisable to move (…). There are better mechanisms in the American system.» This informant felt that restrictions in where you can apply for your first tenured position (e.g. not the place where you took your doctoral degree) may be efficient. None of the other researchers made similar suggestions.

6.9.2 The applied sectors: links to universities and research possibilities

In the applied sectors, the starting point for recruitment is different. Here, you have to be able to attract capable researchers from elsewhere, most often from universities, whereas recruiting at universities often is an «internal» process. An institute sociologist said that to recruit, it is crucial «that the researchers have some links to the university, that they know what's going on and are talent scouts». A mathematician from the same sector made a similar remark: «You need contacts in the teaching institutions and you need to be active in your search for the right people.»

«Access» to the universities thus becomes central. A cybernetics engineer from an institute elaborated on the advantages of being co-located with a university department in the same discipline: «We can follow up on students. We have these unique possibilities by being so closely attached to an educational institution that has both advanced technological degrees and doctoral degrees. (…) What is important in that connection is to get good informal and personal contacts at the university.» Still, even without this physical closeness there are possibilities: «Of course you can do something. We have for instance participated much in doctoral training at Norwegian universities, particularly the old National Institute of Technology, and we have also to a great extent hired people whom we partly have trained» (mathematician, industry).

The other frequently mentioned point in the applied sectors was the attractiveness of the unit (institute, laboratory or centre). Many specifically underlined that the unit has to be known for professionally interesting work: «You have to make sure that it's attractive to do *research* in the unit, that people get the opportunity to do interesting things and to be in a good working climate» (mathematician, institute). To be able to attract good scientists, «It has to be attractive to *be* a scientist in the organisation, (…) to get possibilities for publishing, going to conferences. Good scientists want these things» (clinical medicine, institute). With the exception of technology, possibilities for publishing were mentioned in all fields. An economist complained that the best candidates from the universities rarely applied for positions at his institute. His solution was to «give people the opportunity to write articles and achieve professional recognition».

The ones who did not mention possibilities for publishing still stressed that projects should be professionally interesting and challenging. Institute researchers often specified the need for an institute to promote itself as a research unit, not a place for consultancy or other services to users. High pay was rarely seen as a relevant means of increasing the attractiveness of a workplace: «[In this unit we are able to] define what salaries we want (…) but we don't want people to come here only for the money» (economist, industry). Still, it was again stressed that units need to offer somewhat comparable salary to what the researchers would get in professional positions elsewhere. A chemistry researcher argued for differentiated (and high) pay to attract brilliant senior researchers from elsewhere: «Recruiting senior researchers is not very easy. (…) But if you consider a person who's able to solve the task you want solved, compared with having lots of people who can't do it, the difference is enormous. But the difference doesn't affect the pay.»

Some other remarks from the applied sectors are worth mentioning. A few informants said that researchers tend to stay where they are, even when they are hired «fresh» from the university. This implies that «you have to make very high demands when you hire someone. Here, we often hire quite young people, and we need to have a horizon reaching as far as their retirement» (chemist, industry). Others wanted a stronger focus on keeping people, mainly through offering better pay. Two argued that it is a problem that the best researchers often leave and the institute becomes «a concentration of mediocrity» (chemist, institute). Finally, a sociologist (institute) discussed the dilemmas of criteria for hiring new researchers: «I think our formal authority system can be a problem for recruitment. Maybe we put too much weight on written and published material – we recruit those who are decrepit instead of those on their way up.»

6.9.3 Active recruiting

Ten informants from all sectors elaborated what can be termed «active recruiting» – that the unit has to do more than just advertise vacant positions and judge applicants along certain dimensions. A mathematician from the institute sector stressed, «You need to have an overview of those who graduate in the field. The research directors who are good at recruiting the best are active, call people, get in touch with people in person when they are about to finish their degree. That flatters people.» A sociologist from the same sector said that instead of just announcing positions «like we do now, you could contact people more directly». Even a couple of university researchers made such remarks. A professor of clinical medicine said, «We have to (…) be on constant lookout for new talent. We have to search for students, young medical doctors and social scientists. Clearly we can be more active here.»

A few informants were also concerned about the research unit's public image. «We may have to use the media more and more and market ourselves as a workplace,» a biotechnology professor remarked. In the same vein, an economist from the institute sector said, «An institute like this should promote itself both in professional networks and in general discussions in society, so that outsiders see us and may want to work with these things.»

6.9.4 The most common response: self-reinforcement

Still, the most common response across sectors and disciplines was that good research units attract good researchers. Many informants talked specifically about «self-reinforcement» and an «automatic process». «A good unit attracts people, so there you have a positive feedback mechanism. But all the other factors matter. Salary plays a role, as does the working climate in general,» a cybernetics engineer (institute) said. This does not necessarily mean that to promote the unit is unnecessary: «You have to market yourself, but good research fellows are often self-generating; they attract others» (medical professor).

A chemist from industry said, «You have to expose yourself and receive recognition as a good research unit and thereby attract skilful scientists. Geography and payment is not very important for clever scientists, but a good professional climate is.» Others also made similar remarks about geography, but occasionally added that the effect of attractiveness is valid nationally, but not internationally. A mathematics professor said, «The good units attract people, at least on a national basis.» This informant did not believe that the «international capacities» in any field arrive because of the pay or the resources. «You have to hope for some kind of attachment to Norway, that they have a family who wants to live here or something else.» Another mathematics professor elaborated, «Oslo may have advantages nationally, but not internationally.» Although the department had been able to attract a few «foreigners», this professor did not believe that the resources or possibilities (e.g. for pay at an international/U.S. level) were sufficient to attract many eminent scientists internationally. Thus, the problems of attracting such scientists did not reflect the quality of the Norwegian units (according to the six who discussed the matter), but rather problems with language/culture and obstacles in offering internationally comparable salaries.

Finally, it can be repeated that some informants did not see recruitment as the main issue, but the ability to keep the talents. «Recruitment often comes automatically when a unit has become good. What has been difficult here is to get tenured positions, we have doctoral students and seniors but we lack the intermediary level,» a medical scientist from the institute sector said. A colleague from a university elaborated, «Recruitment is a very important question. (…) The problem is often that you *are* able to recruit good scientists, but you don't have funds or possibilities to *keep* them [after the doctoral degree].» Several were worried about perceived changes in the research system towards ever more user-controlled programmes, less autonomy and decreases in resource levels. «It's very difficult to build up a good unit, and it's very easy to destroy things,» a chemistry researcher (institute) said. A medical scientist from industry said that to insure long-term recruitment, «You can lower the interest rate on student loans, you can initiate tax deductions for R&D expenses in companies and you can increase the funding for the universities.»

In brief, it is evident that the question of recruitment is not isolated from questions of rewards, training of young scientists and the quality of the research organisation in total. In U.S. studies (e.g. Blau, 1973), pay was found to be the central explanation for recruitment. Because of the egalitarian salary system in Norway and the low prestige differences between institutions (cf. Thagaard, 1991), this is not the case here. A few informants expressed frustration over this system – they stated they were unable to offer competitive salaries to attract the people they wanted, or that the gap between the pay as a doctoral fellow or post-doc and an external career made it difficult to keep the most talented graduates. Lack of positions was seen as another problem, and the frequent use of temporary work contracts for the young was stressed as a barrier against keeping the talents, particularly in medical fields (this was also found in Senker, 1999). As has been found in many previous studies (for instance Blau, 1973; see also Merton, [1968] 1973, Zuckerman, 1977), there is a strong dynamic process behind recruitment – the best research units attract good scientists. Some of the informants stressed that good research units nevertheless often actively get in touch with prospective new employees and market themselves as good workplaces.

6.10 Discussion

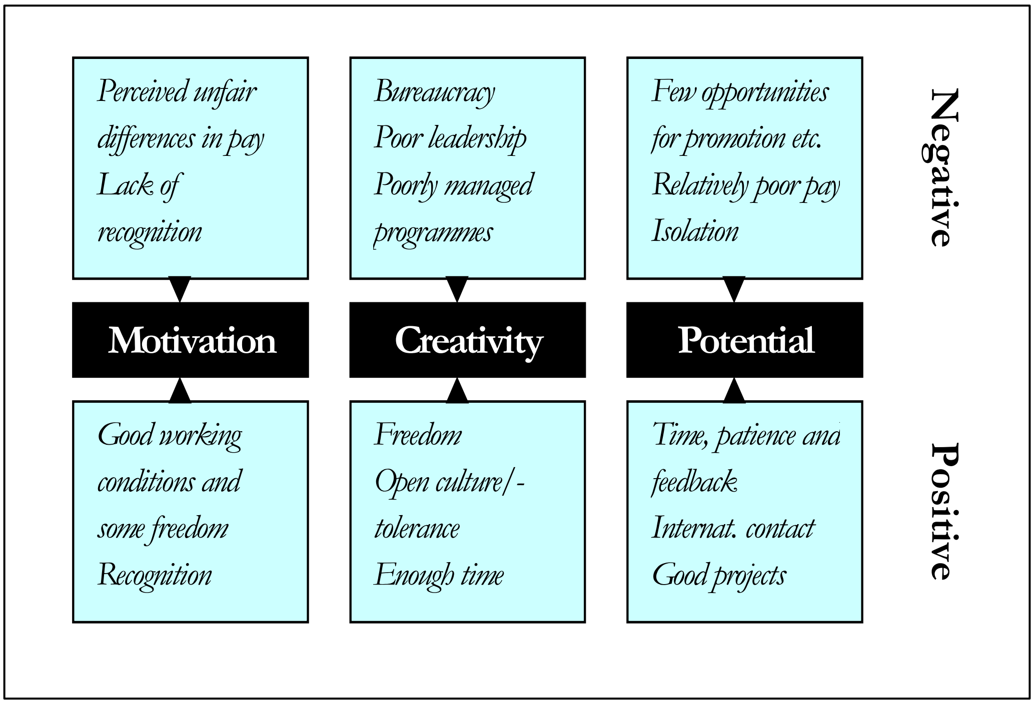
Four research questions or propositions concerning the individual level were specified at the end of 6.1, and they have been elaborated throughout this chapter. They are discussed below along with some other central themes that emerge from the empirical material.

Good researchers may or may not have certain traits in common. Still, individual characteristics obviously do not exist in a vacuum but are embedded in social contexts. We have seen that an «archetypal» researcher does not emerge from my data. Researchers are not a uniform group, and they depend in various ways on recognition, stimulation, motivation, abilities, skills etc., just like other professionals. Some general features that support previous findings can nevertheless be mentioned. Good scientists are highly motivated for research work (e.g. Blau, 1973; Pelz & Andrews, 1976; Fox, 1983; Jackson & Rushton, 1987), they have immense workloads (for instance Harris & Kaine, 1994), and they often work on several problems/methods and tasks simultaneously (e.g. Pelz & Andrews, 1976; Zuckerman & Cole, 1994).

Many of my informants made strong claims about the necessity of communication skills and «general social skills». This does not fit very well with some earlier studies where good scientists are portrayed as not very preoccupied with people and not necessarily equipped with good interpersonal skills (see Stein, 1963; Fox, 1983; Jackson & Rushton, 1987; Reitan, 1996). A new role for researchers could be emerging. This new role demands a person who e.g. interacts much more, works continuously in groups and shares results and publications with others (in some disciplines, this would of course not imply a «new» role, although a higher degree of interaction than previously was sketched also in hard and applied fields). These characteristics need to be given weight when hiring new researchers, it was claimed. Some informants were critical as to whether today's criteria and mechanisms for recruitment are able to capture interpersonal skills and abilities to a satisfactory extent.

In spite of this interactive role for scientists, research quality was tied strongly to the characteristics of the individuals – their creativity, motivation or dedication, persistence, intelligence, knowledge and much more are crucial for the quality of the final products, particularly for their originality. However, these characteristics obviously do not exist in a vacuum. The informants sketched many different ways by which the organisation can destroy, and to a lesser extent improve, aspects like motivation and creativity. I have summarised some of the suggested relationships in figure 6.1 (where potential refers to how potentially talented young researchers can be influenced).

Figure 6.1. *Organisational influences on some individual characteristics.*



It is difficult to make strong claims about the link between individual characteristics and sub-elements of research quality. From the creativity literature, it is natural to propose that originality will be tied closely to the individual. Creativity is essential in research work, and many studies conclude that creativity is easy to destroy but hard to promote. We have seen that most of the informants connected originality with personal characteristics, and around half of them made similar claims regarding solidity. Still, they are tied to different individual aspects like creativity and persistence. The two types of relevance can more easily be assured by the group, the wider organisation or even the research system, but to some extent also these quality elements depend upon the interests and experience of the researchers. Nevertheless, we have seen that there are ways of influencing quality for an organisation. Creativity can be «restrained», «killed» or even «promoted» (probably more difficult), and solidity may be influenced by for instance routines and training (or the lack thereof).

Although individuals largely determine research quality, no informant mentioned a lack of talented researchers. On the contrary, many stated that there is no shortage of e.g. good doctoral students, but that it may be difficult to keep them after they have completed their degree. In addition, talented students may «waste» their skills and abilities in a research unit that does not provide them with sufficient amount of feedback, support and time – a combination of challenge and security (cf. Pelz & Andrews, 1976). These early years in a scientist's career were by some described as crucial for the quality of future research products, or for the desire to do scientific work at all. Because formal systems for taking care of young researchers often are lacking, much can depend on colleagues and not least on a supervisor/mentor. As Thagaard (1991) has described, one can perhaps sketch a mutually reinforcing process in early years between motivation and the support from the organisation, and subsequent involvement in science and high organisational activity (contributing to the unit's qualities).

Such a dynamic process can also be seen connected with motivation in general. Inner motivation and recognition strengthen each other. Researchers who do not get recognition for their work (regardless of its quality) will get dissatisfied and eventually most often lose their motivation for doing research (see Herzberg *et al.*, 1993). In other words, a «reinforcement» interpretation of the «Matthew effect» (Merton, [1968] 1973) is supported (see Fox, 1983). Another important point connected with motivation is that inner motivation is very important in both basic and applied research. This confirms that researchers, at least to some extent, choose their workplace/sector based on the type of professional work they prefer (as found in Cole, 1979).

Inner motivation resulting from scientific curiosity, the joy of doing research work etc., is most likely more central than external motivation resulting from rewards outside of the work itself, although scientific recognition could be important. We have seen that inner motivation is very important in all types of research – also for those who perform applied and user-oriented work. For such researchers, the «inner drive» towards solving practical problems is strong. This confirms that researchers, at least to some extent, choose their workplace/sector based on the type of professional work they prefer (e.g. Cole, 1979). Attempts at making universities do more «applied» research or institutes do more «basic» research, could thus be futile.

It can be noted that (external) recognition was stressed more in this study than in Bailey (1994), but that some again tied it closely to inner motivation. For some researchers, it is in fact difficult to separate clearly between motivation for doing research and recognition in the scientific (or user) community. As a means of increasing motivation, factors of «challenge» (e.g. professionally challenging tasks) seem to be much more efficient than factors of «security» (for instance pay and promotion). It is obvious that people become less motivated without factors of challenge (cf. Pelz & Andrews, 1976), and that personal satisfaction from research work (including professional recognition) is the most central reward for the best researchers (was also found by Bailey, 1994).

Rewards like salary and promotion are not attached much weight by eminent scientists, but they may mean more to young researchers and to those in temporary or non-tenured positions. Recruitment can be linked with vicious and virtuous circles (reinforcement effects). In simple words: good researchers attract other good researchers. The interview data support the distinction between younger and older scientists regarding rewards. The issue of recruitment and rewards can be separated into two problems. On the one hand, there is the challenge to recruit and/or to keep young researchers. In universities, this becomes a question of having students at all, of training them well, and of having positions to offer them when they have completed their degrees. Many informants, particularly from medical disciplines, talked about a lack of positions for younger scientists. In the applied sectors, the recruitment of young scientists may be based on the research unit's connections to relevant university departments (nationally) and what possibilities the unit can offer for research work (e.g. equipment, professional climate, international recognition).

On the other hand, there is the issue of recruiting senior/eminent researchers. To attract (permanently) internationally leading scholars was described as extremely difficult. Poor opportunities for offering competitive pay were claimed a central reason, another was the remoteness of Norway, its language and culture. Recruitment of senior researchers nationally was also seen as difficult. In the egalitarian Norwegian system, few structural aspects provide incentives for moving from one institution to another. Hence, senior researchers tend to remain where they are or move for reasons other than pay, promotion or the perceived prestige of the research units *per se*.

Still, comments from some informants, particularly from the institute sector, indicate that salary (and more differentiated salaries) and opportunities for promotion now are becoming increasingly more important tools for attracting and keeping researchers. It is noteworthy that even if pay was not seen as central to motivation, creativity etc., many elaborated this issue at length. The informants stated that pay becomes more crucial when there are interesting job possibilities outside of research work. A reason for this development in institutes in particular could be that this sector is doing ever more short-term and consultancy work, and thereby the difference between these organisations and commercial firms is reduced. New «modes» of knowledge production (e.g. Gibbons *et al.*, 1994) could also imply that research institutes get increasingly integrated in innovation processes, where research is only a small part of a larger whole. This could lead to the emergence of professionally interesting non-research jobs. Still, only the informants from engineering cybernetics stated that the

Ph.D. candidates with a strong interest for the discipline as such can easily find positions outside of R&D units in universities, institutes and a few large companies.

Differentiated pay is a very complicated issue, and some informants warned that it would lead to many personal and harsh conflicts in a research system with strong egalitarian culture and traditions. Some authors have on the other hand argued that differentiated rewards are beneficial for working life in total because more positions become interesting (e.g. Herzberg *et al.*, 1993), even though differences can become highly visible. This can be tied to the discussion about the «Matthew Effect» in science and whether it is meritocratic or not (see e.g. Cole & Cole, 1973; Merton, 1988). More rewards, recognition etc. to a few good researchers may lead to the production of some very good, but can have negative effects on the research system as a whole. A few researchers could become more motivated and/or get improved opportunities for doing research, while the majority might be dissatisfied due to perceived «unfair» differences. Is it better that a few produce better research while many get reduced possibilities for «excellence»? My informants, largely representing a scientific elite in Norway, disagree on whether increased differentiation (implying a concentration of resources) at the individual level would be beneficial. This dilemma is also obvious in contemporary research policy initiatives like «Centres of excellence».

7 Leaders and leadership

Most of my informants did not describe leaders and leadership as having essential influence on research quality. In fact, many who mentioned this aspect claimed that leaders mainly have negative effects on quality.

7.1 Previous studies of leadership in research units

Many earlier studies have found leadership at the group level to be important to performance. The competence and personality of the unit head was one of two main determinants of performance in Andrews (1979a), and the experience of the group leader was central to group productivity in some natural science and technology groups at Swedish universities (Stankiewicz, 1979; part of Andrews, 1979a). Stankiewicz found that good leadership influences positively both the cohesiveness of groups and their effective maximum size. An analysis of all university research groups in the same data set concludes that leaders have important tasks related to planning and integration and to shaping the unit's culture (Knorr *et al.*, 1979b). Several studies tie leadership to the question of size of research units (e.g. Pelz, 1963; Etzkowitz, 1992; see chapter nine).

Investigations have elaborated beneficial effects of having a «good» leader (e.g. Jacobsen, 1990; Spangenberg, 1990b; Asmervik *et al.*, 1997; Bennich-Björkman, 1997) or that the researchers' «satisfaction» with the leader improves performance (Singh & Krishnaiah, 1989). There are, however, also studies where leadership has not been found particularly important or positive, not even at the lowest organisational level (for instance Pelz & Andrews, 1976; Spangenberg *et al.*, 1990a). One example is that individual creativity may be destroyed by a leader's goal-setting (Pelz & Andrews, 1976). Another finding is that leaders very rarely can make substantial changes in a university department, except when the unit was established very recently (Kekäle, 1997). Related to this, Pelz (1963) found that leaders only have influence (both positive and negative) if the members have a «sense of belonging» to the group (cf. also Stankiewicz, 1979). Researchers seldom mention improved leadership as a way of improving quality (e.g. Martin & Skea, 1992; Kyvik & Larsen, 1993). It is obvious that these issues need closer investigation.

7.1.1 Meanings of «leadership» and similar terms

One critical issue is that terms like «leadership», «leader» and «management» may be repositories of a large number of different meanings. The fact that many researchers seem to detest bureaucratisation and tedious administrative tasks may influence studies of such issues (including the present). Some of my informants were obviously of the opinion that a «leader» is a person, role or function that is (or should be) found only in industry, the military etc., and not in research units. I do not constrain myself to such a perception, but in general assume that research, as all other human actions, is not foreign to phenomena of leadership.

Still, it is evident that «the tradition of academic freedom and the lack of leadership training have given each leader and staff more or less broad scope to follow their own ideas, visions, and assumptions about good leadership» (Kekäle, 1997:211). The history and traditions of a research unit or institution may form strict limitations in this respect: «There is a lack of deliberate and well-planned leadership at the universities, partly due to the traditions prevailing where self-guidance is strongly defended and leadership easily could be taken for control» (Bennich-Björkman & Rothstein, 1991).

An uncontroversial assertion is that scholarly authority and scientific competence are more important features of group leaders in academe than in the institute and industrial sectors (e.g. Knorr *et al.*, 1979b). Some have called this «authoritative» as opposed to «authoritarian» leadership (Premfors, 1986). Strengthened «academic leadership» is frequently found in policy documents as a means of improving research quality in the university sector. An example is Stortingsmelding no. 39 (1998-99), which states that «the most important quality assurance initiative within universities and colleges will (…) be the further development of scholarly leadership functions at all levels» (p. 131).

In the management literature, a conceptual distinction is sometimes made between «task-oriented» and «supportive» leadership (see e.g. Knorr *et al.*, 1979b; also Yeh, 1996, who distinguishes broadly between leaders who «tell» and leaders who «listen»), or simply between *management* and *leadership*. The first-mentioned terms refer to an orientation towards results and goals, while the latter ones imply an orientation towards people and the relations between them (Kekäle, 1997). Along a similar dimension, one can separate between «organisational» and «intellectual» leadership. In academic units, the two clusters of functions are often closely integrated, and the term «academic leadership» often encompasses both «organisational» and «intellectual» tasks (*ibid.*). A large international study found that «professional competence» is more central than «managerial competence» to research unit performance, while they are equally important when it comes to meeting time schedules and budgets (Nagpaul & Gupta, 1989). It is concluded that managerial competence nevertheless is required for research unit leaders, but that it is much less important than professional competence. It should be added that there is a long and unresolved debate in the literature concerning the importance of «personality» or «native abilities» for leaders (cf. Nord & Fox, 1996).

7.1.2 The leader's tasks

Normative recommendations from empirical studies often imply that research managers in all institutional settings should strengthen *supportive* leadership by acting as co-ordinators rather than apply authority directly (e.g. Yeh, 1996). «Directive» or «task-oriented» leadership would conflict too much with strong traditions and desires for autonomy in research units of all types. Several other authors also stress that a leader has important social or supportive (in a more general sense) tasks in a group. An example is Etzkowitz (1992), who states that the professor «has the task of raising or supporting the confidence of the junior members of the group» (p. 41). One of Etzkowitz' respondents described his «biggest job» as being a «psychologist» to «keep up the spirits» of the others in the group. It has been claimed that this «human relations»-oriented management side gets more important with increasing task and environmental uncertainty, which may particularly be the case in the soft sciences (Neuman & Finaly-Neuman, 1990). Research leaders in universities have been found to have the most supportive leadership style when compared to the other sectors (Yeh, 1996).

Still, perhaps the central task of the group leader (or professor), particularly in the university sector, is to *supervise* the junior researchers, frequently indicated as a prerequisite of performance (e.g. Zuckerman, 1977; Reskin, 1979). A remarkable share of Nobel Prize winners had worked under the supervision of former Nobel Prize winners (Zuckerman, 1977). Early studies found a strong relationship between scientific performance for younger scientists (in different institutional settings) and their «intensity of interaction with supervisor» (Pelz, 1963:308). In general, the doctoral study is a period where strong norms and values concerning scientific conduct and standards are internalised by the individual (in a socialisation process) (e.g. Braxton, 1991; also Berger & Luckmann, 1966). The task of the supervisor has been described as learning to recognise good work and to reward it appropriately (Herzberg *et al.*, 1993:136).

An interview study among Norwegian university scientists found that half of the researchers in «good environments» had a motivation for *organising research*, i.e. actively try to improve the research environment, establish contacts, recruit talents etc. (Thagaard, 1991). The other half of the scientists in good units was mainly interested in performing research. Two leader roles were distinguished. The «entrepreneur» devoted much time to organising teams, obtaining resources and assistants, and establishing contacts. The «network builder» directed her or his activities mainly towards other institutions or countries. It can be added that both the entrepreneurs and the network builders had significantly higher average rates of publications, than scientists mainly oriented at performing research. Hence, it seems that leadership not necessarily precludes participation in research, quite the contrary.

Nagpaul & Gupta (1989) found that some characteristics of leaders were important across the studied countries. Good leaders had a high degree of professional expertise, they communicated much with researchers both in their unit and externally, they had good planning abilities and they played an «integrative role». In applied research units, the leader's communication with potential users and understanding of their needs was crucial.

7.1.3 Negative and indirect influences

On the negative side, it has been claimed that seniors may be less receptive to new ideas with increasing age and hence, that seniors can «restrain» the intellectual development and the creativity of juniors. However, this effect, termed «Planck's Principle», has not been supported empirically (cf. Levin *et al.*, 1995). Some authors have nevertheless argued that university leaders in general have a lot to learn from highly innovative firms, and questioned the ability of universities (and the way they are organised and managed) to promote creativity (Bennich-Björkman & Rothstein, 1991).

Knorr *et al.* (1979b) found that leadership had an important *indirect* influence on research performance in technological and natural science groups in universities sector. The «supervisor's quality» affected both the group climate and the planning and integration of the unit's research program, both directly related to performance. Thus, the «human relations» thesis – good leadership leads to high «morale» which in turn leads to high productivity – is confirmed, also in other studies (e.g. Hare & Wyatt, 1988). The relationship is significantly stronger in technological groups, explained by less uncertainty and more integrated «production technologies» (Knorr *et al.*, 1979b). Yeh (1996) also found leadership to have an important influence on the job characteristics of individuals in a research unit, while Nagpaul & Gupta (1989) stressed the leader's role in creating team spirit and «ethos for innovation».

A Finnish interview study in four different academic disciplines tied the issue of leadership to the culture of the department and discipline (Kekäle, 1997). In this investigation, a «leadership culture» was defined as «a group's set of (leadership) patterns, features and traditions as well as the values and assumptions on which these patterns have apparently been based» (p. 15). A central hypothesis and finding was that the «action space» of the leader was more determined by the local culture than the culture was determined by the leader. Four main types of leadership cultures were identified, with main focus on, respectively, collegial and democratic structures, leading groups, strong individual leadership and differentiated or ambiguous leadership cultures.

Finally, it is important to stress that leadership is also influenced by other organisational aspects. Some authors have thus proposed a more «implicit» theory of leadership, where the actions taken to be evidence of leadership are the ones that are typically expected to be performed by leaders and not by others. Leadership is then not a quality in the leader, but rather a cognitive construction of «followers» – their implicit theories of leadership (see Nord & Fox, 1996 for a review).

7.1.4 The department head

At the department (or similar) level, only few studies of these issues exist. According to Mintzberg (1983), the professional administrators in universities and similar organisations have key roles at the boundary of the organisation, between the professionals and for instance governments and various associations. The administrators are expected to protect autonomy and function as a «buffer» against external pressure, but they are also expected to «woo» outsiders to get moral and financial support. This is also the primary role of the top manager in an «adhocracy», which is an organisational design often found among research institutes and industrial R&D divisions (*ibid.*).

It has been claimed that personal characteristics of the department head are of little importance to the scientific quality of the department (Dill, 1986). However, this may depend on the age of the unit – investigations have found that department heads have relatively large possibilities of influencing and changing a unit when it is fairly young (Kekäle, 1997, see also Laredo, 1999). It can also be argued that the high quality of some research units at some periods of time, e.g. the Cavendish laboratory in Cambridge and the Copenhagen Institute for Theoretical Physics, are at least partly due to the leadership of some particularly eminent scientists (Rutherford and Bohr in these specific cases).

A study of public and private technological R&D institutes in the U.S. indicates that the institute leader plays a central part also in the development of scholarly activities (Allen *et al.*, 1988). Investigations of disciplinary differences have concluded that department chairs in hard (or high-consensus) fields emphasise goals related to teaching and research, while those in soft (or low-consensus) fields emphasise goals connected with departmental climate and administrative processes (cf. Braxton & Hargens, 1996:30-31).

7.1.5 Brief summary

We have seen that terms like leader, leadership, management etc. can be defined and elaborated in numerous ways. Traditionally, the leader is a specific person (or position, role), but leadership can also be viewed as a number of tasks or as a cognitive construction of an organisational unit's members. Based of studies of leadership in research units, we can make the following propositions:

- Leadership is probably more important in universities than in applied sectors (this organisational aspect has displayed a stronger correlation with performance in academic research units).
- Leadership will mainly have an indirect effect on research quality by enhancing e.g. «morale», motivation or organisational culture.
- Relevant types of leadership (like «directive» versus «supportive») are likely to vary between academic fields and units, based on e.g. the unit's age, size and the uncertainty connected with tasks and environment. When there is a high degree of uncertainty, the «supportive» or «human relations»-oriented management becomes more important.
- At the department (or similar) level, the leader's role is much more externally and politically oriented, but it is not obvious whether leaders at this level also have important scholarly tasks.

7.2 Leadership at the group/project level

The informants were asked, «Can you describe a good leader of a research group in your field?» and «Is group leadership important to research quality?» Ten researchers did not answer, mainly because research in their field was not conducted in groups (none of the humanities researchers answered). Some of the informants from the university sector took a professor with doctoral students as a starting point for the question. One of them, from economics, added, «We don't have any leaders, only supervisors.» In general, the term «leader» did not give as clear associations in the university sector as in applied units. For instance, a biotechnology professor who talked at length about different aspects of leadership, added, «I do not like the word 'leader' (…) because the leader should not *lead* too much, simply be there.» It seems that the questions for some were interpreted as mainly concerning «formal», «directive» or strictly «task-oriented» activities. Around half of the respondents tried to describe a colleague whom they considered a good leader, while most of the others gave a more «idealist» elaboration (and some of them laughed at their own seemingly unrealistic demands).

7.2.1 Leadership characteristics, tasks and functions

Some of the most frequent descriptions of what a good leader should do and should be, were as follows (roughly in order of frequency):

- Inspire the group members.
- Broadly arrange and organise the group's activities and shield the members from too much administrative and other (non-research or other scholarly) tasks.
- Co-ordinate the work and supervise and give feedback to the group members.
- Be a «uniting» factor, create «team spirit».
- Be enthusiastic and extremely dedicated and hard-working.
- Have an external orientation with contacts among users and/or the international research community.
- Have social skills, be easy to get along with, able to listen, be patient, generous and tolerant.
- Tackle personal conflicts, not afraid to step in and try to solve such issues.
- Initiate new activities and have the persistence to see work completed.
- Obtain contracts/funding.
- Be engaged in recruiting new researchers, active when it comes to getting in touch with talented, potential group members.
- Select, prioritise and formulate problems for the group (this was mentioned only by two informants, both from basic biomedical research).

It is noticeable that the informants put much very weight on social and supportive tasks and functions. The leader portrayed in the above list is only to a limited extent «task-oriented» or «directive». Obviously, a supportive role is central in all institutional settings, not least in the university sector connected with supervision of doctoral students. In other words, the main task of group leaders seems to be quality assurance, not quality control. A few informants talked about a conflict between a leader's formal responsibility (and thus task of control) and the vital informal support. For instance, a medical researcher from the institute sector said, «You have to stimulate, motivate, inspire and supervise, and at the same time you have to control – so the task is impossible or at least extremely difficult.» Many university researchers indicated that formal control almost by definition leads to loss of motivation.

That the supportive role was strongly stressed does not mean that scholarly competence was seen as unimportant. On the contrary, many emphasised that it is impossible to imagine a group leader without high formal competence. A sociology professor for example said, «The leader must have clear and indisputable competence and must be confident of own qualifications, so that the leader does not feel threatened by the group members' work or cryptic questions.» Many of the activities and tasks in the list above are based on formal competence, like feedback/supervision and keeping in touch with the research frontier internationally. Co-ordination of the group's work was often seen as the central scholarly task for the leader (instead of own separate research). A professor in engineering cybernetics said, «Co-ordination is fundamental, for instance getting nine doctoral students to do nine original world-class theses that together form a world-class research product.»

In addition, it was often underlined that a group leader should have a certain personality or certain social skills. «The researchers can be social nitwits, but the leader cannot,» a sociologist in the institute sector stressed. A professor in engineering cybernetics claimed, «Long research experience is necessary, but experience in life is even more important.» Inspiration and stimulation have more than a scholarly side, and dealing with personal conflicts and being tolerant towards new ideas and approaches require skills that do not necessarily emerge from research experience.

Furthermore, the leader has tasks that do not require particular personal abilities or professional experience. A biotechnology professor said, «It is important to spend quite some time solving non-scientific problems, to understand budgets and funding and such things.» Many informants from all institutional settings underlined that the leader «should take most of the administrative work» and «shield» or «spare» the group members from these tasks.

Still, there are obviously many different ways of approaching the leader's role. In many units, getting someone to take care of central leadership functions seems much more central than the leader *per se*. «In practice, one person cannot fill all the necessary functions anyway,» a chemist in the institute sector stated. The composition of the group and the personality and experience of the leader influence the way tasks are distributed. An informant from a technological institute said, «If you have a leader who is also a very talented researcher, then he takes a different role than a leader who is not equally strong in the field. The latter has to leave more of the marketing and project acquisition work to others.»

7.2.2 Non-interference in the university sector

In the university sector, the ideal leader at the group level seems to be a modest or laid-back senior researcher who can take responsibility and make decisions when needed, but who does not «block the light» or «expose him-/herself too much». Especially for the senior personnel who are not leaders themselves, non-interference is expected of the leader.

However, the opposite of non-interference is often expected related to the junior personnel. A professor in mathematics described the leader's main task as «igniting the fire in the young people». Still, this was mainly related to intellectual and social support, not to strong control or «giving orders». «A good group leader means everything, he/she has an enormous impact. I have been in groups abroad where the professor was the main enemy and the doctoral students were slaves; it did not lead to good research,» a biotechnology professor said. He added that giving honour and confidence to others, for instance through co-publications, is important. Another aspect was underlined by a professor in clinical medicine: «One should be sensitive in realising when the young researchers get their first hurts, for instance in the form of tough referee comments, to avoid their entering an unproductive phase or getting depressed for too long.»

The «American ideal» was promoted by another medical professor: «The leader should be the opposite of the old German professor who's not able to delegate and [not able to] view his colleagues as co-workers and helpers.» This informant liked the high degree of teamwork in U.S. universities. «If I sift good and bad ideas too much it's only my little brain that contributes to creativity, and that can't be the best for the unit,» a technology professor stated.

Although non-interference is expected by many senior university researchers, the leader is also often seen as a role model or example to the others. It was often underlined that the leader should be extraordinarily enthusiastic and have an enormous interest in the professional work as such. Not only doctoral students, but also more senior colleagues benefit from a group leader who maintains very strict quality standards. Thus, it seems that leadership can influence the norms of research units. It can be added that there are no clear disciplinary differences in the answers concerning group leadership (apart from the lack of group work in the humanities – but here, several informants wanted «good decision-makers» as department heads, see 7.3 below).

7.2.3 Is leadership more important in applied sectors?

The «model» aspect was also underlined in the applied sectors. A brilliant scientist, who is also friendly, will always inspire and motivate others, several institute and industry researchers stressed. The general impression is that the applied researchers viewed leadership as *more* important than the university professors did. Explanations can be that the latter may not always have considered supervision of doctoral students a leadership task, and that there was a higher frequency of group work in the applied sectors.

Still, there were many exceptions in institutes and industry – a third of the informants did not view group leaders as having important influences on research quality. «Researchers are often very independent and a bad leader leads more to frustration than necessarily to bad research,» a mathematician in the institute sector said. A technologist from the same sector claimed that a really bad leader can be quite destructive, but that the researchers in general are much more important to the institute than the leaders are.

Good formal competence was seen as a necessity also in applied settings, the opposite «only leads to frustration» or to «large culture crashes». This may not always be easy to accomplish, though, and many informants said that the best researchers are not necessarily the ones who become group leaders. A medical researcher in industry said, «The people who have a special interest in administrative work often become leaders here, and that is not always favourable because they can't give the best feedback or make the best professional decisions.» As in the university sector, it is expected that the leader carries out some research work («half-time» some specified), at least on the level required to remain updated in the field. This can also be a challenge. A researcher in engineering cybernetics in the institute sector said, «This is extremely difficult to accomplish in practice (…). The leaders that emphasise both [administrative and research tasks] have to work almost impossibly long hours.»

7.2.4 How is group leadership important?

Although less than half of the informants said that leaders are central to quality, there were still many more who upheld the influence of leadership on the questions analysed here than in open questions concerning good research units (cf. chapter twelve). Even those who did not consider leadership a pivotal factor often added that it may be important in *some* cases. Why were leaders so rarely discussed in the open questions?

One possible reason is that leadership, as mentioned, mainly was seen as an indirect influence on research quality. Leaders can affect the team spirit or group climate and the members' motivation and dedication, and the leader's enthusiasm and work standards may be a model for others. Hence, good leadership is often not directly conducive to the quality of the group members' work. Leaders can obviously influence how researchers (particularly the young) can release (or not release) a potential for becoming good. Still, it seems that the junior personnel may find other partners or models than the leader of their group. Furthermore, my informants all come from well-established research units. Given that leaders only have significant influence in the start-up phase of a unit (cf. Kekäle, 1997), this could be a reason for their not mentioning this organisational aspect as central.

Another explanation can be that most group leaders are not likely to influence research quality, as they are neither extremely good nor very bad in their job. A sociology professor added, after giving an idealist description of a leader, «The leader is of course not particularly important to research quality unless the leader is a champion in the field.» In other words, an extraordinarily talented individual that also has the right social skills can have very positive effects – be a «motivational factor» in the terms of Herzberg *et al.* (1993). Similarly, a researcher without the necessary formal competence and without social skills can have a destructive influence. These two extreme cases may be rare, and the interviews indicate that the very good leaders are the rarer of the two. The combination of high scholarly talent and very good social skills seems particularly uncommon. Long research experience might not increase other important features like tolerance and openness. It can be added that the group leader has a very difficult task. A chemistry researcher from the institute sector said, «Leading researchers is like leading a herd of donkeys that all want to go in different directions: it is a relatively ungrateful task.»

More «ordinary» leaders do not influence quality very much, but may facilitate other's working conditions, for instance by doing a good administrative job. Hence, it seems that most group leaders are «hygiene factors» (cf. Herzberg *et al.*, 1993), laying the foundations for motivation and satisfaction, but not in themselves contributing in a very positive way. Or in the terms of Pelz & Andrews (1976): very good and very poor leaders pose challenges (in a positive and negative way, respectively), while group leadership in most other cases can be regarded as a factor of security.

7.3 Leadership at the department level

The same questions as in 7.2 were asked regarding the next level in the hierarchy (department in the universities, most often the institute in the institute sector, and section, department or centre in industry). Two informants did not answer due to lack of time, and a further fourteen said that leadership at this level is completely unimportant to research quality. One of them added, «in Norway», referring to alternative ways of organising university departments found in other countries. In general, the answers were quite brief, another indication that this is not a very central aspect of good research organisations.

7.3.1 External and political orientation

A clearer role emerges for the department head (or equivalent) compared to the group leader. Department leader is a position that is much more «political» and externally oriented. Most informants sketched a role in national research policy or strategy-making in the firm, and some simply stated that they described «a good politician». «This leader should be a kind of Minster of Foreign Affairs,» a chemistry researcher from the institute sector elaborated, while a colleague said, «He or she has other places to go, for instance the Ministry of Industry and the Ministry of Research and Education.»

Others talked about a «marketing function», where the leader is seen as the organisation's representative in the outside world. Related to this is that many informants described a person who is «visionary» and «full of initiative», «visible» in industry or other sectors, able to «manoeuvre» between different interest groups and able to «reduce tensions». Some added that the leader has to be trustworthy and «not sneaky», and they indicated negative experiences with leaders who had failed to maintain the political balance considered necessary in departments with diverse interests.

Although the department head mainly has political and administrative tasks, almost all informants underlined that research experience is necessary also at this level, mainly «to understand what we are doing here» (stated this way by three different informants). Some still found it problematic that the unit's «best» scientist becomes department head, because this position does not seem to include any time for own research activities. In addition, it is generally expected that the leader does not participate in scientific decisions at all. This point was particularly underlined in industry, where some informants indicated that they had had very negative experience with leaders who had tried to overrule technical decisions made by the research groups. The combination of administrative skills and research experience is not very common, some of the university researchers claimed. One of them, from mathematics, argued that departments should be of a certain size so that the chances of getting a capable department head were higher. Another one, from medicine, argued for higher salary, so that the department would get a qualified leader at all.

7.3.2 Resources and administration

In the university sector, many said that the department head is central when it comes to acquiring and allocating resources. At least the level of basic funding seems to some extent to be influenced by the leader of each department. It was also added that the distribution of resources should be «just». A professor in French language simply said, «The department head should make sure that we all are well and have enough money.» In fields with high levels of external funding, particularly technology and the natural sciences, none of the informants talked about resources connected with leadership at the department level. The need for a marked department leader may be greater in soft fields with little group work.

«Tidiness», «administrative skills» and efficiency or «getting things done» were the most frequent specifications of the leader's desired characteristics regardless of institutional setting. «Shielding» was again mentioned, and the ability to separate the important matters from the unimportant. The leader should make sure that the administration and other non-research functions are carried out as unproblematic as possible, and that the infrastructure is good. In the universities, the department head also has a number of tasks related to the educational side. Some of the frequently mentioned supportive characteristics of group leaders, like enthusiasm, inspiration, patience and ability to listen, were mentioned at the department level as well.

A characteristic that was frequently emphasised in industry (and somewhat in the other sectors) was that the leader at the level above groups and projects should have a strong uniting function. One chemistry researcher talked about «creating a common identity», while another upheld «disseminating common goals, strategies, and visions» as a central task. It could be that cross-disciplinary units (as most of these in industry were) imply larger challenges in creating a common identity. Another explanation is that these comments arise from the management practices often found in industry. A few institute researchers said that the leader should facilitate cross-group communication and scholarly development programmes within cross-disciplinary fields.

Still, the department leader is obviously not a very central aspect of research quality promotion, but the influence may be indirect and long-term. Terrible leadership at this level can lead to frustration, political conflicts over resource allocation or much administrative work if the individual researchers are asked to solve unimportant matters. Good leadership may promote a common identity and an adequate working climate and lead to a relatively steady flow of basic funding. These effects can be important, particularly in the long run, but rarely lead to good research by themselves.

The specifications above confirm Dill (1986) and Kekäle (1997) – the department head is not very central to research quality. Political and external tasks are the most important ones for the leader, and he/she in many ways forms the link between the organisation and the environment (institution, the wider research system, other significant actors). Many of these descriptions fit the theoretical literature very well (e.g. Mintzberg, 1983; Scott , 1992). However, it can be claimed that a very eminent, visible and politically powerful scientist may make a large difference (like at the group level). The informants indicate that these people either are rare, or that it is difficult to make them «take their toll» as department heads.

7.4 Discussion

In 7.1, four propositions regarding leadership were put forward, and they have been discussed in 7.2 and 7.3. The propositions are revisited below.

(Group) leadership is probably more important in universities than in applied sectors. It can be claimed that my interview material does not support this, although my type of data is of course not very well suited to determining such questions. Informants from applied units discussed the

leader's role more than the university professors did, and the former were also generally more inclined to state that the leader is important to research quality. One reason for this finding could be that the ideology of free inquiry and «non-managed» research still is very strong in the universities (cf. Bennich-Björkman & Rothstein, 1991; Kekäle, 1997), while managed research is the norm in applied institutions. Another reason could be that the university informants did not view activities like feedback and supervision, project acquisition, maintenance of contact with the international community and co-ordination of scholarly work as necessarily the leader's tasks (or as having anything to do with leadership at all).

Still, the ideal of non-interference or the «non-leading leader», particularly in the university sector, poses a challenge for recent policy initiatives oriented at strengthening leadership (e.g. Stortingsmelding no. 39, 1998-99). A clear specification of leadership tasks and responsibilities is most likely required to avoid conflicts and misunderstandings based for instance on different perceptions of what a leader is and what this person should do.

Leadership will mainly have an indirect effect on research quality by enhancing e.g. «morale», motivation or organisational culture. This is largely supported. Many informants commented that the leader can affect the team spirit or group climate and the members' motivation and dedication, and the leader's enthusiasm and work standards may be a model for others. But it is also evident that leaders can influence how researchers (particularly the young) can release (or not release) a potential for becoming good, although junior personnel may find other role models than the leader of their group. There is a tension between senior researchers' expectations of non-interference and many junior researchers' need for systematic and regular feedback, social support and assistance with network building. Group leaders may thus experience a role conflict where the tension probably has to be balanced. Such dilemmas are in many other respects inherent in the leader's role – for instance between social support («being kind») and formal control (like keeping budgets and deadlines, critical comments on people's work etc.). In applied units, a tension can furthermore be seen between the promotional system that often implies that the best researchers do not become leaders, and the many scholarly tasks that remain in the leader's hands.

Other investigators have found that supervisors/leaders are often made villains in stories about low morale and poor results, but they are not made heroes in stories of high motivation, productivity and work success (Herzberg *et al.*, 1993). Thus, it could be that investigations based on people's accounts (interviews, surveys etc.) tend to underestimate the role of the leader. I have nevertheless hypothesised above that most group leaders are not likely to influence research quality because they are neither extremely good nor very bad in their job. Extraordinarily talented individuals with the right social skills can have very positive effects, and researchers without necessary formal competence and social skills can have a destructive influence. These two extreme cases may be rare, and the interviews indicate that the very good leaders are the rarer of the two. The combination of exceptional scholarly talent and social skills seems particularly uncommon. More «ordinary» leaders do not influence quality very much but can facilitate others' work conditions, for instance through a good administrative job. Hence, most group leaders lay the foundations for motivation and satisfaction, but do not by themselves contribute in a highly positive way. In the terms of Pelz & Andrews (1976): very good and very poor leaders pose challenges (in a positive and negative way, respectively), while group leadership in most other cases can be regarded as a factor of security. If «exceptional» leaders are indeed lacking, policy measures like strengthened leadership and some types of «centres of excellence» may be difficult to implement.

Relevant types of leadership are likely to vary between academic fields and units, based on e.g. the unit's age, size and the uncertainty connected with tasks and environment. When there is a high degree of uncertainty, the «supportive» or «human relations»-oriented management becomes more important. It is difficult to find clear evidence about this question in my data. All my informants put very much weight on social and supportive tasks and functions. The «ideal» leader is only to a limited extent «task-oriented» or «directive». Still, it is interesting to see that many of the informants from the soft fields, particularly from the humanities, emphasised the need for a good and visible department head. From the interview data, I have the impression that this is more due to the lack of formalised group work than to a higher degree of uncertainty.

Related to the strong emphasis on supportive leadership, it was often stressed that a group leader in particular should have a certain personality or certain social skills. This was elaborated in various ways, for instance by referring to «empathy» or «experience in life». There is more to inspiration and stimulation than a purely scholarly side, and dealing with personal conflicts and being tolerant towards new ideas and approaches requires skills that do not necessarily emerge from research experience. In fact, several comments indicate that the most eminent researchers may not necessarily have the best general managerial skills, making the election or appointment of a leader a very difficult chore.

At the department (or similar) level, the leader's role is much more externally and politically oriented, but it is not obvious whether leaders at this level also have important scholarly tasks. It is evident that the department head's main duties are very much oriented at the department's environment. This person participates in the institutional and/or national struggle for resources and has a lot of administrative responsibilities that require tidiness and efficiency. Poor leadership at this level can lead to frustration, harsh political conflicts and/or much administrative work for the individual scientists, but does not directly lead to low quality research.

Department leaders need to have research competence, although their position does not seem to imply any time for own scholarly activities. In applied research organisations, the leader above the group leaders is also seen as having a strong «uniting» function by creating a common identity, common goals etc. A few university professors stated that an alternative organisation of department leadership, which at the present moment was seen as a low-status task to be rotated among the senior personnel, could make the department head a more important figure and a stronger influence on research quality. Similar to the group level, a very eminent, visible, and politically powerful scientists can make a large difference. Comments from the informants indicate that these people may be rare or unwilling to take the position as department heads.

8 Formal organisational factors

Previous studies have had both broad and specific perspectives on the formal organisation of research work. Here, I will focus on three main issues: autonomy, diversity (at the group and department level) and formal routines for assuring, controlling and improving quality in research units.

8.1 Previous studies of formal organisational aspects

It should first be mentioned, as in chapter three, that to conduct research work in groups has been the traditional mode in the natural sciences, technology and medicine, but this is increasingly becoming the norm also in the social sciences and the humanities. It has recently been argued that the central unit in the research system is the «lab», which could be one group or several groups working closely together (see Laredo, 1999). Furthermore, I assume that industrial firms and probably also some research institutes have a form of matrix organisation, where individual researchers at the same time «belong» to a specific project as well as a group or section more based on professional background (or overall problem etc.).

8.1.1 Autonomy or freedom

Autonomy is often named as a basic characteristic of research units, frequently in addition to a «loose organisational structure» (e.g. Pelz & Andrews, 1976; Premfors, 1986; Yeh, 1996). The literature on creativity furthermore defines autonomy as a fundamental prerequisite for creative work (cf. Tardif & Sternberg, 1988; Hennessey & Amabile, 1988). It can be expected that researchers generally do not like «bureaucracy», particularly if it takes time away from the research activities (see Spangenberg *et al.*, 1990b; also Martin & Skea, 1992).

However, a strong focus on individual autonomy has also been described as typical of low-rated university departments (Andrews, 1979a; Bennich-Björkman, 1997) and poorly performing industrial and governmental R&D project units (Kim & Lee, 1995). It seems that in high-performing units, autonomy is coupled with a «common vision,» «strong group cohesiveness», active «supportive leadership», «a lot of interaction» or «external pressure». (cf. e.g. Pelz, 1963; Pelz & Andrews, 1976; Kim & Lee, 1995; Bennich-Björkman, 1997). Some authors have argued that researchers may use their autonomy for many other purposes than creating good research (Bennich-Björkman & Rothstein, 1991).

8.1.2 Types of diversity

Diversity in general is found beneficial to performance. This issue is perhaps particularly interesting to focus on, as it may be relatively easier to change than many other organisational aspects (see Andrews, 1979c). The causality question is also somewhat clearer. It is more difficult to envisage diversity as a major result of performance than for instance level of resources, contacts or dedication.

In the study of Pelz & Andrews (1976), researchers who devoted some time to teaching and/or administration outperformed the ones whose sole activity was research. This was evident in all disciplines and institutional settings, and the positive effects of having many different *tasks* were strongest for engineers. A Finnish study of university personnel found that teaching and administration were not considered major hindrances to research, «contrary to popular belief» (Stolte-Heiskanen, 1992). In a recent large international survey (of almost 12,000 scientists in several countries), it was found that time spent on teaching did not negatively affect publication productivity (Teodorescu, 2000).

The informants in Asmervik *et al.* (1997) upheld diversity of *people* as a characteristic of good research units. Kyvik (1991) found that research assistants had a positive effect on productivity in the natural sciences and medicine. Still, a large study of clinical research units found no differences between high and low-performers in the units' composition, i.e. age, sex and rank of group members could not explain the (large) differences in ratings (Spangenberg *et al.*, 1990b).

Thus, there are several different types of diversity. Andrews (1979c) studied diversity related to for instance tasks/activities, projects, disciplinarity, methods, people (age, seniority, skills etc.) and funding. None of these alone displayed a strong relationship with performance, or a strong correlation with each other. Interdisciplinarity, engagement in several scientific specialities, to have multiple projects and funding sources, and arrangement of the work so that researchers do several different R&D activities and/or professional functions, were all related to performance at a modest level. However, Andrews found that units that were diverse in several respects, performed much better than «homogenous» units (also when adjusting for type of unit and controlling for size). Five reasons for the beneficial effects of diversity were put forward: it provides useful intellectual resources directly, it provides knowledge and skills that contribute indirectly, it enhances self-guidance (better perception of problems and their solutions), it gives opportunities for productive fallow periods (when one works on several projects simultaneously), and it may offer more security.

How diversity of people can be organised in practice, is another question. One way is to have a large percentage of temporary staff, something that is becoming ever more common (Senker, 1999; Laredo, 1999). A constant turnover of staff has been found beneficial because it provides a steady influx of ideas, techniques etc. However, negative effects of temporary contracts may be that continuity in research is threatened, curiosity-driven research may be reduced and promising young scientists are likely to select other careers (*ibid.*).

At the next organisational level, only few studies of issues like diversity exist. Some of the literature that has focused on the size of departments (see chapter nine), indicates that departments just as well could be «composed» for educational and for administrative purposes (see Trist, 1972; Martin & Skea, 1992; Kyvik, 1995).

8.1.3 Formal quality-oriented routines

Disregarding the peer review system, little literature has dealt with the issue of formal and unit-internal measures of quality control, assurance, and improvement. Some studies indicate, however, that for instance formalised discussions may be beneficial to quality, and the researchers often suggest such ways of quality improvement (Allen, 1977; Jacobsen, 1990; also Kyvik & Larsen, 1993).

Formal means of quality assurance include routines for reading and commenting proposals, various types of «good laboratory practice» and possible certifications of the unit's or institution's system for quality management. Quality control should mainly be related to a unit's outputs, for instance through rules connected with commenting different types of manuscripts before they are formally published. Formal quality improvement measures may for instance be activities aiming at improved communication or creativity.

8.1.4 Brief summary

A number of organisational characteristics can be defined as «formal», i.e. possible to change through explicit decisions made by research unit members, leaders or policy-makers. I have chosen to focus on three issues that are much discussed in the literature: autonomy, diversity and routines for quality assurance and control. The following propositions can be deducted from earlier studies:

- A high degree of autonomy is a typical feature of good research units. However, the literature also stresses that autonomy should not be unrestricted. Good research units can also be characterised by a high degree of interaction with others, a strong common and ambitious vision, and/or user orientation or external pressure, all traits that «modify» or balance autonomy.
- Diversity (at least at the group level) is generally seen as good, both related to people and to tasks. There is a need for better understanding of how diversity is beneficial to quality.
- Little is known about formal routines for quality assurance and control, but researchers are frequently in favour of for instance formalised discussions as a measure of improving quality.

8.2 Group work, project work and general comments

I start the empirical discussion with the informants' elaboration of group work, project work and some general features of the formal organisation of research units.

8.2.1 Group work in most of the disciplines

All informants but one answered the question «Is it common for researchers in your field (and institution) to work in groups?» In industry and in the institute sector, the response was «yes» (apart from in the sociology institute), and in the university sector, only researchers from the humanities and the social sciences answered «no». The traditional individualistic research venture in the soft sciences seems to be maintained, at least in the Norwegian institutions represented here. A summary of the answers can be found in table 8.1.

Table 8.1. *Group work?*

Field/ Sector	Humanities	Social Sciences	Natural Sciences	Technology	Medicine
University	No: 6	No: 2 Yes and No: 4	Yes: 6	Yes: 5	Yes: 6
Institute		No: 3 Yes and No: 1 Yes: 2	Yes: 6	Yes: 6	Yes: 6
Industry		Yes: 3	Yes: 6	Yes: 1	Yes: 2

Those who answered «yes» often added positive comments about group work in general. «It is simply extremely important,» a mathematics professor said, while a biotechnology professor stated, «All those who do good work in this field work in groups.» «I am not sure if it is common everywhere, but I have had the luck of being in a group,» a mathematics researcher in the institute sector commented. Even many of those who answered «no» frequently discussed benefits of working together with others. Two humanities professors mentioned seminars in the department that formally and regularly brought people together, while another said that collaboration is always fruitful. Thus, although research may still be individualistic in some fields, close contact with colleagues is seen as very positive.

In engineering cybernetics, two of the three university researchers underlined that the department was not *formally* organised in groups, but that doctoral students and their professor in all respects functioned as a unit. For these informants, it was important to maintain the distinction between informal and formal group work, because the latter seemed to be tied to «bureaucracy» and lack of autonomy.

The three sociology professors all expressed that group work is not very widespread, but that it is becoming ever more common, for instance related to externally funded projects and international comparative studies. One of them warned against turning all research into group work, because «sometimes you gather the information better in only one head». The economics professors gave similar answers, where temporary groups connected with particular projects are increasingly prevalent. An interesting distinction can be seen between the two social science disciplines. In sociology, the institute researchers discussed an equally (if not more) individualistic research venture as those in the university sector. In economics, group work was described as much more common in the institute sector. One reason for this distinction could naturally be special characteristics of the selected researchers and institutions. Another explanation may be that the distinction between basic and applied research was very clear in economics, but not in sociology (cf. chapter five). An economist from the institute sector, who said that group work was common at his workplace, added, «But we still do sit much by ourselves.» Three other social science researchers expressed the same.

In industry, many of the informants used the terms «group» and «project» interchangeably. For around half the respondents from this sector, projects seem to be the basic level of organisation. The individual researchers may belong to a larger organisational unit, either oriented at a broad problem area or based on a scientific/technical field. In all cases, efforts were made to ensure collaboration. «Although our projects vary much in size and duration, we always try to turn them into teamwork,» a chemistry researcher said.

8.2.2 The significance of formal organisational aspects

The researchers were also asked questions about formal organisational factors and their significance in general. Not everybody felt confident to give answers (18 non-responses), but some gave a long and thorough elaboration on different aspects. Particularly in the institute sector and industry, the discussion of such matters seems to be common. Several informants mentioned that their institute, department or firm had had internal debates about the distribution of tasks, work rotation, group and department size, qualifications of leaders etc. The general impression from the interviews is still that informal aspects of the research units were described as more important than the formal ones. An industrial researcher in chemistry for example said, «I am certain that the importance of the formal organisation is overrated.» A cybernetics engineer in the institute sector stated, «The informal is what matters. The formal organisation doesn't have too much influence on quality, but it's important that the total organisation up to the top management works well and doesn't create frustration.»

Furthermore, the question was obviously understood differently, or the informants referred to different levels (group, whole institute etc.). On the one hand, a mathematics researcher from industry upheld, «The research organisations I know are all largely organised in the same way.» On the other hand, a sociologist from the institute sector asked, «Are any research organisations similar? The places I know are very different, and I think that leadership has a lot of influence [on that]. But in general it is important to have a loose structure and an open organisation.» It was also claimed that there is no optimal organisation of research work. «You have very authoritarian groups that work well and very flat or democratic groups that work well, so I do not think there is a definite answer to that question» (chemistry researcher, university).

8.2.3 Decision-making, work rotation and outsourcing

Some general issues were raised in answers to questions on formal organisational factors (apart from autonomy, diversity and routines discussed below). A cybernetics engineer from the institute sector was concerned about the decision-making process and that it should be democratic: «Many research units consist of people with very strong opinions and very strong needs to discuss matters and get their opinions through. So I believe it is essential to think about how decisions are made, the decision-making process is the most important thing, not the organising as such. (…) People should at least get a chance to express themselves. To force a decision on somebody does not work well here.» In this and in some other interviews, negative experiences with the top management of the institute, firm or department, were expressed.

Another institute researcher, from mathematics, talked about beneficial effects of work rotation: «Rotation of routine tasks and much freedom, combined with much responsibility, is typical for the best research institutes.» A chemistry researcher from the same sector wanted a clearer differentiation of work. He said, «I have seen a lot of examples of lack of work differentiation (…), that researchers do everything from cleaning the test tubes to writing the report. I think this can be a very poor utilisation of resources, so you should at least organise yourself so that you get an appropriate utilisation of your resources.»

Finally, some of the industrial researchers talked about outsourcing or the dilemma between doing the R&D work in-house or getting others to undertake it. All those who discussed this matter, expressed that getting a research institute or consultancy firm to do some R&D work is necessary in periods of huge work loads and much pressure, and that it in general can be a good way of transferring knowledge to the firm. However, strong positive effects of performing a high portion of the work internally were underlined. A chemistry researcher said, «We have increasingly conducted research and development on our own (…), and this has been important also for our self-respect and that we trust we can do things ourselves. We have seen a number of cases where research over several years has led to an insight in the field adequate to find solutions to concrete problems that the company has had, and that you never would have come up with otherwise. You might not have done research on that concrete problem, but you have developed a satisfactory background to solve it anyway.»

Regarding group work, the above findings support much of the investigations on disciplinary differences (e.g. Trist, 1972; Biglan, 1973b; Kyvik, 1991). Comments from the soft scientists indicate that co-publishing is becoming ever more common (confirming Hicks & Katz, 1996), but that this rarely implies unit-internal group work. Even in hard and applied fields, like engineering cybernetics, an «academic individualism» is promoted – all the informants from the university sector in this discipline maintained that even if all researchers work in groups, the formation of the groups happens informally around a professor. Still, it is interesting to note the many positive comments connected with working together with others. Half the researchers from the soft sciences mentioned benefits from regular seminars, international collaboration etc., when asked about group work. A natural conclusion is that researchers who work on their own cannot be expected to do good work unless they interact closely and frequently with external and most often also internal colleagues.

It is furthermore evident that democratic decision-making is valued in all settings, not only in universities (cf. Wyller, 1991). In the applied sectors, some of the researchers discussed work rotation. The reason could be that the professional work here also includes tedious or non-R&D tasks. Outsourcing or the balance between internal and external R&D was mentioned in industrial settings only. Here, some of the informants sketched a tension between building competence in-house versus relying on external suppliers of R&D work. It can finally be added that even if most of the informants did not see formal organisational aspects as having important influences on research quality, some still described beneficial effects. An industrial researcher maintained, «I think that the organisation influences people's well-being – if you give people challenges and responsibility it leads to self-respect.»

8.3 Autonomy and restrictions in autonomy

Some specifications of the formal organisation were very common. A large degree of autonomy of freedom and a «loose» and «open» organisational structure were often mentioned as central aspects of good research units. The most frequent claim was perhaps that research units should be non-bureaucratic. «It is very important that it's not bureaucratic. Any procedure that unnecessarily complicates things like seminars, guest lectures and scholarly discussions must be avoided, or otherwise the most active researchers will not have the energy to do it (…) or the ones who just need to fill their time take such initiatives,» a philosophy professor said.

8.3.1 The need for clearly defined responsibility

Still, some degree of hierarchy and definition of responsibilities was frequently upheld as necessary in the university sector. A chemistry professor maintained, «Apart from openness, the organisation should be a bit hierarchical, so that the responsibilities are clear. (…) In the universities, responsibilities have often been a little too blurred, and we have had many problems at this department during the years, particularly related to the technical staff that has floated around, and that nobody has been responsible for.» It was obvious that many university researchers felt they were making «radical» or «politically incorrect» remarks when giving such answers. For instance, a professor in French language excitedly said that good university departments should be «hierarchical and open. There must be somebody on the top making decisions. I actually think so! Yes!» A «certain hierarchy» seems to be mainly connected with the department level, not the group level. In the groups, other formal aspects were mentioned. «I do not like the old system where the professor was the god. (…) What is vital is to have clear routines for introducing the [doctoral] students to the international research community» (mathematics professor). As in previous studies, it seems that «freedom» often is combined with various forms of control or pressure in good research units.

The need for hierarchy and clear responsibilities was even more frequently expressed in the applied sectors, and particularly by medical scientists. One of them, from clinical medicine and the institute sector, simply stated, «If you have targeted research, it has to be [top-down] controlled, like here.» Often «strong top-down control» or «relatively low degree of autonomy» was specified. Another institute researcher in medicine (basic biomedical science) stated, «I believe that applied research fields like this one have to be controlled very heavily. What you often see when you introduce [top-down] control, is that pockets outside of control arise, and that is completely destructive. (…) But people are extremely willing to accept control if the conditions are equal for everybody.» Others made similar claims, for instance an economist in a private firm, who said, «You have to find a balance here that makes people feel free and actually do their best, without them really having very much freedom although they have a nice working climate. There must not be too much autonomy in practice but people have to perceive that they have much autonomy.»

8.3.2 Tension between autonomy and the need for structure

These last quotes also indicate an important tension or dilemma in the design of an efficient organisation of research work. Another economist, from the institute sector, said, «If the decision-making structure is relatively flat, you can instigate some creativity among the researchers. (…) But of course you need some structure (…), we once applied for the same project from two different groups.» Some informants talked at length about the need for freedom, but also at the same time about effective co-ordination and efficient utilisation of equipment and resources. «You should have individual freedom to come up with ideas, start your own projects and select your collaborators. Group composition must be flexible, but resources, money, equipment, technicians and other support must be utilised optimally as well, also across traditional departmental boundaries» (clinical medicine, university). Authors have argued that many university research groups are very similar to small high-tech firms with the professor as the general manager (e.g. Etzkowitz, 1992). Obviously, not all professors feel confident in a role where their main tasks are resource gathering and the co-ordination and planning of other people's work.

Yet another tension was sketched by a biotechnology professor: «A loose structure is particularly important, it does much to creativity and results in really good and original research. But it does not always make the department the best suited for external contracts, and we struggle with that, because it is not always popular in industry that wishes we were organised in a more structured way.» It can be added that this professor saw industrial funding as fundamental for all the group's and department's research activities (in fact, more than three-fourths of the department's funding came from external sources, it was said).

The data above largely support previous findings. Autonomy (or absence of «bureaucracy») is important (for instance Pelz & Andrews, 1976; Premfors, 1986), it can be linked with creativity/originality (e.g. Hennessey & Amabile, 1988), but it needs to be «balanced» or «moderated» by other organisational aspects (cf. Andrews, 1979a; Kim & Lee, 1995; Bennich-Björkman, 1997). My informants, not least the ones from the soft sciences, argued that there simultaneously is a need for «structure» and defined responsibilities. This for example helps ensure that support staff and doctoral students are taken good care of, as well as co-ordinate the work to some extent. The tension between autonomy and the need for structure and (more or less) clearly defined responsibility does not seem to be resolved, but rather maintained or «balanced» in good research units (see Foss Hansen, 1995; Dougherty, 1996). It can furthermore be mentioned that autonomy is seen as relative and individual; what is important, is that researchers perceive a certain degree of freedom (similar to Andrews, 1979a). In other words, industrial researchers may perceive a (sufficient) degree of autonomy if they compare themselves to engineers (or scientists) in other company units, but maybe not if the liken their situation to that of university researchers.

8.4 Diversity of people at the group level

Two questions in the interviews were concerned with diversity at the group level. All informants were asked «How do you think a research group in your field should be put together?» (diversity of people) and «Can other activities be beneficial to research in your field (e.g. teaching, consultancy, administration, etc.)?» (diversity of tasks). Eleven informants did not answer the first question, while two did not answer the second one.

8.4.1 Levels of diversity

Regarding people, most of the researchers maintained that group «diversity» or «heterogeneity» is positive. A medical researcher from the institute sector said, «In teamwork, one thing is essential, and that is that the team members are different [from each other].» However, many others who ideally wanted diversity, added that «it's not very important» or «we can always manage without it». Three researchers said that it is more important to make sure that there is some changing or replacement of personnel over time. All these referred to positive effects of getting «fresh blood», «new ideas and perspectives» or avoiding that groups turn into an «Old Men's Club» with little interaction and very conservative attitudes. In the university sector, it seems largely to be taken for granted that there is a constant influx of new doctoral students and others.

Although some wanted as much diversity as possible, most talked about «a certain level of diversity», «some mixture», «heterogeneity to some extent» and that competencies and other traits must not become «too widely dispersed». Some kind of «shared platform», «common denominator» or «mutual framework» was often upheld as a necessity to maintain a high level of internal communication and to reap the benefits from «moderate diversity». A medical professor expressed, «It is an advantage to have a common denominator within a group; if you haven't, the researchers will not be engaged in each others work to the same extent, and then you lose the interaction effect.»

There are obviously many different types of diversity, even when the concentration is on personnel. The researchers may vary in length of experience and formal rank, scholarly background, sex, personality and educational background (technicians vs. researchers). All these types were elaborated, particularly the question of juniors versus seniors.

8.4.2 Diversity connected with age, rank or seniority

With one exception, all informants who talked about diversity as beneficial, stated that both juniors and seniors should be present in a group (a medical researcher in industry claimed that the best groups only have senior people). The number of each type does not seem to matter much, although more juniors than seniors was the most typical specification. A professor of engineering cybernetics stated, «You should at least have one [very experienced] senior researcher; we see that there is so much research going on totally without history.» Eight other informants (from all sectors and all but the soft fields) maintained that groups should be formed around prominent researchers.

An institute researcher in mathematics expressed that the ideal group consists of «2-3 very experienced researchers and 4-5 younger motivated people who do much of the practical work». This and other statements indicate that not only experience and knowledge may vary between age groups/ranks, but also motivation. Openness is a further issue: «Young people are often more open, and those who have worked a long time in the field are more committed [to certain perspectives etc.]; so together this can be a fruitful mix» (medical researcher, institute). Although most informants talked about benefits for the young when they are in a group with seniors, a reciprocal relationship was sketched as well. A professor in mathematics said, «Particularly for the doctoral students it is important to get a good interaction with senior people (…) but I also think that it is useful for the older people to have all these young people entering the group and creating some new life.»

Several professors complained that achieving this diversity is not always easy, because of the promotional system in Norwegian universities. «You should have a blend of top positions and middle-rank positions and doctoral students, but this system has been destroyed (…). Now, if you have a [full] professor's competence and you have an associate professorial post, you automatically become full professor. So we have lost the middle-rank positions as a recruitment tool, well, we have lost the middle-rank positions completely» (medical scientist). A sociology professor declared, «The promotional system we have here, based on individual merit, puts some limitations on the composition of groups. I believe this [putting good groups together] is easier in more hierarchical project environments where you have one king and some vice princesses, than in groups with several kings.» As seen in chapter six, many such concerns about the lack of people and positions between doctoral students and full professors were expressed.

8.4.3 Different backgrounds and experience

Some informants from industry and institutes mentioned that people with different scholarly backgrounds often should to be in one group to enable the solving of relevant problems. A few talked about cross-disciplinarity, others about more moderate forms of diversity. An economist in a private firm said, «For good research in economics it's not that important to include other social scientists as well. But it may be fruitful to have people with different specialities, for instance an econometrician and a theoretically oriented researcher.» In general, however, few of the industrial researchers were noticeably concerned about broadly composed groups. A probable explanation is that groups mainly are put together for one temporary project only, and that cross-disciplinarity is a more important issue when different projects are seen together.

Also several university researchers, for instance from French and biotechnology, claimed that broadly composed groups (with respect to scientific backgrounds) provide interesting opportunities for doing good cross-disciplinary research. Many more discussed group specialisation, where each member brings something unique to the group's work (e.g. knowledge of a certain methodology, theoretical framework, equipment etc.). Still, some informants warned against too cross-disciplinary teams: «Everybody maintains that cross-disciplinarity in groups is good (…), and maybe it is if you plan to develop a project or enter a new market. But if you think that the group also should have possibilities of increasing their own competencies, they cannot be too dispersed in their backgrounds» (biotechnology researcher, institute sector).

8.4.4 Balancing the sexes and the personalities in the group

The issue of sex, i.e. to have an equal amount of both male and female researchers in a group, was mentioned by six informants. They argued very strongly for this aspect and for making «equality» an issue when composing groups. An economist in the institute sector said, «I believe it is very, very important to have an adequate mix of males and females. If not, you lose a lot of social dimensions; and the social climate contributes to the scholarly work, people feel more safe and the discussions are more fruitful.» Similarly, from a professor in mathematics: «What I said about the sexes I mean very seriously; when you have a natural ratio between the sexes in an organisation, it yields a different [and much improved] social setting.»

Furthermore, a number of comments were made about personalities and the roles people play. A cybernetics engineer from the institute sector said, «It is very important that you have different personality types (…) that can play different roles in a group.» Some of the «dimensions» specified were: leaders versus «others,» creative versus thorough people, initiators versus people who «carry things all they way through,» visionaries or theorists versus more «down-to-earth» or practically oriented workers, and extrovert versus introvert people. A medical researcher elaborated such dimensions at length: «You need someone who's not original on the team who's willing to repeat boring tasks to get solid statistics and things like that, and of course [you need] the original people with crazy ideas. (…) You need some enthusiasts who can drive things forward and have dreams, but you need much more, and that is often overlooked, people who are depressed and negative and crabby and see dangers and difficulties all the time. And you need at least one parent with small kids who has to go home early to pick them up at the day nursery, if not you risk that a good working team wears itself out in no time. (…) We once drove each other into a kind of euphoria that made it feel like a loss to go home from the lab before ten in the evening. It worked for a couple of years, then everybody fell apart.» Those who were concerned with such issues generally spoke about the inclusion of both «opposites», or of the importance of considering such matters when hiring new researchers. A very common remark was that «not all people in a group need to be creative, but at least one person has to be». Two of the informants warned that it may be difficult to get very different people to work together.

Thus, diversity of people is generally seen as beneficial to research quality, confirming previous findings (e.g. Andrews, 1979c; Asmervik *et al.*, 1997; also Kyvik, 1991). My informants particularly emphasised that both juniors and seniors have to be present in a group, but they were also concerned about a certain combination of male and female researchers, different «personality types» and professional backgrounds. Cross-disciplinarity was as expected most often stressed in applied units (see e.g. Allen, 1977). Almost all informants argued for a «moderate» level of diversity – people with too different backgrounds may present too large challenges for the group and its leader. There must at least be a professional «common denominator» to reap the benefits of group interaction.

8.5 Diversity of tasks

Turning to diversity of tasks, one thing in particular stands out from the interview material. Only seven of the 62 informants that answered these questions, did *not* think teaching could be beneficial to research quality (the seven represented all fields of learning except the humanities; four of them were from industry, the remaining three from the institute sector). A majority of the researchers also thought that applied (non-research) tasks may be positive for research activities.

8.5.1 Combining research with teaching and supervision

Teaching was seen as a factor both of security and challenge. The informants described teaching as a source of inspiration, ideas, feedback and dialogue, as well as a driving force behind reflection, keeping oneself updated, having an overview, thinking more rigorously and doing research on a broader scale. For example, a sociologist from the institute sector said, «Teaching is important (…) because you have to work with your field, become broader, you can get ideas and inspiration; and you become a poorer researcher by being narrow-minded.» A professor in French language stated, «I have always had much use of the teaching; (…) disseminating these texts helps me discover new aspects of them, (…) it gives inspiration and a dialogue (…) that is very stimulating for all parties involved.» Teaching is evidently tied to the joy of working in a field, and all respondents from the university sector claimed that teaching is positively related to research quality.

Still, there are some limitations to the beneficial outcomes. Some talked about time pressure, while others expressed that teaching at low (undergraduate) levels mainly is a routine activity with few or no positive effects. A sociology professor said, «I do experience from time to time that teaching and supervision eat up my time for research without any large cross-fertilisation.» However, some informants sketched that undergraduate courses can be stimulating in periods of low performance or motivation: «In general it's stimulating to have students. (…) But on the one hand, you have the ordinary course teaching that's often of little value, depending on the type of course. And then you have (…) supervision of master's degree and doctoral students, and these two things are often fun. (…) In mathematics research, you're often stuck in problems, and you feel that you sit for weeks without getting anywhere. And then it's nice to have something that you get some sort of result from on the side» (mathematics, university).

In the applied sectors, such dilemmas were rarely mentioned. Researchers in these units apparently mainly teach graduate courses and/or supervise students at master's and doctoral levels, which can explain why so many applied scientists talked about the beneficial effects of participating in activities at universities. As a chemist in industry said, «We do some teaching, but very selectively.» Although eight (out of twelve) industrial informants, as well as most of the institute researchers, talked about inspiration and becoming updated or more broad-minded, some other and more indirect benefits of teaching/supervision were sketched as well. Networking was seen as important, for instance to an industrial researcher in clinical medicine: «We are several in this building who have part-time positions at the university. (…) We see that as beneficial because it expands the unit and you get more and different external contacts.» Even when there were no short-term benefits, some of the industrial informants talked about positive effects from supporting university departments. For instance, a cybernetics engineer said, «We try to assist as opponents in doctoral disputations as I did yesterday, and to provide the university with master's degree problems and with different talks. (…) These are activities that do not promote our own quality in the short run, but they contribute to keeping the discipline alive in Norway.» An institute researcher in the same discipline underlined that the benefit is mutual: «To have close contacts with the university [is vital], without we would not have lasted for so many years or done so well.»

Some of the informants mentioned supervision of doctoral students as particularly positive to own research. A professor of engineering cybernetics said, «Teaching doctoral students can be a good quality control, because they are not afraid of letting you know when you are unclear or wrong.» «You learn so much from your doctoral students,» a French language professor underlined. For many of the respondents, however, supervising doctoral students was seen more as research than as a teaching activity. Not only do many of the professors perform their research in close collaboration *with* these students, it is frequently done *through* them. This was particularly emphasised by informants from the technological fields, from the natural sciences and from medicine.

8.5.2 Product development, consultancy work, technical service and administration

Many informants also mentioned technical services, consultancy, advice to users etc., as beneficial to research. Only two of the researchers from the applied sectors did not name such user-oriented activities. These were described as fundamental to utility value/external relevance. A mathematics researcher from the institute sector for instance said, «Technical service once in a while assures relevance (…) and because of that we rotate people on different tasks here.» This was also referred to in the university sector by all the informants from technology and by two from each of medicine and the social sciences, and by one chemistry professor.

Other reasons for carrying out applied activities were also given. Two of the technology professors stated e.g. that consultancy was the only way for them to achieve a salary level «so I can defend to my family that I work these long hours.» A professor of engineering cybernetics said, «Our consultancy activities are important in bringing in the aspect of practical and social utility of the research (…). They also contribute to processing the labour market for graduates – not all can remain here at the department.» Both product development and consultancy were viewed as necessary by a biotechnology professor, who otherwise claimed to have a strong orientation towards basic research: «Consultancy is very important, to be out in the practical world and look at practical problems in the large pharmaceutical companies. Product development has for us been a central locomotive that has opened lots of opportunities. Some people look down on it [product development], and the concrete 'beads' [refers to specific project] we have made may not be very exciting, but the work resulted in considerable spin-offs in the shape of new knowledge and other things.»

Regarding administrative work, most of the informants were quite negative, at best seeing this as a «necessary evil». A few were in fact extremely negative, for instance a French language professor who stated, «Administration, oh God have mercy on us all, is pure evil.» Still, there were some moderately positive comments as well. A chemistry professor said, «Administration may have positive effects by positioning you in the struggle for resources.» The same argument was put forth by a professor in clinical medicine, who also suggested that being head of the department can make you more experienced as a leader in general, which in turn may positively benefit the research group and projects. Also a philosophy professor stated, «It may not have direct influence, but [it could be positive] to think through administration and find solutions so that the least possible amount of time goes to administrative tasks.» I have a clear impression that the informants who were selected on basis of prestigious prizes only were a little less negative than the others. This may be explained by the «most eminent» to a larger degree seeing it as their duty to take a toll with administrative tasks. Another explanation could be that these researchers had made important contributions and achievements already, largely «freeing» them for other tasks.

8.5.3 The mix of activities

In many research units, a number of different activities are carried out – from technical service to users to supervision of doctoral students. The informants often underlined that the interplay itself is the core of the scholarly work. For instance, a professor in engineering cybernetics said, «The interplay between many of these activities is very important; (…) what we do here is innovation, which I define as a combination of problems, methods, applications and needs.» A researcher from the same discipline, working in the institute sector, also explained, «We have a blend of more research-influenced things where the results are not given, via product development to more consultancy-type things, and that blend is very positive.» As mentioned in chapter five, the discipline of engineering cybernetics displayed many characteristics of a «new» or «alternate» mode of knowledge production (cf. e.g. Gibbons *et al.*, 1994). It can be added that two of the professors in this discipline stressed that doctoral students (who do most of the research work) should be «shielded» from the work related to industrial contracts. One of them said, «We do some contract research and development work, but we often let institute X do that, not the doctoral students, to avoid getting a conflict between the product to be delivered and the time spent on the thesis.»

Still, similar specifications of a broad activity mix were also made in other disciplines. An institute researcher in clinical medicine said, «We would be helpless without the other activities; (…) they can be very different things, from participating at the telephone help desk for public health nurses to going through manufacturing procedures. (…) This exposure to practical life is vital, the set of problems related to relevance becomes part of you.» In industry, most of the informants said that they carried out a large array of seemingly very different activities. Although this in general was seen as positive, some also added that the pressure on an individual's time could become great: «A lot of other activities can be important, project management, teaching, training of new people, (…) but at one point it becomes a question of time prioritisation. (…) You can get updated by teaching a course, but it may conflict with giving priority to the research work» (chemistry researcher)

Finally, it can be added that a reciprocal relationship was emphasised in all institutional settings and in all disciplines. Many of the informants underlined that research work forms the basis of all other activities, from teaching to consultancy. Some warned against making inactive researchers supervisors for doctoral students: «And it is even worse to supervise doctoral students if you're not an active researcher yourself because then I think you may easily become very demanding. You demand a lot from others because you don't have to demand anything from yourself; you become a methodology puritan» (clinical medicine, university). A few also stressed that highly motivated researchers will in most cases also be motivated teachers – the joy of doing research in a field makes dissemination, recruitment and many other activities joyful as well. For instance, a chemistry researcher in the institute sector said, «Enthusiasm for your field of work has a positive effect on almost any activity related to the field.»

This supports previous findings, that diversity of tasks is beneficial (e.g. Pelz & Andrews, 1976; Andrews, 1979c). It is obvious that teaching is seen as very positive (confirming Stolte-Heiskanen, 1992), also in the applied settings. Undergraduate or otherwise less advanced teaching may be a burden, however, while supervising at the doctoral level is often defined as research. Doctoral students are often *de facto* research assistants, particularly in the hard sciences (see also Kyvik, 1991). Development and consultancy work are seen as positive in applied units, because they guarantee user relevance and make the researchers more aware of «real» problems. Administration is most often seen as negative, although a few informants indicate that it may have an indirect influence through securing a certain resource level or improving the researchers' management skills. Andrews (1979c) proposed five reasons for the beneficial effects of diversity. The above discussion supports three of them: intellectual resources (achieved through teaching, consultancy etc. and networking related to these activities), knowledge and skills that contribute indirectly, and a better perception of problems and their solutions. It must be added that for a large number of informants, the mix of professional activities is interesting and motivating, not research on its own. Many good researchers enjoy teaching, giving professional advice and other such tasks.

8.6 Diversity at the department level

Few researchers had strong opinions about diversity at the department (or corresponding) level. 18 did not answer or just said that this aspect was irrelevant to research quality, and not many of the remainder made elaborate statements. The lack of centrality of the composition of departments can also be seen from the differences in answers from researchers in the same unit. For instance, an economist in the institute sector said that diversity at this level was irrelevant, another (in the same unit) argued quite strongly for cross-disciplinarity, while the third said that only the maintenance of a constant influx of new people was central to quality. In general, diversity was seen as beneficial by the researchers in the sample, but more maintained that this «would be nice» rather than «is vital.» Many also talked about the importance of renewal.

Diversity can be tied to people and to specialities in the field. About the first aspect, an economist in industry elaborated, «We have an ambition that we should have diversity, both people with traditional research training and people with experience from government agencies, or even industry. (…) Our experience is that many research organisations have an extremely poor organisation of work; people are not good at all at productively using their working hours. People who come from government agencies often have much better skills when it comes to structuring the workday and getting things done within the deadlines.» A few others also mentioned such aspects, for instance a professor in engineering cybernetics, who said, «We have a good profile at this department. There is a good blend of researchers who work theoretically and internationally, some who work very closely with industry and some who work intensively with teaching.»

«Covering the discipline», the field or the problem area was the most common answer regarding scholarly diversity. «All the large fields within mathematics should be represented, and there should be some prominent figures in the department,» a professor elaborated. Another one, from philosophy, stated, «It is clearly an advantage to have a comprehensive and diverse department. You often stumble over things you may need specialists in.» This informant had recently needed expertise in medieval history, and said that it would have been more efficient if such knowledge had been available within the department. However, another philosophy professor warned against too large and dispersed units, claiming «You shouldn't have fractions that talk behind each other's backs.»

As expected, the informants from universities often talked about covering the main areas of interest to the international research frontier (or to teaching the discipline at an undergraduate level), while those from the applied sectors discussed the necessity of covering the most relevant areas their users were interested in. A few also talked about neighbouring fields, for instance a sociology professor, who said, «You should cover the discipline in a certain breadth; you should have people who cover the most important fields of sociology plus some specialities. (…) And you should cover the boundaries to other disciplines, for instance political science and economics, (…) the link with economics is particularly weak in Norway.» It should be added that, similar to the group level, a moderate level of diversity was most commonly promoted. If departments become too fragmented, the benefits may be lost. Arguments for departmental diversity often imply that the units should have a certain minimum size (cf. 9.3).

A few other comments can be mentioned. Some of the informants simply said that groups in a department should be different without further elaboration. Three researchers, from medicine and the natural sciences, maintained that departments have to be composed with respect to possibilities of sharing advanced equipment. In some interviews, the necessity of having (many) technical support staff members, (many) guests and adjunct professors, mid-rank university personnel and some highly eminent scientists, was discussed briefly.

In industry, a few of the scientists and engineers elaborated principles for composing departments. One (from engineering cybernetics) said that units can be organised directly under user divisions in the firm, or on their own as part of an R&D centre. In this firm, the first strategy had been chosen, and the informant had the impression that it worked quite well. Another industrial scientist (from mathematics) said that departments can be based on «fields» or «problems»: «You have at least two principles. (…) You can imagine an organisation where you have a department of reservoir engineers, a department of geologists, and so on, (…) but we don't have it that way here. We have both geologists, reservoir engineers and more in the same department, so our projects become largely internal to each department, and this seems to work well with us. So I guess I can say that it probably is beneficial to have cross-disciplinary departments.»

The composition of departments (or equivalent) does not seem very central to the quality of research. Departments are most often put together for other reasons than achieving a certain level of quality in the research work, as has been argued in previous investigations (e.g. Martin & Skea, 1992; Kyvik, 1995). Still, some informants argued that the size and diversity of a department in the long run could influence the direction of the research activities – which areas, problems and contractors that can be selected, and the research collaboration that is possible internally. For more about the size of units, see chapter nine below.

8.7 Formal routines for quality assurance and control

The final question that concerned formal organisational characteristics had to do with routines for quality control, assurance and improvement. Two clear assertions can be made, based on the interview data. First, relatively many quality activities are formalised or routinised, also in the university sector. Second, these activities seem not very central to doing good research – they are mainly oriented at quality *control*, i.e. avoiding mistakes and separating the poorest products from the rest.

8.7.1 Traditional activities

It is obvious from the answers that many activities are not immediately thought of as quality control or assurance. When probed, most of the informants for instance talked about regular and frequent seminars and internal workshops, weekly project meetings, laboratory meetings and laboratory routines etc. Only in industry and some of the institutes were such activities labelled anything connected with «quality». When informed about some of the alternatives (laboratory routines, formalised critique of manuscripts and proposals etc.), a researcher (basic research) in a biomedical institute said, «All these activities are carried out as a matter of course in good research units.»

To comment on each other's work is the most common quality mechanism, and most informants mentioned weekly or fortnightly meetings with discussions about the research work as well. Around half the researchers who answered the question talked about publishing in peer-reviewed international journals as the ultimate quality control. The boundary between formal (which to most meant written down) and informal («has always been done this way») is very fluid. Several professors underlined that informal quality assurance is more flexible and less bureaucratic, particularly compared to the quality handbooks that they had seen in the institute sector. Some more special efforts were also mentioned. A philosophy professor said, «We have a bonus arrangement so that the active researchers can get as much time as possible for research, funds for assistants and more, (…) for articles in refereed international journals, a book on an international publishing house etc.»

8.7.2 Quality handbook and certified quality system

The most traditional routines in a «quality management sense» (e.g. quality handbook and certification of the quality system) were found in the applied sectors. All the industrial firms' R&D units had certified their quality systems in accordance with the ISO 9000 standard, and this (or very detailed handbooks, for instance concerning «good laboratory practice») was also found in the institute sector in technology and clinical medicine. However, all the informants in these units said that such measures did not have much to do with research quality. A cybernetics engineer said, «[The institute] has this quality assurance handbook, but quality has to be built into the way we work, it's not something that can be added at the end of a project, (…) that's just polishing. The important thing is to make proper plans and communicate well with the customer if something unexpected arises.» Even with a quality handbook, there are many routines that do not necessarily function well or that have not been established: «Some methodological aspects can always be improved. (…) Thermometers should be checked annually, for instance, (…) but you always assume the equipment is good enough until you get suspicious that it isn't» (chemistry researcher, institute).

Still, a medical researcher in industry underlined some other benefits of formal quality systems: «ISO certification (…) is the only formal routine we have, but that's not the *real* quality. It doesn't assure originality, solidity, scholarly relevance or utility value. But it assures documentation whether the project is good or not, and it's positive that you have to document and file properly so that others quickly can find out what you've done.» Some of the other medical researchers also argued that documentation (and routines for doing it) ensures replicability. In general, however, the existence of quality systems does not seem to imply that researchers more easily can avoid mistakes or come up with better ideas. An industrial researcher commented, «In practice the professional responsibility lies with each individual researcher and because of that it is an enormous advantage to have two people on every project almost no matter how small it is.»

A few other routines were mentioned in the applied sectors (where formal project meetings etc. rarely were mentioned, perhaps because they are not labelled anything with «quality»). Two natural scientists from the same private company mentioned a prize for creativity that is awarded annually to a researcher in the firm (the same informants talked negatively about «brain-storming» and similar attempts at increasing group creativity). A medical researcher from the same organisation said, «Within my field we have just started working on a performance measurement system with different criteria based on for instance interviews and external evaluations.»

Thus, it can be claimed that the formal routines that have been mentioned do not seem particularly central to quality. Commenting manuscripts and proposals may naturally be important, but there are no indications in the interview material that such activities need to be formalised or in print in the university sector (in the other sectors, rules are written down about such matters). One reason that quality assurance mechanisms were judged relatively unimportant could be that they are oriented at the latest phases of the research process. International publishing may be a good example of that. A sociologist in the institute sector said, «We read and comment on each other's manuscripts, that's a duty, (…) and we also have some kind of board of editors for our own publications. That's excellent, but a bit controversial because people think that too little is done to assure quality in earlier phases of the research process.» Even the creativity prizes that were mentioned above are awarded *ex post*. One industrial researcher talked about «a checklist with issues that you should think about before you start a research project», but could not say anything about the effects of such a checklist. It is probably natural that the first phase of the research process (see also chapter twelve) should be the most autonomous and the least bureaucratic, hence, few formal quality routines in the idea phase make sense. Several comments from the informants indicate, however, that research units are on a constant lookout for tools that can enhance creativity and increase the number of ideas. As in previous studies (e.g. Allen, 1977; Jacobsen 1990; Kyvik & Larsen, 1993), researchers themselves believe that formal routines of quality assurance and control may have beneficial effects.

8.8 Discussion

The three propositions from the end of 8.1 will be reviewed below, along with some other central themes emerging from the discussion.

A high degree of autonomy is a typical feature of good research units. However, the literature also stresses that autonomy should not be unrestricted. This is supported by my data. Autonomy – particularly elaborated as «lack of bureaucracy» – is important (for instance Pelz & Andrews, 1976; Premfors, 1986), and it can be linked with creativity/originality (e.g. Hennessey & Amabile, 1988). My informants also emphasise, however, that autonomy needs to be «balanced» or «moderated» by other organisational aspects (cf. Andrews, 1979a; Kim & Lee, 1995; Bennich-Björkman, 1997). There is a need for «structure» and defined responsibilities, it is claimed. This helps ensure that support staff and doctoral students are taken good care of, as well as to some extent co-ordinate the work. This tension between autonomy and the need for structure and (more or less) clearly defined responsibility does not seem to be resolved, but rather maintained or «balanced» in good research units (see Pelz & Andrews, 1976; Foss Hansen, 1995; Dougherty, 1996).

Diversity (at least at the group level) is generally seen as good, both related to people and to tasks. There is a need for better understanding of how diversity is beneficial to quality. Positive effects of diversity are also emphasised in my data. Regarding people, my informants particularly emphasised that both juniors and seniors have to be present in a group, but they were also concerned about a certain mix of male and female researchers, different «personality types» and professional backgrounds (Andrews, 1979c; Asmervik *et al.*, 1997). Cross-disciplinarity was, as expected, stressed the most in applied units (cf. Allen, 1977). Still, almost all informants argued for a «moderate» level of diversity – there must at least be a professional «common denominator» to reap the benefits of group interaction.

When it comes to task, it is interesting to note that almost all researchers (and all from the university sector) underlined that teaching can benefit research quality. Teaching is a source of inspiration, ideas, feedback and dialogue, as well as a driving force behind reflection, keeping oneself updated, having a broader approach and thinking more rigorously. Development and consultancy work is seen as positive in applied units (and by some university informants, particularly in the technological disciplines), because it helps insure user relevance and makes the researchers more aware of «real» problems. All this supports previous findings (e.g. Pelz & Andrews, 1976; Andrews, 1979c; Stolte-Heiskanen, 1992). When it comes to understanding how diversity is related to performance, I find support for three of Andrews' (1979c) five proposed processes. Diversity increases a unit's intellectual resources, it increases knowledge and skills that contribute indirectly (e.g. through development work, teaching etc.), and a better perception of problems and their solutions. It is interesting to see that for a large share of the informants, the *mix* or *combination* of professional activities is interesting and motivating, not research on its own. Many good researchers enjoy teaching, giving professional advice and other such tasks based on scholarly knowledge.

A critical comment regarding time and diversity of tasks can be added. In other parts of the interview, some of the informants stressed that time is a critical and scarce resource. How can we understand this in relation to their positive attitudes towards non-research tasks? One explanation could be the relative weight of the different tasks and activities. As mentioned, Pelz & Andrews (1976) found that good researchers did a number of professional tasks. The scientists and engineers in their sample nevertheless spent between 50 and 75 percent of their time on research. In Norway, studies have shown that university researchers on average spend less than one third of their time on research (Kyvik & Enoksen, 1992). Hence, it could be that Norwegian researchers are so engaged in non-research activities that the pressure on the individual's time gets extremely high.

If we look at the department (or similar) level, diversity does not seem very central to the quality of research. Departments are most often organised for other reasons than achieving a certain level of quality in the research work, as has been argued in previous investigations (e.g. Martin & Skea, 1992; Kyvik, 1995). Of course, in the long run a diverse department may take other research directions than a homogeneous one. For more about the size of units, see chapter nine.

Little is known about formal routines for quality assurance and control, but researchers frequently are in favour of for instance formalised discussions as a means of improving quality. Surprisingly many of my informants mentioned that their research unit has some kind of formal routines in this respect, although these often are oriented at the last phases of the research work (e.g. stopping poor publications) and rarely are attached great significance. It can be claimed that quality activities like «quality handbooks» and formalised «good laboratory practice» may help avoid poor work, but not improve it. Several comments indicate, however, that research units are on a constant lookout for tools that can enhance creativity and increase the number of ideas in the start-up phase of research work. As in previous studies (e.g. Allen, 1977; Jacobsen 1990; Kyvik & Larsen, 1993), the researchers believe that routines of quality assurance and control can have beneficial effects, although formalisation may not be necessary.

Finally, it can be mentioned that the informants talked very positively about group work (or working together with others). One reason may be that individuals on their own most often make little impact in many disciplines. Hence, being an integrated part of a larger group may be the only way to sense a direct relationship between one's efforts and a theoretical or practical change in the disciplinary knowledge, which can be a source of motivation and recognition (cf. Herzberg *et al.*, 1993). Previous investigations on group work and disciplinary differences (e.g. Trist, 1972; Biglan, 1973b; Kyvik, 1991) are supported by my findings. Still, even in hard and applied fields like engineering cybernetics, an «academic individualism» is promoted – all the informants from the university sector in this discipline maintain that although all researchers work in groups, the formation of the groups happens *informally* around a professor.

What the above discussion has shown is that a high degree of interaction is very positive. Researchers who work on their own cannot be expected to do good work unless they interact closely and frequently with external and most often also internal colleagues. Group work and other routines for interaction need not necessarily be formalised, but there has to be at least some kind of traditions to ensure that new organisational members are included in the scholarly exchange.

It is evident that this interaction and many other formal organisational aspects constitute organisational tensions. Diversity is in itself is a form of tension. In some respects, it is clearly a greater challenge to interact with people who are different from oneself, than with people with a more similar background, experience etc. Involvement in other activities like teaching and consultancy also creates a form of strain. The interviews indicate that seeking out these kinds of challenges to a moderate extent is a typical feature of the best researchers and research units.

9 Size and resources

Effects of research unit size and level of resources have frequently been investigated, maybe because they are relatively easy to measure quantitatively. Still both these issues are complex, and the results point in many different directions.

9.1 Earlier investigations

It is natural to distinguish between group size (lowest organisational level above the individual), department/section/institute/laboratory size (second lowest level), and resources. The majority of earlier studies has been concerned with the first of these three aspects. In science policy, both in Norway and in other countries, it has often been assumed that there exists a «threshold» or «critical mass» effect, both at group and at department/institute levels.[1] This frequently seems to imply that funding bodies and others should aim for a smaller number of large units instead of a large number of small units, i.e. a policy for «concentration of resources» (Johnston, 1994). Many authors warn against such a policy, for instance Cohen (1991) who, after a thorough review of a large number of studies, concludes that «management based on simple notions about a hypothetical optimal size (…) of research groups is likely to do more harm than good» (p. 414).

9.1.1 Size at the group level

At the lowest organisational level, the results of previous studies are not unambiguous. Some have found a positive correlation between group size and productivity (Wallmark *et al.*, 1966 and 1973; Blume & Sinclair, 1973) and some that the relationship is dependent upon other variables (Stankiewicz, 1979). Others find no relationship at all (Cohen, 1981; Spangenberg, 1990a and b)[2] or a negative correlation between group size and performance (Knorr *et al.*, 1979a). Both Cohen (1991) and Stankiewicz (1979) have made a number of critical remarks about the methodology of the earliest studies. For example, Wallmark and colleagues (1966 and 1973) left out non-productive researchers when calculating group size, while Blume & Sinclair (1973) did not adjust for co-authorship in their bibliometric indicator (co-publishing is more common in larger groups).

Stankiewicz (1979) found a curvilinear relationship between performance and group size. The relationship was influenced by other variables, however. When «group cohesiveness»

[1] The most recent Norwegian parliamentary report on research does not mention anything about size, but still argues for a policy of concentration of research resources, for example on p. 132 (Stortingsmelding no. 39, 1998-99).

[2] In the latter two studies, the «number of full-time research equivalents» and the «volume of human resources» characterised the high performers, but the total size of the units did not vary between high and low performers.

was low, performance decreased significantly when there were more than seven researchers in the group. Furthermore, there was a strong positive relationship between group size and performance when the leader was an experienced researcher, and a negative relationship if the leader was young. A similar relationship was sketched in Pelz (1963). Here, individual performance was high if group cohesiveness was high and the leader highly competent, and performance was low if cohesiveness was high and the leader «mediocre.» Well-performing individuals were also found under mediocre leaders, but these researchers had a low sense of belonging with the group. Etzkowitz (1992) found that the «ideal» size depended upon the professor's «managerial skills» and the concrete field of research.

A curvilinear relationship seems to be the most common result. A thorough review of a large number of investigations concludes that there is both a threshold effect and a «fission» effect (too large size leads to decrease in performance), at least in the natural sciences (Johnston, 1994). It is difficult to give an exact indication of the «optimal» size interval for a group, because number of people may be counted in different ways (also related to whether the group is a formal organisational entity or not). The most common is to count the senior and junior researchers (including doctoral students), but leave out all kinds of technical support staff. Etzkowitz (1992) indicates an «ideal» range of four to eight persons, while Stankiewicz (1979) concludes that it is risky for a group to become larger than seven researchers. Johnston (1994) states that the optimal size is between three and five academic staff (plus postdoctoral fellows, post-graduate students and technical personnel). Martin & Skea (1992) found that between three and six researchers is a common description of the optimal group size, although one fourth of the respondents desired slightly larger groups.

Still, some authors underline that small groups, and occasionally even individuals, may perform very well (Johnston, 1994), for instance through maintaining close contacts with groups in other locations (Martin & Skea, 1992). Almost all the respondents in Etzkowitz' (1992) study of chemistry professors strongly supported the «individual investigator» (albeit with students and post-docs) as an efficient and productive way of doing science. It is difficult to rule out that also very large groups may perform well – a good example could be some of the groups of Nobel Prize winners (cf. Zuckerman, 1977).

Nevertheless, in many of the investigations it is found that both too few and too many group members often lead to sub-optimal performance, and various explanations are put forward. Relatively large groups may have the possibility of focusing on certain problems or of use methods that smaller groups will not be able to. Apart from that, it does not seem logical to claim that size in itself can have an effect on the quality of the research product. A certain size may instead be beneficial to certain levels or types of communication and leadership, or have other effects. Indeed, the «critical mass» metaphor that often is applied, indicates that when reaching a «threshold» size, a group in one way or the other will benefit from a «chain reaction».

Stankiewicz (1979:197) talks about «intellectual synergy» – that an «unplanned convergence of efforts and ideas» is likely to occur in research groups. Due to «intellectual cross-fertilisation», new ideas may arise more frequently in larger groups), and the volume of human resources can make exploration of such spontaneous ideas possible. Etzkowitz (1992) also ties group size to dynamics – it affects the probability of overlap of student generations and thus of continuity. When group size increases, however, meetings replace informal discussions, and effective control can be difficult (*ibid.*). There are for instance limits to how many doctoral students a professor can supervise, although the number will vary much (even among Nobel Prize winners, cf. Zuckerman, 1977). A result of increasing group size could be fission – two small groups (maybe too small) emerge from one (Johnston, 1994).

Despite the negative effects of too large groups, there are strong internal and external forces at work to create larger units and link them (Etzkowitz, 1992). Internally, one can frequently find a movement towards problems where a support staff is necessary. A more external driving force is «the desire to secure a stable and continuous source of research funds» (*ibid.* p. 44). It could be added that a large number of the studies referred to focus on publication productivity. Given that productivity and quality are not the same (although they are correlated, cf. chapter two), I assume that size is less important to quality than to productivity.

A critical remark could be added about the somewhat «static» nature of the above-mentioned investigations. The question «What are the effects of *changes* in size?» would perhaps be more interesting to focus on. I have only found one study of this issue, where it was concluded that hiring additional scientists had a beneficial effect on the performance of applied research units (Cheng, 1984, based on data from Andrews, 1979a). In basic research units, however, hiring additional technicians was found more beneficial. It can be added that researchers themselves frequently point to hiring more researchers as a means of improving quality (e.g. Kyvik & Larsen, 1993).

9.1.2 Size at the department level

If we move one level up in the organisational hierarchy, there are fewer investigations of the effects of department size on research performance, and many of the arguments for larger units concern «requisite variety» for educational purposes (Trist, 1972). Within the same discipline, one can furthermore expect differences from one country to the other in the size of labs (Senker, 1999). An investigation of a broad selection of U.S. universities found that departments at least should have between 11 and 15 scientific personnel to be productive (Blackburn *et al.*, 1978). This study, which focused on publication productivity, did not take into consideration effects of co-authorship or the very broad diversity of American universities, where the most prestigious institutions also have the largest departments, employing the most productive individuals. A Swiss investigation of two technical universities found no systematic relationship between size and number of publications, although the medium-sized departments (between nine and 22 researchers and assistants) in chemistry, mathematics and physics were the most «productive» in these disciplines (Fritschi *et al.*, 1980).

A British interview study concludes that department size only seems to matter when groups collaborate closely and share the same equipment (Martin & Skea, 1992). The two disciplines where the authors describe a critical mass-effect are biochemistry and chemical engineering (two relatively cross-disciplinary fields). Still, Martin & Skea maintain that effective organisation of teaching and administration could be an argument for larger departments. An analysis of the number of publications and citations of all British university departments in geoscience, physics and chemistry found a weak linear relationship between department size and publication productivity in the latter two disciplines (also reported in Martin & Skea, 1992). The correlation disappeared, however, when Oxford and Cambridge were excluded from the analysis, or when doctoral students were included in the size variable.

Two Norwegian investigations have focused on the relationship between department size, scientific productivity and the quality of the «research environment» (Kyvik *et al.*, 1989; Kyvik & Larsen, 1993). No significant and consistent relationships between size and productivity were found, and in the latter study, the researchers in small departments were slightly more pleased with their «professional environment» than were those in larger units. This effect was particularly seen in the humanities, which could be explained by the more individualistic research venture in these disciplines. Other authors have argued that small units also at the department level can produce excellent research through close international research collaboration (Johnston, 1994).

9.1.3 Resources

When it comes to material/financial resources, only the interview study of Martin & Skea (1992) found these important, but the authors indicate that the reference to resources also seems a bit «ritualistic» as it was much more frequently referred to in open than in closed questions. Most investigations have not described any significant or systematic relationship between performance and financial resources (e.g. Pelz & Andrews, 1976; Stolte-Heiskanen, 1979; Jacobsen, 1990; Kyvik, 1991). Some units with large funds perform poorly, and some units with little money perform well. However, there are some studies that find factors like «large projects» and «number of full-time research equivalents» to be typical of high performers (Spangenberg, 1990a and b), and these factors may naturally be related to resources.

One interpretation is that resources are the effect of high performance, rather than its cause (cf. Fox, 1983 and 1992). Furthermore, the centrality of resources in many of the theories of cumulative advantage (see section 3.3) does indicate that the effect of funds needs to be investigated further. This issue has more to it than mere size or level, however. It has for instance been found that increasing «short-termism» in funding at a macro-level may have adverse effects on research quality, in addition to being discouraging when it comes to recruitment to research work (Senker, 1999). It is claimed that two or three year contracts are inadequate for high quality research because of the resulting lack of stability.

Returning to the unit level: one particularly interesting finding is that the actual resources available to a unit is only weakly related to the individual researchers' perception of their adequacy (Stolte-Heiskanen, 1979). Two reasons are postulated. First, that there often is a «halo effect», implying that «if there are no established objective criteria of adequacy, and if research units are on the average well provided with resources that are also defined as adequate by general opinion, then even units with comparably low resources evaluate them like the better-off majority» (*ibid.* p. 148). Second, that there is a «structural effect» related to traditional scientific manpower resources, where units with relatively high resource levels express dissatisfaction. Perhaps the most intriguing finding is that «subjective» resource levels, i.e. the unit members' satisfaction with their human resources, was quite strongly related to unit performance. «Objective» levels did not display a significant relationship with performance. Hence, the researchers' «subjective reality» (Berger & Luckmann, 1966), as available through interviews, is definitely a relevant focal point (see also Visart, 1979).

When it comes to scientific *equipment*, there is little evidence at hand. It seems natural to assume that this will vary much between disciplines and between various settings (e.g. «little science» versus «big science», cf. Price, 1963). Again, subjective perceptions of adequacy may be more important than objective resource levels (Stolte-Heiskanen, 1979), although material resources in general do not seem very central to performance. An interesting point for study could be whether researchers need «state-of-the-art» equipment to do good science, or if «more ordinary» facilities will do. Etzkowitz (1992) ties equipment to resources by finding that «older students pass on to younger ones the fine points of using equipment that they often know more about than the professor does» (p. 33). Thus, a certain size (or the existence of post-doc positions, etc.) may be necessary for efficient *use* of the equipment.

In chapter three I hypothesised that both financial resources and equipment can be regarded as «hygiene factors» (cf. Herzberg *et al.*, 1993). More resources could lead to «decreased dissatisfaction» among the researchers, but not necessarily to increased motivation and quality. Resource levels could thus help avoid poor performance, but not (at least not by themselves) induce high performance. Or, in other words, additional resources above a certain «satisfactory» level are not likely to influence quality (see also Johnston, 1994).

9.1.4 Brief summary

To conclude briefly, before turning to my own empirical findings, the results from previous studies are not unambiguous when it comes to size and financial resources. The following constitute some general propositions/starting points:

- At the group level (or otherwise at the lowest organisational level above the individual), there can be an optimal size. Still, the margins seem to be relatively wide, and the effect may not be seen in all fields. Larger groups should be more important in applied settings, and the experience and competence of the leader is probably strongly related to group size.
- At the next organisational level, size seems less important to research performance. Some evidence exists that university departments in certain disciplines can benefit from shared equipment and inter-group collaboration. There is little evidence at hand about the institute sector and industry (where the effect of size probably is dependent upon other factors like firm size, mission of institute etc.).
- Financial/material resources do not seem very central to research quality, but the nature of the (lack of) relationship needs some exploration.

9.2 Group size

In the previous chapter, it was seen that the informants talked very positively about groups in general. When asked «Is there an optimal size of research groups in your field?» many of the arguments for group work were repeated (eight informants did not answer this). A mathematician from industry argued against isolation: «If you put people in an isolation ward you'll never promote creativity and enthusiasm.» A professor of engineering cybernetics said that teamwork often is necessary due to needs for scientific equipment: «One person alone can get fantastic results or a professor with three doctoral students. But due to the need for equipment, you need more people than that most of the time, and then you get better and more results. Groups larger than 10 people are also possible.» This informant talked about an internationally leading scholar who had 60 doctoral students simultaneously. Keeping up with the research frontier was another argument: «You need experts in different methods, (…) and it is a clear advantage when several work on ideas and keep up with the literature – it's impossible to be updated in the literature on your own» (biotechnology professor).

9.2.1 The contingency of size

From the answers, it is evident that there is not *one* optimal size of research groups. Answers varied, also within different disciplines and sectors. It makes more sense to talk about minimum and maximum sizes or limits. When size increases, there are both advantages and disadvantages. A clinical medicine researcher from the institute sector said, «The more people you have, the broader a field can you cover, but the communication gets poorer at the same time.» In general, it can be claimed that the challenge is to «maintain focus and good communication combined with a certain breadth» (cybernetics engineer, institute).

The most common response was «That depends…» An efficient group size is contingent upon several different factors (roughly in order of frequency):

- The leader, especially her or his supervising capacity.
- Characteristics of the project or task – size of project/task/problem, need for equipment, methodological approach (e.g. experiments vs. computer simulation), degree of cross-disciplinarity, user needs etc.
- The goal of the group – this was a common answer in the applied sectors. More practically oriented work and a wide portfolio of contractors/users require larger groups.
- The definition of the field – naturally, a broader definition of the group's speciality most often implies an increase in size.
- The people on the team – not all feel comfortable in large groups.

Many informants discussed several of these aspects. A medical scientist in the institute sector said, «I guess there is [an optimal size], but the concrete number will vary with the project leader and the type of problems you are working on. (…) The group should be so large that the leader's capacity is utilised completely, but not very much larger, normally around ten people.» A mathematics researcher from the same sector stated, «I think that ten to 12 will work well, but the leader has to be scientifically strong. More people will only make difficulties for the leader, less people will not be robust related to a varying portfolio of projects and problems with flexibility.» Thus, as seen in previous studies, large groups only seem to work well when the leader is a brilliant scientist. In fact, some of the informants express that e.g. the number of doctoral students a researcher supervises, is a good indicator of her or his eminence.

If we go down to concrete numbers, the most common response was that efficient groups are between three to five and six to ten people. A sociology professor expressed, «Four to five people are nice, if you get many more you quickly get a lot of co-ordinating work. (…) But if you are three to four you have a possibility of supplementing each other and have somewhat different strengths and weaknesses.» I have the impression that natural and medical scientists favoured somewhat larger groups than the social scientists did, but there are several counter-examples. Some of the informants sketched very wide limits: «I don't think so [that there is an optimal size]. It's problematic when you work on your own and it's problematic when you're more than 30 people. I myself cannot lead groups larger than 12, but it could be me there's something wrong with» (medical researcher, industry).

9.2.2 Minimum levels

The lower limit was discussed by many of the researchers. A cybernetics engineer from the institute sector simply stated «You need to stay together as a group without becoming under-critical in size.» Although many expressed that teams need just be two researchers, several wanted more people than that. A professor of medicine upheld, «You need to have a certain minimum to get a group; to sit and have meetings for only three, four, five people gets too confined.» Between two and five people seems to be the minimum size of research teams. Some of the specifications of the effects of too small groups were as follows:

- Lack of flexibility, vulnerable to changes in personnel or project portfolio; may be forced to turn down interesting proposals/opportunities.
- Less or poorer internal communication, discussion and critique, not enough creativity or mutual inspiration, more difficult to stay updated in the field (literature, seminars, conferences etc.).
- Low efficiency concerning use of scientific equipment or supervisory capacity, too small resources to be able to do interesting work, not visible enough to get interesting research contracts.
- Too narrow focus – the group is not versatile or cross-disciplinary enough, has a limited range of available methodologies etc.

9.2.3 Maximum levels

Upper limits were also elaborated, but not to the same extent as minimum levels. One reason could be that when group size exceeds a certain level, you often have the possibility to reorganise and make two smaller groups. No such alternatives exist when groups become under-critical in size. The concrete range of answers about maximum limits was wide. Some wanted very small groups: «I don't think you need more than three on our research projects – more would kill the project. If four are going to sit and discuss a project much [life] is sucked out» (economics researcher, institute sector). It is interesting to see this quote together with the statement of the medical professor referred to in the preceding subchapter, who felt that meetings for only three to five people were inefficient. The contrast seems to rest on very different ways of working in the two fields (and for the latter informant, the number included all technical personnel, students, etc.).

Most medical researchers defined relatively large maximum limits: «I think there is a practical limit around 15 as to how many people that can actually work *together*» (institute sector). A medical professor said, «The upper limit gives itself when it becomes difficult with supervising capacity.» As mentioned, some of the informants talked about internationally prominent scientists leading groups of 30 or 60 people. Some of the effects of too large groups that were elaborated, are the following:

- Difficulties for the group leader – not enough oversight or not enough supervisory capacity, problems with co-ordinating the work.
- Informal subgroups emerge, creating internal competition or «small group mentality», reduced communication or inefficient communication patterns.
- Too much administrative work and/or too many meetings.

It can be seen that both too large and too small groups may result in inefficient communication patterns. There seems to be a practical limit to the number of close working relationships a researcher can have, although it may vary with the way the work is organised, as well as with individual characteristics. Few other issues were touched upon, although one informant was concerned with changes in size: «I think the important issue is flexibility. That you can go up and down in size depending upon the needs» (chemistry researcher, institute).

A medical scientist (institute) elaborated inefficient communication patterns due to size in an interesting way. He discussed his collaboration partners in the university sector and said, «We can mainly state that small is beautiful. (…) We do see in Bergen how the size of the university (…) makes it much easier to work there than here in Oslo, because there [in Bergen] the groups are so small that they realise they need each other and it is easy to create co-operation. While here [University of Oslo] there are many single groups that are so big that they think that if they are going to co-operate with anyone at all, it will definitely not be with anyone in Norway!» This statement also indicates that the size of groups could influence how well a department will function as an integrated organisational unit.

The above seems to confirm a curvilinear relationship between performance and group size (cf. Pelz, 1963; Stankiewicz, 1979; Etzkowitz, 1992; Martin & Skea, 1992; Johnston, 1994). However, the margins can be wide – the lower limit was two researchers for some of the informants, and a few claimed that good groups can be 15 people or even larger. The differences largely follow disciplinary boundaries, and hard scientists (particularly from medicine) favoured larger groups. There were also variations in the answers internal to each discipline, and it is difficult to claim that there exists *one* optimal size of groups. An efficient size depends upon many factors, for instance characteristics of the work to be done, the group leader, the people in the group and the group's wider environment. Earlier investigations have mainly used the quality of the leader as an explanation (e.g. Pelz, 1963; Stankiewicz, 1979; Etzkowitz, 1992). To focus on good or efficient communication patterns rather than on a concrete number of people is an advice that can be deducted from my interview data.

9.3 Department size

As with diversity, it seems that size at the departmental level is not very important to research quality. About half the sample (30) did not answer or stated that this aspect was not central. A professor in clinical medicine said, «The question is a bit irrelevant if you look at research. (…) This department is organised based on teaching of anatomy.» It was furthermore often claimed that external contacts can be more important: «You can definitely say that there is no minimum size. (…) But you have to look at external contacts too. (…) I for instance have more collaboration with people sitting in London than I have with people sitting here. We who are here are often hired to take care of somewhat different things» (sociology professor). The answers seem to be influenced by the present size. A professor of engineering cybernetics said, «We've been around 100 people [including technical staff and doctoral students] for 30 years. That's a nice number, (…) it's large enough to generate big and interesting results, and small enough for people to know each other personally and have a good common climate.» Even those who were critical towards their own department focused most often on other aspects than its size.

Compared to group size, the «optimal interval» of a department is much wider. Around half of those who responded claimed that there is practically no maximum limit (most of these come from the university sector). A professor of mathematics said, «In this department I think it [large size] is a giant advantage. (…) For instance, if you have internal conflicts in a section, you are integrated in a larger system supervising that; and you have a lot of service staff. (…) And when you are bigger it's much easier to avoid inbreeding and to enter new fields.» This scientist talked negatively about smaller units and asserted that larger units overall are more flexible and more open (other informants claimed exactly the opposite). The arguments were supported by a colleague in the same department: «Large departments are less dependent upon individuals. More people can invite external scientists and maintain networks.» A cybernetics engineer in the institute sector upheld that an institute can be very large if it is well integrated on both the technological side and the market side.

A medical scientist (institute) argued for large units also partly because of possibilities for sharing equipment, but underlined that other solutions were possible: «It's tempting to say 'as big as possible' because that would give more methodological opportunities. (…) Possibilities for sharing equipment may have positive effects. But it doesn't matter much as long as somebody at Blindern [University of Oslo] or others in Oslo do the same thing.» If there is a practical size limit based on available funds or positions, a philosophy professor wanted specialisation rather than breadth: «I know about some studies in the U.S. of optimal sizes. It seems that if you're less than 17-18, (…) the department either gets so thin that you only have one person in each main field who becomes a little isolated. (…) Or, you have to disclaim several central fields. If you have to choose, the latter would be the best strategy.» An economics professor maintained, «There's often a positive correlation between [department] size and quality. This is not a statement on principle, but an empirical observation from the economics departments in Norway.» Still, one could ask whether some departments become big because they are good, rather than the opposite.

However, many respondents, particularly in the applied sectors, were critical towards large departments or institutes. A sociologist in the institute sector said, «I am sceptical to the frequently claimed economies of scale; small organisations can have small administrations and little bureaucratisation and get more informal contacts.» Similarly, from a chemistry researcher in the same sector: «We're the largest [institute in the field] in Norway, and I don't think that's an immediate advantage. There can be much wear and tear, many administrative routines and focus on things that are irrelevant.» Also university scientists, particularly in the technological fields, argued for smaller units: «I don't believe in these mammoth departments, I believe in relatively small departments where people know each other better. My department of biotechnology with eleven full professors is large enough at any rate.»

In industry, most of the researchers said that the question was irrelevant. Three discussed the size of industrial R&D units in general, and one of them stated that «more than 200 [people] will give a jump in bureaucracy that increases the internal distances.» Claims like this one were also made by some of the informants from the institute sector – increases in size at one point might make an extra hierarchical level in the organisation necessary.

Still, it was often argued that the number of people *per se* is not very central. Having an efficient administration or providing a broad education at the undergraduate level was often seen as more important. In some applied units, the leader's role was frequently seen as a central determinant of departmental size. A mathematician said, «We are in a process of discussing that matter here. (…) I believe you easily can be 20 people, here we are 21, but it does lead to more personnel responsibility for the department head, who has to carry out some more co-worker conversations [formal annual talks about e.g. career and organisational issues] and supervise more people. I see the department leader as the last level where it should be possible to have an overview of what is going on technically, which means that the size of the department should be discussed based on technical characteristics rather than on definitions of a specific number of people.»

Some informants also talked about how the field is defined. A professor of French language said, «We are relatively big (…) and that has worked much better than we ever thought. (…) I don't think size has to do with number of people, but more with the number of specialities you try to integrate.» From this and other interviews, it appears possible to conceptually extend your field or discipline to justify a larger department.

To conclude briefly, the issue of size at the organisational level above groups seems to be most relevant in the university sector. In the other sectors, I cannot draw any conclusions from my data due to the large differences in types of institutes, firms, etc. However, the informants from applied units seem to put much weight on the characteristics, experience, professional background and tasks of the leader when discussing this issue.

Although many argue for «large» university departments, quite a few also argue for «small» ones (particularly in technological fields). Small would be around ten full-time professors, while large can be three or four times as many. The minimum size supported by my informants is somewhat smaller than what is suggested in earlier studies (e.g. Blackburn *et al.*, 1978; Fritschi *et al.*, 1980). It is evident that both some large and some small departments are perceived as dynamic, flexible and well-functioning, making it natural to claim that size is not be a central variable (as in Kyvik *et al.*, 1989; Martin & Skea, 1992; Kyvik & Larsen, 1993). Given the possibility of external collaboration, it is at least difficult from my data to argue for large units with respect to the quality of research. Nevertheless, coverage of the field, an efficient yet sizeable administration, and to offer teaching and supervision within many different specialities can be arguments in favour of large departments. These have also been put forward in earlier investigations (e.g. Martin & Skea, 1992). Some of the issues to consider would be technical/scientific criteria (what should be covered), the definition of responsibility of personnel, what is thought an efficient administrative unit and how the department should be organised (groups, division of tasks and responsibilities etc.).

9.4 Resources/equipment

Turning to the question of resources (including equipment), the interviews show that this may be a necessity for research, but will never guarantee a good result. A certain basic level of resources is required to have the potential to do good research, but an abundance of time and money can never guarantee that this potential is released. This confirms earlier investigations (e.g. Johnston, 1994; see also Herzberg *et al.*, 1993 claiming that resources is a «hygiene» factor).

Around twenty of the informants mentioned time resources as critical, and said, «Money or time; in the institute sector those two are convertible quantities» (mathematician). The rest mainly discussed money and scientific instruments. Some fields depend on much and up-to-date equipment, and all researchers need a well-functioning personal computer. Apart from that, a small level of resources that are not allocated to a particular purpose – some «flexibility in the budgets» – was strongly emphasised. Money for fundamental research or high-risk activities was what the researchers needed the most (and what some said was lacking the most). This was often connected with having enough time.

9.4.1 Computers and computer staff

Informants in all fields and disciplines mentioned computers as a central research tool. «We need computers that work and that are strong enough to run the software we use,» a professor of mathematics said, while a French language professor underlined, «We need well-functioning e-mail to be in touch with external actors.»

What was even more strongly stressed, however, was the need for support personnel: «You need good (…) computers including people who take care of them, so that the researchers don't have to deal with that side of it» (cybernetics engineer, institute). A colleague elaborated: «For us it's so important to have good computer equipment and good maintenance of it that we've refused to let us standardise by the parent institute's standard solution.» A similar and general argument was made by a professor of clinical medicine: «Computer support is vital, if you know what I mean, people who can help me when things don't work. People who can find out why this software doesn't run or why the hardware doesn't work.»

9.4.2 Other scientific equipment

Eleven of the respondents said that scientific equipment is very important to research quality (from all sectors and all but the soft sciences). A mathematician in industry said, «The more practically oriented the projects get, the more resources, in the form of equipment, are required.» Some specialities or problems are obviously more resource-intensive than others, also within the hard fields. «Equipment is of course important, I have had to leave some research fields due to lack of the proper equipment,» a professor in engineering cybernetics maintained.

Some researchers stressed the necessity of having up-to-date equipment to play a role internationally: «Our instruments are very important, our laboratory facilities and our chemicals; we need to have the same terms of competition as good units internationally. But you don't need *more* equipment than your needs dictate. Some research units buy the latest fashion in advanced equipment, but you can't make good research when you kill flies with a sledgehammer. A poor and irrelevant problem doesn't get better when you solve it with instruments that cost 100 million instead of 100 thousand» (biotechnology professor). A colleague in the same department said, «Equipment can be very important. Still, I would say that a typical characteristic of poor research units is that they start out with fancy equipment instead of good problems and ideas. It doesn't help with equipment if you run short of problems.» These statements indicate that there is not necessarily a strong relationship between resource levels and quality, and/or that high resource levels may rather be the result of quality (historically) than its cause. «Some of the best things I have done I did with scarce resources and small budgets and tight deadlines,» a chemistry researcher said.

The competition aspect was also emphasised by a biotechnology researcher from the institute sector: «Of course you don't enter a race in a Beetle if your competitor drives a Porsche, it's that simple. Then you redirect your research because that path is closed to you. (…) We could never have done the research we do today without automating the equipment. (…) [Talks about another institute in the field] (…) They have this guy who has to inject samples let's say every twenty minutes. And they can afford that, because that person's salary already is covered in the basic budget. But they can't afford to buy an autoinjector at a fraction of the cost! (…) People here are not very preoccupied with salary and raises and things like that, they see the instrument budget as more important. (…) If you're going to stimulate a good researcher, it's not enough to give him a salary raise, he appreciates much more a travelling opportunity, some new equipment and things like that.» We see that this informant (and others) underlined that researchers can feel motivated by improved equipment, and that e.g. budgeting procedures may make it more difficult to invest in new instruments.

Several informants underlined that there is a strong relationship between personnel resources and instruments. For instance, a chemistry researcher in industry said, «It's important to have good equipment, but you don't need the absolutely latest model. I think that the most important perhaps is the relationship between the human resources and the equipment, that is, that the researchers manage to utilise the equipment fully. I've seen examples abroad of old equipment that's been impressively utilised.» «It doesn't help to get money to buy equipment if you don't have the capacity to utilise it,» a clinical medicine researcher from the institute sector said, while another in the same field in industry stated, «We are very dependent upon investments in scientific equipment. It is very different within this field to operate with old-fashioned and out-of-date equipment. (…) But you get nowhere with modern equipment if you don't have people understanding its use, using it the right way and making the right priorities; there's no substitute for human resources.» A close relationship between people and instruments was sketched, as well as the problems that can emerge when there are changes in personnel. Thus, when one plans to invest in new scientific equipment, some issues to consider are the capacity for learning and for utilising it (efficiently), the money and people for operation and maintenance, and the long-term use independent of particular individuals.

When it comes to other types of resources/equipment, it can be noted that eight researchers (from all disciplines but the technological) underlined that good (and preferably internal to the unit) libraries are important to do good research. A mathematics professor said, «And then you have library expenses, (…) even if much now is available electronically (…) we are still very dependent upon good libraries.» An informant from French language stated that resources for publishing own books had been important to the department's development.

9.4.3 Financial resources in general

Another researcher from French language studies happily told about an increase in budgets the last years that she felt had had many beneficial effects: «Now we are able to travel whenever we have the capacity, and that's had an enormous impact. We now have a lot of travels, invitations, guest lecturers, (…) symposiums and seminars, and the budgets for it.» About two-thirds of the respondents talked about the importance of having the possibilities of arranging or joining seminars, going abroad etc. on a short-term notice. Surprisingly many (around a third) of the respondents, mentioned explicitly that travel expenses (or expenses for having guests) are a bottle-neck.

In general, it was claimed that «to have people and some flexibility for current activities is much more important than to have the big machinery» (clinical medicine, institute). Several underlined that funds «with no strings attached» are necessary for testing out new ideas and remaining updated in the field, or for recruiting new doctoral students and post-docs. A cybernetics engineer said, «Money that can be spent relatively freely is what matters, more than equipment; at least we don't feel equipment as a critical issue here.» As mentioned, some also underlined that the work must be organised in a way that gives researchers at least some time for long-term and/or fundamental research, or that money is important because it can be «traded in» for more time (money can «buy free» a researcher from short-term obligations).

The above discussion shows that resources is a much more complicated issue than just a question of funding levels. Many comments by my informants indicate that it is possible to obtain good results with relatively low resource levels, and that many resourceful research units produce uninteresting, unoriginal or otherwise poor results. This may account for the lack of relationship between resources and performance described in the literature (e.g. Pelz & Andrews, 1976; Stolte-Heiskanen, 1979; Jacobsen, 1990; Kyvik, 1991). Still, a certain basic funding level is necessary, and some fields depend on having as good instruments as their competitors and collaborators internationally. Hence, it may be difficult to view the question of resources isolated from questions of ambitions. If the research unit aims to be among the best in the world (or aims to serve users with such ambitions), much higher resource levels are required than if one wants to produce good research on a smaller scale (confirming Harris & Kaine, 1994).

Still, my interviews do indicate that some types of resources are perceptibly and worrisomely scarce. Many claim that «free» money for long-term, high-risk or just basic research is necessary, also in institutes and industry, and that this, at least partly, is lacking now. A few researchers in the institute sector (particularly from technological fields) stated that they work almost full-time on contract research, and they push for an increased level of basic funding to be able to do some long-term research at all (one of them desired 25 percent free funds). There also seems to be a notable shortage in the research system for travelling (also short-term for conferences and other meetings) and inviting foreign guests for long or short visits.

The need for scientific equipment largely follows disciplinary boundaries (see 3.4 for investigations of disciplinary differences). Two interesting points can be deducted from my interviews. First, computers play an increasingly central role in research work. For instance, many of the informants from the humanities talked about the necessity of «well-functioning» computers. This also leads to a need for computer support staff, which may have implications for the way research units are organised. Second, it is difficult to consider the investment in and use of equipment isolated from personnel issues. Somebody has to learn to use scientific equipment, they must have the time and capacity to do it, and they need to teach others before they leave the unit. Similar to what Etzkowitz (1992) found, this often seems to be taken care of by doctoral students in the university sector.

9.5 Discussion

I deducted three propositions from earlier investigations in 9.1. These are reviewed below along with some other central issues concerning size and resources.

At the group level, there can be an optimal size. Still, the margins seem to be relatively wide, and the effect may not be seen in all fields. Larger groups should be more important in applied settings, and the experience and competence of the leader is probably strongly related to group size. My interviews mainly confirm a curvilinear relationship between research performance and group size (cf. Pelz, 1963; Stankiewicz, 1979; Etzkowitz, 1992; Martin & Skea, 1992; Johnston, 1994), and that margins can be very wide. According to some informants, groups could be as small as two people, while a few claimed that good groups can be 15 people or even more. The differences largely follow disciplinary boundaries, and hard scientists (particularly from medicine) seem to favour somewhat larger groups. There are variations in the answers internal to each discipline, and it is difficult to claim that there exists *one* optimal size of groups. An efficient size depends upon a lot of other factors, for instance characteristics of the work to be done, the group (or project) leader, the people in the group and the group's wider environment. Thus, my data point to several contingencies of size, not only to the leader (which is a main focus in e.g. Pelz, 1963; Stankiewicz, 1979).

At the next organisational level, size seems less important to research performance. Some evidence exists that university departments in certain disciplines can benefit from shared equipment and inter-group collaboration. There is little evidence at hand about the institute sector and industry where the effect of size probably is dependent upon other factors like firm size, mission of institute etc. I can say little in general about the applied sectors based on my data material, because the organisational level above group varies much for these informants. It could be mentioned that many of the institute and industry researchers put much weight on characteristics (experience, skills, professional background, tasks, etc.) of the leader when discussing the issue of size at the level above groups.

From the interviews, it seems evident that both some large and some small university departments work well and are dynamic and flexible, making it natural to claim that size may not be the central variable (as in Kyvik *et al.*, 1989; Martin & Skea, 1992; Kyvik, 1995). At least when there is the possibility of external collaboration, it is difficult from my data to argue for large units with respect to quality of research. Although many informants argued for «large» departments, quite a few also argued for «small» ones, particularly in the technological fields. Small was most often defined as ten full-time professors, while large may be three or four times as many. The minimum size supported by my informants is somewhat smaller than what is suggested in earlier studies (e.g. Blackburn *et al.*, 1978; Fritschi *et al.*, 1980). Nevertheless, covering the field, getting an efficient yet sizeable administration and offering teaching and supervision within many different specialities may constitute better justifications for large departments. These arguments have also been put forward in earlier investigations (e.g. Martin & Skea, 1992). Some of the issues to consider would be technical/scientific criteria (what should be covered), the definition of responsibility of personnel, what is thought an efficient administrative unit and how the department should be organised (groups, division of tasks and responsibilities etc.).

Financial/material resources do not seem very central to research quality, but the nature of the (lack of) relationship needs some exploration. We have seen that the issue of resources is much more complicated than a simple question of funding levels. Many comments indicate that it is possible to get good results with relatively low resource levels, and that many resourceful research units produce uninteresting or otherwise poor research results. This indirectly confirms earlier investigations and may account for the lack of relationship between resources and performance in the literature (e.g. Pelz & Andrews, 1976; Stolte-Heiskanen, 1979; Jacobsen, 1990; Kyvik, 1991). A certain basic funding level is nevertheless seen as necessary, and some fields depend on having as good instruments as their competitors and collaborators internationally. It is difficult to consider the question of resources isolated from questions of ambitions. If research units aim to be among the best in the world (or to serve users with such ambitions), much higher resource levels are required than if one wants to produce good research on a smaller scale (see also Harris & Kaine, 1994).

My interviews furthermore suggest that some types of resources are perceptibly and worrisomely scarce. Many claim that «free» money for long-term, high-risk or just basic research is necessary, also in institutes and industry, and that this, at least partly, is lacking now. A few researchers in the institute sector (particularly from technological fields) stated that they work almost full-time on contract research, and they call for an increased level of basic funding to be able to do some long-term research at all (one of them specified 25 percent free funds). There also seems to be a notable shortage in the research system for travelling, both long-term and short-term, and for inviting foreign guests for long or short visits.

The need for scientific equipment largely follows disciplinary boundaries – hard and applied fields naturally require more expensive and advanced instruments. Two interesting points can be deducted from my interviews about this issue. First, computers play an increasingly central role in research work in all settings, also in the soft sciences. This also leads to a need for computer support staff, which may have implications for the way research units are organised. Second, it is difficult to consider the investment in and use of equipment isolated from personnel issues. Somebody has to learn to use scientific equipment, they must have the time and capacity to do it and they need to teach others before they leave the unit.

The recent «crisis» regarding resource levels in Norwegian research, which is often mentioned in the newspapers, is not very well reflected in the interview material here. Few of my informants talked about a crisis or tried to overestimate the importance of funds. An explanation could be that I have «picked the winners», who may have more resources than the average Norwegian scientist, particularly if resources largely are the result of good research (cf. Fox, 1983 and 1992). Although many of the researchers in my sample had few complaints about their present level of resources, it should be added that some felt they had no more resources than what they perceived a necessity for doing research at all. Many also talked about a lack of positions and, as mentioned, lack of opportunities for travels and visits.

Finally, there seems to be an underlying tension in the issue of group size. As Etzkowitz (1992) also has described, groups may experience a «drive» towards larger size, because an increasing number of group members could mean more stability, access to funding, scholarly opportunities, intellectual synergy and many other beneficial effects. At the same time, increases in size could lead to fission, more administrative work and more frequent or harsh personal conflicts. Thus, there may be forces in the work itself driving the research unit towards a larger size, while e.g. social considerations can imply that the unit remains small. This is probably an important organisational tension at the group level, which again may require «balance» or «equilibrium».

10 Informal organisational characteristics

Within social studies of science there is a long tradition of elaborating informal aspects of research work. Particularly influential has been the notion of the «ethos of science», defined as an «affectively toned complex of values and norms which is held to be binding on the man of science» (Merton, [1942] 1973:269). Four basic norms were put forward: universalism, «communism» (in brackets in the original), disinterestedness and organised scepticism. Later scholars, and Merton himself, have added more norms and made slight changes to the original four.

The norms have been criticised, and e.g. Mitroff (1974) has put forward a set of «counter-norms» (particularism, private property, interestedness and organised dogmatism). It is claimed that particularly the task uncertainty of fields, disciplines, and problems determine if the counter-norms or the «conventional norms» are dominant. Still, the centrality of norms is not questioned, but rather the contents of such informal organisational aspects. Another dimension that is added is that of tension. Culture is not seen as a single set of values and norms shaping scientists' behaviour, but rather as a number of contrasting values and norms that leave room for ambivalence and blurring of individuals' judgement. There may furthermore be a conflict between the culture of a technical/scientific field and that of a firm, or between the culture of academe and the culture of science (cf. Hackett, 1990).

I will not go deeper into the debate on norms here (for more see e.g. Foss Hansen, 1988), but in the following primarily concentrate on earlier investigations of research unit performance. Still, it can be added that organisational culture is seen as central to organising for innovation (Dougherty, 1996). It is for instance argued that it is necessary to clarify the nature of the «code of conduct» seen fundamental to enable organisations to balance tensions connected with innovation (*ibid.*). Weick & Westley (1996) argue that tension can be maintained by focusing on certain aspects of organisational culture as humour («culture as language»), improvisation («culture as an action routine») and creating a pocket of order in chaos («culture as artefact»).

10.1 Earlier investigations of informal characteristics

There is conclusive evidence that informal organisational characteristics have important influences on research performance. Allen (1977) found that informal aspects were almost as central to performance as formal ones (see also Foss Hansen, 1991). Earlier investigations have for instance elaborated on «commitment», «cohesiveness» and «enthusiasm» at the unit level, a beneficial or friendly (work) «climate» or «atmosphere», «strong common norms and visions» (for instance related to originality and publishing in international journals), the research group as a «quasi-family» and «innovative climate» or lack of «bureaucratic culture» (Pelz & Andrews, 1976; Andrews, 1979a; Stankiewicz, 1979; Singh & Krishnaiah, 1989; Jacobsen, 1990; Spangenberg, 1990a; Etzkowitz, 1992; Martin & Skea, 1992; Jones & Sullivan, 1994; Harris & Kaine, 1994; Asmervik *et al.*, 1997; Bennich-Björkman, 1997). Such issues are often tied to aspects of internal communication (see chapter eleven) or creativity (cf. e.g. Bennich-Björkman & Rothstein, 1991).

In general, it is claimed that individuals «will tend to conform» to a culture where there are strong expectations of productivity and quality, or lack of such expectations (Hare & Wyatt, 1988:319). The distinction between formal and informal characteristics is not very clear – «autonomy» can for instance be seen as related to the formal decision-making power of the unit and its members, but also as a central «norm» or «value» in research units. I prefer to speak broadly about «tolerance» instead of «autonomy» when it comes to the informal side of the organisation. Still, «culture and structure are interwoven: cultural innovations may follow from changes in structure and behavior, or they may occur as independent adjustments that prove just as adaptive as structural innovations» (Hackett, 1990:246).

10.1.1 The many facets of culture

In the literature, there are hundreds, if not thousands, of definitions of the term *culture* alone. A relatively narrow meaning can be defined, where culture for instance refers to a coherent system of assumptions and basic values distinguishing a group and directing its choices. On the other hand, it can also concern a group's beliefs, models of behaviour, technology, symbols and artefacts (see e.g. Kekäle, 1997). Previous quantitative studies of «group climate» or «group culture» have included items like «spirit of innovation», degree of dedication to work, adequate consideration of new ideas, acceptance of ideas from junior members, degree of co-operation and frequency of staff meetings (cf. Knorr *et al.*, 1979b). A much used definition is found in Singh & Krishnaiah (1989) who see climate as a «shared and enduring molar perception of the psychologically important aspects of the work environment» (p. 333). That it is shared may of course in itself be a central beneficial feature of the climate, making it more similar to the Mertonian ethos (although the contents may vary).

In the work group literature, the key to good performance is often described as «sharing»: «The authors all stress the importance of shared norms, with differential emphasis on shared visions, shared meanings, a sense of shared responsibility for group outcomes and co-ordination among group members» (Shulman, 1996:360). At the same time, it is often added that sharing is not necessarily productive. For instance, if low productivity norms are shared, poor performance may be the result. The idea that a strong, unified culture is a «good thing» has become widely accepted, but also criticised, because it is so surrounded with tensions and political conflict (Clegg & Hardy, 1996).

Culture has been a hot topic in organisation theory and management literature for more than a decade, although much of the interest has been highly prescriptive. The best-selling example is probably Peters & Waterman (1987) who tie financial results to the value systems of different firms. Wilkins & Ouchi (1983) is another much referred-to work. They claim that the importance of the organisational culture varies with task uncertainty and measurability of the organisation's output. When the task uncertainty is high and it is difficult to measure the output, like in most research organisations, the organisational culture is particularly important. This could explain why informal characteristics seem to play a large role in research units, as well as provide a starting point for hypothesising about disciplinary differences. In disciplines without a well-established theory or «knowledge core», like the humanities and many of the social sciences, informal aspects may be relatively more important.

An interesting perspective on informal organisational characteristics can be seen in Andrews (1979c), who considered «motivation» to be a feature of research units as a whole. It was found that with respect to this construct, the variance between units was twice as large as the variance within them. Team motivation was positively related to performance, but Andrews adds that the question of causality is difficult to answer. High team motivation can be a result of good performance rather than its cause.

From the literature, it is furthermore evident that the culture in research units has both a «professional» and a «social» side. Some authors mainly address professional aspects like informal scholarly discussions, critical attitudes, spontaneous recognition for publications etc. (Jacobsen, 1990; Asmervik *et al.*, 1997; Bennich-Björkman, 1997). Others also draw the attention to the social aspects, for example stating that for some members «the group is a 'quasi-family' as well as a 'quasi-firm'» (Etzkowitz, 1992:38).

10.1.2 The working climate: challenge or security?

A few authors claim that productive researchers work in environments described as «cold», «hostile» or under extreme «external pressure» (Fox, 1992; Kim & Lee, 1995). Others stress that the working climate should be «good», «friendly» or «humane» (Jacobsen, 1990; Stolte-Heiskanen, 1992; Harris & Kaine, 1994; Bennich-Björkman, 1997).

Different explanations for this divergence can be put forward. Maybe the productive researchers in «poor» working climates are the exceptions to a rule? Or maybe climate is more important to juniors than to seniors? Another explanation could be rooted in the fact that it is the qualitative studies that most strongly advocate a nice working climate, while Fox (1992) focuses on publication productivity and quantitative data only. Scientists may thus in an interview setting overemphasise the effect of the working climate. On the other hand, the university researchers with the highest publication output in Stolte-Heiskanen (1992) were also in general the ones the most pleased with their department.

10.1.3 Brief summary

The culture or climate of research units may obviously be both a factor of security and a factor of challenge (or maybe both) (see Pelz & Andrews, 1976). From earlier studies, it is furthermore natural to conclude with the following propositions:

- «Organisational culture» or climate, research culture etc. is most likely important to research quality, at least at the group level. As other organisational aspects, culture has both a professional or scholarly side, as well as a social side.

- Organisational tensions and their «maintenance» of «balance» has been particularly elaborated in connection with informal aspects, but it is unclear how this works.

10.2 The influence of the culture/climate

Informal organisational aspects were much discussed in open questions about good research units (cf. chapter twelve). «Collegiality» and «openness» were particularly underlined. The first aspect referred to good personal and scholarly relations that can be a source of feedback and critique, but also of more general support and inspiration. Openness, apart from referring to «non-isolation» and frequent communication, had much to do with «tolerance» regarding new ideas, unfamiliar approaches and «strange» people. It was also related to a sense of «freedom» or «liberation» and to a positive attitude towards external impulses. An economics professor stated that the informal dimensions are the central ones when characterising research units: «The research organisation is important, and a good research organisation requires a good climate. The criteria for organisation and climate are much the same.»

10.2.1 The importance of informal aspects

The informants were also asked a more specific question about organisational culture or climate: «Can you describe the organisational culture, or the climate or chemistry among the personnel in a good research unit in your field?» (And follow-ups about how this can be related to quality.) For some, this question initially seemed very difficult. However, the word climate was meaningful to many of the researchers, and with some help to get the discussion started, 59 out of 64 answered. That «climate» was the word that frequently trigged the discussion, implies that the elaboration frequently centred on interpersonal aspects – the relationship between the individuals in the unit. Climate was easily tied to quality: «I think it's obvious that a good working climate will influence quality positively» (chemistry professor). A cybernetics professor said, «It's definitely important, but it's hard to say how.» Some of the researchers underlined that the climate in good research units may not be different from the climate in other types of units. In the words of a chemistry researcher from the institute sector, «The well-being factor is important, and I think research units are not different in this respect from other organisations.»

Informal aspects were in general considered very important: «It's obvious that for optimal working conditions for people, (…) the issue of organisational culture is very important. Cultural aspects are of great significance» (economist, industry). Three quarters of the informants from industry claimed that this was «vital» or of «central importance», and about half the researchers in the other two sectors made similar statements. A sociologist from a research institute stated, «This [organisational culture] is the most important organisational aspect.» The existence of an ambitious and open culture was seen as significant in building up research in new areas. For instance, an industrial scientist maintained, «I would claim that we have been able to develop ourselves to a considerable research group that also has been noticed internationally in very short time, and that's been based on our culture (…) [with lots of] openness, and competition you could say, in openness.»

Some of the industrial and institute scientists elaborated what they perceived as the climate in the university sector: «It's amazing how good a climate we have here. (…) I know that at the department of chemistry [at the university] it's been horrible at times, (…) lots of pride. I don't claim that we're all free of that, but compared to the university it's like heaven and hell. (…) I have never seen a university department that's avoided that trap» (chemistry researchers, institute). This and many other interviews indicate that taking a post in an applied institute or in industry is a clear choice – not only based on individual orientation towards application and utility value (cf. chapter six), but also based on a perceived poor working climate in the universities. Although the universities sometimes were seen as too competitive, a certain degree of internal competition was often seen as positive in applied settings as well. A sociologist from the institute sector described a good organisational culture as «mildly competitive, it's good that people compete sometimes».

10.2.2 Specifications of beneficial working climates

Many different expressions were used in the elaboration of informal aspects. The most frequently encountered were as follows:

- Collegial, helpful, lots of informal communication, spontaneous recognition of good work, inspiration, mutual respect and sympathy.
- Open, tolerant and generous, allows mistakes and aberrations both professionally and socially.
- A feeling of well-being and belonging, loyalty, feeling of unity and common goals, «esprit de corps».
- Somewhat competitive (some stated that no internal competition is optimal for the young people), but without «sharp edges», «optimal friction» between the individuals.
- Few intrigues and personal conflicts.
- Good mood, sense of humour, fun activities, friendship.
- Ambitious and oriented at achievement/performance.

Two of the researchers were preoccupied with the maintenance of organisational culture. One of them, from a biomedical research institute, said «It's important with continuity [of personnel] so that traditions and culture are maintained.» High proportions of temporary staff and few post-doc and intermediate positions were some of the problems that were pointed to (which have been a concern in other recent studies as well, e.g. Senker, 1999).

10.2.3 The working climate influences motivation, creativity and communication

When asked why informal aspects are important, a majority pointed to the motivation of the unit members. This is similar to what was found in chapter six, where «good working conditions» were seen as a major positive influence on motivation. A cybernetics professor and an institute researcher in the same discipline both said, «It [the working climate] influences the individual's motivation,» while a mathematics researcher from the institute sector stated, «A poor culture and poor personal chemistry is restraining and demotivating.» A medical professor said that because «Basic research demands an enormous dedication and it demands mutual enthusiasm», the informal aspects are central. Informants from all disciplines and institutional settings mentioned this relationship. «If you feel part of a team, (…) it can give you more time and inspiration,» a philosophy professor maintained. It may thus be claimed that where there is no formal teamwork, the informal sense of belonging and of collegiality become even more central. Motivation and inspiration were most often directly tied to quality: «Inspiration and well-being are preconditions for both solidity, originality and relevance» (chemist, industry, see also chapter six).

Not only (high) motivation and similar variables were underlined as results of good climate. Several (particularly from the medical sciences) also claimed that «creativity and imagination [are promoted] by the organisational culture» (basic biomedical scientist, institute). «Imagination and creativity are very dependent on motivation and the shape you're in,» a researcher in clinical medicine from the same sector elaborated.

Communication in various forms was frequently mentioned as well. «Collaboration, collegiality (…) I believe it is very important, without well-being both work effort and productivity decrease. When you have team spirit and chemistry between people in the department and on the project, everything goes much easier» (mathematics, industry). A cybernetics engineer from the institute sector said that the organisational culture «influences collaboration which is at the heart of good research», and a professor of the same discipline talked about «synergy effects» of having a common culture and a good working climate. It was repeatedly stressed that the working climate and the relationship between the research unit members affect the level of communication. An economist in the institute sector said, «If you have a nice social climate you feel better and then it's easier to go and ask others for help and advice.» A similar argument was made by a professor of French language: «People must not only have [professional] respect for each other but also sympathy. (…) Because the other then feels recognised and you get a scholarly discussion and exchange.» Hence, it seems that the professional or scholarly activities often are based on good interpersonal relations, elaborated with terms like friendship, sympathy and collegiality. As Allen (1977) found, professional exchange is also a form of social exchange, which can be promoted by non-professional ties between the researchers (see chapter eleven for more on communication).

Most of the informants proclaimed a strong relationship between informal aspects and motivation and quality, but a few saw the organisational climate as mainly a «hygiene» factor, i.e. with no direct contribution to good performance, although lack of it may lead to dissatisfaction. «The climate clearly has to be on a certain level if it's not going to influence quality negatively. You could have this very social and nice climate without getting anything done, too, but I think that it has to be on a certain level at least to prevent poor results» (cybernetics engineer, institute). A similar point was made by an economist in the same sector: «I am not sure if it is very important to the research, but a poor climate can definitely have very negative effects.» Only one of the informants stated that a poor working climate could have beneficial effects: «I guess [a good working climate] is good for the research because you can get ideas and some criticism maybe. But on the other hand you could imagine that if there are poor relations each researcher sits in the office and works intensely, undisturbed by the others» (philosophy professor). Thus, in my interviews, there are hardly any examples of units with poor or «hostile» climates that produce good research, but a few claimed that a good climate not necessarily will lead to good research.

10.2.4 Culture and productivity

Although informal organisational aspects frequently were tied to motivation, which again often was tied to quality, productivity was another issue raised in more than half of the interviews. A chemical professor stated, «It stimulates to increased effort, [a good working climate makes] you spend an immense amount of time.» «I am at least certain that it influences quantity – productivity increases much [in a good working climate]» a professor of biotechnology stressed. Similarly, several informants said that in periods of interpersonal problems in the research unit, productivity can suffer a lot. «We did have problems with the personal chemistry earlier, and we got so little done,» a medical researcher from the institute sector said. A sociology professor claimed, «I believe that you get *more* done as well when you have good interpersonal relations; (…) deep conflicts are always destructive [to quality and productivity].»

Thus, as was seen in chapter six, motivation and personal characteristics are not the only central variables when it comes to producing good research. Intense work is also required: «What is alpha and omega all the time is that those who do research in a group have the necessary incitements to research. (…) And the important thing is to inspire people to make an effort and to make an effort for many hours each day» (medical professor). In addition, the interview material indicates that motivation, which is related to the organisational culture/climate, may influence productivity more than quality. Low motivation is not good for either of them, while a strong motivation can be beneficial to productivity, which in turn may be good for quality (these two aspects are naturally not unrelated).

My interviews support earlier studies in finding that informal organisational aspects are central to research quality or performance (e.g. Pelz & Andrews, 1976; Andrews, 1979a; Stankiewicz, 1979; Singh & Krishnaiah, 1989; Jacobsen, 1990; Etzkowitz, 1992; Harris & Kaine, 1994, Asmervik *et al.*, 1997; Bennich-Björkman, 1997). The «working climate» or the social side of informal organisational aspects was the focal point in the interviews. Many previous results were confirmed – a good working climate can benefit motivation (for instance Andrews, 1979a; Jacobsen, 1990), creativity (Bennich-Björkman & Rothstein, 1991) and internal communication (e.g. Allen, 1977; Stankiewicz, 1979; Martin & Skea, 1992).

A few commented that it is possible to have a good working climate without this resulting in good research, but almost all researchers claimed that it is practically impossible to do good research over time in a poor climate. My data give the strongest support to the literature focusing on good, «friendly» or «humane» work conditions (e.g. Jacobsen, 1990; Stolte-Heiskanen, 1992; Harris & Kaine, 1994; Asmervik *et al.*, 1997; Bennich-Björkman, 1997) rather than authors who claim that the work environment can be «cold» or «hostile» (Fox, 1992; Kim & Lee, 1995). Aspects like openness, tolerance, helpfulness and a «sense of unity» were generally emphasised. The good research unit described by my informants thus equals the «quasi-family» proposed by Etzkowitz (1992).

10.3 Tensions in the informal organisation

It was often underlined that the professional sides of research work are in most cases taken care of automatically in research units. If quality improvement is desired, a focus on social relations was often recommended. «It [quality] depends on personal chemistry, it is important that those in the group are on the same wavelength. (…) They should give each other mutual criticism and encouragement and focus on the social relations – the professional relations come more automatically» (mathematics researcher, institute). To become friends with colleagues was often elaborated as beneficial (and frequently as a natural consequence of collaboration). A philosophy professor stressed, «You should be on so friendly terms that you share opinions within a field, and that does not happen everywhere. (…) But it may be sufficient to have colleagues abroad who are also friends.» Several added that good ideas often arise «over a pint» or «when sharing a pizza». A clinical medicine researcher saw this as a particular challenge for the Norwegian research system: «Compared with other countries, it's clear that Norwegian research has a giant problem. We go home to wife and children relatively early, while in other places, they go to the pub and drink beer the rest of the evening. And for research, beer drinking would be better. But I don't think I would switch – it's a choice of values.» This supports Kyvik's (1991) claim that not all scientists have ambitions of becoming «eminent» or maybe not even internationally recognised.

10.3.1 Encouragement versus criticism

Other conflicts were also sketched. A biotechnology professor underlined the necessity of being kind to one's colleagues and students, and to encourage them whenever possible. Still, he added, «There's of course the danger in positive feedback that quality criteria are reduced just to be nice, there's an important balance there. I'm usually mild towards the doctoral students in the beginning, although I emphasise a good elaboration of the problem, but I'm strict in the last half-year, when they're writing. There's a conflict between inspiration and stringency.» Hence, a tension can be envisaged between a direct focus on the quality of the research, which may imply strict or «unmerciful» standards, and efforts to inspire and encourage colleagues and students.

Obviously, not all colleagues can become friends. A philosophy professor talked at length about «good personal relations, that you at least cope with things together and don't dislike each other. (…) But it does happen with eminent people that they are not very amiable.» The informant continued by quoting the famous Finnish philosopher Von Wright, who after a seminar reportedly said, «They [the scientists at the seminar] were extremely intelligent and extremely unpleasant.» This supports the claim made regarding leaders in chapter seven – those who have the best formal leadership competence may not be the ones who have the best social or supportive skills.

10.3.2 Collaboration versus competition

A chemistry professor similarly argued that it can be a challenge to make good researchers work with each other and tolerate each other. «It's like in sports – you have to have individuals with much self-confidence, but they must also allow others to have that self-confidence.» Some underlined that this does not necessarily rest on scholarly agreement. A professor of French language said, «There are people here that I disagree with in all essential matters, but with whom I have a very warm-hearted relationship. (…) And that's an inspiration.»

The tension between collaboration and competition can be claimed to be at the bottom of these matters. Although internal co-operation is judged as very beneficial, colleagues also (at least to some extent) compete for limited resources, recognition and positions. Some of the informants were concerned with this tension, for instance a mathematics professor who said, «They say that it's good to compete, but it's not like that always, because it leads to envy and to a little distrust. You (…) close up a little because you're afraid that others may get more honour than you and so on.» A sociology professor suggested that a certain indifference to each other's work can be positive because it can lead to «pluralism» or diversity in the long run. Much internal interaction and little competition leads to a strong common culture, but the negative side is that the unit can become less diverse (and diversity is generally a positive challenge, cf. chapter eight).

10.3.3 Maintaining the balance

It can be claimed that at the heart of all these tensions lies the issue of challenge versus support. Both need to be present in good research units, and it seems essential to maintain some kind of balance between them. Researchers want for instance moderate diversity of people and tasks, and a certain level of internal competition coupled with social support and inspiration. The balance need not necessarily be considered internal to the research units. A professor of clinical medicine said, «I think that people work best – and now I think mainly about doctoral students – in a unit where they get a suitable blend of challenge and support. You do get large challenges from the international research community that you encounter at conferences and when you write your articles. So we can be more on the support side, because I tend to see us as a base from which our young people go out into the world and present their stuff, write their articles and do their projects. And we're the home base to which they return to lick their wounds, and they get encouraged to go out there again. (…) The danger is of course that you get too kind and supportive, but since we have the ambition that everything should be published internationally, I feel that we've taken that into account.»

Personality characteristics were often upheld as a central influence on organisational culture and climate. Many of the informants consequently argued that the «fit» or «friction» between a potential new member's personality and the present climate of a research unit, was important to judge when one interviews candidates for vacant positions. Several also stated that formal organisational aspects influence the informal ones. A chemistry researcher from the institute sector said, «The overall conditions and regulations do put some limitations on the culture. The promotional system is for instance (…) crucial to the internal competition. (…) This affects both the social life in the units and the research that is carried out.»

Many informants strongly advocated the egalitarian culture of research organisations, but some also said that this aspect makes it difficult to e.g. initiate highly individual monetary reward mechanisms which could have positive short-term effects. A couple of other respondents stated that strained budgets have negative effects on the informal sides of the organisation. An industrial researcher maintained, «We notice fluctuations in bad times with more pressure and budget cuts, then it's a big challenge to avoid the negative effects of the organisational culture or just the atmosphere of the unit.»

The above discussion has shown that my informants were concerned with elaborating dilemmas mainly at the individual level, for instance the question of encouragement versus criticism for doctoral students. This fits well within the security versus challenge framework of Pelz & Andrews (1976), and the organisational culture is clearly a source of both. Some of the other tensions that were specified can be tied to the discussion of norms in science. The issue of collaboration versus competition may be linked with the question of communalism versus private property (cf. Mitroff, 1974; also Merton [1942] 1973). The balance of these tensions seems to imply for instance collaborating with some (researchers or units) and competing with others, and (perhaps more frequently) collaborating in some respects (e.g. large projects, political support) and competing in others (like Research Council funding).

10.4 Discussion

As in previous chapters, I end this one with a review of the propositions put forward in the beginning of the chapter.

«Organisational culture» or climate, research culture etc. is most likely important to research quality, at least at the group level. As other organisational aspects, culture has both a professional or scholarly side, as well as a social side. My interviews support previous studies in finding that informal organisational aspects are central to research quality or performance. Because the interviews were centred largely on «working climate», «local» aspects were elaborated rather than the culture of the whole institution, firm, discipline etc. Many previous results were confirmed. A good working climate can for example benefit motivation (see e.g. Andrews, 1979a; Jacobsen, 1990), which in turn was tied to productivity.

It is interesting to see the strong link that was advocated between informal aspects and productivity/working long hours. For many, it is necessary to work very hard and very much to become a good scientist, and people could find it difficult or impossible to labour long hours in a poor climate. A few commented that it is possible to have a nice working climate without doing good research, but almost all researchers claimed that it is practically impossible to do good research over time in a poor climate. My data give the strongest support to the literature focusing on good, «friendly» or «humane» job conditions (e.g. Jacobsen, 1990; Stolte-Heiskanen, 1992; Harris & Kaine, 1994; Asmervik *et al.*, 1997; Bennich-Björkman, 1997) rather than authors who claim that the work environment can be «cold» or «hostile» (Fox, 1992; Kim & Lee, 1995).

The working climate was furthermore seen as positively related to creativity (Bennich-Björkman & Rothstein, 1991) and to internal communication (e.g. Allen, 1977; Stankiewicz, 1979; Martin & Skea, 1992). If it is beneficial for research quality to have good and frequent contacts with internal colleagues (most stated this, cf. chapter eleven), a good working climate seems to be a basic precondition. Some of the recurrent specifications were openness, tolerance, helpfulness and a «sense of unity». The good research unit described by my informants thus equals the «quasi-family» proposed by Etzkowitz (1992).

Organisational tensions and their «maintenance» of «balance» has been particularly elaborated in connection with informal aspects, but it is unclear how this works. From my data it is evident that the organisational culture or climate can be a source of challenge and of support, and that it frequently is both. A number of dilemmas were elaborated, for instance the question of encouragement versus criticism related to doctoral students. What is the proper balance between security and challenge in this respect (cf. Pelz & Andrews, 1976)? For some, the answer was a «separation in time», i.e. focus on encouragement in the early phases and a move in the direction of scholarly criticism and maintenance of professional standards later. Others discussed the external/internal divide, and argued that doctoral students (and others) receive enough challenge from the international scientific community. Given that an international orientation is strongly expected, it is thus sufficient for the research unit to be supportive and encouraging.

In general, differences between types of personnel can be seen in the question of challenge versus support. Several of the (senior) researchers talked about beneficial effects of a certain level of internal competition (or possibly indifference) – a source of challenge for those who have achieved professional self-confidence. On the other hand, many of the informants elaborated social support for doctoral students in particular, frequently exemplified with accounts of young people with high potentials, who would have become brilliant scientists had they received more encouragement and inspiration.

Another frequently encountered tension was collaboration versus competition. Again, the argument was that a «moderate» or «mild» degree of competition can be stimulating to the researchers, but that too much competition is destructive, because it leads to too much «private property», «interestedness» or «particularism.» Behind this issue, we can see the long discussion about norms in science (cf. Mitroff, 1974; also Merton [1942] 1973). My data indicate that these value or norm conflicts are never completely resolved, and I see no clear disciplinary or sector differences in this respect. Internally, the competition issue may be completely removed if there are no positions, prizes etc. that are desired by the unit's members. This would not constitute a «balance» of tension. Externally, a moderate degree of competition can be achieved for instance by collaborating with some (researchers or units) and competing with others, and also by collaboration in some «arenas» (e.g. large projects, political support) and rivalry in others (like Research Council funding).

11 Communication

In general, communication is a pivotal feature of good researchers and good research units. Some general reasons are the centrality of publishing results in most types of research, the often democratic and collegial nature of research organisations, and the tacit component of scientific work that can only be transferred through personal contacts (e.g. Blau, 1973; Collins, 1985). Communication is of course a fundamental aspect of all social life, and probably just as complex as social life in general.

11.1 Earlier studies of contacts/communication

There are at least two chief dimensions to the issue of contacts or communication in and around research units. As with (other) aspects, there is both a «professional» and a «social» side. In addition, the literature often distinguishes between (unit-) internal and external communication, the latter including international contacts. I can only present some of the studies here; already more than twenty years ago it was claimed that the «literature produced in the domain of communication in science and technology amounts to thousands of published documents» (Visart, 1979:224). In fact, it is difficult to find an investigation within social studies of science and technology that in one way or the other does not deal with communication. Again, I will concentrate on earlier studies of research performance and its determinants. A broad overview of different types of communication is found in table 11.1 (where «users» are broadly defined as all non-researchers with a strong and direct interest in the research work).

Table 11.1. *Types of communication in R&D units.*

Dimensions of communication	*Local or national*		*International*	
	Other researchers	***Users***	***Other researchers***	***Users***
Internal *or* ***intra-organisational*** *(the definition will vary between units)*	Group, department, laboratory, institute, university	Users in own firm (only relevant to industrial researchers)	R&D personnel in own firm abroad (relevant to industrial researchers)	Users in own firm abroad (relevant to industrial researchers)
External *(most often defined as outside of the firm, institute or university)*	Researchers in other fields, departments, institutes and firms locally and nationally	Users in firms, government agencies etc.	The international scientific community	Multinational firms located abroad, international institutions (EU and others)

A large number of studies have found a positive relationship between contacts with *external* colleagues and performance (e.g. Allen, 1970; Crane, 1972; Blackburn *et al.*, 1978; Visart, 1979; Spangenberg, 1990a and b; Busch & Colwell, 1991; Kyvik, 1991; Harris & Kaine, 1994; Kyvik & Larsen, 1994; Teodorescu, 2000). In the latter four studies, and in other investigations outside the U.S., «international» contacts are stressed as particularly important. Informal networks of colleagues in a field have been termed «invisible colleges» (Crane, 1972). With the rise of electronic communication, such colleges can have become even stronger, or new «electronic colleges» may have emerged. In general, external contacts are more important in basic research (e.g. Andrews, 1979a; Katz & Allen, 1982).

In applied research and technological development a more local communication pattern has been established as the most central, although external contacts also may be beneficial (particularly through specific individuals, see below) (Allen, 1977; Cole, 1979; Katz & Allen, 1982). Project-external, but still intra-organisational, communication will be the most typical feature of applied research units, while groups focusing only on technological development mainly benefit from the quality of the project-internal communication (Katz & Allen, 1982; also Visart, 1979).

Furthermore, in technological disciplines outside of the university sector, cross-disciplinary contacts will often be conducive to performance (Cole, 1979). It has been found that high-performing engineers communicate beyond their own disciplinary group twenty times more frequently than the low performers (Allen, 1977). Pelz (1963) found that medical scientists in U.S. national institutes benefited from contacts that were «quite different from themselves in terms of values» (p. 309), and that contact once or twice a week was enough when communicating with «similar» colleagues. An international study found «work contacts» in general (both internal and external) to be a central influence on performance, and more significant in user-oriented units (Singh & Krishnaiah, 1989).

It can be added that the large size of the R&D units in Allen's (1977) investigation increases the probability of having a colleague in the organisation who can fill a knowledge gap. This will not necessarily be the case in smaller units. Still, external information may be important even in large R&D laboratories, for instance as sources of ideas for innovations (see e.g. Marquis, 1988; von Hippel, 1986). Allen (1977) found that a small number of engineers acted as *technological gatekeepers*. Significantly more than their co-workers, the gatekeepers exposed themselves to external sources of technical information. They read more, especially the refereed sophisticated technical journals, maintained external personal contacts and communicated more with customers and technical vendors. In general, however, the lower-rated solutions in the technological R&D projects of Allen (1977) relied more heavily on written sources than did the higher-rated. It can thus be argued that at least in technological fields, external sources of information, both formal and informal, are important to the performance of projects, but not important to all R&D personnel directly.

Several studies conclude that *internal* contacts are important for university scientists as well, particularly in natural science and technology but also in the other fields of learning (Visart, 1979; Spangenberg, 1990a; Busch & Colwell, 1991; Kyvik & Larsen, 1993). One of these investigations actually found that intra-organisational communication is more important than external in all types of research, although both are central to performance (Visart, 1979). The researchers who collaborate with their colleagues have in general been found more productive and/or more often cited (Price & Beaver, 1966; Lawani, 1984; Stephan & Levin, 1987; Kyvik & Teigen, 1996). Improved internal communication is often mentioned as a means to improving quality (e.g. Jacobsen, 1990; Stolte-Heiskanen, 1992). An interesting finding is that the pattern of network relationships is similar across disciplines and institutional settings (Visart, 1979). Hence, some types of contacts contribute to user-rated performance, and others influence scientific performance.

Frequency of contacts is obviously essential, and some evidence suggests that it is better to have frequent contact with many than with just a few (Pelz & Andrews, 1976; Allen, 1977). Few investigations have focused on the explicit *contents of communication*. What are e.g. external colleagues useful for? Critical comments on manuscripts, information on publication or funding opportunities, exchange of results that have not yet been published and exchange of research equipment (in a broad sense) and knowledge of its application, are some of the benefits that a researcher's network can have. Some authors maintain that scientists use their networks to gather resources and to gain support for scientific claims (Latour & Woolgar, 1979; Latour, 1987). It has been found that collaboration is not only useful for filling gaps in skills, techniques etc., but also for gaining access to materials like blood and tissue samples and patient histories (Laredo, 1999).

A natural assertion is that the internal communication patterns probably have a stronger «social» side than the external ones (but general social support may naturally also be a feature of the «invisible colleges» that a scientist is a member of). A few earlier studies have upheld the importance of general social interaction and unconventional settings (Jacobsen, 1990; Bennich-Björkman, 1997). Allen (1977) has tied social and professional communication together, by maintaining that general social interaction (playing games, eating and drinking etc.) can facilitate social exchange – it may reduce the costs for a researcher who would like to ask a colleague for help (and by that «reveal» a lack of knowledge). It should finally be mentioned that although most authors find that communication patterns are more a cause of performance than the result of it (Pelz & Andrews, 1976 make this point very clearly), a strong two-way relationship probably exists here.

As far as I know, no investigations exist of new forms of electronic communication and whether these have changed scientific communication patterns in any way. One reason for the lack of focus on electronic communication in the literature could be that by the time the investigators would have produced their results, the users would already be onto the next generation of computer technology (see Shulman, 1996). In 1983, Mintzberg postulated that «more sophisticated instruments – such as the computer (…) reduce the professional's autonomy» by bringing about more teamwork and more reliance on the support staff. On the other hand, it has been asserted, «technology only provides us with more and faster opportunities for communication. It does not provide us with communication *per se*, let alone better communication. The problems inherent in the communication process are not removed by (…) technology» (Shulman, 1996:369).

Summing up briefly, the following research propositions can be made before turning to my own empirical data:

- Patterns of communication are likely to vary along the dimension basic/applied – a difference in patterns should thus be seen between sectors and to some extent between disciplines. The more basic the research work, the more are important external and international contacts. Still, a high frequency of communication is important in all settings. In applied research, user communication is crucial to quality.
- There are different types of contacts, and the distinction between e.g. formal and informal communication has rarely been elaborated in earlier studies of research performance. Both types may be beneficial to assurance and control of research quality, but also as a means of transferring various types of knowledge and research technology. The rise of e-mail and other ways of electronic interaction may have made communication faster, but has probably not influenced the frequency and quality of contacts.

11.2 Patterns of communication and different institutional settings

In chapters seven through ten, we saw that contacts and communication were mentioned in various ways during elaboration of both formal and informal organisational aspects. Issues like diversity of people and organisational culture/climate were tied to communication, with a frequent remark that to have numerous internal contacts benefits quality and productivity. The informants were also asked direct questions about such issues, for instance related to who it is beneficial to have contacts with, and what is exchanged during communication. Seven informants did not answer for various reasons (although all of these in one way or another had mentioned communication in other parts of the interview).

A high level of interaction is clearly a central characteristic of good research units and good researchers. A chemistry researcher from the institute sector said, «All good researchers [I have met] have had very large personal networks.» Some tied this to the personal pleasure of doing research: «Inspiration and motivation are important results of collaboration and communication» (mathematics, institute). Others underlined that all aspects of quality can be directly influenced by contacts. A professor of French language said, «What you've discussed thoroughly with somebody else is always better.» A mathematics professor said that this is frequently a reiterative process: «It's incredibly important to know somebody who's a bit different [from yourself]. (…) [Contacts are useful for] feedback on what we do, to go through several rounds to make it right, to explain better what we do and why.» Hence, communication is a quality control mechanism for many: «You need to discover weaknesses, get good feedback. You have to have something in between sitting at home researching and standing on the speaker's platform at Harvard» (clinical medicine, university).

As expected, there are differences between institutional settings in communication patterns. The variation is not as large as one would anticipate from the literature, though (cf. chapter three). Internal (group or department) contacts were judged very important by many university professors, while industrial researchers stressed the benefits of international research collaboration. It could be claimed that the similarities are just as striking as the differences. This will be elaborated further below.

11.2.1 Communication in the university sector

International contacts were mentioned as an important stimulus of and input to research by all university informants. Some saw it as a basic precondition for scientific work. A professor of clinical medicine said, «To be able to digest everything about new research you have to share the tasks and collaborate both internally and internationally.» Some mainly described their international contacts as colleagues or even «friends» they regularly and informally keep in touch with. Others elaborated formal relationships: «Our international contacts are often [connected with] concrete collaboration. We plan co-publications and exchange ideas and research materials» (basic biomedical scientist).

External (frequently international) contacts were seen as necessary, particularly in the soft fields, because researchers often are hired to «maintain» different specialities. Something similar was sketched by a philosopher, who said that the researchers in his field often were oriented towards different countries where the specialities or certain traditions were particularly strong. A French language professor claimed that it was often difficult to get a good dialogue internally about research issues: «It's vital to have international contacts. (…) In the department, we live an everyday life, so it's impossible to have [fruitful scholarly dialogues] within the institution. The daily routines take their time, and no one has the time to talk about their research.» It should be added that all those who were part of a group stated that group-internal communication is essential to quality, and some also said that a high level of interaction in the department is beneficial.

All the respondents from universities stressed the general importance of communication. Even those who mainly worked alone, often underlined the benefits of formal and informal collaboration: «We do individual research, but it is very positive to write an article together with researchers in other countries, for instance by e-mail» (economics professor). A French language professor told, «I haven't had much experience with collaboration. (…) But I wrote this book with someone and that was a glimpse into another world. (…) And now we've thought about maybe doing something more, because it was definitely appetising.» Thus, communication has not only to do with quality assurance and control, but also with to the pleasure of scientific work. A mathematics professor put it this way: «[When you collaborate] you get twice as good. (…) And it gives you an additional motivation, (…) this interaction. (…) I used to write by myself mainly, but lately I've written most of the things with others, and that is actually quite pleasant.»

Apart from general quality assurance/control and inspiration, several other reasons for communication were given. A biotechnology professor mentioned sharing of equipment: «You often need instruments that give you access to other measurement methodologies, for instance cyclotrons in the U.S., Japan and Grenoble.» A chemistry professor discussed sharing of work connected with problems that stretch across several specialities: «We often collaborate formally when two different areas are covered. (…) Let me give a concrete example, we collaborate with a group at Department B on so-called oestrogen effects, (…) and we fill distinct functions.» Many informants also elaborated aspects of relevance and other quality elements. Another chemistry professor discussed contacts with industry, scientists in other fields and groups nationally and internationally, and tied this to different types of originality and relevance (user needs, cross-disciplinary problems, national priority areas and relevance to the research frontier). He added that there may not always be a rational decision behind a contact: «Some of this is determined by where the needs are [related to problems, methods etc.], some of it is determined by this personal chemistry and whom you know, and then some of it rests on coincidences.» Cross-disciplinary contacts were mentioned by professors from chemistry, engineering cybernetics, medicine and philosophy. One of the latter said, «I believe most of us benefit from communicating our knowledge, also with people from other fields. Philosophy may be special because it borders on many other fields.»

Communication with users was emphasised in the technological disciplines. A professor of engineering cybernetics said, «[Industry contacts ensure that] we get informed about what is relevant in industry, with the reservation that they have a very short-term view. And they cannot possibly keep track when the development in the field has this speed. But I have acquaintances in industry and try to get funding for scholarships for doctoral students.» Another of the informants from this field asserted that much of the scholarly development takes place in private firms, not in universities. Several of the technological informants expressed concern because a large share of their doctoral students had been «headhunted» by large European firms, «It's tragic that European industry sucks all competence [in this speciality] out of Norway,» one of them said. Although a few saw «short-termism» in industry as a problem, others took this as a matter of fact. The same can be said of intellectual property issues. Temporary confidentiality agreements were accepted by many, but not without some concern: «In industry we sometimes collaborate in more closed circles. I have from time to time signed confidentiality agreements – I sometimes have nightmares that I end up in some kind of courtroom in California for sharing information that I was not supposed to share! [laughs]» (biotechnology professor).

Relations to users were also mentioned in sociology, clinical medicine and the natural sciences. Even the philosophers discussed a responsibility for keeping in touch with the «general public». One of them elaborated, «For instance does sitting in ethical committees provide you with familiarity with people who are in very particular circumstances. You see how many factors there are, the complexity. Then you get a little careful in generalising.»

11.2.2 Communication in and around industrial research units

In industry, user contacts were most commonly underlined as important, as can be expected from the applied activities with strong focus on utility value found here. For the informants in my sample, this also implies much internal communication, because the users are found within the company. A mathematics researcher said, «We need to have good contacts with user groups internally to make sure that the research is well anchored in the firm's activities.» This was elaborated further by a chemist: «It's important to have a system that gives you a customer contact, and that the customer is active in the start-up phase and defines the project tasks, and in the end phase where the issue is to transfer the results.» A special task was described by a cybernetics engineer: «We also often become a kind of link between academia and the business units of the company. (…) They have people with links to the academic world and they see new things in cybernetics or seemingly new things, (…) but they're not sure what to make of it and then they ask us (…) if this is applicable for us or not.»

Still, external relations were almost as often underlined as internal ones: «We get some analysis work done externally, some special toxicological analyses we have to buy externally. (…) And we often try to do things together with research groups internationally» (clinical medicine). In fact, ten (out of twelve) of the industrial informants maintained that international contact was somewhat or very positive to their definition of research quality. From the interview material, it seems that the industrial researchers have the broadest array of contacts. Most of them had more or less frequent communication with university scientists in Norway and abroad, with various institutes, with other firms in the same business or suppliers and consultancy firms, and with various groups within the company. A chemistry researcher said, «All internal and external groups are important to us in one way or the other, both professionally and commercially. (…) The communication is also similar with all groups, it can be purely qualitative information about general issues or concrete project discussions.»

Although collaborative projects with and/or contracts to university scientists were referred to as common, many other types of relationships with the university sector were sketched. Assisting in teaching and supervision has already been mentioned (chapter eight), and industrial researchers also stated that they occasionally call up professors for more concrete advice and feedback on particular ideas and questions, or to get a general overview of recent developments in the field. A cybernetics engineer said, «We sometimes contribute with some funds [to professors] so that when they're abroad on a conference that we can't participate in, they give us a brief report about it.» He added further that he had given a recently retired professor the task of making a list of all the best university departments in the field worldwide, with information about specialities and key people to get in touch with if needed.

Such informal contact outside of collaborative projects was frequently upheld as important. It may not always be easy to achieve, however. A mathematician stressed, «The universities are paid for by the government, while the institutes have to charge for their services. This means that you can't talk too long with a person from an institute without him needing a budget to allocate work hours to. The same applies to a certain extent to other companies – we easily become formal, you need a contract, project description and so on. Informal communication can frequently be important, but maybe a bit difficult to facilitate. If I'm going to the University of X to talk to some professors there, I need to get permission from my department head and find a budget to cover the expenses.»

In general, the industrial firms represented in the sample often call on external sources, both in institutes and universities (and to some extent specialised consultancy firms), to do part of their research and development. One said, «External colleagues help developing our tools and do parts of the projects. (…) I guess we spend 30 percent of our funds on buying research externally.» This «outsourcing» had two explanations. First, several informants said that other groups were called upon in periods of unusually high activity, helping them deal with temporarily massive workloads. Second, a sharing of work strategy was sketched because it would be impossible to keep all needed competence in-house in any case. A chemistry researcher said, «In some fields we have made strategic decisions where we say that in this field we're not big enough to maintain an adequate professional weight and activity ourselves. Those have mainly been conscious decisions.»

These outsourcing decisions can be controversial. There seems to be a tension between some researchers' desire to build up competence in the company and others' (often managers') decision to buy research and development services externally. A cybernetics engineer elaborated, «We consider Institute A to be very similar to us, so we mainly use them for taking some of the work off our hands when we have too much to do. (…) There has been a tendency that when we get funds alone or with somebody else, those funds have gone to A, and A has done a large part of the work. I think that's wrong, because if these fields are so important to us and we're talking about building up competencies in a new area, then we probably should have done it ourselves. When you get A to do it without our having the competencies, it's difficult to appropriate and make use of the results, and it's difficult to ensure that the results are of the type that we need.» Two other informants also expressed that it is imperative to have a very close relationship with the external contractors to make sure that all the necessary knowledge and competencies are transferred.

11.2.3 The institute sector: less international?

In the institute sector, a pattern of communication similar to industry's can be seen. Even so, I have a general impression that international contacts are a bit less common in institutes (there are of course exceptions) than in industry and universities. Institute researchers may on the other hand collaborate with a number of different user groups (contractors). Another impression is that the institute researchers who did not talk about irreconcilable conflicts between utility value and scholarly relevance most often stressed that they have close contacts with both users and universities. A cybernetics engineer, «Frequent contact with users has much influence on the research quality of a concrete project, but when it comes to the quality of our competence and the type of competence we have to acquire in the long run, the contact with the university is very important.» The researchers who found it very difficult to combine demands for scholarly and external relevance, mainly communicated with one of the other sectors. There seems to be a «trajectory» or reinforcement effect here – if you have had several highly applied projects (maybe with no research content at all), then it becomes harder to enter a fruitful exchange with a university professor (see 11.3 below).

Communication is still a central feature of research also in the institute sector. A mathematician described the typical pattern this way: «With users we collaborate on concrete projects with applied goals, and with universities we have seminars and publishing activities.» A cybernetics engineer maintained the same: «We have seminars and other professional meetings with the university. (…) With industry it's often concrete project co-operation to ensure that there is a degree of actual professional collaboration.»

User contacts are clearly important to the institute researchers, who all (with a few medical scientists who only did basic research as exceptions) depend on contract research in addition to EU funds and Research Council projects. The latter two are also frequently user-oriented. A close relationship was often described, for instance by a chemistry researcher: «The users own the problem so-to-say, and it's obvious that you can come up with solutions that are so-called excellent for the researcher, but that would be completely useless for the users. If you don't communicate well with your contractor, you may end up delivering something that's of no use.» Only the social scientists sketched a slightly different user relationship, for instance that government agencies may be pleased with research (or evaluations etc.) that are of «poor» quality (see chapter five for more on this).

A close relationship with the university was often described as essential, especially to maintain competencies in the long run. University professors are often part of a team that gains project or programme funding through e.g. the Research Council or EU. A mathematician said, «We collaborate with some university professors. You often have good relations to the place where you got your education.» A few other special relations were elaborated, for instance by a chemistry researcher who talked about internationally leading professors: «We have hired several good foreign scholars in our field as consultants. They come here once or twice every year and tell us about what they think are the exciting developments in the world. We can also use them for more concrete advice.»

One of the cybernetics engineers stated, «We collaborate with university B and with industry and with other groups at this institute, but we don't collaborate very much with other institutes in Norway.» This was underlined by more than half of the informants from this sector. It seems that several of the institutes (or groups within them) are the only ones nationally within their speciality. Those that had extensive collaboration with others in the same sector in Norway were mainly (with a couple of exceptions) from the social sciences. A sociologist said, «There are two or three others in the same speciality in Norway, and it's very important to have regular contact with them, to hear if they've read anything exciting lately and so on.» An economist furthermore elaborated, «For us it is natural to include other institutes [in our projects], for instance on noise measurements we use A and on risk analysis we use B, and then we have C and D that are experts in their fields. And then you have this dimension where you bring together economists, engineers and sociologists. This clearly has positive effects on the total project.» Still, a colleague from the same institute maintained, «We don't have any formal general agreements with other institutes about co-operation. The ones we collaborate with on concrete projects are also our competitors around the next corner. But sometimes we apply for project funding together.»

As mentioned, international collaboration was not as common in the institute sector as in the other two institutional settings. Still, about half the informants stated that international contacts are important. A sociologist for example said, «Colleagues internationally may be important to get in touch with regarding international publishing, which is something that has to be learnt.» Others claimed that this dimension is getting ever more central: «We've had a little of it [international research collaboration] previously, but it's been growing very fast in recent years with this EU funding» (economist). A clinical medicine researcher claimed, «For us the formal project collaboration is what's central. (…) But this house has a substantial weakness: we should have been a lot more internationally oriented.»

In this subchapter, we have seen that communication is considered a central feature of good research units (confirming e.g. Pelz & Andrews, 1976; Visart, 1979; Lawani, 1984; Stephan

& Levin, 1987; Spangenberg, 1990a; Kyvik & Teigen, 1996). As expected, there are clear differences in communication patterns between institutional settings (see e.g. Visart, 1979; Katz & Allen, 1982; Singh & Krishnaiah, 1989). The university researchers stressed international contacts (like in Kyvik, 1991; Harris & Kaine, 1994), but they also emphasised good internal (group and/or department) communication, confirming e.g. Visart (1979), Busch & Colwell (1991) and Kyvik & Larsen (1993). Interaction with users was stressed by some of the professors, not only from technological disciplines, but also from soft fields.

Industrial scientists talked about user communication and accented contacts with suppliers and researchers in other disciplines (like in Allen, 1977; Visart, 1979; Katz & Allen, 1982; Singh & Krishnaiah, 1989). Somewhat unexpectedly, the industrial informants also stressed international scientific communication. The reason could be that I have picked visible senior researchers as respondents in this sector, and these are probably more likely to be technological gatekeepers (cf. Allen, 1977). Gatekeepers display an unusual communication pattern with more external contacts and more connections with the professional literature.

Researchers in the institute sector emphasised user contacts and links with universities. The former improve the quality of projects, while the latter help maintain competence and recruitment in the long run. Preserving both types of contacts was by many seen as a necessity if the institute is to become a good research unit – a «hybrid organisation» as described by Mathisen (1989). International communication was stressed, but to a lesser extent, although many comments indicate that this is getting more important, not least through EU funding. It is clear that the different types of contacts often imply different types of communication – and differing requirements for the exchange process. This will be elaborated more below.

11.3 Types and contents of communication

In 11.2, I distinguished between communication patterns in the three different institutional settings. Within all settings, there are obviously different types of communication. As a starting point, we can distinguish between formal project collaboration, conferences and guests etc., and informal communication.

11.3.1 Formal collaboration and organised types of communication

Formal collaboration, i.e. research together with someone external to the unit, seems very common in all sectors and disciplines, apart from the humanities and to some extent the social sciences. But also in the latter fields collaboration is reported to be increasing, first in the form of writing scientific articles or books together, but frequently moving on to doing research in co-operation. Co-publishing is of course very common in the hard sciences as well. A professor of engineering cybernetics said, «Some write papers together with colleagues abroad, we also write papers with our doctoral students and we write papers with industry. We often have people from industry as co-authors.» Collaboration is not only a result of researchers' need for feedback and quality control, but also due to characteristics of the problems *per se*. A biotechnology professor said that frequently occurring «large and complicated problems» are often shared with other groups. Cross-disciplinary problems are another case that most often requires collaboration across groups, departments or institutions.

Conferences, seminars, workshops and so on were also mentioned as arenas of contact and communication. Those who talked about it often added that it is not necessary to participate in every meeting. A medical professor said, «I go to conferences, naturally. There's particularly one [annual] conference in haematology that I find useful.» The same point was stressed by a researcher in a biomedical institute: «[In addition to formal project collaboration,] I also think that it's very fruitful to participate in meetings, workshops, to exchange experiences and ideas, and get reactions to what you're doing. But not too much, I believe it's sufficient to go to a congress once or twice a year.» In fields were the scholarly development is slower, the general social interaction at meetings was stressed the most: «I often feel that seminars yield relatively little, it's not the scholarly contents that are important, but that you meet people and maintain some social relations. If you subscribe to the relevant journals and report series, you mainly know what's going on» (economist, institute).

Some of the university informants also described beneficial effects of sabbaticals or of guests in the department. A philosophy professor said, «We have few collaborative projects, but spending a sabbatical year at another university and for instance inviting guest lecturers, can mean very much.» A biotechnology professor dryly remarked, «We try to exchange personnel, and [an important effect is that] it shows people that the grass is not greener elsewhere.» In general, it can be claimed that most good university groups and departments have guests and go abroad for medium or long-term stays. A few of the industrial researchers also mentioned that temporary exchange of personnel with other research organisations could be beneficial, to learn new theories and methods and transfer it to the firm, or to transfer some «perceptions of real life» to scientists at universities and institutes.

11.3.2 Informal types of communication

Informal contacts can refer to many different activities. A sociologist from the institute sector said, «We often work alone and stay in touch with the field through the literature. Still, it's important to have contacts, but the informal ones that are the most important are often so impenetrable and variable that it's difficult to say anything general about them. We collaborate firstly with colleagues in other groups nationally, and then with researchers internationally.» The distinction between formal and informal contact is not sharp. A sociology professor elaborated, «There are different degrees of closeness and permanence, but at least for me there is a group of researchers in Norway and in other European countries that I pursue relatively habitual contact with, that I see regularly and that constitutes an important reference group for me.» An example of an in-between forum could be an informal group that nevertheless meets regularly: «We have this group that meets at hospital X, where we take turns at presenting results» (medical professor). It can be added that many saw informal contacts as important also related to formal collaboration. An institute researcher in clinical medicine said, «Informal contacts are decisive also in project collaboration – to know what people do and where.»

The exchange of unfinished or unpublished research results in informal settings was often mentioned. A biotechnology professor said, «It's almost impossible to picture good research without a good international network. A good network ensures that you don't have to wait a year to read something in a journal, you get to know the results before they are published.»

«Unpublished research results are often exchanged in social settings,» a mathematician from the institute sector stated. An interesting comment was made by an economist in industry, who said, «Informal contacts do not mean very much to us, because we're not on the research frontier. For us the central sources of inspiration and motivation are in-house.» Thus, if one wants to do research at an internationally leading level, at the research frontier, and/or if the scientific development is very fast, a network of informal contacts may be necessary. These loose acquaintances also form a sort of «preparedness» or «reserve» that one can call upon if needed. An economist from industry stated that it is «very useful to have these weak ties; (…) you may need information on labour market research in another country and then you can call someone you've had a beer with once».

To build this network, is a difficult and long-term operation. Many invoked notions as «friendship» and «trust», for instance a chemistry researcher from the institute sector who said, «Informal communication is very important. (…) And it has a lot to do with the personal chemistry. To have a close relationship is very important, I think. There's clearly a lot of competition between researchers, and if you don't confide in a person, you keep the information to yourself. (…) Building trust and all that is very important internationally, (…) building trust at a general social level. (…) You may be a brilliant professional but if you lack the ability to get along with other people, then it's obvious that… [shakes his head].» A colleague from the same institute elaborated, «All types of contact are in a way valuable, also general social companionship. If you're going to collaborate well, you have to build trust, to be able to trust others and build up the trust of others in you. That is the precondition for getting something done across institutions.» One explanation for these comments is that trust may be particularly important in settings where confidentiality and other intellectual property issues arise.

It should be mentioned that few (less than five) talked about electronic communication (they were not asked directly about this). One of the exceptions, a professor of engineering cybernetics said, «The Internet is important. Most people have their own homepages and put out all their publications there.» Another professor, from chemistry, stated, «Sharing work with colleagues in international groups is important and has become a lot easier due to the technological development – transferring files and so on.» In other words, both formal (sharing data, co-publishing) and informal (getting and staying in touch through e-mail and web pages) communication has become easier.

11.3.3 What is communication about?

Several informants were concerned with elaborating the specific contents of communication. «We talk about everything – feedback on research, information about funding sources, unpublished results. The inspiration and motivation is important, to associate and discuss informally and to meet out of seminars and conferences,» a sociologist from the institute sector maintained. A chemistry researcher in industry specified, «Internally we talk about work processes that we all are part of, about important decisions. It gives us team spirit. Externally we discuss the concrete projects, their status, implementation, needs etc.» A medical scientist from the same sector said, «Collaboration has largely to do with methods, communication about methods. You learn other methodologies through visits and exchange of people. International conferences are important both to oversight and insight. Personal acquaintances may be important for the exchange of cell lines and things like that.» It can be seen that communication for many has much to do with methodological issues. Other informants gave similar statements, for instance a sociology professor who told, «We often exchange more technical than theoretical or substantial information. There's a lot of spoken exchange about technical issues – how do we solve this and so on, much about methodologies, about data collection and statistics.»

In the experimental sciences, much more than «pure knowledge» is exchanged, as the above quote from the medical scientist indicates. A biotechnology professor specified, «There's an exchange of organisms and samples that only we or some others are able to make, like bacteria cultures and chemical tests,» and an industrial scientist in clinical medicine stated, «We exchange all types of knowledge, anything from computer software to chemicals.»

We have seen that the distinction between formal and informal communication is not very clear. It is also evident that one influences the other. An economist in industry for instance said, «It has often [started with] project co-operation, but then it continues with more informal communication.» The opposite was described by a sociologist from the institute sector: «There are many [processes] here. One is that you and some colleagues find out that you to a considerable extent have common interests and advantages from talking together. Maybe it's just a 'snout factor', that you like each other and want to collaborate, and then this is the start of a common project that can be relatively close.» There can obviously be a positive influence in both directions – collaborative projects can yield informal contacts, and people you meet in informal settings may be later co-workers on specific projects.

11.3.4 The reciprocal nature of communication

It was often stressed that communication must not go in one direction only. «Two-way communication with external colleagues and users is what's important,» a mathematician (institute) underlined. A biotechnology professor said, «Lectures and things like that [oriented at industry] only give one-way communication, which is not good for collaboration. We have seen that collaboration based on one-way communication often falls apart.» Many informants, particularly from the technological disciplines, were positive towards contract research for industry and others, but often wanted this organised as collaboration rather than as a process where results are just exchanged for money.

From this it follows that both (or all) parties must have something to contribute in scientific collaboration and maybe in all types of communication. An economics professor strongly expressed, «You have to have something to collaborate *on*. And you have to have something that you're able to add to it.» The same was stressed by a chemist in industry: «[Internationally] I think it's important to stress that there should be *co-operation*, so that both parties have a professional input.» Scientific communication is evidently a form of social exchange, which for instance carries with it requirements of reciprocity and balance (cf. Blau, 1964). Reciprocity implies an expectance of returns, and balance means that the parties are interested in staying out of debt and in maintaining an equivalence between inputs and outputs. An institute researcher explained, «If you are personally acquainted with a basic researcher, (…) he likes your face and you his, then you can get collaboration. But you must all the time make sure that you get a real exchange, so that everybody comes out with more knowledge and nobody exploits the other.»

That professional communication is very similar to general social exchange can also explain the centrality of trust that was seen in many informants' statement. Unlike economic exchange, the obligations and expectations of social exchange are unspecified, which means that one has to trust that the other party will behave as expected. Advice, assistance and other typical benefits of social exchange are not independent of the supplier (as in many types of economic exchange), but rather dependent upon the interpersonal relationship.

It can be added that there consequently are limitations to the exchange possible to a researcher. Her or his competence, knowledge and network constitute opportunities and limitations for social and professional exchange. A biotechnology researcher from the institute sector stressed, «You have to have something to offer when you're going to collaborate. Money may do in some cases, but competence is more important, particularly when you are dealing with basic research groups. You have to have competence to be able to appropriate competence, and that can be a problem [if you've only worked] with confidential industry projects.»

As mentioned above, unique scientific tools, data and instruments are sometimes exchanged in informal two-way relationships. In chapter nine it was concluded that such resources can be necessary preconditions for research (at least in some disciplines), but they do not otherwise display a very positive relationship with quality. Here, we have seen that informal acquaintances may be the only way to acquire many of these resources. Hence, although a satisfactory funding level cannot ensure quality, it could constitute a fundament for the development of fruitful informal networks, because resources makes it possible to produce data or scientific tools that are useful to others.

11.3.5 Trajectories of communication

One could talk about «trajectories» or «reinforcement» related to scientific communication. The contacts that a scientist attains in an «early phase» (doctoral study and the years immediately following) could have a strong influence on that individual's career – not only on the scientific direction, but to some extent also on the quality of the future work. It should be added that the doctoral supervisor obviously is important when it comes to introducing doctoral students to the scientific community. Thus, as was expressed also in chapter eight, leaders may have a very important long-term and indirect influence on the quality of researchers' work.

As general social exchange, scientific communication and collaboration often arises out of a problem or goal that can only be achieved through interaction. A medical professor said, «We need to exchange ideas and teach each other different methods and techniques. Nobody can master them all, and that's how collaboration emerges.» When searching for this needed complementary competence, many researchers turn to those they presently know, often people they have encountered by chance at a professional meeting. As many of the informants stressed, there clearly is a coincidental element in this, particularly in the initial phase of communication and collaboration. For instance, a chemistry researcher discussed at length many cross-disciplinary collaboration projects at his institute, and added that all of them were «more a result of coincidences than of necessities».

We have seen throughout 11.3 that the boundaries between different types of communication often are unclear. Informal and social contacts may lead to formal project collaboration, and vice versa. The social side of conferences and other professional gatherings was emphasised the most, and it was often underlined that trust (and eventually friendship) is an important precondition for fruitful scholarly exchange (confirming Allen, 1977; Jacobsen, 1990; Bennich-Björkman, 1997). Still, there is a two-way link between communication and performance (like in Pelz & Andrews, 1976). To be an attractive contact a researcher needs to have something to offer – primarily interesting results, but state-of-the-art equipment can also play a role. If a researcher falls outside of the main professional communication channels, this does not only imply fewer sources of feedback and support. In many cases, this also means that the researcher will not gain access to unpublished information, be part of the exchange of research materials and data, and other central scholarly processes. Thus, communication can be linked with dynamic processes and may explain large differences in performance and productivity.

11.4 Discussion

Two propositions were presented in 11.1 based on earlier studies of research performance and communication. These are reviewed below along with some other central points regarding this issue.

Patterns of communication are likely to vary along the dimension basic/applied – a difference in patterns should thus be seen between sectors and to some extent between disciplines. The more basic the research work, the more important are external and international contacts. Still, a high frequency of communication is important in all settings. In applied research, user communication is crucial to quality. Communication is clearly seen by my informants as a central feature of good researchers and good research units (confirming a number of studies including Pelz & Andrews, 1976; Visart, 1979; Stephan & Levin, 1987; Spangenberg, 1990a; Kyvik & Teigen, 1996). Furthermore, there are differences in communication patterns between institutional settings, as expected (e.g. Visart, 1979; Katz & Allen, 1982; Singh & Krishnaiah, 1989).

The main anomaly in my data is the relatively strong weight put on international contacts by industrial scientists. This can be explained if the industrial informants largely are technological gatekeepers, who display an unusual communication pattern with more external contacts, and who have more connections with the professional literature (cf. Allen, 1977). Still, a few of these respondents emphasised that companies with a technological leader profile operating in international markets, need to remain in touch with leading research units world-wide (see also Gemünden & Heidebreck, 1995). In addition, strong (and often international) university links were frequently seen as a prerequisite for recruiting the most talented students, a critical issue for technologically leading firms.

User communication was seen as essential to research quality in the applied sectors. Not only does this ensure a good definition of the problem, but it can also help ensure user support and involvement, which contribute to a good transfer of results and competence. As was seen in chapter six, a good relationship with users can furthermore contribute to the pleasure of and motivation for doing research. Industrial scientists in particular may have broad networks that include suppliers, consultancy companies and competing firms (like in Allen, 1977; Visart, 1979; Katz & Allen, 1982; Singh & Krishnaiah, 1989). Some university informants, particularly from technology and to some extent the soft fields, also mentioned benefits of contacts outside of the scientific community. Apart from providing useful research input, user interaction can have positive effects on the labour market for students etc. It is perhaps noteworthy that a majority of natural and medical scientists did not mention extra-scientific contacts. Apart from this, I have not been able to see very clear patterns in disciplinary differences (which again may be due to the small number of informants in each discipline).

Good and frequent internal communication was emphasised in all settings, like in Visart (1979) and Cole (1979). Although external contacts may replace internal communication, at least in the university sector, a good internal working climate was without exceptions seen as an advantage (cf. chapter ten). In the institute sector, it was emphasised that both user contacts and links with universities need to be maintained, creating a «hybrid» organisation (cf. Mathisen, 1989). User contacts can improve the quality of projects, while university links help maintain competence and recruitment in the long run. The institute researchers did not emphasise international communication as much as the informants from the two other sectors, and several of them criticised their own institute for being too little oriented at other countries. An increasing number of EU-funded investigations, more weight on international comparative studies in some fields and an orientation at international communities of users are some trends that could contribute to changing this pattern in the future.

There are different types of contacts, and the distinction between e.g. formal and informal communication has rarely been elaborated in earlier studies of research performance. Both types may be beneficial to assurance and control of research quality, but also as a means of transferring various types of knowledge and research technology. The rise of e-mail and other ways of electronic interaction may have made communication faster, but has probably not influenced the frequency and quality of contacts. We have seen that the boundaries between different types of communication often are unclear. Informal and social contacts can lead to formal project collaboration and vice versa, and networks of good researchers often consist of people who are both friends, partners in projects and informal advisors to each other.

The social side of conferences and other professional gatherings was emphasised the most. It is in these surroundings that you «build trust» and extend your network. It was frequently stressed that trust is an important precondition for fruitful scholarly exchange (confirming for instance Allen, 1977; Jacobsen, 1990; Bennich-Björkman, 1997). A few informants stated that e-mail has made it easier to get in touch and remain in touch with people, and to exchange documents and unfinished materials. The impact of electronic communication on the frequency and quality of interaction seems small, as expected.

Communication and performance obviously displays a two-way relationship (like in Pelz & Andrews, 1976). To be an attractive contact, a researcher needs to have something to offer – primarily interesting results, but state-of-the-art equipment could also play a role. If the researcher falls outside of the main professional communication channels, this does not only imply fewer sources of feedback and support. In many cases, this means that the researcher will not gain access to unpublished information, be part of the exchange of research materials and data, and other central scholarly processes. As other authors have found, networks are very useful for gathering resources, support, and for appropriating research materials that are not publicly and readily available (see e.g. Latour & Woolgar, 1979; Laredo, 1999).

This furthermore implies that dynamic processes are evident in scientific communication. One fruitful exchange leads to another exchange, which after a while can turn into a powerful network for an individual or a research unit. Similarly, an unsuccessful interaction, where for instance one of the parties was unable to fulfil the requirements of reciprocity in social exchange (cf. Blau, 1964), may lead to a termination of the interaction between those parties. This can create positive and negative «trajectories» or «paths», signifying important processes behind reinforcement and accumulation of advantage effects (see for instance Merton, [1968] 1973 and 1988; Cole & Cole, 1973; Fox, 1983; Kyvik, 1991 and subchapter 3.3).

The trajectory or «path dependence» literature, for instance related to technological development and «lock-in» (e.g. Dosi, 1982; David, 1985; Arthur, 1994), does not give rise to much optimism about the possibilities of research policy influencing issues like networks, at least not in the short run. Today's opportunities depend upon the many decisions, results, remote events and accidents of yesterday. Large differences in performance and productivity between individuals and between research units could thus largely be based on (more or less) institutionalised patterns of scientific communication.

Finally, it can be mentioned that contacts and communication can be tied to the issue of tension in research organisations in at least three different ways. First, the reciprocal nature of all types of social exchange makes interaction a kind of strain or pressure in itself (see Blau, 1964). Staying «out of debt» and maintaining equivalence between inputs and outputs can be a source of challenge, while the trust that is built through successful interaction can be a source of security and support. Second, we have seen that the institute sector's position in the research landscape can make it necessary for it to uphold strong links both with users and with universities. These hybrid linkages (see Mathisen, 1989) can naturally be a source of tension, because users and university researchers may have significantly different conceptions of what good research should be (see also chapter five). Third, a few industrial scientists stated that they sometimes need to keep to themselves what they are working to avoid that other companies start R&D on the same problems. This may create difficulties for fruitful professional exchange with others, and signify a tension between norms of «universalism» and «private property» (cf. Merton, [1942] 1973; Mitroff, 1974).

12 Conclusion: research quality and the research organisation

In this chapter, the empirical data that I have examined so far are summarised, and a few more questions from the interviews are included in the analysis. In 12.1, I elaborate the relationship between organisational characteristics and quality elements, and the link between quality and the research process. Answers to open questions about good/bad research units are discussed in 12.2. This subchapter includes a discussion of dynamic processes related to time and accumulation of advantage, and a summary of «typical» features of good and bad research units. In 12.3, I return to the «tension» framework that was put forward in chapter three, and subchapter 12.4 consists of specifications along disciplinary and institutional dividing lines. Finally, the theoretical and practical implications of the study are discussed in 12.5. My three main research proposals are briefly reviewed in 12.3.3 (the first and second) and 12.4.3 (the third).

12.1 Influences on the sub-elements of quality

The four quality elements proposed in chapter two have been elaborated (chapter five) and tied to characteristics of individual researchers (in 6.5). Here, I connect the quality elements with organisational aspects in general. During the discussion of the four proposed quality elements in the interviews, the informants were also asked to elaborate on how the organisational environment (broadly speaking) could influence in a positive and negative way on solidity, originality etc.

12.1.1 Solidity

The answers to «What can promote and restrain solidity?» are summarised in table 12.1. Numbers in parenthesis refer to the number of informants that mentioned that particular aspect.[1] Seven informants left this question unanswered (thus, 57 valid responses).

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[1] What does it signify that a certain number of people mentioned a particular aspect? Several reasons for an informant's not naming it could be envisaged. An influence on solidity etc. could be taken for granted (like a certain basic level of equipment), simply be forgotten in the interview or be «unknown» to the researcher. However, I do assume that the most important factors, the «motivational factors» (as opposed to those that are completely unimportant, the «hygiene factors,» cf. Herzberg *et al.*, 1993 and chapter three) would probably *not* be taken for granted by most informants. Hence, the number of people mentioning an aspect gives an indication of its importance. However, there may be «hygiene factors» that are a prerequisite to performance but cannot lead to improved performance, that are not named by a fair number of informants. Between 45 and 60 answered

(CONTINUED)

Table 12.1. *Influences on solidity.*

Solidity	Size and resources	Formal org. aspects	Leaders, leader-ship	Contacts, communi-cation	Inform. org. aspects	Individual characte-ristics	Other
Promoting	Equipment (17) Time (13) Size of group or project (4)	Formal procedures (4) Rewards (1)	Compe-tence of project leader (1)	Criticism from collea-gues or supervisor, peer review (13)	Tradi-tions (4)	Abilities, compe-tence (19) Training of researchers (12)	
Restraining	Financial pressure (4) Limited time (10)	Publishing pressure (6) (mainly formal)		Isolation (2)		Lack of moral (1)	Promising too much in con-tracts (3)

We can see that there are two important influences on solidity. First, this quality element can be tied to the resources that a unit possesses. Enough time seems to be particularly central, and almost as many mentioned «limited time» as a negative influence, as the number of researchers who mentioned «enough time» or «much time» as positive. Good research equipment is also conducive to solidity, an aspect particularly underlined in the experimental disciplines, as expected. A few specified size of groups/projects and the importance of having a «free financial hand.» Several of those who talked about time, equipment or funds, added that the crucial point is to have correspondence between the goal of the research projects and the level of resources.

Second, solidity can be related to characteristics of the individual researchers, both their abilities and the formal training they have undergone. Many talked about competencies like «thoroughness», «intelligence», «persistence» and «being systematic». It was often stressed that although researchers can learn to become more precise, thorough etc., such abilities are largely «inherent». People who are «clumsy» can never become good researchers, a few added. When it comes to the training of researchers, the doctoral education was referred to. Some of the normative statements included that the training should be «systematic», «thorough», focused on methodology and limited in time.

Communication was also named relatively frequently. Peer review of publications and constructive criticism from colleagues can improve the solidity of the research or weed out what is not solid enough. Daily contact with supervisor was underlined by two informants. Although a few warned against coming under the influence of someone whose work is «foggy» or «methodologically weak», isolation is no alternative. Several other aspects mentioned are related to time. To promise too much in contract research and be forced to publish early or

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each question analysed in 12.1, and the aspect that was mentioned most frequently (individual creative abilities as an influence on originality) was referred to by 40 researchers, or a little less than 70 percent of those who answered that question. For a more general discussion of the qualitative methodology of the investigation, see chapter four, where I among other things argue for «simple counting» as a means of improving validity and reliability.

voluminously, can result in too little time to make the research solid. One informant claimed that some pressure to publish is positive, because it forces the research results to undergo peer review.

Informal aspects were not often mentioned. Four informants brought up a research organisation's «traditions» of making solid work and not accepting «facile»/«superficial» methods and analyses. A good «natural science basis», continuity and stability were referred to. As described in 8.7, formal procedures for quality control were not seen as important. An explanation can be that such procedures may help avoid mistakes and errors, but that is not enough to make research solid or good. Another reason is that to give comments on manuscripts and proposals, and to advise colleagues when the carry out the concrete work, need not be formalised, and are most likely done as a matter of fact in good units. Only one respondent talked about the project leader as an influence on solidity.

The above results can provide us with an elaboration of the role of resources. We have seen that resources often are seen as a precondition for solidity, and in chapter five, solidity was described as a precondition for practical utility. Informants from applied units emphasised that before you e.g. introduce a new pharmaceutical drug on the market, or before you start building a pilot plant for a new production process, you need to be as certain as possible that nothing will fail – that everything is well tested and documented. This can explain the result in earlier studies that projects get larger and more expensive when they are closer to the applied end of the research spectrum (cf. table 3.3). The reason that few claimed that resources are central in the production of good work might rest on the high status of originality in all settings. Money, time and equipment do not produce original work.

12.1.2 Originality

Similar to the last section, the answers to the question «What can promote and restrain originality?» are summarised in table 12.2. Here, 59 (92 percent) of the informants gave a valid answer.

Table 12.2. *Influences on originality.*

Originality	Size and Resources	Formal org. aspects	Leaders, leadership	Contacts, communication	Informal org. aspects	Individual characteristics
Promoting	Money for high-risk research (8) Time (5)	Freedom/independence (8) Rewards for creativity (4) User needs (1) Some «free» time (2)	Enthusiastic supervisor (1)	Cross-disciplinary contacts (8) Active internal discussions (3)	Culture for creativity (19)	Creativity etc. (40)
Restraining		Strong control (15) Solidity focus (4) Administrative routines (3) Publishing pressure (3)	Leader does not support creativity (3)	Isolation (1) Too integrated in one school of thought (1)	Rigorous culture (4)	

The aspects in table 12.2 are very similar to the «influences on creativity» discussed in sub-chapter 6.7. It can be seen that three important influences on originality were mentioned. Individual characteristics are the most central. This was elaborated with terms like «creativity», «imagination», «intelligence», «openness», «no fear of mistakes» and «extraordinarily good overview of the field and what has been done earlier». As seen in chapter six, a combination of creativity and very good overview was frequently referred to as a fundamental precondition of originality. Indeed, some authors have defined «creativity» as originality coupled with scholarly relevance (Tranøy, 1986).

Informal/cultural aspects of the research organisation were also mentioned by many. A «culture for creativity», «open culture/openness to new ideas», «feeling of safety and support even when one makes mistakes», «tolerance for doing weird things» and «more generosity than competition» were some specifications. Two researchers elaborated, «It is much easier to be creative if someone in the unit has produced something original earlier.» A few talked about negative effects on originality, for instance as a result of a research culture that is «very conservative» or «rigorous».

The organisation of work also seems important to originality. «Freedom», «independence» and «autonomy» were frequently used words in discussions of how creativity can be promoted, particularly in the university sector, but also in the other ones. Similarly, too strong top-down or external control of the research venture may restrain originality. However, one of the researchers from the institute sector said that utility demands from users can have a positive influence on creativity.

Some other aspects that were mentioned quite often include cross-disciplinary contacts (particularly in the institute sector), active internal discussions (because creativity can also be a group phenomenon) and resources. Original research is by definition more high-risk, it was claimed, and a certain financial security is therefore necessary. Projects with short time horizons, especially in industry and in the institute sector, make the researchers «play it safe» and choose well-tested approaches and methods. Some researchers said that a strong focus on solidity, pressure for publishing results quickly and many administrative routines can restrain creativity. Again, leadership was mentioned by very few informants as a central influence on originality. Furthermore, those who suggested this aspect largely claimed that it is easier for a leader to destroy creativity than to promote it. Some leaders obviously do not contribute to an innovative climate, and they may be a source of pressure and control, all of which have been found negatively related to creativity in earlier studies (see e.g. Premfors, 1986; also Kekäle, 1997; Bennich-Björkman, 1997).

That it is relatively easy to destroy creativity is reflected in many statements, confirming earlier results (Pelz, 1967; Pelz & Andrews, 1976). More than half of the sample asserted that you only «make the overall arrangements» for people to be creative, but you cannot «create» it directly. Still, four of the researchers said that monetary or promotional rewards oriented at creativity can stimulate people to produce more original work. Several informants, particularly from the applied sectors, were on the lookout for other formal mechanisms, often after having been disappointed by «brainstorming» sessions. I discussed this issue in 6.7.3 and concluded that although creativity is more easily killed than incubated, it is also closely linked with organisational aspects. Hence, creative abilities and organisational preconditions for creativity need to be regarded together.

Finally, one industrial informant stated that creativity and all informal aspects of research units also can be related to national culture and general organisational culture (of a private firm). If creativity and «weirdness» are not valued in society or in the company in general, they will not be valued as much (as they should be) in research units either.

It is perhaps fruitful to distinguish between macro and micro level factors in this discussion of influences on originality. The university researchers in particular talked much about macro characteristics. Examples are (government) funding of high-risk research and a high degree of freedom in the research system. At a micro level, originality is the result of a researcher's creative abilities and the degree to which her or his immediate environment accepts or rejects new ideas and approaches.

12.1.3 Scholarly relevance

Table 12.3 contains the answers to the question concerning influences on scholarly relevance. Because this term was described as meaningless to the industry researchers and many of the informants from research institutes, the number of valid responses is lower (49, 77 percent of the total).

Table 12.3. *Influences on scholarly relevance.*

Scholarly relevance	Size and Resources	Formal org. aspects	Leaders, leader-ship	Contacts, communi-cation	Infor-mal aspects	Individual characte-ristics
Promoting	Time (5) Library (1) Scientific equip. (1) Funds – inter-nat. visits (1)	Planned relationship in doctoral theses (2) Rewards for collabor. (1)		Scholarly contacts (31) Cross-disci-plinary con-tacts (2)	Tradi-tions for rele-vance (1)	Abilities (4) Knowledge (being up-to-date, etc.) (10)
Restraining		Focus on user relevance (3) Efficiency pressure hin-ders publi-shing (5)		Isolation (6)		

From this table it can be seen that one factor stands out as a positive influence – contacts with other researchers (or isolation as a negative influence). This was elaborated in many ways, for instance in the form of «meetings», «conferences», «international collaboration», «continuous dialogue with the leading persons in the field» and «long-term visits abroad». Informal communication was emphasised, not formal collaboration related to concrete projects. A few also added that active participation in the international peer review system is an advantage to get to know the field well.

As found in 6.5, individual characteristics also play a role related to scholarly relevance. Some mentioned various abilities (persistence, analytical skills, intelligence, memory etc.), but more talked about a researcher's intimate knowledge of the field. This again can be related to resources, for instance time to read within projects/contracts and having a library. Two university professors from technological disciplines stated that it is important to plan a link between different doctoral theses to be able to produce results that are internationally interesting.

Some claimed that focus on user relevance and efficiency pressure can restrain scholarly relevance. All of them came from the institute sector, and they mainly argued that there often is too little time for scientific publishing in concrete projects, even when the results would have had some interest to other researchers. One institute researcher from the social sciences stated that «the main contact with the discipline happens through the literature», and underlined that projects ideally should include both time to read and time to publish.

It is natural to conclude that library resources, reading time etc. are the basis for scholarly relevance, but do not influence the degree of relevance – they are the basic preconditions for «knowing the research frontier». Contacts with the scientific community (mainly internationally) then helps the scientists come up with ideas and approaches that are relevant to others.

12.1.4 Utility value

The answers to «What can promote and restrain the utility value of the research?» are summarised in table 12.4. Many of the university researchers thought that this was an inappropriate question for them, so the total number of valid responses is again relatively low (45, 70 percent of the total).

Table 12.4. *Influences on utility value.*

Utility	Size and resources	Formal org. aspects	Leaders leader-ship	Contacts, communi-cation	Infor-mal aspects	Individ. characte-ristics	Other
Promoting	Scientific equipment (1)	Targeted, user con-trolled (11)		Early user contact (22) Basic and applied groups close (2) Good dissemi-nation (10) Mobility of personnel (3)	Traditio ns for focus on prob-lems, not methods (1)	Motiva-tion for utility (2) Basic compe-tence (2) Entrepre-neurial (1)	User compe-tence (4)
Restraining	Small groups (1)	Too strong focus on utility (3)		Patenting (1)			Lack of user com-petence (6)

Answers to this question vary systematically with the respondents' sectors. The researchers in industry and many from the institute sector stated that early phase contact with users is the most central positive influence on utility value. Their main argument was that this largely is the only way the researchers can build up an «understanding of reality» or «understanding of the practical world» that is necessary to produce useful research. University researchers, on the other hand, mainly talked about «good dissemination of research results» and «publishing in trade journals and popular science journals» as a way of promoting utility. It was often added that scientists should have the ability to write clearly and briefly and to use other means of publishing results than reports and articles. Given the different types of utility value that were discussed in chapter five, this seems to be a natural distinction based on the purpose of the research activities in the sectors. A few university professors added that strong user control of course could increase the short-term utility of research, but that this would hinder originality and thus the potential of useful research results.

Another aspect, chiefly mentioned by institute researchers and some university professors with extensive contract research activities, is the competence of users. None of the industrial scientists talked about this as a central influence, maybe because their activities are more applied and in almost all cases carried out with strong user involvement (organisationally most industry researchers in the sample were very close to their firm's business units). As the table shows, more informants mentioned user competence as something negative. Two medical researchers said, «There are often barriers in user organisations against trying new approaches and ideas» and «You have to have a layer of people in industry able to read scientific publications, a layer that's lacking today.» A biotechnology professor maintained, «We cannot possibly influence how our research results are put into concrete use,» and that the «quality» of for instance development and design processes should be not be the researchers' responsibility. Two social scientists from the institute sector stated that the competence of their users (in public agencies) has increased much in later years after a multiplication of people with long and advanced educational background in government agencies.

For some of the researchers, personal characteristics could play a role too. A few stated, «Some researchers are primarily motivated by utility value,» while others stressed that broad basic scholarly competence is necessary to facilitate «technology push», not just «market pull». An industrial informant wished that researchers had been more entrepreneurial by e.g. more often starting their own company and following their research activities all the way from basic research into concrete utility. Several informants stated that strong user control of the research or to have very specific goals with the activities is positive for the utility value. It is interesting to note that this aspect was seen as very negative to creativity. Hence, the tension between originality and utility value, as discussed in chapter five, can create an organisational dilemma.

To sum up – for applied researchers, the key influence on utility value can be found in early phase contact with users. Basic researchers, on the other hand, uphold user relations after the research is completed. A brief elaboration of the research process and its phases would thus be worthwhile.

12.1.5 Quality elements and the research process

One question in the interviews concerned the most critical phase of the research process. The question was open-ended to also explore how the informants' distinguish between different phases. Many talked about features of the research process as a whole, and about one fourth stated that all phases are important and that it is impossible to select one of them as the most critical. Even most of those who pointed to a specific phase (or several) as particularly important, claimed that «everything» has to be good. Some compared the research process to a chain – it is not stronger than its weakest link.

The informants generally described the (good) research process as open and very long lasting, the latter implying that researchers should be persistent and have long-term outcomes in mind. Although good planning and well-defined and delimited ideas and problems were underlined by many, some said that one should strive to keep the conclusions and detailed «theme» open as long as possible. Three medical scientists talked about surprises or unexpected outcomes and stated that it is important to have the resources and a flexible enough planning to be able to change things in the experiment and analysis phases. A researcher in clinical medicine from the institute sector stated, «Planning is terribly important and was not much valued earlier, (…) but one has to make sure to plan for open questions and not for a given answer.»

Regardless of field and institutional setting, the research process seems to consist of a number of related steps, of three major phases. First, in the *idea phase*, ideas are generated, they are processed and the rest of the work is planned, including choice of research design/methodology. A few informants added that the overall «level of ambition» is determined in this first phase, and an industrial scientist stated that the establishment/planning of intellectual property rights is central at this point in the process.

Then, in the *work phase*, experiments are carried out or data are gathered in one way or the other. How this is done naturally varies between disciplines. Even the researchers from the humanities and a sociologist mainly occupied with theoretical work talked about a work phase in this way, which for many of them consisted of critical reading and analysis of relevant literature.

Finally, the data one has gathered is analysed, and something is written about the analysis and about what has been done earlier in the process. This can be termed the *analysis and writing phase*. Although most of the informants claimed that some steps are more important than others are, it cannot be concluded from the interview material that some steps are relatively unimportant to quality.

It is perhaps not surprising that among those who pinpointed one or two phases as the most critical, the first phase was mentioned most frequently (by almost two-thirds). «This is where the potential for quality is determined» and «If the idea is not good, the rest cannot be good either» were common comments. The first activities – definition and processing of the problem or area of inquiry – were often linked to originality. Some underlined that this cannot be done quickly. A philosopher said, «The starting point is of course the most important. But it may take a long time to get to the starting point.»

Contrary to most other respondents, a university professor in sociology upheld that good research products occasionally start out with a «woolly» or poorly defined problem; but he found a good and clear idea an advantage nevertheless. Two cybernetics researchers stated that it is possible to «repair the damage» caused by poor planning and definition in the idea phase, although projects also become much more expensive in such cases. On the other hand, three informants working in biomedical fields claimed that experiments that are poorly designed or carried out cannot be «made right» again except by starting from scratch. One of them asserted that this often is the case, exemplified with projects lacking control groups or initial measurements. In general, around half the respondents described the research process as a road with no later entrances. Making a wrong turn somewhere means that you never can get back on the road again. Thus, many saw the research process as relatively linear – failing at one step affects all the subsequent steps negatively.

Informants from industry and the university sector also linked the earliest steps of the process to relevance (intra-scientific or external). When research is planned and a formal project established, much of the relevance is established as well, these respondents asserted. Many university researchers consequently argued that communication with colleagues is important in the idea and design phase. The respondents who put the most weight on practical utility value (in industry and engineering cybernetics) emphasised that linking the research to users, the firm's goals etc. very early, is crucial to quality. A cybernetics professor added, «Small and [industrially] irrelevant problems may require just as much resources and effort as large and relevant questions,» a further reason for involving industrial actors in the design of research projects. It is interesting that none of the interviewed researchers from the institute sector talked about relevance when discussing the early phases. Instead, two of them (from biotechnology and cybernetics) described the «transfer» of results and competence to the (end) users as the most critical phase of the process. A chemistry researcher from the same sector mentioned «selling the ideas» to potential contractors as critical. Again, it seems that the institute sector is somehow «caught in the middle».

Quite a few described also the analysis/writing phase as critical. Three defined this as the most important step, while thirteen found the first and the last phases equally important. These thirteen come from all disciplines, not only from the soft sciences where the quality of the writing can influence the «intrinsic» quality of the research (cf. 5.2.1). Another interesting point is that eight of them come from the institute sector. It seems that much of the knowledge transfer to the institutes' contractors is in the form of, or at least based on, written reports. Hence, the final writing/documentation becomes very important.

Only one informant described the work phase as the most central, while two found this as crucial as the idea/design phase. These three all work in experimental biomedicine. It should be added that many of those who find «all» steps of the process important, talked about experiments or other kinds of data collection. Still, it is noteworthy that so few emphasised the phase where the «actual» research work is done. An explanation is perhaps that with a good design and problem, you largely «know what to do» in the work phase, a point which several informants made. Furthermore, some stated that they have formal quality assurance mechanisms and/or follow well-established practice in this phase.

It should be pointed out that the answers seem somewhat based on personal priorities. Although there is a relatively clear distinction between sectors as outlined above, and between disciplines (particularly concerning the contents of the work phase), many stated that others could have different opinions about which phase is the most crucial. Some began with «Since I find originality etc. especially important, I accentuate…» or «Personally, I find phase X the most challenging.» The three respondents from the institute sector working in sociology (all from the same institute) illustrate this well. One found analysis/writing the most important step, another emphasised the planning of the data collection while the last pinpointed the problem definition and overall project planning.

To conclude, it seems that originality and relevance largely are determined in the first phase of the research process. Here, an idea is generated and processed and the research is planned, including design decisions. For the respondents in the institute sector, the analysis/writing phase is where relevance is assured. University scientists publish in well-established channels, and in industry, users are often involved from the beginning. The «work phase» in the middle is of course important too, but few informants found the activities here as crucial to quality as the idea generation/processing. The relationship between the research process and quality is summarised in table 12.5.

Table 12.5. The research process and quality elements.

Phase	Activities	Influence
The idea phase	Generation of ideas Processing of ideas Selecting research design/methodology Planning the specific work	Originality Scholarly relevance (universities) Utility value (industry, a few technology professors)
The work phase	Carrying out the concrete research work/collecting data Activities vary with discipline	Solidity
The analysis/writing phase	Analysing data Writing a report, paper, documentation, user guide etc. (preparations for knowledge transfer	Solidity, scholarly relevance Utility value (institutes, some university researchers)

12.1.6 Comparison

In table 12.6, I have summarised all the main results from 12.2.1 to 12.2.4. Some organisational aspects are grouped together, and I have removed all aspects that were only mentioned by one informant. I have put the most frequent answers (mentioned by more than ten people) in bold typeface.

Table 12.6. Comparison of influences on the quality sub-elements.

Element/Aspect	Solidity	Originality	Scholarly rel.	Utility value
Size (of group etc.)	4			
Scientific equipment	**17**		2	
Time resources	**23**	7	5 (time to read) 5 (time to publ.)	
Financial resources	4	8		
Autonomy/freedom		8		
Formal planning and/or external/user control	3 (neg. infl.)	**22** (neg. infl.)	2 3 (neg. infl.)	**11** 3 (neg. infl.)
Formal quality assurance	5			
Rewards for creativity		4		
Publication pressure	7 (neg. infl.)	3 (neg. infl.)		
Good leadership/leaders		3 (neg. infl.)		
Scholarly communication	**15**	4	**37**	2
Cross-disciplinary contact		8	2	
Early user communication				**22**
Competent users				**10**
Dissemination to users				**13**
Informal organis. aspects	4	**23**		
Formal researcher training	**12**			
Individual characteristics	**19**	**40**	**14**	5

This table shows that the quality elements normally were coupled with different organisational and individual characteristics. Many of the organisational factors were only mentioned concerning one or two of the quality elements. In other words, to improve originality, a different strategy has to be selected than when one aims to improve other aspects of quality. The table can be considered a link between the research unit performance approach and the specification of research quality approach.

Tensions between the quality elements (cf. chapter five) can also be seen at the organisational level. The clearest example of tension seems to be related to formal planning/external control of the research activities. This could have a positive influence on utility value, and a negative influence on originality. It must not be forgotten that for a research work to be regarded as good, it has to score well both in solidity, originality, and scholarly relevance or external utility value (unless the work is extraordinarily original). Hence, organisational tensions are probably unavoidable if one wants to produce good research, and this issue is specified further in 12.3.

It can be seen that individual characteristics are central to all aspects of quality; probably most important to originality and least important to utility value. However, the interviews indicate that different individual abilities and competencies influence the quality elements. As in chapter six, creative abilities were linked with originality, and thoroughness and precision with solidity. Many of the informants underlined that it is rare to find people with all the necessary skills for producing good research. Creative people were often seen as not very thorough and patient, while systematic researchers very good at laboratory work may lack creative abilities. Thus, this can provide us with an explanation for the strong emphasis on diversity of people that was described in 8.4.

12.2 Defining the «ideal» research unit

I start this elaboration with responses to open questions about good/poor research units or «environments» (12.2.1 and 12.2.2). In 12.2.3, I rank various organisational characteristics, and I elaborate the dynamic properties of research units in 12.2.4. When good research units or environments[2] were specified in open questions, many different words and expressions were used (of course). It seems that when answering, the respondents thought of their own group or they described «the leading U.S. group» (several stated this explicitly).

12.2.1 Long-term collegiality and openness in good units

In general, the «typical» answer was that the good environment of a researcher is characterised by «openness and good collegial communication». The most frequently mentioned aspect had to do with *collegiality*. Almost all the informants stated that this is important in good research units. For most, collegiality had both a professional and a social side. Some

[2] The Norwegian term «miljø» («milieu», «environment» or «surroundings») can refer to a concrete organisational unit, the «climate» of a workplace as well as the general social and physical environment of an individual. This was the term used in the interviews, and it explains why no informants mentioned «calibre of staff» etc., as a characteristic of «good research milieus».

talked about «good personal chemistry» and «intellectual dynamics», others about «daily interaction» between colleagues, others yet about an internal atmosphere characterised by «critical generosity» and «lots of interaction and trust». The importance of having a high frequency of interaction/critique and high levels of trust was often pinpointed. A few stressed that one's colleagues should be «bright», «clever», «friendly», «interested in other's work and achievements», «intelligent», «motivated» etc., but this seemed to be taken for granted by most respondents. Some added that the best groups/departments most often are those that employ one of the discipline's leading scientists (internationally).

Good collegial relations were described an important source of «recognition», «motivation», «inspiration» and «criticism». These were frequently used words in the discussion of the role of the organisational environment. Many emphasised that «constructive» critique/feedback is a central aspect, and that good social relations in the group/department are a basic requirement for providing and dealing with critique. «Critical collegiality» was often defined as people being somewhat dissimilar when it comes to personal characteristics and/or scholarly standing. Diversity or «breadth» was for most a desired attribute of the unit. Around half the respondents from the applied sectors, and a few university professors, mentioned a cross-disciplinary mix of people as a feature of the best research organisations.

Another key word in the discussions was *openness*. This term seemed to have two important meanings to the researchers. First, it implied a certain level or frequency of communication between the organisation's members, and that research results are not kept secret. Second, openness referred to an aspect of the organisational culture for many of the respondents. An open culture is one that is «tolerant of mistakes» and tolerant of people that «are weird», «choose alternative ways» and have «strange ideas». Other related terms used were e.g. «liberating», «free» and «a sense of unity». These two factors – communication and collegiality – may represent both «challenge» and «security» (cf. Pelz & Andrews, 1976). A good working climate and a sense of collegiality should definitely be factors of security, while openness, related to both communication and some kind of «intellectual veracity», can be a source of challenge.

Patience or a certain *long-term attitude* was also among the frequently mentioned characteristics. To build a good research group/department takes many years, it was underlined, and some added that ruining it is a much quicker affair (these researchers were often concerned about budget cuts). The foremost groups manage to survive fluctuations in external support for their research teams, without resorting to «passing political fashions», two remarked. Several emphasised that all research work is long term and that projects must be seen together as a whole. It should be added, however, that many respondents from the applied sectors maintained that the best groups are able to take on research efforts with several different time horizons, and with both theoretical and practical aims. Being «targeted» and «linked to policy/strategy», and «flexible» at the same time, was a frequently encountered description in industrial, and to a lesser extent institute, research. Still, some university researchers also claimed that the best groups in their fields and sector work with very specific common goals in mind, or within an unusually highly specified theoretical and methodological framework.

Finally, some informants claimed that good research groups have a certain *minimum size* and/or *resource levels*. Not least the respondents from the humanities and the social sciences stressed this aspect. A size above a certain level allows several people to work on related problems and thus facilitates interaction locally. In technology and the natural sciences, resources/equipment largely seemed taken for granted, and many did not mention it. Six informants talked about having a good or «dedicated» leader as important, and some additional aspects (like routines for quality assurance) were mentioned by a couple of respondents.

It is perhaps slightly surprising that resources were not much referred to in open questions (less than one-fifth of the informants mentioned this). Although resources rarely are found a central determinant of research performance, some authors have claimed that researchers frequently and «ritually» bring up this issue in interview settings (Martin & Skea, 1992). One explanation for the fact that my informants rarely talked about financial resources (although some did, and very strongly too) may be that the resource situation is different from British research units (which Martin & Skea studied) to Norwegian units. Another explanation could be that my long interviews often succeeded in creating an atmosphere where there were less such «ritualistic» occurrences.

One could ask why the two most central aspects – collegiality and openness – did not emerge clearly in table 12.6, which was based on questions like «What can promote and restrain originality/solidity etc.?» To some extent, openness and collegiality are included in the aspects scholarly communication, cross-disciplinary contacts, communication with users, dissemination of results and informal organisational aspects (in the table). On the other hand, it could also be argued that in open questions, the informants largely talked about «positive» factors that do not conflict with each other. Yet another argument could be that collegiality and openness are more «general» and overall features of the good research units, and that these aspects cannot be tied directly to some of the sub-elements of quality, but rather constitute a more fundamental precondition for good research work.

12.2.2 Poor units: isolation and personal conflicts

In discussions of «poor» or «bad» environments for research, or characteristics of groups and departments that do not produce good results, many answered briefly, «It's the opposite of what I just said.» Those who did elaborate on this question (around half the respondents), mentioned two characteristics in particular – *isolation* and *personal conflicts*.

Isolation had one principal meaning to the respondents – lack of communication. People who work on their own without talking to colleagues in their own organisation or externally, rarely produce good research. A couple of the respondents from the soft sciences said that there may be counter-examples, but that this is still the general rule. For a few informants, isolation also meant that the group is too small, it has not achieved a «critical mass», and a few specified that too small human (and other) resources is typical of poor organisations.

It is again interesting to note that lack of internal communication was more frequently mentioned than lack of external networks, and that both formal group work and informal collegial collaboration were emphasised. Although some respondents underlined that working in groups is not necessary for the production of good research, very individualistic work is still a typical characteristic of poor groups and departments in all fields and sectors (similar to what was found by e.g. Bennich-Björkman, 1997). It is difficult to isolate yourself when you are in a group. A good external collegial network, particularly abroad, seems to be the only way good research can be made by scientists working on their own.

These points were also connected with personal conflicts, the other recurrent answer. Poor research units can be characterised by an atmosphere that is «hostile», by «envious» people who see each other as «competitors» and/or simply do not like their co-workers, and by critique that is «too harsh and merciless». In such an organisation, the conditions for good collegial communication are sparse, and it is easy to become isolated. Two of the philosophers said that «grumblers» can destroy the atmosphere in a department. Although the grumblers may be quick and active when it comes to giving comments, the feedback is most often negative and never constructive.

Some other aspects were mentioned by seven to nine informants. Poor research organisations often have a culture that inhibits originality and variety, and where people are «afraid of making a fool of themselves». To have a too authoritarian or oppressing leader is a related characteristic. Substandard groups furthermore work «superficially», «too short-term» or «more oriented towards political trends than scholarly needs». Three institute researchers mentioned that poor groups neither have good relations to academia nor to users, and three informants from industry stated that «too widely dispersed competence» is a negative aspect.

12.2.3 Which are the most important factors?

In general, my methodology is not well suited to ranking of organisational aspects. Still, the informants were asked to give their personal view of what the most important influences on research quality are, and some distinct results emerge from these answers.[3] The researchers were given five alternatives (some of the organisational aspects were merged). The results are summarised in table 12.7. It can be mentioned that the total number of responses was 58 – one informant did not answer, and five found it impossible to rank the factors. «They are all extremely important» was the general comment from these. Numbers in the rightmost column indicate how many informants ranked that factor.

Table 12.7. *The informants' ranking of organisational factors.*

Factor:	1.	2.	3.	4.	5.	Sum
Size and resources	2	3	16	3	13	37
Formal organisation	1	1	4	8	24	38
Leaders and leadership	3	3	8	3	16	33
Culture and communication	13	20	6	2	1	42
Quality of the individual researchers	56	1	-	-	-	57
Sum:	75	28	34	16	54	-

[3] See also chapter four where I argue that the informants' views have a value of their own.

The sum of rankings[4] indicates that the easiest task, relatively speaking, was to name the most important and least important factor. The right-hand column shows that the quality of individual researchers was the easiest dimension to rank. This was unanimously described as the most central determinant of research quality.

Culture and communication come in a clear second place, and eleven of the researchers found this as central as the quality of the personnel. Size and resources (especially money) were more important to many of the informants than the remaining two (clusters of) organisational aspects, although quite a few also claimed that size/resources are the least central characteristics. As can be seen from the table, leaders/leadership and formal organisational factors were quite often placed at the bottom of the ranking. However, around half the informants found it difficult to «make priorities» in this end of the scale. In addition, there were many moderating comments.

Regarding resources, several informants stressed that this is a prerequisite for good research, indeed for research at all. «If you take away my resources, I can't do anything,» a professor in medicine stated. Another maintained that time is a critical resource, while money is not particularly central to quality. Others claimed that high level of financial resources often is the result of having produced good research, more than its cause.

Industrial researchers often added that the size of projects determines the significance of leadership and formal organisational factors. Some commented that leadership is important at the group level, but not above that. Leaders and leadership were again frequently focused upon in a negative way. «A poor leader can ruin everything regarding those four other factors,» a professor in economics asserted, while an institute researcher from engineering cybernetics said, «Poor leaders can destroy much, but a good leader can never make good researchers out of poor professionals.» This very rough ranking corresponds well with the specifications we have seen in the six previous chapters (naturally). If we go back to the examination of the literature in 3.2.3 and 3.2.4, it is also evident that the ranking fits well with the «average» of earlier investigations – human resources and contacts/communication emerge as the most central influences on quality.

Still, my ranking is somewhat problematic. For instance, we saw in chapter seven that the issue of leaders and leadership is very complex, and I argued that although (present) leaders may not be very influential on quality, leaders *may* have a great influence. This depends e.g. upon the quality of the leaders and possibly upon leadership training. In addition, it can be repeated that interviewees tend to blame poor performance on the leader, but not give him or her credit if performance is good (see Herzberg *et al.*, 1993). Perhaps is the message from those who refused to rank just as important as the ranking – in the long run, all organisational and environmental characteristics may be important to a research unit's development, albeit at different moments in time and depending upon each unit's particular circumstances.

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[4] This does not add up to the total number of informants since two aspects were often seen as equally influential.

12.2.4 The effects of time – accumulation of (dis)advantage

Many dynamic processes were described during the interviews. We have e.g. seen that organisational factors have dissimilar influences depending upon the age of the research unit. For instance, in the ranking question discussed above, eight of the respondents said that a focus on formal organisational aspects (formal routines, external or top-down control etc.) and strong «task-oriented» or «directive» leadership can be very important in the early phase of a research unit's or project's life. Furthermore, resources can be the result of performance just as much as its cause, forming a complex two-way relationship (as in Latour & Woolgar, 1979). In other words, organisational characteristics may play different roles, depending on the life cycle of a research unit (confirming Kekäle, 1997). This can explain the proliferation of academic research centres and other new forms of research organisations (see Etzkowitz & Kemelgor, 1998) – by establishing a new organisational unit, researchers (and others) are able to exert more than a marginal influence on its central characteristics.

In 3.3, I briefly went through many earlier investigations of «accumulation of advantage». I concluded that tiny differences between researchers and between research units in talent, resources etc. may give rise to much greater differences in performance after consecutive events that reinforce behaviour and increase (decrease) competitive advantage (cf. Merton, [1968] 1973; Cole & Cole, 1973; Fox, 1983; Merton, 1988; Kyvik, 1991). The events can lead to more (or less) resources (e.g. Latour & Woolgar, 1979), improved (or reduced) chances for recruiting the most talented scientists (Blau, 1973) or simply sustained (or decreased) motivation for scientific work (for instance Fox, 1983; also Blau, 1973; Thagaard, 1991).

By analysing the interview data, I have found that dynamic processes mainly were elaborated connected with individual-level variables – particularly motivation and recruitment – and communication, i.e. the two features that were seen as the strongest influences on research quality. Motivation was particularly linked to a reinforcement process (cf. Fox, 1983); recognition is a positive and requisite input to the motivation of individuals. Recognition from the external scientific or user community may sometimes be lacking, regardless of the quality of the research, making it necessary for the research unit and/or leader to recognise and perhaps reward good work. This was particularly stressed in the institute sector.

Recruitment was also seen as a self-reinforcing process. Good research units attract talented young PhD students or junior researchers, who contribute to sustaining or even to improving the unit's quality (as in Blau, 1973). Still, some of the informants expressed concerns that a growth in opportunities for interesting jobs outside of science, a significant and ever-increasing salary gap between scientific posts and other jobs, and/or a lack of junior positions may make it hard for even the best research units to recruit the most talented candidates. It was generally claimed that the recruitment of senior researchers was very difficult due to the lack of opportunities for offering better pay (or other benefits), reluctance to move from one place to another and other features of the Norwegian research system. It is also evident, as Kyvik (1991) hypothesised, that many talented researchers choose not to (try to) become eminent, to become internationally leading figures in their fields. Several informants stated that they give higher priority to family life than scientists with greater personal aspirations can do. If aspiration is not a central point in the recruitment of junior researchers, these not-so-ambitious people may be spread rather evenly in the Norwegian research system. This can provide us with an explanation for the seeming lack of large prestige differences between institutions in Norway, as well as indicate a process that limits accumulation of advantage effects (cf. Merton, 1988).

As seen also in chapter eleven, a strong two-way link between communication and research quality was emphasised by many informants. Subsequent contact most often depends upon the actors' ability to fulfil requirements of balance and reciprocity in present relationships, at least in the foreseeable future (cf. Blau, 1964). In addition, interaction with other researchers and/or users can be viewed as the main medium of recognition. Successful communication leads to trust, which was seen as a fundamental requirement for crucial forms of informal contact. Not only can trust yield more communication with more actors, but it may also help the scientists gain access to information, equipment and other resources that are not publicly available. An analogous «vicious» circle was described as the result of poor communication. If you have nothing that is of value to the other party to contribute in scientific interaction, the exchange will often expire.

This is an important point considering the interaction between universities and applied sectors. Many specified a tension between scholarly relevance and utility value – e.g. are broad or general problems frequently the most interesting to other researchers, while narrow and highly specified ones are the most interesting to users (with some exceptions, cf. chapter five). Fruitful professional dialogue across institutional settings may thus hinge on the ability of research institutes and industrial R&D units to extract benefits from their work other than utility value, and on university researchers' ability to draw conclusions that applied scientists and users will consider useful to them.

Resources were also tied to dynamic processes through accumulation of advantage effects. Good units tend to get more resourceful, but more money and better equipment does not necessarily lead to improved research. Still, it can be repeated that a relatively high level of funds may constitute a «safety net» for the research unit to survive periods of e.g. low external support, poor supply of new scientific talent, scientific «revolutions» and other events that can prove fatal to units with little resources. In addition, comparably «wealthy» units may have more freedom to spend the money, more «flexibility» in their budgets.

Leadership and formal organisational aspects were seldom elaborated with dynamic processes, although a few informants were e.g. concerned that there may be a tendency in research units to become less diverse with time. These researchers suggested a continuous influx of new personnel as a way of avoiding this. Hence, a lack of positions may not only contribute to the missing out on scientific talents, but it can also lead to more homogeneous research units, while most informants upheld moderate diversity or heterogeneity as beneficial to quality.

We have seen that «vicious» and «virtuous» circles in research units largely are connected with the most important organisational characteristics – communication and individual-level aspects like motivation and recruitment (indirectly a main influence on the individual level). Small events, coincidences and small differences between individuals and between organisations can thus lead to large differences over time through dynamic processes that may be very difficult to influence. Few structural incentives for moving and few aspirations for becoming internationally leading (both at individual and organisational levels) can contribute to a reduction of these effects, though. The «early phase» is obviously very important both in the life cycle of a research unit, in the research process (cf. 12.1.5) and in the career of an individual. For young researchers, high motivation, a good environment and an introduction to professional networks can become mutually reinforcing, leading to a virtuous circle (e.g. described by Thagaard, 1991). At the organisational level, the first years of a research unit's life may be the only period when leaders and policy-makers might make a decisive and relatively immediate impact on the unit's development.

12.2.5 Summary: differences between good and poor research units

Some of the main differences between good and poor (or «bad») research units are summarised in table 12.8. In this table, I have also mentioned some organisational aspects that may be poor criteria for separating between units. All good research units will not necessarily score well on all the items in the table. Units that over time perform well and «evoke» the best from their members will probably still have a profile that is similar to the one in the left column of table 12.8 (judging from my analysis in chapters six through eleven).

Although it was not a topic of discussion in the interviews, I have the impression that my informants often described a group or department that is nationally leading and contributing to the research frontier (in the university sector), but not necessarily among the «top ten» in the world. World-class units will most likely have some characteristics additional to the ones listed in the table, e.g. employ some of the leading scientists in the field. In the table, I have made a rough overall picture and extracted a common denominator across disciplines and institutional settings (such differences and similarities are elaborated in the next subchapter).

Table 12.8. *Good and poor research units – differences and similarities.*

Good research units	Poor research units
• High dedication/motivation for research work among the personnel • Moderate degree of turnover • Much support *and* critical feedback to young members (and good balance between support and feedback) • Recognition for good work if lacking from others • Links with universities to recruit actively talented young researchers (institutes/industry) • A leader with both very good professional and social skills/competence (may be rare) • Mix of professional activities in the unit – teaching and most often other tasks (in addition to research) • Group work (formal or informal) or regular internal professional interaction • Moderate degree of diversity among the personnel • Some flexibility in the budgets • Openness, tolerance – a good working climate • Some internal professional competition • Much communication; well-established scientific (and often user) networks • Good links with users and universities (institutes)	• Low dedication/motivation for research work among the personnel • No influx of new people (due to lack of positions, applicants etc.) over several years • No support or critical feedback to young members • No internal recognition for good work whatsoever • No links to the university sector (institutes and industry) • Very poor leader who might be intolerant of mistakes, highly critical towards new ideas, authoritarian etc., or without the necessary formal competence • No autonomy, much «bureaucracy» (implying little time for research, much frustration, and more) • Isolation, personal conflicts • No group work and no internal interaction • Poor working climate • No internal competition or very hard competition • «Closed» culture, intolerance towards mistakes, little friendship and social interaction) • Low degree of external communication; networks have few nodes and weak links
These characteristics may be similar in good and bad research units: • Salaries (except when there are good opportunities for interesting and well-paid professional jobs externally) • Promotional system • Quality assurance routines (quality handbook, ISO certification of the quality system etc.) • Size of groups (in some disciplines: at least if above a minimum and below a maximum, but margins may be wide and depend upon e.g. the type of research, the leader's characteristics, etc.) • Size of department, institute (levels above group) • Resource levels (unless the unit aspires to be internationally leading, in that case may state-of-the-art equipment and relatively high resource levels be necessary)	

Four comments can be added to the discussion of the «ideal» (or «nightmarish») research unit in this subchapter. First, I would like to emphasise that the crude summaries above are based on interviews with 64 scientists representing ten disciplines and three institutional settings. There are many other disciplines and many other types of R&D institutions with their own particular history and environment, where other variables could be important. For instance, it is difficult to picture a CERN or other «big science» institution that does not benefit from a certain size. Still, considering the many previous studies in the field, as well as my own findings, it is difficult to picture a research unit that would not benefit from a high degree of interaction, dedicated personnel and a good working climate. In addition, I think that reflecting on issues like leadership, size, activity mix etc. can be beneficial in any research unit. Even after interviews lasting more than two hours, a fair share of my informants were eager to elaborate more on some of the issues raised. A scientist from the institute sector said, «These questions are so important. We never discuss these things here.»

Second, it bears repeating that the organisational characteristics can be tied to different aspects of quality. Roughly speaking, originality rests on individual creativity and more indirectly on aspects like the research culture, diversity and leadership. Solidity can be tied to resources (time, money and equipment) and to various personal characteristics. Internal and external relevance stem primarily from different types of contacts and communication.

Third, I believe it is important to stress that although more or less all informants stated that the quality of the people is the most important influence on research quality, none of them claimed that there is a shortage of talented individuals in the Norwegian research system.[5] Several maintained that «the talents are there» but that the mechanisms to keep them in research work and/or «release their potential» are lacking or are becoming insufficient.

Fourth, it can be added that research unit performance most likely would benefit from being studied with a «social capital» perspective (e.g. as depicted in Coleman, 1988). We have seen that good research units are characterised by a certain quality and frequency in internal and external relations as well as by an open and collegial culture, and that dynamic processes can lead to large performance differences over time. Social capital is a theoretical construction that aims to incorporate issues like networks, norms and the dynamics of social relations. In many ways, this theory is an extension of the social exchange theory (cf. Blau, 1964 and chapter eleven above) to the meso and macro levels. It has previously been used to e.g. investigate the success and failure of new regional democratic institutions in Italy (Putnam, 1993), to understand the effect of financial aid to developing countries (Ostrom, 1995) and to explain high school dropout rates (Coleman, 1988). A few authors have attempted to use the concept in studies of innovation and researcher mobility (Fountain, 1998; Gabbay & Zuckerman, 1998). In my opinion, a social capital perspective on research units would be interesting and useful for three main reasons. First, the perspective implies a strong focus on communication and networks, not only as information channels but also as a source of trust, expectations and obligations. Second, the theory gives a strong argument for a close link between networks and norms (and other informal aspects of social life) (particularly Putnam, 1993). And third, the social capital literature stressed self-reinforcement and the iterative nature of social relations. The theory may thus provide alternative explanations for the much-discussed cumulative (dis)advantage processes in science. A social capital perspective used on one or several research units (as a whole), could be a fruitful continuance of the literature on research performance and the link between quality and organisational aspects.

[5] A few were worried about the status of the natural sciences in secondary education and the long-term impact this could have on recruitment.

12.3 Tensions in research units

In chapter three, we saw that some authors have proposed a theoretical orientation that can be called a «tension» or «paradox» perspective – research units (or other organisations) are seen as characterised by aspects that seem antithetical, ambiguous, inconsistent or dichotomous (Foss Hansen, 1995; Dougherty, 1996; Weick & Westley, 1996). Tensions in research units have been described in terms like security versus challenge, elitism versus egalitarianism, freedom versus responsibility and basic versus applied research focus (Pelz & Andrews, 1976; Andrews, 1979a; Foss Hansen, 1995; Dougherty, 1996). Throughout the empirical chapters, we have seen that my informants have told many stories that fit well within such a framework. They have described tensions related to both research quality and the organisation of research work, as well as sketched ways to «balance» or «maintain» them, even without having been asked a single question about these issues directly.

12.3.1 Tensions in the quality concept

In chapter five, we saw that there are several inherent tensions in the quality concept. These are briefly summarised in table 12.9 (cf. 5.2.3 for a more thorough discussion). No major tensions between solidity and scholarly relevance/practical utility were sketched.

Table 12.9. *Tensions in the research quality concept.*

Tensions	Solidity	Scholarly relevance	Practical utility
Originality	Systematic work vs. more «free-flowing» originality; creativity vs. thoroughness at individual and organisational levels	Following major trends vs. breaking with tradition	Short-term utility vs. more radical originality (requiring long-term focus); unoriginal work may be very useful
Practical utility		Broad/general problems vs. narrow/specified problems	

I have named these tensions «inherent» because they stem from criteria that scientists try to meet in every piece of research work. The tensions can be pictured as «forces» that pull the research in different directions. I see three important ways in which this can happen:

- *Attention* – a researcher or organisation that emphasises one of the aspects, may end up «scoring» poorly in another aspect (without necessarily intending to do so). For instance, strong norms of user relevance in an institute may make the organisation less attractive for collaboration with universities.
- *Time* – the informants emphasised that both originality and solidity demand time and patience. Research projects most often have a limited duration, and scientists need to allocate their time on different activities that may further only one of the quality elements, not all. A lot of time spent on e.g. idea generation and idea processing leaves less hours, weeks, months or years for the later phases of the research process.
- *Perspective* – following a trend and/or aiming to make one line of research and arguments ever more convincing and tenable, can over time lead to a decline in

originality and more resistance towards new perspectives and paradigms. This may be seen both on the individual and organisational level.

There is not only tension between the quality elements. For instance, work that is scholarly relevant by filling knowledge holes, opening up new areas or discovering general principles, is by definition original as well. Also, a new fundamental understanding of nature or society will usually have practical implications. Finally, it should be repeated that although «good research» answers more or less to all the quality elements, very original work may be viewed as good without necessarily being solid – this can be improved in later investigations.

12.3.2 Organisational tensions

Many organisational tensions have been discussed in chapters six through eleven. Almost all organisational aspects carry with them some kind of strain, by themselves or together with other ones. In table 12.10, I have summarised what I see as the most central ones.

Table 12.10. *Organisational tensions in research units.*

Organisational aspect	Tension
Individual	Ambitions of becoming eminent vs. desire to lead a «normal life»
Mechanisms to «release the potential» in young people	Social support coupled with possibilities for long-term concentrated work vs. critical professional feedback and autonomous tasks with little support
Rewards	Undifferentiated vs. differentiated pay to attract/reward competent scientists
Promotion	Appointing the most ambitious (management-wise) people as leaders vs. making the best scientists leaders for research units (particularly in industry)
Leadership	Juniors' need of support/rules vs. seniors' expectations of non-interference Strict focus on quality standards vs. inspiration and general social support
Internal/external balance of work	Doing the research work internally vs. «outsourcing» all or parts to others (particularly in industry related to the definition of «core competencies»)
Formal organisation	Need for structure and responsibility vs. need for autonomy and flexibility Autonomy vs. interaction/interdependence «Loose structure» vs. attractiveness when it comes to doing contract research
Size	Positive drive towards larger units (due to increased stability, access to funding, etc.) vs. disadvantages of being large (fission, reduced interaction, etc.)
Diversity of people	Diversity is in itself a form of tension – it is most often a greater challenge to interact with people a little different from yourself
Diversity of tasks	Involvement in other activities can create pressure on the individual's time Other activities can create strain by being highly intellectually challenging
Organisational culture	Strong sense of unity vs. heterogeneity Collaboration vs. competition
Communication	Expectations of reciprocity/balance implies that communication can be a tension in itself User contact vs. creativity Contact with both users and universities (institutes) Ensuring intellectual property rights vs. open communication (industry)

These organisational tensions can be tied to research quality in two different ways. First, some organisational aspects can promote one aspect of quality and restrain another. User control is for instance mainly seen as beneficial to utility value, while such control also is seen as an obstacle to creativity (cf. table 12.6). Second, the organisation can be a source of «creative tensions» (cf. Kuhn, 1963; also Pelz & Andrews, 1976) – e.g. may the «eternal» battle between unorganised chaos and the drive towards higher levels of organisation and efficiency in society be a source of creativity (see Tardif & Sternberg, 1988).

Apart from the first element in table 12.10, all the tensions are effective at a meso level (which is in focus in this thesis) – they influence individuals and their dedication, motivation, understanding, creativity and more. At a macro level, hardly any tensions were sketched, e.g. between the norms of the research units and their «organisational host», i.e. the university, institute or firm they are part of (cf. Hackett, 1990). The only ones who touched upon this were a few informants from applied units who e.g. discussed problems related to defining the «expected value» of research projects and the strain between the top management's focus on economic indicators and the researchers' wish for other criteria for high-risk project selection.

In the universities, the informants did not describe tensions between their units and the institutional level, although some described the Research Council of Norway in slightly or highly negative terms. There is clearly a deep cultural conflict between the Research Council and at least part of the Norwegian scientific community. In addition, the differences in quality criteria and organisation of research work between institutional settings can be an obvious cause of tension across sectors. It can perhaps be argued that Norway's large institute sector between universities and industry, contributes to reducing such system-level strain (and possibly creates new ones).

A few additional comments can be made. First, some of the informants emphasised that good research units «seek out» tensions. They can for instance try to employ somewhat different people, focus on many professional tasks and combine norms and formal mechanisms of social support with strong demands or expectations of high ambitions and an orientation towards the research frontier. Second, the dilemma or balance in industrial R&D units between doing the work internally and/or externally was not mentioned in the other sectors. Deciding «what we should *not* do» can be controversial, and several informants were of the opinion that particularly universities need to make more of these decisions. Especially some applied scientists expressed frustration that universities lacked the will or ability to build up good units in areas they saw as important to Norway.

Third, it must be emphasised that tension is not the same as personal conflict. Severe personal conflicts were unanimously seen as «disastrous» and destructive to the working climate of an otherwise possibly good unit. Scholarly disagreement is naturally not negative unless it escalates into a hard personal conflict. Fourth, there are tensions related to time that are not well reflected by the above table. Particularly applied scientists stressed that research units need to take on projects with different time horizons simultaneously, and they talked about the benefits of being «targeted» and «flexible»/«broad» at the same time. A few university professors furthermore talked about how a strong common organisational culture can lead to too much homogeneity over time. They saw planning for long-term diversity as central, even though this could conflict with short-term benefits from e.g. massively exploiting a line of research or taking on a lot of contract research and thereby gain resources. As a final comment, organisational dichotomies like internal/external, professional/social and formal/informal, which abound in the literature, do not necessarily constitute organisational tensions.

12.3.3 Can all tensions be «balanced»?

The literature often suggests that organisational tensions or paradoxes need to be «balanced» or «maintained» to ensure innovation and/or performance (Pelz & Andrews, 1976; Foss Hansen, 1995; Dougherty, 1996). Behind this claim lies the assumption that there is a curvilinear relationship between performance and tension (as in Pelz & Andrews, 1976). This is also reflected in the summary above and in the many specifications that my informants offered throughout the interviews. I do not see statements like «not too large, not too small», «different people but not too different» and «a certain breadth combined with a certain depth» as naïve expressions of moderation and a «golden mean», but rather as strong emphasis on balance between the various forces in research organisations.

Still, some tensions are obviously more difficult to balance than others, and in some cases, «equilibrium» may be impossible to obtain. The issue of differentiated pay can be an example. In most research units, it would be impossible to have individually-negotiated salaries for some, but not all, of the scientific personnel. Furthermore, some research units have a very strong egalitarian culture, making differentiated pay a possible source of envy, personal conflicts and deterioration of working climate. Challenges related to rewards can thus be seen more as dilemmas that need to be solved locally or centrally instead of tensions spurring creativity or other benefits. Nevertheless, a «middle road» could be to offer bonuses for particularly good work, e.g. international publication in prestigious journals. Informants from all sectors mentioned such bonuses. For instance, a philosophy professor said that his department offered to «buy you out» of teaching obligations based on your publication productivity (weighted towards the international community).

The list of tensions in table 12.10 is yet another indication of how hard and complex the leader's task is. Very good professional and social skills, along with a willingness to work long hours, are probably necessary to maintain a balance between opposing forces. Perhaps the leader has an even more challenging role in this period of time characterised by increasing external control of research work, where it may be difficult to maintain a perception of independence and autonomy among the scientific personnel.

Working life in an organisation focused on originality, with many forces pulling in opposite directions, is not necessarily easy. Previous investigators have found that eminent/ambitious scientists have a higher «tolerance for ambiguity» than others (Jackson & Rushton, 1987), and some of my informants have indicated likewise. For instance, some stated that good researchers have a high tolerance for work that is open, vague and unfinished, and many scientists do not feel comfortable when there are too many rules, too much order and too little «chaos». If some individuals do not thrive in such an environment due to less tolerance for tension and ambiguity, that could be yet another process behind cumulative advantage. Very ambitious scientists may seek out the units where the tensions are most evident and the possibilities of becoming «eminent» are higher, while the not so ambitious end up in units with a more «calm» and clear-cut profile. It can be added that the strong emphasis on a good working climate in my interviews can be explained if good collegial relations are a precondition to tolerating tensions (as proposed by Weick & Westley, 1996).

At the heart of many organisational tensions is the issue of challenge versus support. To maintain motivation and to «release their potential», researchers need a certain degree of support and recognition for work done. Challenges, on the other hand, can stimulate creativity and help make the researchers productive and updated. Support and challenge go hand in hand in good research units, and in this respect, scientists most likely are no different from other professionals. What may be particular is the extremely open nature of many research organisations, hence, balancing challenge and security need not be seen as an internal task. This framework was first specified by Pelz & Andrews (1976) but has not been much used since. My elaboration will hopefully help revive this perspective as well as connect studies of research units with contemporary perspectives in organisation theory.

«Tensions» often imply political processes. We have seen that tensions can stem from varying needs between junior and senior personnel, different interests between researchers and research managers etc. «Balance» in this framework may imply a successful compromise between opposing political forces. I consider the lack of focus on political aspects a weakness of the present study and a challenge for later investigations (of quality and its determinants) that apply a tension perspective.

Finally, my first two main research proposals can be briefly reviewed. In the first of these, I suggested that *research quality can be divided into four more or less incommensurable elements – originality, solidity, scholarly relevance and utility value– and these elements together constitute major tensions in research work*. In chapter five, I concluded that this is confirmed, but only partly. There is obviously tension between quality aspects, and we have seen that the decomposition worked quite well for a large majority of the informants. However, all decompositions, also the one I have proposed, lose a «facet» or «aspect» of research quality. Even after long interviews with experienced researchers who were prepared to talk about quality, a tacit and largely «personal» factor remains that is not covered by originality, relevance etc. It is difficult to regard this tacit and highly subjective component as anything but a legitimate and integrated part of research quality that escapes decomposition and, to some extent, elaboration.

In the second main research proposal, I put forward that *research organisations can be characterised by a number of organisational tensions that reflect conflicting demands in quality criteria*. Again, many organisational tensions have been described, confirming this part of the proposal. Some tensions are indeed based on what we saw in table 12.6 – the quality elements can be tied to different organisational aspects. Making a piece of research solid, original and relevant thus implies balancing forces that affect the researchers' time use, attention or perspective. However, three other types of organisational tension can be described that do not necessarily reflect conflicting quality demands. First, we have seen that research units can be characterised by «creative tensions», e.g. the conflict between «chaos» and organisation/efficiency.

Second, we have seen that a balance between «security» and «challenge» often is seen as necessary for researchers to remain creative and motivated/productive. Third, some organisational tensions can be due to varying political interests in and around research units, or due to conflicts between «ideal research units» and e.g. workers' rights.

12.4 Main similarities and differences

Throughout this investigation, I have sketched differences and similarities between disciplines and between institutional settings/sectors. These are main dimensions for an elaboration of the diversity of the research system, and I will summarise and analyse my findings below. In 12.4.1, I discuss disciplinary differences, while sector differences are elaborated in 12.4.2. The third main research proposal of this study, that the relationship between research quality and organisational factors is similar in all settings, is deliberated in 12.4.3.

12.4.1 Disciplinary differences

First, I once more stress the indicative and tentative nature of this section. Some disciplines are only represented by three informants and no one by more than eleven. I will concentrate on the aspects where I judge the answers to differ significantly between all the informants from one field and those from another. It may appear somewhat strange to start a discussion about disciplinary differences in this manner. Obviously, there are major differences between research work in e.g. engineering cybernetics and French language. Still, both humanists and engineers talked at length about issues like openness, collegiality and interaction with colleagues. Furthermore, when French language researchers brought up the beneficial effects of good relations with the public interested in literature, and engineers emphasised good interaction with representatives from relevant industries, they may be referring to processes and activities with important similarities.

In chapter three, I elaborated cognitive and social disciplinary differences. Cognitive dimensions are e.g. hard/soft, paradigmatic/pre-paradigmatic, pure/applied and degree of codification (see Kuhn [1962] 1970; Zuckerman & Merton, 1972; Biglan, 1973a and b; also Braxton & Hargens, 1996). Social differences can imply a distinction between rural and urban cultures and convergent and divergent fields (Becher, 1989). Some authors stress that there is a complex two-way relationship between the cognitive and social dimensions, if the distinction is valid at all (Braxton & Hargens, 1996).

In chapter five, I described a number of differences in my empirical data that can be termed «cognitive». For instance, humanists focused on good arguments, economists on well-specified models, mathematicians on elegant mathematical evidence etc. These differences are intuitively understood as dependent upon the nature and fundamental methodologies of each discipline (see also 2.3.5). Originality criteria (degree and type of originality) can vary between fields, but may also be due to phase of development, not only characteristics of the field *per se*. After a major fundamental contribution, researchers may become more preoccupied with application and «small-scale» originality. Specifications of utility value follow naturally from the «external audiences» of the disciplines. An interesting point is that some of the soft scientists claimed that well-written works are better than poorly written ones, that otherwise contain e.g. the same empirical data. Hard scientists also emphasised the importance of writing well, but for a different reason – quality reviewers can have large difficulties in judging the («real») quality of the work if a manuscript is poorly written. This can be explained if the «degree of codification» is higher in the hard sciences (cf. Zuckerman & Merton, 1972), or if language is the «code» that soft scientists need to master. It can be added that many comments from my informants support Cole's (1992) distinction between the core of knowledge and the frontier. At the research frontier, quality judgements always are very difficult, possibly resulting in a low level of consensus even in hard fields. Hence, «consensus» may be a poor variable for distinguishing disciplines (as have been proposed by Braxton & Hargens, 1996).

Many earlier investigations of social differences are confirmed. Hard scientists depend more upon (funds for and the quality of) their equipment, they work in groups and they often work through/with their doctoral students and assistants (cf. Biglan, 1973b; Becher, 1989; Kyvik, 1991; Braxton & Hargens, 1996). Still, many soft scientists stressed that they have frequent and formalised seminars and other activities, resulting in a group of people getting together for scholarly purposes regularly. The lack (mostly) of group work in the humanities and the social sciences, particularly in the universities, furthermore makes the department head a more important role to research quality. The department head needs to «make clear decisions» and «take formal responsibility» for the conditions for research work in the department, it was frequently claimed. In addition, philosophers and other soft scientists emphasised strongly that young researchers need to get regular feedback, encouragement etc., which probably occurs more automatically in formal group settings. Interaction and sharing of work is maybe more important than working in groups *per se*, and even some of the hard scientists stressed that group work is not formalised in any way, but happens «naturally» around good senior researchers.

It bears repeating that engineering cybernetics appears different from all the other disciplines in my data. For the researchers in this discipline, a practical and direct form of utility value was the central quality criterion in all sectors, making user relations very important. In many ways the informants sketched a «Mode 2» knowledge production with great emphasis on cross- (or trans-)disciplinarity and on finding a practical context and problem before starting research at all (cf. Gibbons *et al.*, 1994). Even the language differed; the researchers used expressions like «user demands», «client satisfaction», and «we need to establish ourselves in the market». There still seemed to be a clear division of labour between the three sectors, with the university researchers largely focusing on developing and adapting new methods and on opening up new areas of application. It can be added that these not necessarily are characteristics of engineering cybernetics everywhere – more theoretically oriented and less cross-disciplinary units are found at universities in other countries. The engineers asserted that the field in Norway «always» had been organised this way, indicating that «Mode 2» not necessarily is a new mode of knowledge production, but rather the traditional way of developing (at least some types of) technology. These characteristics may of course still be spreading to other disciplines. Biotechnology, the other technological discipline in my sample, did not stand out this way. The reason is probably that this discipline is very close to the natural sciences.

As can be seen from e.g. table 12.6, the relationship between cognitive and social characteristics of disciplines is complex, as proposed in recent literature (Braxton & Hargens, 1996). Strong traditional links with industry could be the source of the emphasis on industrial relevance in engineering cybernetics, but the informants also indicated that to seek practical relevance is part of this discipline's «nature» (without it, you would get «mathematical modelling» or another speciality). The current organisation of research work follows long and enduring scientific norms and traditions, but is also based on historical resource levels, control mechanisms and more. For instance, one of the sociologists suggested that research work could (and should) have been organised differently (e.g. more group work) if funds were available for large-scale international surveys and other expensive types of investigations. «Externalism» or «internalism» alone thus yield incomplete pictures of research and the way it is organised (as emphasised by Foss Hansen, 1988).

12.4.2 Differences between institutional settings

If the distinctions between disciplines often seemed unclear, sector differences in most cases were conspicuous. The specifications of research quality and good research units both varied consistently between institutional settings, confirming findings in other broad-based investigations (Cole, 1979; also Marcson, 1972; Pelz & Andrews, 1976).

It is particularly notable that the answers and specifications from institute researchers and industrial scientists in most respects were very similar. It could be that the large and often industrially oriented institute sector in Norway in fact carries out many R&D activities that in other countries normally would be found in industry (or split between industry and universities). Some comments from my informants indicate that Norwegian institutes carry out «tiers» of traditionally industrial R&D missions – they explore the tools of the future and help create these tools (cf. Zettelmeyer & Hauser, 1995, who define this as part of the mission of industrial laboratories). In addition, several industrial scientists stated that they often use institutes not to do more fundamental or long-term work, but rather to lessen the pressure in periods of peak workloads. The link between the institute sector and industry in Norway obviously deserves further investigation.

Regarding research quality, we have seen that the main distinction between sectors is to whom and for what the research should be interesting. Put simply, it can be stated that scholarly relevance mainly is a criterion in the universities, while practical and societal utility value is emphasised in the applied sectors. Perhaps is the most important implication of this the shorter time horizon in institutes and industry. There are nevertheless exceptions – university professors can do work oriented at immediate utility value, institute researchers, particularly from social and medical sciences, may be preoccupied with scholarly relevance, and industrial scientists can carry out projects where practical returns only are expected more than a decade later. The institute sector to some extent seems to be «caught in the middle», because here researchers state that they sometimes face incompatible demands for both practical utility value (strong user orientation) and scholarly relevance (publication and/or doing more general and long-term projects). As I have elaborated in 12.3, institutes e.g. able to maintain a good balance in their links to users and universities seem to deal better with this – the quality tension finds an organisational counterpart.

Another basic distinction in the research work can be read out of the specifications of the research process. In universities, informants often wanted improved dissemination of results and publishing in trade and popular science journals to increase the (potential for) utility, i.e. user communication after the research work is carried out. Some added that this is a difficult task, not only to find time to do it but also to write in a manner suited for a more «lay» public. A few professors (particularly the technologists, but also others) accented the benefits of general user contacts for understanding «real» problems and for prioritising areas and approaches that have a higher potential for becoming useful. Scientists in industry stated that early phase contact with users is the most central positive influence on utility value. Some of the institute researchers said that linking the research projects to users at an early stage is important, but could also be difficult to accomplish. A majority of these informants saw the «transfer» of the results to the users/contractors as the most central challenge for achieving utility value. It can be added that applied scientists generally put more weight on cross-disciplinarity, which follows naturally from the overall pattern and mission of the institutions (cf. table 3.3). This means that they often need to maintain a higher degree of diversity and a more complex communication pattern than their university counterparts do.

The differences between sectors are obvious from a number of specifications of such organisational challenges that the institutions face. University professors stressed international contacts as the best way of «releasing the potential» in young researchers, while applied informants saw obtaining a good and balanced project portfolio as the best way to do this. One reason for the difference could be that the phrase «young researchers» in universities refers to doctoral students (who often are urged to do part of their study abroad), while «young researchers» in institutes and industry may be those who have completed their degree and started working on more short-term tasks.

Recruitment of researchers is another issue that poses different challenges in various settings. For universities, the problem becomes one of detaining the research fellows after they have obtained their degrees. A good and inspiring training and enough resources/positions are some of the main challenges here. In applied units, the informants stressed that the organisation needs to maintain close links with university departments to be able to identify and approach the talented graduates. Some were of the opinion that good leaders should address these graduates personally, instead of relying on announcements of vacant positions. It must be stressed that in all settings, there is a strong dynamic process at work – research units with a good reputation have smaller problems in attracting talents than those with a poor reputation have. To some extent, it can furthermore be claimed that applied units have a particular challenge in assuring a continuous inflow of new people. This happens more automatically in universities with their ever-changing student population. However, if we look above the doctoral student level, the challenge is probably greater in universities with a lack of positions in many departments.

Although all scientists may benefit from also having other activities than research work, the number of additional tasks is greater in applied units (confirming Allen, 1977; Andrews, 1979a). Some informants from institutes and industry said that not only did they improve their competence by teaching and doing development work, they also found inspiration and knowledge in e.g. technical consulting, writing software and producing documentation for users. Applied scientists furthermore often get the teaching tasks considered the most beneficial – advanced level courses and supervision of master's degree and doctoral students.

Systematic differences between institutional settings can also be seen when it comes to main communication patterns. Applied scientists naturally emphasised user contacts, while university scientists upheld contacts with the international scholarly community as essential, although all types of contacts were seen as important by informants from all settings. My industrial informants emphasised the international dimension of R&D work, probably mainly due to the selection of firms and respondents from this sector. However, it cannot be disregarded that industrial (and institute) research is becoming ever more international, due e.g. to increased globalisation and the availability of international R&D funds.

It can be mentioned that the relationship between the sectors seems very close in Norway. In some respects, the sectors constitute tensions for each other. Applied units need links with universities e.g. to ensure recruitment, but contacts with university scientists also pose challenges, because researchers need something more than money to offer in scholarly exchange. Practical perspectives can create useful correctives to the basic research activities of university professors, but may distort them from fundamental work. Despite these tensions, several informants felt that research units in universities, institutes and industry are «in the same boat». Many industrial and institute researchers were concerned with what they saw as poor public support for Norwegian universities or a tendency to distribute research funds in the public sector based on geography, rather than on quality or an aim to build up strong departments in some select fields. The quality of the research units in the universities affects the quality of all other research units in the country in the end, it was asserted. Many university scientists also wanted strong applied/user/industrial units in their fields to get a fruitful interplay and to release the potential for utility that they saw in their research results.

Finally, all sectors are naturally characterised by much more diversity than I have suggested above. I have carried out interviews in large firms or in small companies with advanced biomedical products, and these are not a representative sample of Norwegian private firms, not even if only those doing R&D work are counted. We have also seen throughout the empirical analysis that there are numerous differences in the institute sector. Some institutes, particularly those in sociology and biomedicine in my sample, have a profile much more similar to university departments.

12.4.3 Does research work have a common denominator?

The third main research proposal of the present investigation was put forward in chapter three, stating that *the organisational factors that influence quality elements, or the mechanisms that link quality with the organisation, are similar across fields and across institutional settings*. I consider this mainly confirmed (see Jacobsen, 1990; also Andrews, 1979a, Visart, 1979 for earlier investigations that have found or hypothesised the same). Throughout this and the other empirical chapters, we have observed very many similarities across disciplines and institutional settings. In addition, most of the organisational differences can be explained by varying specifications of quality criteria.

In the interview material, no clear disciplinary differences can be seen when it comes to the benefits of external contacts and internal interaction, the role of diversity of people and tasks, negative effects of isolation and personal conflicts, and the need to identify and recruit scientific talents. In chapter six, we saw e.g. that the process that influence creativity and motivation seemed the same everywhere, and almost all informants proposed a strong link between motivation and productivity. A sharp relationship between creativity and freedom, little «bureaucracy» and an open and tolerant culture, was maintained in all settings. Even though researchers generally are dedicated to their work, research is nevertheless an activity described as very demanding and difficult, which can explain the unanimous emphasis on social support, mutual inspiration and a good working climate.

Concrete resource and equipment requirements and communication/collaboration patterns may vary between settings, but the processes through which research quality is influenced by organisational factors nevertheless look very similar. Different specifications of solidity demands, different criteria of originality (theoretical/practical, radical/incremental) and different types of relevance can largely provide explanations for the variations in organisational specifications. For instance, increased weight on practical relevance makes user contacts central. Thus, some processes and relationships are similar in all settings, and they constitute a common denominator for all types of research work. It must be added, however, that this does not mean that «diversity» is not a primary characteristic of the research system as a whole. On the contrary, the focus on «scholarly relevance» in some units and «practical utility» in others makes a tremendous difference. What I have maintained here is that organisational aspects and mechanisms influence the same elements of quality regardless of setting.

12.5 Implications

Above, I have elaborated «good research» and «good research organisations» – two central themes for better theoretical understanding of research units and for suggesting practical means of improving quality. My analysis has used two sources: earlier empirical and theoretical studies, and in-depth semi-structured interviews with 64 Norwegian senior researchers. The informants represent universities, institutes and industry in ten different disciplines. In this final subchapter, I review and summarise what I see as the main theoretical and practical implications of the investigation.

12.5.1 Theoretical implications

My analysis has implications primarily for the literature concerned with research quality and the literature seeking to understand research organisations. In addition, my efforts to link these two traditions have some theoretical implications.

Starting with research quality, I claim that this study has shown that a relatively simple and general «model» of quality can be valid in many types of research work. Earlier investigations have suggested either a simple decomposition where research quality has two criteria (Ravetz, 1971), lists with many criteria (e.g. Chase, 1970; Buchholz, 1995; Kaukonen, 1997; Andersen, 1998) or complex multidimensional frameworks where quality is seen as a combination of various aspects and attributes (Hemlin & Montgomery, 1990; Hemlin, 1993).

Drawing on these models but aiming for a «middle way» between complexity and simplicity, I have proposed a decomposition with four main «elements» – solidity, originality, scholarly relevance and utility value (or external relevance). This model was well or fairly well received by a large majority of my informants. Not only were these elements mainly seen as covering the essentials of good research, they were also largely viewed as more or less incommensurable. Although the elements often were specified in distinct ways in different disciplines and institutional settings, the labels themselves were meaningful across such dividing lines. In my opinion, this simple decomposition of quality manages to capture the essential aspects of good research: the demand for something new (originality), the demand that conclusions and arguments should be well-founded (solidity) and the demand that research in one way or another should have a purpose, be it «advancing knowledge», «increasing cultural understanding», «improving health» or «creating competitive advantage» (i.e. relevance).

One of the problems with many of the earlier studies is that the contents of complex terms like «originality» and «relevance» have not been specified much. Although it can be useful to decompose «quality» into more tangible sub-elements, these sub-elements may constitute complex categories deserving further elaboration. This has been one goal of the present investigation. We have seen that originality has two main dimensions – incremental versus radical and theoretical/academic versus practical/applications-oriented. Solidity criteria vary according to the nature of each discipline and speciality, and the methodologies and equipment that are preferred. Scholarly relevance can be specified in terms of cumulativity and generality, two complex terms that I have tried to specify further. Utility value or external relevance can be connected with «general» or specific users, varying time frames and different «utility domains», e.g. health, environmental or economic issues. There is still a need for more in-depth studies of, for instance, how originality criteria can vary within a research field according to its phase of development and the research unit's orientation towards the international scientific community and user groups.

Another theme that deserves more attention, is how quality criteria are combined in «entrepreneurial science» (cf. Etzkowitz, 1998) or «Mode 2 knowledge production» (see Gibbons *et al.*, 1994). The difficulty of combining concrete user demands with a desire to contribute to fundamental scholarly development was emphasised by many informants. It seems that cross-sector co-operation often ends up in traditional industrial R&D or private sponsorship of academic research. However, some informants stressed that the combination of basic and applied demands is possible and/or necessary and can be a source of productive and creative tension. Why and how some find this easier may have to do with the maintenance of balance in organisational tensions, but there is nevertheless a need for deeper understanding of why some succeed in combining quality criteria and others fail. It can be argued that if «Mode 2» or «entrepreneurial science» indeed constitute new manners of research work, they need to develop new criteria of quality to remain stable.

I believe that it is also necessary to create stronger connections between the research quality literature and traditional theory/philosophy of science. I have reviewed some articles and books representing the latter in this thesis, mainly to show why research quality investigations often seem to have started «from scratch». Although terms like «objectivity», «truth», «simplicity» and «rationality» are much disputed, some may still feel that «the baby is thrown out with the bathing water» if these in many contexts are replaced with e.g. the everyday notion of «solidity» or the policy-inspired term «relevance».

This investigation has to some extent looked into the question of quality assessments. Peer review is the traditional mechanism of quality control in science, and many authors have been concerned with «bias» in such reviews (like Mahoney, 1977; Cole *et al.*, 1981; Travis & Collins, 1991). I have argued that the problem of bias can be linked in particular with the problems of defining and elaborating scholarly relevance. My interviews indicate that this element clearly is the most tacit part of the quality concept, making it an obvious source of biased judgements. The informants are furthermore relatively negative towards possibilities for much elaboration in this respect. Quality judgements always include an element of personal preference, feeling and intuition, and this subjective and tacit component may be regarded as a legitimate and integrated part of «good research».

If we turn our attention to the research organisations, this investigation has elaborated and specified many earlier studies and the problems and relationships that they have described. I have tried to provide explanations for controversial and puzzling findings, for instance related to leadership in research units and to the importance of resources. I do not repeat these findings here (cf. chapters six through eleven and the summary at the beginning of the thesis). What can be added, is that I mainly have used the categories and organisational aspects of earlier studies (the majority of which being quantitative), and this may be a weakness of the present investigation. If we look at what my informants talked about in open questions about good and bad research units – issues like collegiality, openness, trust, personal conflicts and social support – these are topics that have not been much studied in the «research performance» and «publication productivity» literature. Here, data that are more «countable» (e.g. age and years of experience of leader, level of resources, full-time research equivalents) have been preferred. There is still a need for qualitative investigations within a «determinants of quality» framework with a stronger focus on e.g. cultural and political aspects of research units. As I see it, the main weakness of the organisational part of this study is its possible bias towards the perspectives of seniors/eminent scientist. To compensate for this, it is necessary for later investigators to gather data from all members of a research organisation (which also would allow for a better exploration of e.g. internal group dynamics). It is obvious from my interviews that the same working climate, leader etc. can be judged very differently by different individuals – if it is indeed relevant at all to talk about working climates and leaders independent of others' perception of them. We need to have a more complex view of research organisations that allows for varying perceptions, but a tension framework can still be a fruitful starting point. I have also suggested that a social capital framework may be a good starting point for later studies, because this perspective focuses on the connections between norms, communication and dynamic processes, all central aspects of good and poor research units (cf. 12.2.5).

My perspective and choice of methodology can be claimed a synthesis of three sources: the assertion in Pelz & Andrews (1976) that research units can be characterised by opposing forces of «security» and «challenge», the central claim in Andrews (1979a) that individual perceptions of e.g. resource levels and autonomy are more important to performance than more objective measures of the same aspects, and finally, the recent calls for using a «paradox» or «tension» framework for increased understanding of research units (e.g. Foss Hansen, 1995; also Dougherty, 1996; Birkelund, undated). Although the tension framework cannot be directly seen from the interview guide, I believe it has proven a useful concept for analysing the interview data.

I have found and specified many organisational paradoxes in research units (more than simply security versus challenge). The interview data indicate that the good units «seek out» tensions, for instance by instigating a recruitment policy leading to diversity (of backgrounds, age, sex and more), by striving for a project portfolio that includes both theoretical, practical, broad, narrow, short-term and long-term work, and by combining high levels of support and responsibility for young scientists with equally high expectations of performance and top quality professional contributions. My data point to three main functions of these tensions.

First, they reflect conflicts inherent in the demands to good research. For instance, if the work is required to be both practically useful and to contribute to the development and application of state-of-the art methods, the organisation will probably need to maintain good links with users and the international scientific community (or actors who function as gatekeepers to it). For the individuals in the organisation, this will constitute a tension. Not only can a time pressure arise out of the necessity of communicating with many external actors, but this communication will also expose the researchers to perspectives and demands that are likely to be perceived as difficult to combine. Thus, tension can be a key word for connecting the «research quality» and the «determinants of performance» literature. Research organisations need to maintain or develop tensions or paradoxes simply to reflect the inherent tensions in the quality criteria they relate to.

Second, and related to the first function of tensions, they can be connected with the centrality of originality in research work (see Kuhn, 1963). The fundamental demand of making a new contribution (e.g. to the international research frontier) that simultaneously is perceived by others as «relevant» and «important» is most likely a basic source of tension in research work (as it may be in other organisations where creativity and innovation are central aspects). My data support the earlier claim that not all people are able to support this kind of tension (Jackson & Rushton, 1987; also Kuhn, 1963). Thus, good researchers may have a higher tolerance for ambiguity and paradox, making them better suited for work in the «best» research units, assuming that these units also have the highest levels of tension.

Third, tensions can be linked with the maintenance of individual, and possibly group, motivation and inspiration. The language of Pelz & Andrews (1976) seems well suited here – researchers need to be subject to a blend of security and challenge to remain motivated. My informants emphasised this very much when they talked about doctoral students, i.e. the start of a potential scientific career. Social support and inclusion in scientific networks were mentioned, combined with friendly, yet critical feedback and transfer of quality criteria. In addition, scientific communication is for many a positive tension in itself. Communication is a source of recognition, feedback and inspiration (factors of security), but it also carries with it expectations of reciprocity and balance (that may constitute a challenge). My interviews furthermore indicate that motivation is particularly closely related to productivity. To become a good researcher, one needs to work long hours, to think about work-related puzzles outside the office and/or the laboratory, and to spend much time on a good dissemination of results (some called this «mediation quality»). This may be very difficult if motivation is low. It should be noted that there is probably nothing special about researchers in this respect. Individual motivation has been described as the dynamic result of two opposite forces in more general literature (Herzberg *et al.*, 1993).

It should be added that not all conflicts and challenges in research organisations can be considered productive tensions. Severe personal conflicts probably have no beneficial effects on quality and productivity. It is also evident that the needs of researchers vary, and that different ideals when it comes to e.g. leadership and resource allocation can give rise to political conflicts. My informants particularly elaborated junior scientists' need for supportive leadership, professional feedback and more, while seniors often expect non-interference from a research unit's leader.

There is a normative claim in much of the literature that tensions need to be «balanced» or «maintained» (e.g. Pelz & Andrews, 1976; Foss Hansen, 1995; Dougherty, 1996). Although I find general support for this claim, I have also found that balance or equilibrium in some respects may be very difficult to achieve. One example is the question of differentiated pay and other rewards, which could be impossible to balance with the strong egalitarian culture of most research units, making the issue a possible source of envy, personal conflict and deterioration of working climates. Another example is perhaps the different needs of juniors and seniors, as described in the preceding paragraph. «Balance» in this respect could mean a successful compromise between opposing political forces, and later studies will probably benefit from a stronger focus on political aspects of research units than what can be seen in this thesis. Behind the perspective I have applied lies the assumption that there is a curvilinear relationship between quality/performance and tension. If it is possible to develop indices of variables like tension, ambiguity or paradox, this could be tested in later quantitative studies. With such a methodology it would also be useful to test the hypothesis that good research units can be characterised by higher levels of organisational tension than poor ones. It should be mentioned that there is also a need to clarify further many of the terms used within this framework, for instance «tension», «ambiguity», «paradox» and «dichotomy». This may contribute to clarifying if these in all cases are productive, if «balance» or «equilibrium» always is a possible goal, and how they influence different individuals.

The tension perspective can also be used to shed light on other theoretical discussions in the social studies of science literature. I would like to mention the long debate about norms in science as an example (cf. Merton, [1942] 1973; Mitroff, 1974; and Foss Hansen, 1988 for a review). Merton ([1942] 1973) asserts that science is governed by a single set of norms (an «ethos»), while Mitroff (1974) has argued that norms and «counter-norms» exist side by side in scientific disciplines, although the task uncertainty of problems and specialities will make one set of norms dominant. Later authors have for instance argued that modern science is undergoing a normative shift – a «new» cluster of norms is emerging that incorporates commercialisation of R&D knowledge (see Etzkowitz, 1998). With my theoretical perspective and findings regarding e.g. informal organisational aspects, it can be claimed that good research organisations always can be characterised by opposing norms. Many of my informants, particularly from the institute sector, stated that their main challenge is to balance traditional academic values with the values of industrial utility and capitalisation of knowledge. Also scientists working with fundamental research assert that they are inspired by, and sometimes actively try to encourage, the practical application of their results. Changes in the research system may thus represent a change in the balance between opposing forces, rather than the substitution of one set of norms with another. To capture the «essence» of a research organisation, one may have to look at e.g. how ambiguous values are balanced, rather than look for a single set of characteristics.

12.5.2 Practical implications

To bridge the theoretical and the practical implications, it can be stated that the literature often emphasises that research units are dynamic (see for instance Merton, 1968 [1973]; Cole & Cole, 1973; Latour & Woolgar, 1979; Merton, 1988; Kyvik, 1991; Thagaard, 1991). Effects of reinforcement, accumulation of advantage, reductions in critical forms of communication and feedback, and less «creative tension» over time can lead research units into virtuous and vicious circles. However, despite the dynamic nature of research organisations, the informants in this study (and in other investigations, e.g. Kekäle, 1997) stressed that the organisation often is very difficult to change. One explanation is of course that dynamic processes like distribution of recognition and allocation of resources are largely beyond the control of scientists at individual and group levels. Another explanation is, as I have found, that only the initial phases of a research unit's life and a scientist's career offer good opportunities for policy and management initiatives. This may prove a barrier to the practical utility of all investigations of research organisations (as well as of organisations in general): a unit's present norms (or norm balance), communication patterns, mix of personnel and interpretation of its history constitute limitations for practical action.

Still, I think this thesis has many practical implications. There is, in my opinion, clearly a potential for learning emerging from my critical review of the literature, elaborated and specified with the comments of central Norwegian scientists. Researchers, research managers and policy-makers interested in improving quality and R&D organisations should be able to find many relevant starting points in my empirical and theoretical chapters, although a doctoral thesis may not be the best mechanism for transferring knowledge about good research and good research units.

If we start with the research quality part of the thesis, we have seen that my suggested decomposition of quality, with relatively neutral and everyday notions like solidity, originality, and relevance, is most likely not as contested as criteria based on e.g. «truth» and «objectivity». The decomposition may thus constitute a good starting point for many practical situations where quality is to be controlled, assured or improved. The Research Council of Norway has in fact started using my quality elements in some of their programme announcements and referred to them in policy discussions.

In research policy documents in Norway, there is a tendency to distinguish sharply between «scientific quality» on the one hand and «external relevance» on the other. This is valid in some types of university research, but does not seem very well suited to describing most research activities. Even many university scientists are inspired by and preoccupied with practical extra-scientific relevance, and user relevance is most often built into the process from the beginning in applied research. Still, policy initiatives may need further specification of «relevance», for instance the domain (health, economy, culture etc.), time frame (when can the research be expected to yield «returns»), and transfer mechanisms (how will a potential for utility/application result in concrete results). Some of my informants criticised the Research Council for having too narrow a definition of relevance, looking only at economic effects and short or medium term returns. Related to this is the occasionally occurring claim that the Research Council sometimes or often uses reviewers incapable of judging the quality of a research proposal.

The decomposition with four quality elements could perhaps also be used to develop better «diagnostic» tools for looking at research. If e.g. a research evaluation shows that a discipline or department does not produce original works, one may want to look at the autonomy and the culture in the units. On the other hand, if the problem is (too) few publications in international journals (a possible lack of scholarly relevance), improved possibilities for travels, visiting scientists and international co-operation can be necessary remedies.

Although the opportunity for policy initiatives to influence research organisations in the short term can be questioned, it is obvious that the influence can be great in the long run. Many informants asserted that the rules of promotion at universities in Norway have had negative (but possibly unintended) consequences for research. We have conclusive evidence that diversity (e.g. juniors vs. seniors) and a moderate degree of turnover is positive for research quality, but the promotional system and the lack of incentives to move between departments/research units in Norway can have made it difficult to achieve this productive diversity. For instance, it has recently been claimed that the tiny turnover among the scientific personnel at the University of Oslo (less than one percent annually) may be an obstacle to the development of good research units (cf. Sivertsen, 2000). The average age at many university departments in Norway is furthermore very high, and turnover seems to take place through «generation shifts». In my opinion, an important challenge for research policy/strategy is whether it is possible to find better ways of securing a stable and continuous influx of new talents into research units, particularly at universities.

Recruitment of talent was an important issue in the interviews and may be a difficult task Norway if the country is to increase R&D expenditures (out of GDP) to the OECD mean, implying an increased demand for scientific recruits. Although talented individuals uniformly are seen as the most important determinant of quality, none of my informants indicated a shortage of scientific talent in Norway. However, many were worried that a lack of positions (again, particularly in the universities) or an ever widening salary gap between the public and the private sector, can lead to a dramatic recruitment situation in the future, even for the best research units, which usually have no problems in attracting young and able researchers. Although pay generally is not seen as very important to researchers, at least if there are few possibilities for advanced professional work outside of science, some stated that rewards (not necessarily monetary) for e.g. international publications, hard work and creativity could have beneficial effects. Others asserted that a highly differentiated reward system (excluding the traditional academic recognition) may be a source of serious personal conflicts. It can be mentioned that it is obvious from many comments that not all researchers aim to become internationally leading figures in their field. Policy initiatives implying resource concentration, e.g. centres of excellence, will therefore need to identify carefully the individuals willing to dedicate themselves more or less completely to research work.

Many recent policy documents have been oriented at «strengthening leadership» in all parts of the research system (e.g. Stortingsmelding no. 39, 1998-99). My data indicate that also this may be a very difficult task. There is an ideal of a «non-leading leader» throughout the research system, at least among the established seniors. In addition, there is a possible lack of leadership talents, i.e. people with unusual professional talents combined with very good social skills. One starting point for policy initiatives could be a clear specification of leadership tasks and responsibilities to avoid conflicts and misunderstandings based e.g. on different perceptions of what a leader is and what this person should do. More formal and systematic training of leaders can be another starting point. Given the strong ideal of individual autonomy and the linguistic difficulties (many did not feel comfortable with the terms leadership and management at all), a main policy challenge is perhaps to strengthen leadership and initiate other mechanisms that may imply a certain external control, without triggering a feeling in the scientific community that «our autonomy has been taken away from us». In the present climate, this will require much skill and careful persuasion.

The question of diversity of task can serve as a good example of how managers and policy-makers need to use research findings with care. A large majority of studies, including the present, point to beneficial effects of having more professional tasks than e.g. basic research only. However, to take the study of Pelz & Andrews (1976) as an example, high-performing individuals who were involved in many other activities than research, still spent more than half of their time on their primary research operation. The policy challenge may be to create conditions for diversity and to ensure that the research work does not «get lost» in the pressure from other tasks. It could for instance be questioned whether research institutes have a financial and legislative situation that is conducive to maintaining diversity of tasks, which for most would imply strong links with both users and universities. According to many of the professors in this investigation, increasing undergraduate teaching loads are becoming a problem for many university departments.

In the Norwegian policy debate, calls for upgrading of equipment, particularly in the hard sciences, are often made. This was also done by several of my informants. A clear policy recommendation emerging from my analysis is nevertheless that investments in equipment cannot be viewed independent of personnel issues – somebody has to learn to use the equipment, they must have the time and capacity to do it, and they need to teach others before they leave the unit. The question of resources is obviously complicated. Although increased resources for a research unit do not guarantee good results, this does not mean that the present level of resources is satisfactory. For instance, many complained about a lack of funds for travels and some flexibility in the budgets to allow for unforeseen activities and investigation of anomalies. In addition, it is probably unrealistic to encourage research units to become «internationally leading» without making sure that they have «competitive» equipment, travel funds etc. in an international perspective. Because resources maybe are more a result of performance than its cause, it can be argued that there has to be a sufficient level of funds in the research system (available through peer-reviewed competition) that allow research units of an international standard to emerge.

A general impression from the interviews is that there is a widespread perception that the Norwegian research system is in a deep crisis, mainly due to lack of sufficient funds, lack of support for fundamental and long-term research, and lack of political and industrial interest in (and maybe understanding of) research and its importance. I am in no position to assess the validity of these claims, but it could be asserted, based on my findings, that a «crisis mentality» among the country's scientists in itself may have adverse effects. Lack of recognition and support from society could lead to reduced motivation or morale, which, as we have seen, can have negative influences on productivity and creativity. Thus, a continuing feeling of crisis may send the research system into a negative spiral with ever more problems of quality, productivity and recruitment. Many informants used Finland as an example of how a small country may both solve an economic depression and build up a good science base, and they of course wanted something similar done in Norway.

The tension framework can also constitute a guiding principle for practical recommendations. I have described that researchers and research units need a good balance between «security» and «challenge» (and other aspects) to remain productive and produce good research. Transferred into a policy recommendation, it could for instance be stated that increased resources to research units (increased security) could be balanced by e.g. demands for contributions to the international scientific community (challenge). Making an effort to recruit more young researchers (through offering tenured positions, more pay or other rewards) can perhaps be coupled with training of leaders to make them better suited to manage the role conflict they may experience due to the frequently strong expectations of non-interference from senior researchers.

Finally, policy questions like «What is the optimal size of a research unit?» and «What is the optimal balance between basic and external funding?» probably do not have meaningful single answers. The answers depend upon the context, e.g. the discipline, sector, tasks, ambitions, quality of the leader etc., as seen throughout the empirical part of this thesis. Since the answers to such questions depend upon contexts, it can be asserted that the primary challenge, when it comes to improving research quality in Norway, rests with the individuals and leaders in the research units. As Foss Hansen (1988) has argued, researchers to a much larger extent need to reflect about and discuss issues concerning organisation and management of research work. It seems like many research units have failed in this respect. The scientists in my study were very preoccupied with the issues raised during the interviews, but they indicated that they rarely deliberated such themes with their colleagues. Only a few informants (most from industry/institutes) stated that they had participated in discussions about e.g. the advantages of different unit sizes, leadership characteristics and leadership training, as well as in concrete initiatives to improve quality. Particularly the issue of making priorities between different areas, problems, competencies etc. was mentioned as something that needs to be addressed formally and explicitly both at unit, institutional and national levels.

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