ECONOMIC PLANNING AND THE GROWTH PROBLEM IN DEVELOPING COUNTRIES

By *Ragnar Frisch*[1])

I must apologize for having very little to contribute to the special discussion on the economy and economics of the Soviet Union and the other East European countries. I am most definitely no expert on these questions, but it comforts me that these topics were treated at this seminar in such an excellent way by Mr. Dobb, Mr. Kaser, Mr. Svendsen and other experts. My own contribution will consist in discussing economic planning methodology in general, and in particular the form that is most appropriate in developing countries. What I have to say by way of introduction might perhaps appear to you to be philosophical rather than technical, but I hope you will agree that in the end it is very relevant to the practical problems of planning.

The ideas I want to bring before you are listed in brief outline on the first page of the paper that has been circulated.[2]) I will start by making a confession which may serve as an elaboration of the idea which is listed in point 2.

[1]) University of Oslo.

[2]) The list of subjects referred to here, which was distributed to the participants in the seminar, was the following:

1. Three attitudes towards Soviet economics.
2. Discussing planning methodology in general. Not specific results.
3. The programming approach.
   3.1. Scientific and objective.
   3.2. In principle all-inclusive.
   3.3. The optimum way of thinking.
   3.4. The operational character. Quantification in practice.

4. The need for simplification.
   4.1. Limitation of data.

The ultimate purpose of progress is, in my opinion, something far beyond an increase in living standards. It is cultural, spiritual and moral and it is a training in the philosophy of helping others.

This basic wisdom is a heritage from the great Oriental and Middle East thinkers and sages of old. It has been passed down to us through the centuries and millennia in many different forms, but always with emphasis on the superiority of contemplation, serenity, goodness and duty as compared to the material desires. To quote but one example we find it typically expounded in the Indian Bhagavad-Gita, which is part of the immense epopee Mahabharata.

Bhagawad-Gita recites a metaphysical talk between the young prince Ardjouna and God before a big battle, God being disguised as one of Ardjouna's companions. Here we learn that whenever action is needed and unavoidable, it should not be motivated by a desire for pleasure, material advantages and domination over others, but should spring from goodness and a feeling of duty. Nothing should be considered as belonging to oneself. One should cherish a feeling of love for everybody, friends and enemies alike, and should wish the best for all creatures, men and animals. An emanation of this virtuous attitude we find in the famous saying of Mahatma Gandhi: "Infinite resistance to the wrong doing and infinite love for the wrong doer."

But superior to all action, even the most virtuous, are contemplation, serenity of mind, composure and inner tranquillity. Only through these states of mind is it possible to be delivered from the sham of the material world with its desires and pains.

4.2. Limited possibilities of statistical and technical processing.
4.3. Limited computational facilities.
4.4. Administrative problems. The human factor. Communication theory. The pyramidation problem.

Conclusion: Accepting simplification in a positive spirit. (Not defeatism).

5. Examples of pre-programming ways of thinking.
6. The channel model. An example of a macroeconomic programming model.
7. Technical computational problems.
   Speed of calculation, store capacity, access time.
   Different type of stores:
   High speed memory (magnetic core)
   Magnetic drums
   Magnetic tape.

Such thoughts were not confined to cultivation in the exclusive circle of a few intellectuals. They penetrated deep into the thinking of the millions and influenced their behaviour and outlook in a most profound way.

It is a significant fact that this eternal wisdom has survived in the materially underdeveloped but culturally, artistically and spiritually highly mature countries of the Orient and the Middle East, but it has been almost completely forgotten in the over-complicated, industrialized countries of the West. It has been forgotten to a point where a faint gleam of the old wisdom, when it occurs, will appear to be a sensational "discovery" of something new. Much has for instance been written lately about the "discovery" that it is necessary to find a new guiding principle, a new *purpose*, in the economies of the extremely commercialized and developed countries. It has become more and more obvious that the increase in productive capacity in these countries no longer tends to serve the real and worthy *needs* of the population. To find an increasing outlet for such consumer goods as can be sold at a profit in a free market economy, it has become necessary to invent ever new needs that can be forced upon the public through high pressure salesmanship, inducements to buy on credit and a reckless exploitation of people's fear of appearing not to be able to afford what the "others" can.

Slum-clearing, improvement of general sanitation and health services, general education, a general dissipation of cultural values, improvements in old age pensions, social security in general and the hundred other worthy things that can only be realized through Government initiative, represent wants that certainly do not need to be invented. They are there, but their satisfaction has lagged behind and only very slowly has it followed the general economic progress. The reason for this is simply that it does not in a commercial sense pay to satisfy these wants. There is no profit motive behind them. It pays better dividends to use the productive resources of the nation for the creation of and the satisfaction of more and more crazy *commercializable* wants.

In this way the materially highly developed nations have been led more and more towards the extreme opposite of the ancient

Oriental and Middle East wisdom. Life in the most highly developed countries has become more and more hectic, more and more concentrated on how to get hold of the newest gadgets for pleasure and high pitch entertainment—and on how to find means of *paying the oldest bills* due.

It is no coincidence that this development towards inner restlessness and tension has taken place simultaneously with a cult of the noisy, the ugly and the insane in all forms of art. And also simultaneously with a frightening increase in juvenile and adult criminality and a wave of psychiatric ills.

Is this necessarily the price we have to pay for economic development? Do the materially underdeveloped countries have to go through this same cycle only to *rediscover* in the end the millenial truth which the ancient Oriental and Middle East thinkers and sages tried to teach us?

It would be defeatism to think that this is necessary. We *must* find a way to abolish poverty, illiteracy, malnutrition and ill health without losing the priceless heritage of old culture and old wisdom.

This is possible, but it takes a determinate policy to achieve it.

In the first place, the economic development must be *guided*. It cannot be left to itself. In the second place, we must always clearly recognize that material development has its real dangers. At every turn of the road we must watch carefully that nothing is done that can work counter to the ultimate purpose of progress: the cultural, the spiritual and the moral values.

To be concrete: it serves a higher ideal to give the population of a materially underdeveloped country an opportunity to eat more eggs and to stimulate its craving for harmonious art, meditation and high morale, than to furnish it with the latest gadgets for "enjoying" exciting entertainment.

Material development is necessary, indeed. Nobody with a beating heart can fail to be moved by the present state of affairs in materially underdeveloped countries. But it must always be remembered that economic development is only a means towards a higher goal.

This confession, obviously, is based on a judgement of ultimate values. And it should therefore, perhaps, be outside the realm of the objective scientist. But it has such a basic meaning for the whole work on economic development that I must be forgiven for stating my case clearly before I now turn to the strictly economic analysis.

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The smaller the part of the national income used for consumption, that is, the larger the part used for domestic investment or for exports, the easier it will be for the country to ensure later a rapid increase in the national income. It does not take much originality to understand that here is the crux of the problem for the materially underdeveloped countries. The living standards are so low that it is out of the question to press them even lower. It is therefore very difficult for such a country to start its upward move without foreign aid, in the form of either loans or gifts. To become more wealthy through its own efforts, a country has to start by *being* wealthy.

This raises an interesting philosophical question: why is it that some countries are to-day highly developed in the material sense and others underdeveloped? This question is precisely of the same sort as the question of the ultimate causes—genetical, biological and historical—of the fact that the earth has become inhabited by such and such differentiated species of plants and animals.

It may be an alluring intellectual exercise to ponder on this, but such studies would not seem to be of much use for the politician or scientist who is eager to help to overcome as quickly as possible the sufferings of man. Such a politician or scientist will have to concentrate on the more immediately relevant factors and on the practical problems.

In the materially underdeveloped countries that strive to achieve rapid economic progress one is nearly always confronted with the same pattern of economic difficulties and conflicting goals. To create employment and raise living standards as quickly as possible in a rapidly increasing population one starts more or less by force and active Government intervention all sorts of economic activities, improvements in agriculture, industrial developments in light industries as well as in heavy industries like steel, fertilizer, electricity production etc. Since all this activity means spending lots of money, an inflationary pressure emerges in the investment sector and there is a heavy drain on foreign resources. On the other hand, the investment activity increases purchasing power in the hands of the consumers. Social reforms such as redistribution of land tend in the same direction. People want more food, more clothes—and perhaps more children. Since most of the production that has been started does not immediately yield consumer goods, the inflationary pressure spreads to the consumption sector. To combat this latter form of inflationary process, one would have to redirect productive forces into consumer goods production. But this would retard final progress, a very unattractive alternative. And again there is the eternal conflict between high standards of living through high production per man-hour and the necessity of creating new jobs.

It is an easy matter for a conservative economist to raise his finger and warn the underdeveloped countries about all these difficulties, and to tell them that the economic history of the western countries over the past centuries teaches us that economic progress is a slow process and that therefore the underdeveloped countries must be patient and wait for slow improvement. This sort of "advice" is not very much to the point in the world of today with its new technologies and new ways of thinking. The picture is completely changed. We must think in a different, a truly progressive way.

In the more advanced countries of the West the problems are partly the same and partly different. For instance, here a new and special sort of inflationary spiral emerges which no country has been able to avoid. It works in booms and depressions alike. It is created by the fact that the price-wage fixation to a large extent takes place through collective bargaining or state organized negotiations between labour, industry and agriculture. The bargaining must take place in this form if a general economic warfare is to be avoided. But in such negotiations it is always easier to reach an agreement by raising some rates than by lowering some rates, and so necessarily the inflation goes on. And each party will blame the others for "contributing to inflation". So it seems that in whatever direction one looks, the situation is the same. By trying to solve one problem, one creates several new problems. The whole picture is bewildering and it seems hard to know precisely what course to follow.

Here is where economic programming comes in. If speed with safety is to be possible at all in the materially underdeveloped countries, and I would add even in the materially more advanced countries, it must be through a rational form of economic programming. This brings me to the third point on my list: The programming approach.

The programming approach as I would like to define it is very ambitious. It goes much beyond the technique of material balances so much in vogue in some of the eastern countries. True programming is much more difficult to apply than the method of material balances. At the present stage the prospects for a practical application of a true programming approach are perhaps best in the medium sized developing countries with at least a certain level of industrialization and a certain amount of statistics and a reasonably trained staff of statisticians. This type of country seems to be the most promising field of application of rational planning techniques at the present stage.[1])

I shall state briefly the main characteristics of the true programming approach to planning as I see it.

In the first place it is *scientific and objective*. It must be based on a clear cut logical scheme where in particular the number of

[1]) *Note added January 1961.* In the last year a very significant new development has taken place in the Soviet Union toward the application of more rational methods of economic planning, based on intensive statistics, econometrics and mathematics. In this respect a paper by Academician V. S. Nemchinov, Moscow: "Die Anwendung mathematischer Methoden in der Wirtschaftsforschung und Planung," *Sovjetwissenschaftliche Beiträge*, October 1960, is highly interesting. The following excerpts from his letter to me of 2 December 1960 is not only significant from the viewpoint of the trend in scientific economic planning, but is also indicative of the Soviet spirit of peaceful co-existence. He writes: "We are sure here, in the USSR, that application of mathematical methods in economic analysis and planning can be fruitfully developed under our conditions both on the microeconomic and macroeconomic level. This is why we are developing our research in a broad field embracing the whole volume of problems connected with these two groups of practical tasks, as well as all "intermediate" problems (e. g. regional problems, analysis of microregional interdependence etc.).

I believe that further exchange of views and information will be mutually useful, because it makes it possible not only to acquaint oneself with achievements of his foreign colleagues, but also to learn and better understand different points of view."

degrees of freedom in the reasoning emerges in a precise way. It is impossible to satisfy these requirements without formulating the analysis in terms of a precise theoretical model.

This scientific character of the analysis does not, of course, mean that it is independent of politically formulated goals. These goals do come into the picture, but only as data for the scientific programmer. They serve to define what in the programming terminology may be called the preference function. Sometimes these goals must be formulated *in very specific terms*, and this is perhaps one of the most important differences between the classical economic analysis and the modern programming approach. And the results of the analysis must be presented in such a way that they do not hinder political manoeuverability. The results must only be in the nature of advice, and they should be formulated in such a way that the responsible political authorities can see clearly how much it will cost in terms of the preference function if the authorities decide to depart from the advice for some political or humanitarian or other reasons that are not stated explicitly in the preference function.

Second, the economic programming model must be *all-inclusive* in the sense that all relevant features of the economy are included simultaneously, at least in an aggregated form. And all relevant alternatives must be included so far as choice of technology is concerned.

Third, the analysis must be formulated as a true *optimum problem*, i. e. it must be formulated in such a way that the results emerge as the best possible solution that is attainable under the given conditions. One of the most urgent needs in developing countries to-day is to accustom the authorities to think in optimum terms and not to let the decisions on investments projects and on other important aspects of the economy be based on ad hoc partial considerations, perhaps under the influence of pressure groups.

Whithout going into detail I may illustrate the programming formulation in a schematic way as follows.

Suppose we consider a number—perhaps a very great number—of variables, $x_1, x_2, \ldots, x_N$, describing the constellation of the economy. And suppose that a certain function of these variables, $f(x_1, x_2, \ldots, x_N)$, is taken as our *preference function*, i. e., a function which we want to maximize. It may perhaps be the rate of increase of national income over a given number of years or some other formulation of the goals. Further suppose that the structure of the economy is expressed in terms of certain *relations* between these various variables. Finally we must introduce certain *bounds* on these variables. This means that for each of the variables, say for no. i, we have prescribed a lower bound $\underline{x}_i$ and an upper bound $\bar{x}_i$ between which the variable x_i must lie, i. e.,

$$\underline{x}_i \leqq x_i \leqq \bar{x}_i.$$

If some of the variables are not bounded in this way we can consider this as the special case where either the lower bound $\underline{x}_i$ is minus infinity or the upper bound $\bar{x}_i$ is plus infinity (or both) for the variable in question.

The *selection* part of a programming problem will then be to find such values of the variables $x_1, x_2, \ldots, x_N$, as will maximize the preference function under the constraints expressed by the relations and the bounds. And the *implementation* part of the programming problem is to find ways and means of steering the economy in such a way that the desired constellation is achieved. Finally there is the *follow-up* problem which consists in checking and controlling the execution of the program.

This is a very brief indication of the logic of a programming problem. The analysis may be elaborated in different directions, for instance in the direction of what is called parametric programming. This means investigating how the solution will depend on changes in the various data, changes in the preference function, changes in the bounds etc. Or the analysis may be refined in the direction of introducing a stochastic element, that is to say the probability distribution of the data and of the solution, and so on. I shall not enter into these technicalities.

The programming analysis must be truly *operational* in the sense that the concepts and quantities involved actually have their counterparts in observable, statistically and technically and economically fairly well-defined phenomena in the economy, and are of such a nature that the results of the analysis can be taken as a guiding principle for *action* on the burning economic political issues. Sometimes this means that the concepts must be specified in considerable detail. And a number of detailed practical questions must be settled regarding the way in which the quantities involved in the theoretical model are to be measured.

These desiderata constitute an ideal which we should strive to follow, but which it is never possible to realize completely. In practice we face the need for simplification. There are several reasons for this.

First of all, the data may not be so abundant and precise as the statistical, the technical and the economic experts would like. You know that the appetite of these people for better and more reliable data is insatiable and frequently one has to put up with something less perfect.

Second, it is not only a matter of getting raw data but also of processing them in such a way that they become usable for the analytical purpose one has in mind. This processing is an immense practical task that demands great understanding, accuracy and feeling of responsibility on the part of the large staff that takes part in the work. It is also a question of rational organization of the work. This implies the use of modern data processing machines and—equally important—a wise organization of the human factor involved. I have a certain amount of experience in organizing work of this sort and find that it is quite a task to impress on associates and assistants the need for precision and responsibility in handling such an enormous amount of data, and to apply foolproof checks in all directions where this is possible.

Third, there is the question of limited computational facilities. The programming problem in its ideal formulation with a considerable number of break-downs and a truly dynamic model will be so big that it is unmanageable even by means of the very large modern electronic computers. So, also on this score, it will be necessary to look for simplifications and aggregations. Not to mention the fact that a thorough solution will be very costly, because it will always be necessary to run a series of tentative solutions and, in the course of these tentative solutions, to modify some of the conditions or some of the assumptions made in the analysis. Our experiences so far in solving mathematical programming problems of this kind tend to show that we have to rely heavily on my multiplex method[1]). I don't see how our problems could have been handled by any other method except at a larger cost.

Fourth, there is the human factor involved in carrying out and following up and checking the execution of the plan. The human factor is just as important in this phase of the programming as in the processing of the data. Not only downright corruption, but also a lack of understanding and the general shortcoming of humans will put definite limits to what can be achieved. Sometimes it will be necessary to compromise between what is administratively feasible and what would have been an ideal optimal programming solution if more adequate administrative possibilities had been available. Here we meet the typical problems that are considered in modern abstract communication theory and in the study of imperfections in the giving and receiving of orders. This is what, in an abstract sense, is designated under the name of noise in information channels.

In this connection should be mentioned what we may term the *pyramidation* problem, that is the general problem of the extent to which it is possible to decentralize the decisions and the optimum number of levels on which the decision making machinery is to be organized.

All these difficulties will make it necessary to accept considerable simplifications in what one would like to see as the ideal programming study. These simplifications should be accepted in a positive spirit. There should be no feeling of defeatism. Even with a considerably simplified decisional programming model it is likely that one will be able to elaborate a framework for macroeconomic decisions which gives better results than what could have been obtained by more or less haphazard, ad hoc and partial decisions.

With this definition of a true programming analysis in mind it may be useful to survey rapidly some types of analyses that are much in vogue but are not adequate for a true programming analysis. They are rather what I would call examples of *pre-program-*

[1]) The method is described in several memoranda from the University Institute of Economics, Oslo, and in *SANKHYA, The Indian Journal of Statistics*, 1957.

ming ways of thinking. This survey is what is listed as point 5 in the synopsis.

First let me mention the great emphasis that is often put on such a concept as the savings rate, i. e. the part of private income that is not used for consumption. Frequently one tries to estimate this rate on the basis of past data and *before* the decision on investment and other decisions on economic policy are taken, and then, afterwards to use this estimate of the savings rate as basis for decisions on investment and on other aspects of the economy. This way of proceeding is to put the cart before the horse. The savings rate is not a datum for economic policy decision in a true programming sense, but it is itself a consequence—one might almost say an incidental consequence—of the programming decisions. In a developing country where it is the explicit purpose of the authorities to change the past course of affairs and transform the economy from a stagnant one into a truly progressive one, it has little meaning to estimate a priori the savings rate by means of data that have emerged under a different economic policy and perhaps different economic institutions. The data from which to start in a true programming analysis must go much deeper down into the technological and behaviouristic structure of the economy. For this reason I have always been rather sceptical about the usefulness of such an extremely simple analytical tool as the Harrod-Domar growth model. Models of this type may have a certain descriptive value when applied to an economy that is left more or less to itself under a régime of a rather free market economy, although even for this purpose they are too aggregated to have much explicative power. A growth model with sectorial breakdowns and other refinements which give it much more explicative power has recently been given to us by Mr. Leif Johansen[1]), who is participating in this seminar. But even his model is more in the nature of a specific growth model and does not have the features which I think essential in a true programming analysis.

In this connection should be mentioned also another special type of fallacy which is frequently encountered in economic planning work, namely to put up as a target a more or less arbitrary rate of

[1]) *A Multi-Sectoral Study of Economic Growth*, Amsterdam, 1960.

development of national income, and then try to find out what consequences can be deduced from such an assumption. Such a starting point for the analysis has no logical basis and owes its popularity, I think, only to its simplicity. (To introduce the national income development rate in the preference function is an entirely different matter. In this case optimum calculations are made).

Indeed, in the first place it is frequently not established that the postulated rate of development is *possible* at all under the given technical, behaviouristic and political conditions. And even if it were, one has no guarantee that it is the rate that corresponds *best* to the goal that the authorities would like to reach if it were possible. For instance, why was not the assumed rate put 10 or 20 or even 50 per cent higher? Only a true programming analysis can answer this question.

In the second place, even if the rate is given, it is in no way a sufficient criterion for deciding upon the specific investment plans and other economic plans to be followed. A given rate of increase in national income may, for instance, be obtained by a policy of extremely expensive long range investments combined with a very liberal consumption policy and a heavy reliance on foreign aid in the form of loans or gifts. Or the given rate may be obtained through a policy with emphasis on short term investments, a drastic reduction in consumption and little reliance on foreign aid. Or through a policy with some other specifications. In a true programming analysis all these features as well as the rate of increase in national income will follow as parts of the optimal solution.

As a final example, I would like to mention the following: Much attention has been paid to what is termed a *balanced* growth. This too is an example of the pre-programming way of thinking. Two very pertinent questions arise here. What is really a balanced growth? And why should the growth be balanced? There is no way of giving a rational answer to these questions except by starting from well-defined technical and behaviouristic data and a clear formulation of the goal to be obtained and a given initial situation of the economy and a dynamic programming model covering this setup. The solution of this programming problem will then tell us precisely which sectors it will pay to keep underemployed and for how long. The optimum amount of imbalance and its optimum distribution over the sectors and over time will emerge simply as features of the optimum solution. And it does not seem possible to define what this optimum amount and distribution of imbalance will be except through a dynamic programming analysis. Once a true programming view point is adopted the "balanced growth" way of thinking becomes of secondary importance.

Also many of the other much discussed and often controversial partial questions of planning and growth will fall into focus, I believe, and appear in their logical interrelationships when the problem is approached in a true programming spirit.

Turning now to a specific example of a programming model, the *channel model*, I would like to state quite explicitly that many different types of models are conceivable and may be useful for different purposes, provided they satisfy the criteria which I have put up for a true programming analysis. We may for instance start from programming at the establishment level, taking this word in the standardized meaning of a factory or a technical unit, and proceed by aggregation to higher levels. Some big investment projects may, perhaps, be considered as so many separate sectors, and so on.

The channel model about which I am going to say a few words, is a typical *selection* model, not a model for the study of the implementation problem. It has emerged after a long series of considerations leading to a sort of an optimum compromise between the too complicated and unmanageable and the too simplified and trivial.

The analysis starts from an interflow table[1]) of which the upper left corner is a regular input-output table. The remaining rows and additional specifications put particular emphasis on the breakdown of inputs in special categories: Wages, distributed ownership income, non-competitive[2] imports etc. The model also emphasizes the breakdown of investments into specified channels. There is, in most cases, one channel corresponding to a given sector. And for certain sectors there is a small number of, so to speak, parallel invest-

[1]) Mimeographed copies of the tables distributed at the seminar and referred to in the text may be obtained free of charge from the University of Oslo Institute of Economics.

[2]) Instead of the term non-competitive it might perhaps be better to use the term *complementary*.

ment channels. For instance, there will be investments in horizontal and vertical expansion in agriculture, horizontal meaning the reclamation of land, and vertical the expansion of capacity of production on a given piece of land.

In each channel there is supposed to be a stock pile of investment projects, each described according to a standard scheme of data. An extremely important task is to make this stock pile as *large* and *diversified* as possible. All possible efforts, imaginative, technical and otherwise should be used to enlarge and improve this stock pile of projects.

Once the stock pile is given, an upper limit is put to the amount that can be spent in each channel. This is an example of the bounds I mentioned before. A fair number of channels to consider may be between, say, 30 and 50, but 70 or 100 will be more satisfactory. And, of course, if the big investment projects are considered one by one, individually, the number will be much greater. It is assumed that in each channel the investment is characterized by the following features.

There is a certain *time distribution of expenses* that will follow if the decision to start this investment is made, and I emphasize the word *if*. It is only the expenses that would follow *if* the decision is made. So far no decision has been made. This time shape of the expenses is characterized by what is called the carry-on coefficients.

The second character of an investment is its *capacity effect*, i. e. the increase in the capacity of production in a given sector that will follow if one decides to start this investment. There will be a waiting time where no increase in capacity emerges. Next a growing time where the capacity is increased up to the maximum that will follow from the description of this investment project. For instance, in a hydro-electric power station some machines may be ready for use the third year, some the fourth year and the rest the fifth year. Next there will be a stationary time during which the capacity is maintained fully, assuming, of course, regular maintenance but no straightforward renewal. Finally, there will be a declining time, until the scrapping of the capital equipment that has been the result of this investment, if one decides to accept it. The gross to gross[1])

[1]) I. e. gross output to gross investment.

"output to capital" ratio is also a part of this information that characterizes the capacity effect in each separate channel.

Third, there is what I call the *infra effect* of the investment. That is the effect which the investment will have on the various coefficients. This is a more specific use of the word "infra" than that which is implied when we speak of the relation between investment in railways, roads and other big civil economic projects and the usefulness of these projects for military purposes. But the logical essence is the same, namely the interrelationship between sectors and investments. The introduction of the infra effect in the specific sense in which I use the word, makes the programming problem more complex. From the mathematical point of view it becomes quadratic instead of linear (and even of a more complex form).[1])

Finally, in the model it is, of course, necessary to introduce structural relations expressing consumer demand and other structural relations of the economy.

The time horizon to be considered is essential. Even if the planning period itself is limited to, say, five years, it is necessary to consider the repercussions over a longer period. Otherwise one would, for instance, not be able adequately to take account of the capacity effect of such long-lived capital goods as a hydro-electric power station.

The need for distinguishing between the planning horizon and the repercussion horizon introduces a particular difficulty which we may call the *truncation effect*. It consists in the fact that on the one hand we cannot disregard the effects that will produce themselves beyond the planning horizon, but on the other hand the variables that are contained explicitly in the model only give an adequate expression for the several aspects of the economy during the planning period proper. By certain plausible simplifying assumptions one tries to assure a workable solution.

The choice of the preference function is a separate question. The nature of the optimal solution will, for instance, depend essentially on whether we want a rapid rate of growth over the first years or

[1]) A preliminary study of the infra effect is given in my contribution to the volume in honour of Erich Schneider: *Stabile Preise in Wachsender Wirtschaft*, Tübingen 1960.

we are satisfied with a slower rate in the first years in order to get a much more rapid development later. Our attitude towards the desirability of avoiding too much reliance on foreign aid also comes into the picture and, possibly, considerations of employment and other aspects of the economy. It is necessary to use several different definitions of the preference function and several alternative bounds on, say, the foreign indebtedness of the country or on employment etc. For each such set of data the corresponding solution will have to be worked out. In other words the analysis will have to be of the parametric programming type. This is useful as a practical help to authorities in formulating the preference function that is finally to be used.[1])

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Finally, I would like to say a few words on the logical structure of electronic computers of the current types now available. It is, of course, not necessary for the economist or statistician to have a thorough knowledge of the technical refinements of these machines, but it is highly desirable that they have at least some idea of the *logical structure* of the machines. This is essential in order that the economists and statisticians may be able to shape their problems as much as possible in a form which is agreeable to the machine, or at least sympathetic to the coding expert.

An electronic machine can do the same kind of computations as any competent human computer can do with pencil and paper. But the machine can do the job in milliseconds (one thousandth of a second) or in microseconds (one millionth of a second) instead of the seconds, hours or days which may be needed if the work has to be done by a human computer.

Therefore the logical principles of the machine can easily be explained by looking into what a competent human computer can do with pencil and paper.

The human computer will have in the middle of his desk a big sheet of paper on which he makes his computation. And on the left

[1]) At present a good sized problem of this sort is being run on the electronic computer belonging to the *Norwegian Defence Organization*. The work is done under my supervision on data for an underdeveloped country. In this connection I would like to mention the highly competent and constructive coding work done by Mr. Ole-Johan Dahl, research worker connected with this machine.

Folder of data and intermediate results.	Big sheet of paper on the computor's desk.	The University Library and the Central Bureau of Statistics located in the other end of the city.

side of his desk he will have a folder of data and intermediate results that emerge in the course of his computations. And back in this folder he will probably have written instructions that tell him what sorts of computations he is going to make. Finally in the other end of the city there are the University Library and the Central Bureau of Statistics, where he has access to an enormous amount of information and data stored in shelves full of books. Occasionally he may need also some of these data.

The efficiency of his work depends on three things: First, on how quickly he is able to *make calculations* on the big sheet of paper immediately in front of him. Second, on how much data and intermediate results and calculation instructions the folder on his table—and the shelves of the University Library and the Central Bureau of Statistics—*can hold.* And, third, on how quickly he is able to *get hold of* any information which he needs. These three features are technically termed the *calculation speed*, the *store capacity* and the *access time.*

On the big sheet of paper each figure is so to speak immediately accessible. The access time is practically zero. The eye can move from one corner of the paper to another in practically no time. But the store capacity here is very limited. True enough one could build a very big desk with a very big sheet of paper on it, but this would be extremely expensive and unwieldy.

Therefore, it is convenient to have the folder on the left part of the table. In this folder the store capacity is much larger than on the big sheet of paper, but in turn the access time is longer. It takes a little time to look up in the folder what is needed at any moment. The access time in the folder is, of course, all the shorter the better the system of classification used in the folder. The store capacity in the folder, while much larger than the store capacity of the single sheet of paper, is however limited.

If the University Library or the Central Bureau of Statistics are drawn into the picture, we get a store capacity that is for all practical purposes infinite. But in turn the access time is here very long. Or, to be more precise, there is a peculiar difference between the way in which the access time manifests itself in the folder and in the library. If we are to look up an information in the folder, this will take an amount of time which is practically *independent* of what we were looking for in the folder a little while ago. But when it comes to the library, this is not so. Here it is very essential to plan the *order* in which we are going to fetch the data. It would be very time consuming if we were to run back and forth to the library to pick up now one piece of information and now another. We must plan ahead the kind of information which we are likely to need from the library for the next days or weeks or months and then *copy this information* on the sheets which we insert in the folder. From the folder we can then look this information up fairly quickly whenever we need it. When a piece of this information is needed for actual calculation we will further copy it from the folder to some convenient place on the big sheet of paper on the desk.

These selected figures that are now copied on the paper, can then be combined with great speed, and the result can be put back into the folder for later use, or perhaps even be sent back with a messenger boy to the library for temporary storing there.

The electronic computer does not use pencil and paper but various kinds of electric and magnetic signals. These signals are expressed in binary digits, that is in a system where there are only two known symbols, namely 0 and 1, or if you like "yes" and "no". In this system our usual numbers will be expressed as follows: zero = 0, one = 1, two = 10, three = 11, four = 100, five = 101 and so on. A word or a number is made up of a sequence of such 0 and 1 signals. Usually this sequence—the wordlength—is represented by something between 40 and 50 binary digits. This corresponds roughly to something between 12 and 15 decimal digits. (Certain machines, or parts of machines, may have a device for translating 4 or 5 binary digits to one decimal digit and perform the actual calculation in decimal digits, but this is no exception to the general rule that the basic working system of the machine is expressed in binary digits.)

On an electronic computer the device which corresponds to the big sheet of paper is called the *high speed memory* and is technically in the form of a large number of ferrit cores, one for each binary digit. Here the access time is of the order of one or two microseconds, that is to say, roughly one millionth of a second. This means that we can look up a new figure in about one millionth of a second.

It is difficult to visualize what this really means. You can do it perhaps by a comparison. Suppose that you have a very lazy human computer. He is so lazy that it would take him, say, 10 days to move his eyes from one figure written on the big paper on his desk to another figure written on that same paper. This man would need roughly, I think, 15 months to compute the product of the two numbers 13 and 27. If we compare the relative efficiency of this lazy computer to that of an ordinary human computer, we have an illustration of the relative efficiency of an ordinary human computer to that of the machine.

The store capacity in the high speed memory may be from 1024 words to 16 times 1024 words (and in some machines even larger). The figure 1024 is used as a unit because it is a power of 2, namely 2^{10}.

The folder to the left on our computer's desk is in the electronic computer represented by *magnetic drums*. They are cylinders on the sides of which is impressed information in the yes- and no-system. They revolve at a high speed. And there are reader heads able to pick out the number—or word— we want when it comes along as the drum revolves. Therefore, the access time will depend essentially on the speed of rotation of the drums. The revolution time may be, perhaps, around 12 milliseconds. The usual procedure will be to transfer one *track* of information—or a half track—from a drum to the high speed memory when this information is needed for the computation.

The store capacity will depend on the size and the number of drums. A drum may contain anywhere from a few thousand to perhaps 24 times 1024 words. And one installation may contain anywhere from a few drums up to perhaps 16, or even more drums. This gives a store capacity of from around 10 000 words up to perhaps half a million or a million words in a very big installation.

Finally, the library in the other end of the city is represented in the computer by a *magnetic tape.* Here the access time—if you should need to wind up the whole tape—will not be calculated in microseconds as in the high speed memory. It will be a matter of several minutes. But if you can arrange the work in such a way that you transfer the relevant part of the tape information to a magnetic drum or even to the high speed memory at *the right time before the information is needed,* the whole work may nevertheless proceed quickly.

On tape the store capacity is practically unlimited. Not only will one tape contain an enormous amount of information. But several tapes may be combined into big aggregates.

There is only one limiting factor for store capacity in the high speed memory or on drums or on tape and that is the *cost* of the installation. A relatively small sized computer may cost perhaps one million Norwegian kroner, and a really big sized computer may run into fifty or even a hundred million kroner.

I am afraid that a coding expert would be horrified by the lack of precision in this extremely simplified explanation, but I believe that my explanation does give the logical essentials which the economists and statisticians need to know. It is my opinion that the time has definitely passed when a competent economist and statistician can afford to be completely ignorant of modern computing machines.

DISCUSSION

Observations were made by Mr. Hans Jacob Kreyberg, Mr. Michael Kaser, Mr. Leif Johansen, Mr. Knud Erik Svendsen, Mr. Yousry Sadek, Dr. Rolf Krengel and the lecturer.

Regarding the preference function, one speaker wished to know how Professor Frisch arrived at the specification of such a function. The speaker's own opinion was, that in general, people have great difficulties in making their preferences explicit. Usually they express a mixture of their true preferences and their own private models. Since Professor Frisch in his lecture did not mention the three attitudes towards Soviet economics, one of the speakers asked him to do so. He was also interested in the structure of the decision-making process, and whether there was a strong influence of the decision-making structure on the choice of programming. Concerning the programming in the Soviet Union, he thought the few Soviet attempts were largely limited to linear programming, although they have begun to extend into quadratic programming.

One speaker pointed out the importance of internal reserves in the underdeveloped economies and the aid of technological know-how to these countries. He described the Soviet material balances from the early nineteen-twenties as preprogramming methods. He thought, however, they now passed into the programming period and would be able to apply this far more efficiently than many western countries. A main problem in programming in the East European countries was to find the combination between the flexibility in planning and the strict programming computation. Concerning the "Channel Model," he thought there was a weak point in the application of the model regarding the stock pile of investment projects. The "Channel Model" has to take this stock pile as given, and the achievements in the plan, computed by means of the "Channel Model," will be confined within the limits set by the stock pile. With relation to the preference function, he found it difficult to see the usefulness of computing results according to these functions as long as people can not tell exactly or approximately the composition of their preference function. He would rather try to depict some representative possibilities within the restrictive boundaries of the model, and ask people to choose directly from this set.

Observations were made as to the view of Professor Frisch that it was not logical to start with a given growth rate. The speaker said one often wonders if the Eastern countries do not in some respects start with some goals which they want to obtain, and calculate what is necessary to reach these goals. In many respects the plan was not only a question of obtaining the optimal solutions of different relations, but having a plan was also a mobilizing effect. To this question another speaker said that he could not see that there was a conflict between the programming approach to economic planning, as set out in the "Channel Model," and the mobilizing effect of having a plan with certain specific goals like in the Soviet Union. He thought one could use the "Channel Model" or some similar model, compute the plan, find out which rate of growth of national product was to be achieved, and then, on that basis, start the propaganda or the mobilizing effect. Another comment concerned the too strong use of mathematics in economics. The speaker did not need mathematical methods he said, to know that people in Africa or India have not enough to eat and that they have an underdeveloped agriculture and industry.

Professor *Frisch*, in winding up the discussion, made the following observations:

Regarding the *three attitudes* to Soviet economics: One can either take an over-negative attitude, distrusting any information, statistical or otherwise, that comes from this country, using all one's mental energy and imagination to "prove" that this information is misleading. Or one can take the over-positive attitude which consists in believing as a matter of dogmatic theology every rosy picture of the Soviet economy that is circulated. The third attitude is the truly objective one which has been displayed so eminently in this seminar.

Regarding the *vicious circle* in the underdeveloped countries: We must, of course, not only think of foreign aid but also of developing the hidden resources —material and human—in these countries. The development of Japan is a case in point. Without much foreign aid this country has made big strides in light industry, for instance in quality products like cameras, optical instruments etc. In a different direction China has made progress without much foreign aid. But in most countries the conditions for a successful take off is less favourable and some foreign aid is necessary.

Regarding the specification of the *preference function:* It is admittedly difficult to formulate interview questions that will reveal the preferences of responsible politicians without awaking unintentionally their own thinking in terms of their own model, whatever it is and however imperfect it may be. The preference function must be purified from such thoughts. A familiar example from the application of the theory of choice to the analysis of consumer demand will illustrate the particular aspect of a preference function which it is essential to retain in programming work. If a set of indifference curves (or surfaces) and a budget equation under constant prices are given, the substitumal can be constructed and thus it can be shown how the equilibrium point changes as the income increases. In order to expound this theory we need what may be called the *free* preference function, i. e. a preference comparison between all points in space, not only between points on the substitumal. I think the corresponding problem in programming can be solved. It is possible to formulate a well thought out system of questioning which is such that, while the responsible politicians do not fully understand the nature of the information the expert is looking for, they are nevertheless able without too much difficulty to give answers from which the expert will be able to compute the kind of information which he needs. A number of memoranda from the Oslo University Institute of Economics—based on experiences also in underdeveloped countries—is concerned with the technique of such interviews.

Other questions of a more statistical nature are really more difficult from the programming viewpoint. For instance, what is really meant by the figure which we take as an expression for the national product? Even without going into the troublesome question of prices that change over time or the question of market prices vs. factor cost etc., we may get a sample of the difficulties by thinking, for instance, of the serious moral dilemma in which a bachelor statistician (not living in Finland) will find himself if he wants very much to marry his female servant, but at the same time feels that he ought not to do anything detrimental to the national product. If we really try to go to the bottom of these and similar questions, we may get into a mood of despair. But no defeatist attitude should be allowed. To any practical problem we *must* find a solution.

Regarding rational programming methods in the Soviet Union: As a scientist I can only feel happy to see refined programming methods applied everywhere on the macroeconomic level (not only to specific problems of an entrepreneurial character such as a specific transportation problem or the organization problem in a specific factory etc.).[1]

Regarding the *flexibility* of the planning work and the sending of draft plans back and forth between different levels: In the case of a material balance method the sending back and forth is mathematically speaking only a technique of iteration which can be replaced technically by a method that aims directly at finding the exact solution. But the administrative aspect remains. It is impossible for one human being—or a few—to keep track of all details in an economy. This is why a certain *pyramidation* of decisions is unavoidable and should be faced squarely.

Regarding the importance of a good *stockpile of projects:* I have stressed this importance very much myself on several occassions, although time did not allow me to go into detail when I presented my lecture. From common sense or from the experiences of previous calculations one will often know that there are certain features of investment projects which are particularly valuable in helping to push ahead towards a high optimum solution. Therefore, the planning authorities should issue ahead of time what may be called a project guidance. But this being said, I want to add that it is dangerous to go too far in this direction. We must rely on the creative imagination of all layers of the whole population. And for best results the project-makers should not be put in a Procrustean bed. Everybody should be encouraged to bring forth new ideas however wild they may look.

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[1]) See also the footnote on Sovjet methodology added above on p. 57.

But a collection of ideas is certainly not *enough*. One will need a systematic method for distinguishing between what is valuable and what is useless from the viewpoint of the preferences of the policy makers. Only scientific programming can provide such a criterion.

Regarding the need for calculating *different solutions* according to different preference functions: In theory it would be nice to have only one preference function. But in practice the problem must be approached through tentative steps. This is only another aspect of the need for a close and constant co-operation between the responsible political authorities and the analytical technicians, a theme to which I have reverted again and again in memoranda and other publications. One will never arrive at an exact setting of the problem to begin with. One has to feel one's way and experiment *on the computing machine* (in somewhat the same way as the military strategists fight battles or even wars on the computing machine). This will not only serve to bring out the true preferences of the responsible politicians, but may also frequently reveal holes in the model of the technical analyst. For instance, several years ago when we started our macroeconomic programming research in Oslo and we wanted to find out the best way to save foreign currency, the machine discovered—quite correctly—that a really effective way to do this would be to stop all consumption and let the population starve. And on another occasion the machine discovered—again quite correctly—that it would be an excellent solution to work certain production sectors with a *negative* production because this would *create* scarce resources that could be very effectively used in other directions. The answer to such difficulties is, of course, that we had forgotten to include all the realistically relevant bounds in the model.

Regarding the *mobilizing* and *inspirational* effect of targets: Of course, this effect exists and should be fully exploited. But the targets should be publicized only after the plan has been elaborated by rational programming methods.

Regarding the need for *birth control* in underdeveloped countries that have a high rate of population increase: The attitude to take to this question depends entirely on the specific situation in the country one has in mind. Frequently the problem appears more serious than it really is, precisely because one has not taken sufficient account of the increased possibilities of rapid economic growth that stems from a rational application of scientific programming. The popular exercise consisting in computing what will happen if a population growth curve with a given rate of growth persists for many hundred years, reminds me of the concern of the philologist who had found a tendency for words to become shorter and shorter and therefore feared that some day in the future we would all have become dumb.

Regarding the *usefulness of mathematics* in the field of programming. The problem cannot be fruitfully discussed in an abstract way, but depends on the situation in the country and, of course, on the programmer having a minimum of common sense. A macroeconomic programmer would not need much mathematics to discover that there is a need for raising living standards in many countries in Africa and Asia. But he certainly will need mathematics if he wants to find out the *optimum way* to achieve an improvement.

To a large extent effective programming is an *art*, not a science. Creative intuition and practical sense will always be needed. What scientific programming does is not to do away with these mental powers but to push forward by leaps and bounds the *frontier of demarcation* where we *have to* start using our intuition and practical sense. This is really what scientific programming does, and it is in this spirit that I have tried to convince you of its usefulness.