TIK WORKING PAPERS
on
Innovation Studies

No. 20161220

http://ideas.repec.org/s/tik/inowpp.html

New Indicators of Smart Specialization: A related diversification approach applied to European Regions

Artur Santoalha[*]

Draft

December 2016

Abstract

This paper proposes two new indicators of S3 (Smart Specialization) to investigate where different European regions stand in terms of this policy concept. The first indicator is designed to quantitatively rank regions in a given year, and the other is elaborated to capture the evolution of S3 over time. The suggested indexes are based on the concept of technological relatedness, and applied to the case of European regions (NUTS 2) by means of the OECD REGPAT database. The results suggest that the process of S3 is more developed in regions located at the core of the European continent, as well as in Northern European regions. In contrast, the regions located in Southern and Eastern Europe persistently present lower scores than other European regions.

Key words: smart specialization, related diversification, patents, European regions

JEL codes: O33 R58

---

[*] University of Oslo - Centre for Technology, Innovation and Culture – Postboks 1108 Blindern 0317 Oslo
Email address - artur.santoalha@tik.uio.no

1. Introduction

S3 (Smart Specialization) is a policy concept that has recently acquired increasing importance (Foray et al., 2011). Nevertheless, as far as we know, it is a missing a well-accepted framework to quantitatively measure this policy concept. According to Foray et al. (2011), S3 is "a perfect example of "policy running ahead of theory"". This statement points out the fact that policy makers have been already developing their policy initiatives towards S3, even in spite of not being endowed with the necessary tools to measure and theoretically understand it. Therefore, the nonexistence of such framework constitutes a relevant lack in terms of research that this article wants to close.

In an ongoing work that Boschma et al. (2016) are developing, it is proposed a framework for the S3. It is suggested that this policy concept is about developing new specializations (justifying the word specialization present in the policy concept), in harmony with the local capabilities existing within each region (feature from where derives the concept smart). Departing from this framework of analysis, Boschma et al. (2016) associate S3 with the emergence of new specializations, in new technologies, industries, or other sorts of regional capabilities that are related to the existing ones within a given territory. In a nutshell, a connection is established between the concept of S3 and the idea of related variety at regional level. Going towards the same direction, Boschma and Gianelle (2014) also defend a similar idea.

Nevertheless, as far as we know, the use of the relatedness concept as a proxy to quantitatively rank regions in terms of S3 has not been experimented so far. Therefore, it is this field of research that we want to explore. Approaching the concept of S3 from this perspective, we propose the implementation of different indicators able to capture, at least in part, the situation faced by European regions regarding this policy concept. In order to do so, first of all we develop an indicator to measure the current stage (or the most recent available) of the European regions in terms of S3. Moreover, we also suggest the implementation of an index to understand how S3 has been evolving over time for a given set of regions (NUTS 2). In both cases it is done resorting to the concept of relatedness.

Our indicators are tested resorting to data on patents, which derives from the OECD REGPAT database. Using such database leads to a framework of analysis based on the technological relatedness approach, once we work with the different technologies underlying each type of patents. Therefore, this paper has a threefold purpose. First of all, we intend to contribute to the literature on S3 proposing new indicators to measure, at least in part, this policy concept. Then, by the means of OECD REGPAT database we intend to test these indicators. Finally, doing so, we expect to provide a first-hand ranking of the European regions' in terms of S3, understanding where different territories stand in terms of this policy concept and how they have been evolving over time.

The rest of the paper is organized as follows. In section 2 is presented, very briefly, the concept of S3. Furthermore, we also discuss the reasons underlying the need of quantitatively measure this policy concept, as well as why we deem that the concept of technological relatedness is appropriate to do so. Section 3 is devoted to the discussion of our data sets, while the presentation of our empirical strategy (step by step), namely the methodology and indicators that are going to be used, is introduced in section 4. Our main results are presented in section 5. In section 6 we discuss our results in light of the policies and institutional framework adopted by specific regions and / or countries. Finally, we conclude in section 7.

2. S3 and related diversification

2.1. S3 - The concept

S3 is an approach to innovation policies that aims at prioritizing R&D and innovation projects in some activities where they are more beneficial for a given territory (Foray et al., 2009). This policy is based on "the simple idea that i) regions cannot do everything in science, technology and innovation and ii) they should promote what should make their knowledge base unique and superior" (Foray et al., 2011, p.3). Having such approach, this policy unavoidably targets the promotion of certain activities, technological fields, and even industries, at the cost of others (vertical prioritization). For this reason, Foray et al. (2011) argue that S3 attitude towards regional development radically differs from what has been the common practice so far (mainly based on horizontal policy measures, targeting the overall framework where different economic agents act). Moreover, another novelty underlying this policy concept is the adoption of place-based policies, in contrast with the "one-size-fits all" approaches (Moodysson et al., 2015).

Nevertheless, a consensus regarding the way regions should delineate their S3 strategies (and operationalize the process of vertical prioritization) is difficult to achieve. While some authors argue that the process should be the outcome of a bottom-up approach (Foray, 2013; Camagni and Capello, 2013; Boschma, 2014), there are also those who sustain that this process, especially in small and not specialized regions, should be led top-down (Iacobucci, 2014). In the later case, regional policy makers play a more prominent role in the definition of the S3 strategy. Reversely, in the former are the stakeholders that lead the strategy delineation, being afterwards adopted by regional authorities. However, according to Iacobucci (2014) the bottom-up approach is likely to be biased towards the interests of the involved stakeholders, thereby failing the objective of elaborating an overall regional strategy. In a moderate position it is possible to find McCann and Ortega-Argiles (2013) arguing that S3 should be faced as a "partnership-based policy process of discovery and learning on the part of both policy-makers and entrepreneurs". In the context of S3, this perspective is the one prevailing nowadays (Rodriguez-Pose and Wilkie, 2015; Boschma and Gianelle, 2014; Foray, 2013).

This view goes towards Rodrik (2004), according to whom the private sector is in charge of the discovery of new activities, while the governmental role (policy makers) is to evaluate the potential of the proposed priorities, providing then the tools for the most capable actors to foster the development of such priority areas. In a nutshell, there can be an intervention of the policy making authorities, if such process does not undermine the market logic underlying the EDP (Entrepreneurial Discovery Process), according to which ultimately are the entrepreneurs (in a broad sense) who, based on a trial error approach, discover and define priority areas to be developed in the context of the S3 policy. The prominence attributed to stakeholders in the context of this policy framework constitutes a way of achieving a decentralized process of prioritization of activities, taking advantage of the benefits underlying a market-driven procedure in order to do so. The adoption of such framework averts using exclusively top-down (old fashioned) policy approaches that deal with prioritization resorting to centralized and bureaucratic procedures.

2.2. S3 as a process of related diversification

Concerning priorities, Foray (2013) mentions that they should be defined at an intermediate level of aggregation, somewhere "between sectors and very micro-activities" (principle of "mid-grained granularity"). Moreover, it is also suggested that priority areas should fulfil the principles of inclusiveness (different types of stakeholders should be included), novelty (new sorts of activities should be explored) and relevance (priorities should be pertinent to the regional economy and able to induce structural changes). In this sense, new emerging activities should be supported only in the dimensions that are relevant for those sectors that are already implemented in a given territory. For instance, resorting to the first example present in table 1, it is easy to understand that such strategy is based on the expansion of the existing knowledge base towards the creation of a new area of activity (nanotech industry) in order to develop (upgrade) an existing industry (pulp and paper). Nevertheless, the prioritization should be focused neither on the pulp and paper industry, nor on the nanotech industry as a whole, but simply on the application of nanotechnologies to the pulp and paper industry.

Table 1. Examples of S3 and their underlying related diversification logic

Examples	Existing sectors	New emerging sectors	Activities to be prioritized	Related diversification logic
Development of nanotechnologies for the pulp and paper industry in Finland	Pulp and paper industry	Nanotechnologies	Nanotechnologies applied to pulp and paper industry	Modernisation
Development of IT applications for the management of archeological heritage in Italy (Florence)	Exploitation of archeological and historical heritage	IT applications	IT applications for the management and maintenance of archeological and historical heritage	Modernisation[1]
Plastics firms diversification from car industry to biomedical innovative applications, in Basque Country	Plastic sector applied to car industry	Plastic sector applied to biomedical applications	Diversification of the plastic sector towards biomedical applications	Transition
Transition, in Austria, from fine mechanical and optical engineering to medical technologies	Fine mechanical and optical engineering	Medical technologies	Transition from mechanical and optical engineering to medical technologies	Transition
Automotive subcontractors diversification from the car industry to new sectors, in the British Midland	Automotive subcontractors working for car industry	Automotive subcontractors working for other industries	Exploring a transition path for automotive subcontractors from car industry towards new markets	Transition
Emergence, in Toulouse, of entrepreneurial activity in areas related to satellites and GPS technologies	Aeronautics (Airbus)	Satellites and GPS technologies	Development of Satellites and GPS technologies	Diversification

Source: Foray et al. (2012) and Foray (2013)

Therefore, S3 fosters existing activities in a given region through the emergence of R&D and innovation in new sorts of domains that, to some extent, complement the existing ones. Doing so, this policy promotes the structural evolution of the targeted economies, through an "accumulative process that links the present and future strengths of a regional economy in a particular domain of activity and knowledge" (Foray, 2013, p. 63). This process of structural transformation of a given economy has almost always inherent a logic of related diversification, which can take three forms, namely transition, modernization and diversification in a strict sense (see examples in table 1)[2]. Concerning transition and diversification (in a strict sense), to the extent that resources are scarce, finite, and limited, new activities can replace (totally or partially) the existing ones, reason why it is

---

[1] Although Foray et al. (2012) consider this example as a case of "radical foundation of a new domain", according to the logics of related diversification presented by Foray (2013) it seemed more adequate to us to categorize this situation as a case of modernization.

[2] According to Foray (2013), structural transformation can also be unleashed by a process of radical innovation (these cases are not approached in this research).

possible to assume that there is competition between the emerging and the new activities. Oppositely, in the case of modernization, the relationship that is more adequate to characterize both activities (emerging and existing) is complementarity.

Therefore, the term specialization should not be misinterpreted in the context of S3 policy, because it can, erroneously, convey the message that such policy targets the specialization of the overall economic structure of a given region. Oppositely, the idea underpinning the S3 policy concept is to promote the emergence of new areas of activity that resort to and complement those already existing, promoting therefore a process of related diversification. In this sense, as stated by Foray (2013), S3 is "not about generating technological uniformity and mono-culture or prioritizing sectors or eliminating areas of activities". On the one hand, if the priorities are complementary to other activities already existing in a given region, supporting the former will give almost always a renewed vigor to the latter. Therefore, the existing and the new activities are not necessarily mutually exclusive. On the other hand, this policy is conceived in a dynamic way, such that the set of activities defined as priorities at a given point in time are not supported forever (after a given time period other priorities will be discovered and supported).

In this sense, technological / industrial relatedness can be interpreted as a guideline that can potentially be followed by regions as part of their process of S3 (Boschma and Gianelle, 2014). Beyond the fact that relatedness follows the spirit of S3, it also seems to have undeniable advantages. It is argued that relatedness enhances spillover effects and knowledge transfer, thereby fostering innovation and economic growth at regional level (see Boschma and Frenken, 2011 for a review). Moreover, related industrial variety is also assumed to have a positive effect on the survival rate of the firms (Boschma and Wenting, 2007; Klepper, 2007), and a positive / negative impact on their probability of entering / exiting the market (Neffke and Svensson Henning, 2008). With this we are not saying that unrelated activities are not viable in a given territory, but simply that relatedness can constitute an appropriate framework to approach the topic of S3.

2.3. S3, the need to measure it, and related diversification as an adequate framework

The need of implementing methodologies to allow the construction of indicators on S3 is recurrently mentioned in literature (David et al., 2009; Barca and McCann, 2011). Moreover, it has been highlighted that empirical studies related to regional S3 are rare, existing few attempts to measure it (Iacobucci, 2014; Caragliu and Del Bo et al., 2013). Having this in mind, Caragliu and Del Bo et al. (2013) proposed and estimated a new indicator of S3 based on regions' comparative advantage. However, such indicator of S3 is estimated at a low level of desegregation (only for 15 NACE 2 digits industries), attributing little or no importance to the emergence of new activities and the extent to which they are related to the existing regional structure. In this sense, we need a framework of analysis, as well as (quantitative) indicators that, at least, fit more perfectly some of the principles underlying this policy concept (see, for instance, Foray, 2013).

Different scholars have suggested the association of S3 with a process of related diversification (Foray, 2013; Mccann and Ortega-Argilés, 2015; Boschma et al., 2016). This fact creates a new window of opportunity for research. As suggested by Boschma and Gianelle (2014), "the concept of relatedness provides a tool to identify regional (unused) potentials and a framework to target and select promising activities" (i.e. priority areas). Beyond the fact that related diversification approach is one of the main ideas underlying the S3 policy concept, this approach, as highlighted by Boschma and Gianelle (2014), can perfectly match the main principles and policy procedures consecrated in the S3 literature, not being conflicting with most of them. The only questionable aspect concerning the mobilization of this framework of analysis to approach the topic of S3 concerns the EDP, as the related diversification approaches risk to be regarded as dealing with the prioritization from a centralized perspective. As such, relatedness techniques can be criticized due to the absence of entrepreneurs' intervention in the scope of the process of vertical prioritization.

However, Boschma and Gianelle (2014) suggest that these different approaches are compatible, proposing a way to reconcile both perspectives. The logic underlying the S3 policy is not inverted if the policy makers intervention in the process, which is highly desirable, does not replace the role private partners are expected to play, namely to decide, in the last instance, the set of areas and activities with higher potential to receive support in terms of R&D and innovation. In this sense, what is suggested is the adoption of a sequential approach, according to which in a first step, resorting to relatedness techniques, a loose set of areas of activity with higher potential to be supported in terms of R&D and innovation are identified. Then, having these areas as a point of departure, the EDP can be done as usual, being attributed to the entrepreneurs the role of establishing a vertical prioritization among these pre-selected activities. This mixed approach (relatedness methods and EDP) would shrink the number of activities eligible to be considered by the entrepreneurs in the context of the EDP (Boschma and Gianelle, 2014). Only those activities that for a given territory are considered to have the highest potential would remain[3]. It is under this general framework of analysis that the following sections should be interpreted. Based on the ideas of S3, relatedness, and priority areas defined according to their degree of relatedness, we hope to shed some light concerning a new framework in order to approach the topic of S3. In the next sections we propose and test new indicators of S3 in order to understand the situation of different European regions regarding this policy concept.

3. Data

In order to perform this research it is used the OECD REGPAT database, which has information on patent applications both to the EPO (European Patent Office) and PCT (Patent Co-operation Treaty). To each single patent application, it is attributed one (or more) technological fields according to the IPC (International Patent Classification)[4], which is the standard classification system used by the WIPO (World Intellectual Property Organization) to categorize patents into different areas of technology. This categorization system is hierarchical, in the sense that each IPC code attributed to a given patent (application) integrates a set of symbols to identify a section, a class, a subclass, a group, and a subgroup[5].

---

[3] Such restriction would also ease the role played by policy makers in the sense that their monitoring effort would be substantially reduced.

[4] 8th edition

[5] A given IPC code includes a letter which identifies an IPC section, then the IPC class is composed by a two digits number, which is followed by another letter that represents the IPC subclass. After this, there is still another number with a variable number of digits (1 to 4 digits) which denotes the IPC group, which in turn is followed by a slash (/) and another number with a number of digits varying between 2 and 6, indicating the IPC subgroup (e.g B62C50/02). In total, and according to WIPO, there are 7 IPC sections, 129 IPC classes, 639 IPC subclasses, 7 314 IPC main groups, and 61 397 IPC subgroups.

In this database most of the patent applications are regionalized resorting to inventor(s) or applicant(s)' addresses, being attributed to each NUTS3, TL3, or equivalent territorial unit a given patent application or a share of it[6]. This fact allows the use of fractional accounting when assessing the total number of patent applications that can be attributed to a given region. Once some patents have several inventors/applicants belonging to different regions (or the same inventor is affiliated to different organizations located in different regions), this is the most appropriate way to proceed in order to evaluate the total number of patent applications existing at regional level. The matching of patent applications to higher level territorial units (countries and NUTS2 or TL2) is also provided.

Finally, this dataset, for each patent application also includes information on application year. Regarding this aspect two different variables are available, namely one which states the actual application year to the patent office at stake, and another variable identified as priority year, which is defined as the year in which the first filling for a patent took place. As we want to measure regional technological achievements, we will use the latter concept, which is closer to the time at which invention underlying a given patent actually took place. This differentiation is relevant in the sense that a given patent application process depends on administrative and bureaucratic procedures, often leading to the existence of time lags between the time the invention takes place and the time when the application is formally registered at a given patent office (Maraut et al., 2008).

The dataset includes patent applications concerning more than 200 countries, including also more than 5500 regions (NUTS3, TL3, or equivalent territorial unit). Among all patents available, and given our research question, we decide to select only those concerning EU28 plus EFTA countries (Iceland, Lichtenstein, Norway and Switzerland). Taking into account only this group of countries it is verified that patent applications are distributed across 44 years, starting in 1964, being the most recent year for which patent applications are available 2015. Overall, for the whole period considered, and taking only into account the selected countries, 1 722 152 patents are available (see table 2). However, for some years the number of existing patent applications is very low (almost 0), which can lead us to suspect that for these years data is incomplete, reason why we decide to exclude such observations from our analysis. Therefore, we exclude data concerning the period between 1964 and 1979, as well as the observations available for 2014 and 2015[7].

Table 2. Total number of patents per year

Year	N patents	Year	N patents	Year	N patents	Year	N patents	Year	N patents
1964	1	1981	16 260	1990	31 315	1999	60 254	2008	79 072
1966	1	1982	17 199	1991	31 305	2000	65 562	2009	78 024
1968	1	1983	19 519	1992	31 842	2001	66 182	2010	79 104
1969	2	1984	21 266	1993	33 216	2002	66 243	2011	80 388
1975	1	1985	23 224	1994	35 271	2003	68 626	2012	79 116
1977	2 286	1986	24 949	1995	37 216	2004	72 719	2013	76 555
1978	7 426	1987	28 434	1996	42 999	2005	75 793	2014	15 770
1979	11 753	1988	31 039	1997	48 775	2006	79 710	2015	11
1980	14 442	1989	32 355	1998	53 859	2007	83 065	**Total**	**1 722 152**

---

[6] For further details see Maraut et al. (2008)

[7] As it is possible to observe in table 2, from 2013 on there is clearly a break in our series, reason why years 2014 and 2015 were excluded from our analysis.

Source: OECD (2016) and author's computations

For the remaining years, for each region available in our dataset, we compute the number of patent applications pertaining to a given IPC class, and that is attributed to each specific territorial unit. Therefore, for each year, region, and IPC class we obtain the total number of existing patents. As it can be seen in Appendix I, when we account the total yearly number of patents by IPC class, the results obtained are quite different from the total number of existing patents[8]. In terms of regional territorial units, although there is available data at NUTS3/TL3 level, we decide to develop our analysis in terms of NUTS2/TL2. The reason underlying such decision is related to the fact that, in general, the existence of regional data at NUTS3/TL3 level is scarce and limited. Therefore, it can reveal to be more useful to carry out this work at NUTS2 level, because such approach widens our possibilities to cross, in the future, our results with other sorts of regional data, deriving from other statistical sources (like Eurostat).

4. Methodology

4.1. Step 1 - Revealed Comparative Advantage

Taking into account our sample of observations as described above, the first step is to follow, among others, Hidalgo at al. (2007) and Montresor and Quatraro (2015), to determine the degree of proximity among all technological fields attributed to the patent applications present in our dataset. In order to do so, first of all, for each year and region it is computed the RCA (revealed comparative advantage) concerning every single technological field (IPC class or subclass) that presents at least a share of a patent application attributed to it. The RCA is computed according to the following formula:

$$\mathrm{RCA}_{izt} = \frac{PATizt}{\sum_{z=1}^{n} PATizt} \Big/ \frac{\sum_{i=1}^{m} PATizt}{\sum_{i=1}^{m} \sum_{z=1}^{n} PATizt} \tag{1}$$

where RCA_{izt} represents the revealed comparative advantage of region i, in technology z, at year t, while PAT_{izt} should be interpreted as the number of patent applications that in a given region i and year t are attributed to technological field z. Actually, this indicator, for a given year t and region i, compares the regional share of patents regarding a given technology z, to the share of patents for the same technology as computed for all other regions at time t. In a nutshell, this index shows us to what extent a given region, at a given moment in time, is relatively more or less specialized in a given technology, than the rest of the world (in this case, all other regions together). If for a given year, region, and technology the indicator acquires a value greater than one, it means that region i, in that particular year t has a specialization in technology z.

4.2. Step 2 - Degree of proximity and relatedness among technological fields

Then, for each region and year we establish all combinations of two technological fields for which a given region, in a given year, presents, at least, a share of a patent application. Having all possible pairs of technological fields present in our dataset for a given region and year, we compute the

---

[8] This is a consequence of the fact that, as already previously explained, to each patent, different IPC categories are attributed.

degree of proximity between each one of the technological fields composing a given pair. The degree of proximity follows the formula below, where a and b represent two different technological fields:

$$\Omega_{ab} = \min \{P(RCA_a > 1 \mid RCA_b > 1), P(RCA_b > 1 \mid RCA_a > 1)\}, \tag{2}$$

$$\text{where } P(RCA_a > 1 \mid RCA_b > 1) = \frac{P(RCAa > 1 \cap RCAb > 1)}{P(RCAb > 1)} \tag{3}$$

In (2) Ω_{ab} should be interpreted as the degree of proximity between technologies a and b, while the expression $P(RCA_a > 1 \mid RCA_b > 1)$ represents the conditional probability of finding in our sample observations where technology a has a RCA>1 given that for technology b RCA>1. For the purpose of the computation of Ω_{ab} and its underlying probabilities, it is important to highlight that in our sample one observation is a pair composed by a region and year. Overall, in our sample we have more than 8000[9] pairs of years (from 1980 up to 2013) and regions. Basically, the degree of proximity between two technological fields is computed based on the frequency according to which it is possible to find the co-occurrence of a specialization (RCA>1) in these fields, for a given region and year.

As argued by Boschma et al. (2012), after obtaining the degree of proximity for all pairs of products (technologies in our case), the most difficult task is to determine what is the minimum degree of proximity that is required in order to consider that two products (technologies) are related. Following the authors, who adopt a conservative position, we assume that two technological fields are related if they present a degree of proximity equal or larger than 0.25. Therefore, and according to this criterion, it is created a dummy variable (R) to identify pairs of technologies related to each other. The dummy variable is expressed as follows, where a and b represent two different technologies:

$$\begin{aligned} R_{ab} &= 0 \text{ if } \Omega_{ab} < 0.25 \\ R_{ab} &= 1 \text{ if } \Omega_{ab} \geq 0.25 \end{aligned} \tag{4}$$

As it is thoroughly explained in Appendix II, we are going to work with IPC classes (rather than subclasses)[10]. Under such framework, it is possible to find 1786 technology-pairs that are related to each other, which corresponds to 22% of all possible pairs of technologies.

4.3. Step 3 - Relatedness density for the different technologies in different regions

To compute our indicators (see the next steps) we need to determine for each technology (present or not in a given region) its relatedness density, which allows us to identify for each region, technological fields with a potential for S3. The ascription of potential for S3 to a given technological area is based on the degree of relatedness between that area and the technological fields for which

---

[9] In the case of classes the number of observations is equal to 8285, while concerning subclasses the number of observations is equivalent to 8335. This difference lies in the fact that those regions that for a given year present patents attributed to just one class/subclass are excluded from the sample.

[10] Computations were also performed for subclasses. However, as explained in appendix II, the use of classes seems more adequate to the framework we are applying.

there are records of patents for a given region and year. In order to compute for each one of the existing technologies (regardless the fact they are present or not in a given region) their degree of relatedness with the technologies present in a given region, we resort to the concept of relatedness density (RD), as proposed by Boschma et al. (2016), which is computed as follows:

$$RD_{zit} = \frac{fzit}{Fit} \tag{5}$$

$$\text{where } f_{zit} = \sum_{s \neq z} Rsz\text{it} \tag{6}$$

In equation (5) RD_{zit} is the relatedness density of a given technological field z, in a given region i and year t, F_{it} is the total number of technological fields s that exist (for which there is at least a share of a patent attributed to the region) in region i and at year t, and finally f_{zit} should be interpreted as the total number of technological fields s existing in region i at year t, and that are related to technological field z. In a nutshell, this indicator gives us, for each technological field z, to what extent it is related to other technologies s existing within a given region. The index ranges between 0 and 1, where 0 represents the case in which, for a given year and region, a given technology z is not related to any of the other technologies s present in that region for that year. Reversely, if the indicator takes the value 1, it illustrates a situation where, for a given region and year, a given technology z is related to all technological fields s that are present in a given region, in a specific year.

Having computed the relatedness density for all existing technological fields[11], in all regions and years integrating our dataset, the difficulty is how, based on this indicator, to ascribe to certain technologies a potential for S3. As such, we assume that a given technological field z has a potential for S3, if its relatedness density is above the relatedness density of 75% of the existing technological fields, such that:

$$\begin{aligned} P_{zit} &= 1 \text{ if } RD_{zit} \in Q_3(RD_{zit}) \\ P_{zit} &= 0 \text{ if } RD_{zit} \notin Q_3(RD_{zit}) \end{aligned} \tag{7}$$

where Q_3 represents the third quartile of observations, while P_{zit} should be interpreted as a dummy variable that takes the value one if a technology z in a given region i and year t has a potential for S3 and 0 otherwise. As it is clearly explained in Appendix III, the observation of the number technological fields that met the potential for S3 criterion for those years for which the indicator was computed, when assuming ex-ante and ex-post relatedness, leads us to the conclusion that our analysis should be performed at ex-post level. Moreover, the selected threshold (observations belonging to the third quartile) seems also an adequate one.

Nevertheless, one shortcoming of this index is the fact that it ignores that different technologies s that exist in a given region have, probably, different degrees of importance and strength (for instance,

---

[11] As it was already mentioned above, our technological fields depict all existing IPC classes (129 according to WIPO). However, relatedness density was computed only for 122 IPC classes, which is the total number of existing classes in our sample of observations. This difference is explained by the fact that 7 out of the 129 IPC classes defined according to the WIPO, in our sample of more than 8000 pairs of years and regions, were never attributed any patent.

their RCA is different). In this sense, this fact should have been taken into account when computing the relatedness density of a given technological field z. It can be misleading to assume two different technologies z as having similar relatedness densities, when one is related almost exclusively to technologies s that in the region at stake present a specialization, while the other technology z is almost exclusively related to technologies s that for that region exhibit no specialization (RCA<1). In order to overcome this weakness of the indicator, it is recomputed but assuming F_{it} as the total number of technological fields s that exist (for which there is at least a share of a patent attributed to the region) in region i and year t with RCA>1, while f_{zit} should be now interpreted as the total number of technological fields s existing in region i and year t with RCA>1, and that are related to technological field z. Both indicators are computed in order to verify if there are relevant differences between them. From now on, when the first version of the indicator is used it will be identified as standard, while we refer to the second approach as restrictive, once for its computation it is considered a subset of the possibilities taken into account for the computation of our standard version.

4.4. Step 4 - The static indicator

With this indicator we want to grasp what is the current situation of European regions in terms of S3. Therefore, we compute it applying the most recent available data, namely 2012[12]. Moreover, the indicator is also computed resorting to data from 1990 and 2000. In spite of its static character, picking such years also allows to understand how this index has evolved for different regions over the years. The index we propose in order to rank different regions in terms of S3 is computed as follows:

$$S3_{it} = \frac{nit}{Nit} \tag{8}$$

such that:

$$N_{it} = \sum_z Pz\text{it} \tag{9}$$

$$n_{it} = \sum_z Pz\text{it if } RCA_{zit} > 1 \tag{10}$$

where $S3_{it}$ represents the degree of S3 of region i in year t, N_{it} should be interpreted as the total number of technological areas (IPC classes / subclasses) in region i and year t with potential for S3, and n_{it} is the total number of technological areas (IPC classes / subclasses) in region i at year t that are assumed to have a potential for S3, and that also exhibit a revealed comparative advantage (RCA>1). At bottom line, this indicator shows to what extent a given region has already acquired (or not) a specialization (actually, revealed comparative advantage) in the technologies where it is assumed to have a potential for S3. The index ranges between 0 and 1, where 0 represents the case in which a given region, for a given year, does not present any specialization in any field where it has potential for S3, while the value 1 illustrates the situation where a given region has already acquired a specialization in all technological fields where it is assumed to have potential for S3.

---

[12] In spite of being available data for 2014 and 2013 as it can be observed in figure 1, the number patent applications recorded in that year is lower than in the previous ones, reason why we decided to carry out our analysis resorting to data concerning 2012.

4.5. Step 5 - The dynamic indicator

Our second indicator has a dynamic character, since it is designed with the objective of measuring the evolution of the European regions in terms of S3, during a given time period. In order to evaluate the evolution of a given region during a given timespan we are inspired by Boschma et al. (2015). According to the authors, a given US state is assumed to develop a new industry i between year t and t+5, if at t the RCA of i was below 0.5, and if it increased to more than 1 at t+5. Adapting this concept to our purpose, we define the evolution of a given region in terms of S3, during a 5 years timespan as follows:

$$\Delta S3_{it,t+5}=\frac{xit+5}{Xit} \quad (11)$$

where $\Delta S3_{it,t+5}$ is an index measuring the evolution of region i, between year t and t+5, in terms of S3, and X_{it} should be interpreted as the total number of fields that at year t the region i still did not have a specialization, but that were related to fields in which the region already had a specialization (RCA>1) at that time. Finally, x_{it+5} is the total number of technological fields included in X_{it} in which the region i acquired a specialization (RCA>1) five years later. In a nutshell, this indicator shows us to what extent a given region i acquires specializations in those technologies that five years before were related to technologies where the region had a RCA. This index can range between 0 and 1, where 0 illustrates the situation in which, at t+5, a given region did not acquire a specialization in any of the technologies identified at time t. Reversely, if the indicator takes the value 1, it represents the situation where at t+5 a given region acquired specializations in all technologies that were identified at time t. Finally, two different versions of this indicator are computed, namely one in which for the computation of X_{it} are simply considered fields without a specialization (RCA≤1), and another, more restrictive, in which for the computation of X_{it} are taken into account only technologies whose RCA is below 0.5. Again, the first version of the indicator will be identified as standard, while we will refer to the second approach as restrictive.

5. Results

Our empirical analysis starts observing our index (8)[13] that measures for each year the degree of S3 exhibited by a given region. In table 3 it is possible to observe the descriptive statistics concerning this indicator for those years for which it is computed. The number of observations per year increases over time, such that our sample includes 225 regions in 1990, 258 in 2000, and 277 in 2012. The reason for this rising trend in the number of regions is easily explained by the fact that some of them only in the more recent years present data on patents. Concerning the results obtained for the index, its average value ranges between 0.27, for the year 1990, and 0.3 in 2000. In 2012 the maximum value observed for the degree of S3 (0.81) was verified in the region of Veneto. Reversely, in the same year, the regions with the worst scores presented a value equivalent to 0 for the indicator under analysis (table 3). Such low values are experienced by regions in Greece (Sterea Ellada, Peloponnisos, and Anatoliki Makedonia, Thraki), Romania (Vest, and Sud-Vest Oltenia), Bulgaria (Severozapaden), Poland (Warmińsko-Mazurskie and Podlaskie), Portugal (Região Autónoma

---

[13] In this section only the standard version of the index is approached. As it can be observed in appendix IV, both versions (standard and restrictive) do not lead to substantially different results.

da Madeira), and France (Guyane). The maximum value for the degree of S3 (0.87) was recorded in 2000, being ascribed to Länsi-Suomi, in Finland. Oppositely, in 2000, the regions with the most modest scores in terms of S3 also registered 0 for the indicator at stake. Among them, it is possible to find the region of Severozapaden (Bulgaria), and Lubelskie (Poland). Finally, in 1990, the highest value for the degree of S3 (0.74) was verified in Tübingen, in Germany. Again, the lowest levels correspond to a null degree of S3 that was verified in nine European regions, spread across eight different countries.

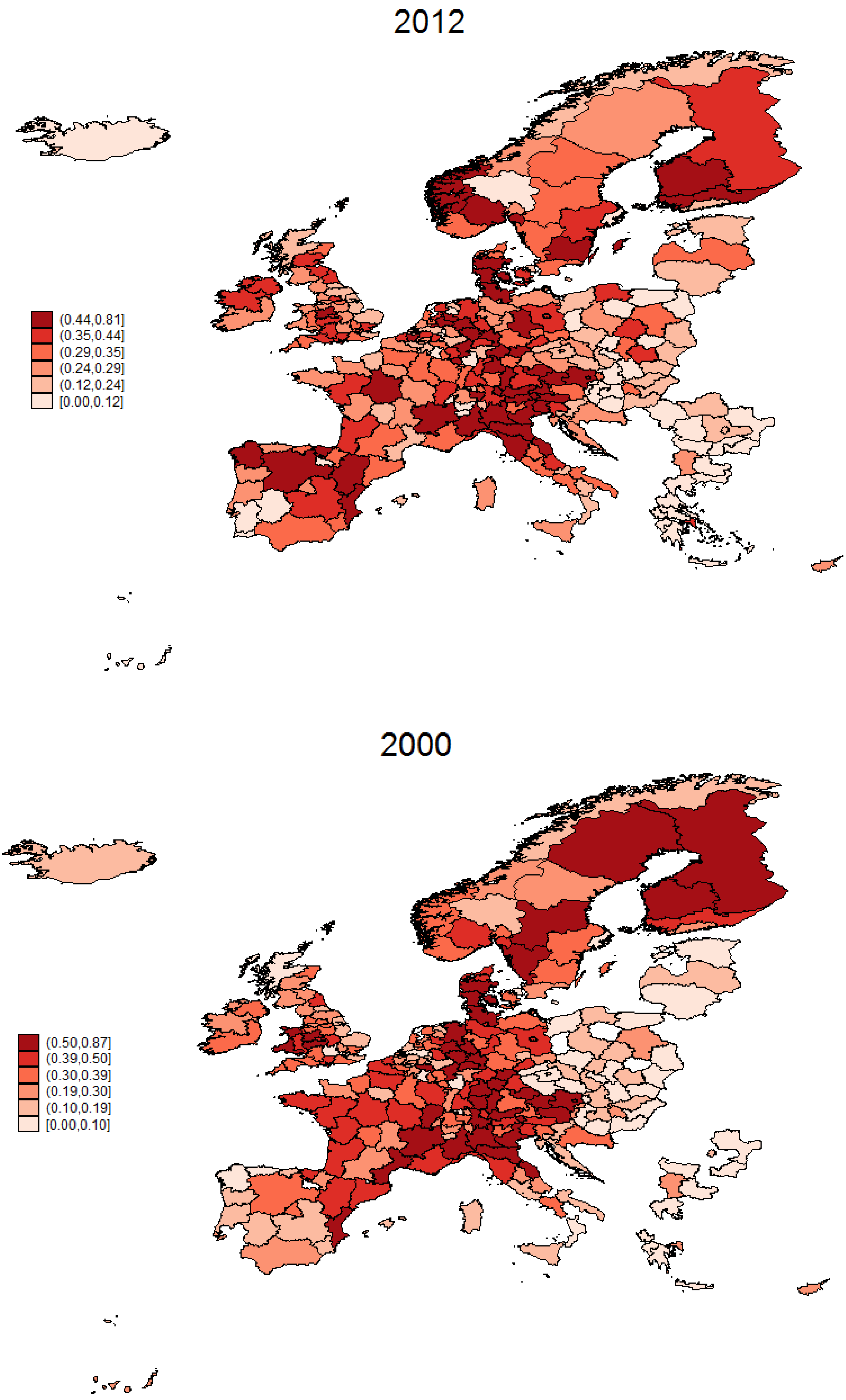
Table 3. Degree S3 by year

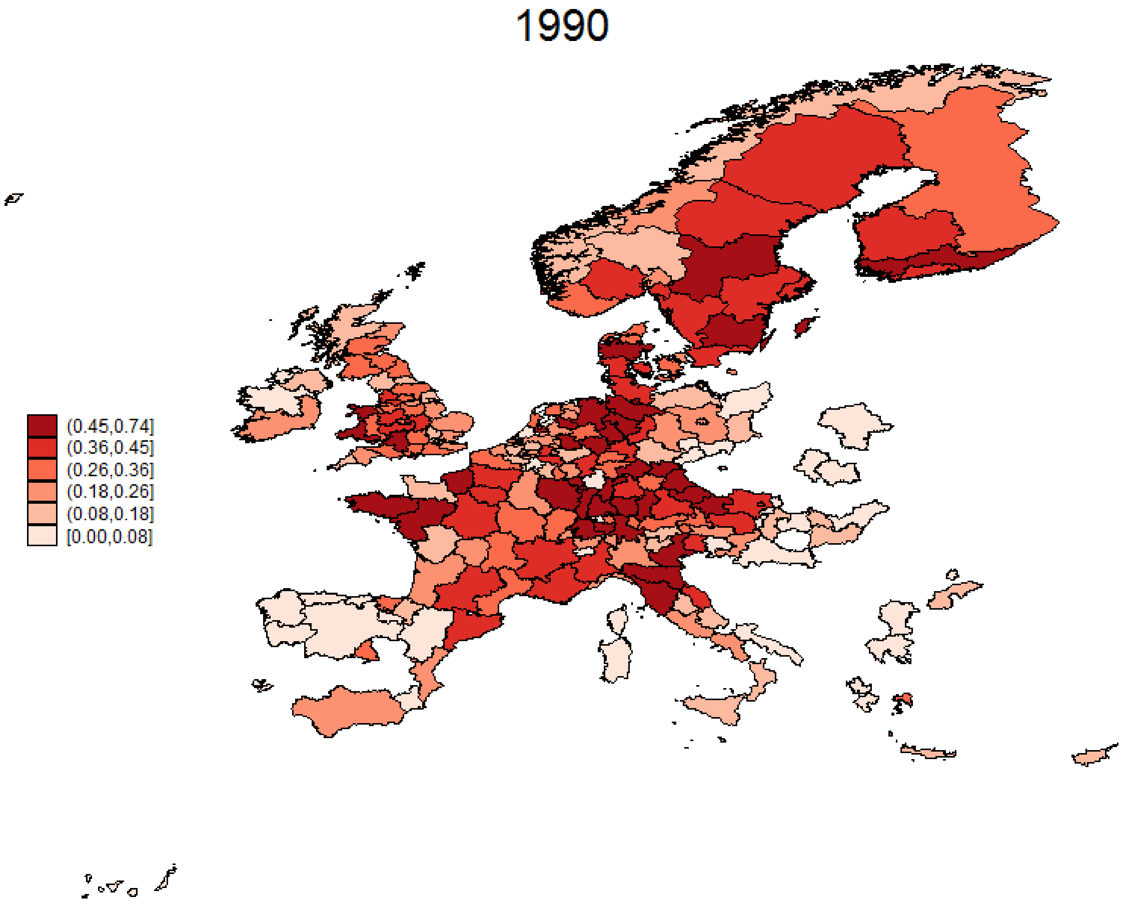
	2012	2000	1990
N	277	258	225
mean	0,29	0,30	0,27
max	0,81	0,87	0,74
min	0	0	0
std dev	0,16	0,18	0,18

Source: author's computations

In figure 1, again, it is possible to observe the results obtained for the same indicator as above (8), however, in this case, the results are shown in a map for each year, displaying all the regions considered in our analysis. Overall, there are two main conclusions that can be drawn. The first one is that between 1990 and 2012, in most of the regions, there is a positive evolution concerning the degree of S3, with this index showing improvements over time (in spite of the existence of few exceptions). The other interesting conclusion is that the regions that occupy a leading position in terms of S3 are almost all at the core of the European continent, as well as in the North of Europe, while the most modest scores can be observed in regions located at the European periphery, namely in Eastern and Southern Europe (mainly Portugal, South of Italy and Greece).

Figure 1. Degree S3 – standard version





Source: author's computation

Observing the average of the indicator for the different years by country (see table 4), it becomes clear that Austria is the country with the highest average value for the degree of S3 in 2012, with a value equivalent to 0.42. Denmark, Finland, Germany, Italy and Sweden are also among those with best scores. Reversely, the most disappointing average values for our S3 indicator in 2012 are presented by Bulgaria, Greece and Romania. In what concerns the year 2000, the best average value was recorded in Lichtenstein, followed by Germany and Austria, and Finland, all of them with an index above 0.4. Oppositely, among the less advanced countries in terms of S3, it is possible to find Czech Republic, Estonia, Lithuania, Malta, Poland, Romania, and Slovakia, all of them with average values lower than 0.1. Finally, in 1990, those countries with the most remarkable figures for the average degree of S3 are again Lichtenstein (0.48), Sweden (0.45), and Finland (0.43). By contrast, Bulgaria, Croatia, Hungary, Iceland, Poland, Portugal, Romania, Slovakia were those countries whose average values for the degree of S3 are clearly at the bottom of the distribution. From this analysis (together with the observation of table 4) it is also possible to conclude that in countries such as Bulgaria, Greece, and Romania, the weak average scores are constant and persistent over time. Conversely, Croatia, Ireland, Malta, Poland, Portugal, Slovenia, and Spain illustrate examples of countries whose average situation in terms of S3 showed substantial progress during the period between 1990 and 2012.

Table 4. Mean by country - Degree S3

Country	2012	2000	1990
Austria	0,42	0,45	0,34
Belgium	0,30	0,27	0,21
Bulgaria	0,09	0,10	0,07
Croatia	0,26	0,25	0,04
Cyprus	0,29	0,27	0,13
Czech Republic	0,21	0,09	0,11
Denmark	0,40	0,40	0,34
Estonia	0,14	0,06	-
Finland	0,37	0,44	0,43
France	0,30	0,38	0,35
Germany	0,38	0,45	0,37
Greece	0,08	0,10	0,11
Hungary	0,16	0,11	0,09
Iceland	0,14	0,19	0,08
Ireland	0,33	0,30	0,13
Italy	0,39	0,37	0,26
Latvia	0,34	0,15	-
Lichtenstein	0,28	0,52	0,48
Lithuania	0,13	0,08	-
Luxembourg	0,31	0,39	0,28
Malta	0,24	0,02	0,11
Netherlands	0,27	0,28	0,26
Norway	0,29	0,30	0,21
Poland	0,20	0,09	0,06
Portugal	0,15	0,16	0,04
Romania	0,08	0,08	0,06
Slovakia	0,15	0,07	0,04
Slovenia	0,32	0,25	0,13
Spain	0,32	0,27	0,14
Sweden	0,34	0,37	0,45
Switzerland	0,28	0,31	0,34
United Kingdom	0,29	0,31	0,27

Source: author's computations

Actually, the idea of the existing dichotomy between northern and central European regions, and southern and eastern European regions is also corroborated by table 5. As it is possible to observe, in 2012, most of the countries with less than 50% of their regions exhibiting a degree of S3 below the median of our sample of regions are mainly southern and eastern countries. Reversely, those countries where more than half of their regions present a degree of S3 above the median are mainly northern and central European countries. There are only few exceptions to this regularity, namely the cases of Lichtenstein, Norway, Switzerland, Belgium, and France, as well as the situation of Italy and Spain. In the first case, in spite of being considered core / northern countries of the European continent, Lichtenstein, Norway, Switzerland, Belgium, and France present less than half of their regions with a degree of S3 above the median. Regarding Italy and Spain, in spite of being clearly considered southern European countries, they present more than half of their regions with a degree of S3 above the median. While in Italy this situation is largely due to the scores of the northern regions of this country, in Spain the cause for such outcome seems to be less clear.

Table 5. Percentage of regions, by country, whose degree of S3 is above the median (2012)

Country	Number of Regions (%)	Country	Number of Regions (%)	Country	Number of Regions (%)	Country	Number of Regions (%)
Estonia	0 %	Lithuania	0 %	Switzerland	43 %	Spain	65 %
Lichtenstein	0 %	Bulgaria	0 %	Belgium	45 %	Germany	68 %
Portugal	0 %	Greece	11 %	France	46 %	Italy	71 %
Iceland	0 %	Czech Republic	13 %	Netherlands	50 %	Sweeden	75 %
Malta	0 %	Hungary	14 %	Ireland	50 %	Denmark	80 %
Croatia	0 %	Slovakia	25 %	Slovenia	50 %	Austria	89 %
Cyprus	0 %	Poland	31 %	United Kingdom	51 %	Luxembourg	100 %
Romania	0 %	Norway	43 %	Finland	60 %	Latvia	100 %

Source: author's computations

Such facts can lead us to reflect about to what extent there is a correlation between our indicator on S3 (8), and some regional macroeconomic variables and in particular GDP per capita. Moreover, given the way our indicator was constructed (resorting to data on patents) it is also important to assess the correlation between our index and the number of patents existing within each region (both the absolute number, as well as per capita values). A high degree of positive correlation between patents and the proposed index would be the sign that our indicator may possibly be biased, since it attributes (by construction) higher scores to regions with more absolute / relative number of patents. Nevertheless, as it is shown by table 6, this is not the case, considering that the existing correlation between the proposed indicator and patents (total number and per capita values by region), although positive, is very low. Concerning GDP per capita, as expected, there is a moderate and positive correlation between this variable and our indicator. We also check the correlation between patents and GDP per capita, and the different components of our index, namely the denominator and the numerator. The same exercise is performed for the interaction between the denominator and the numerator, through the means of the difference between these two elements, in order to assess if there is any relationship between, for instance, the number of patents and the number of unexplored related technologies (i.e. technologies with a potential for S3 with RCA<1). However, as it can be observed in table 6, the magnitude of correlation between patents and the denominator, the numerator, and the difference between both is also very low. The bottom line here is that the fact that our S3 indicator scores higher for Northern and core Central European regions is not simply explained by the fact that these regions have typically a higher level of economic and technological development. As we will argue in the next section, S3 patterns are instead related to policy strategies and choices made by regional and national authorities in different European countries.

Table 6. Correlation between different sets of variables (2012, 2000, and 1990[14])

	Patents	Patents pc	GDP pc (PPP)
N	760	674	475
Number of technologies with a potential for S3 (1)	-0,15	-0,10	-0,24
Number of technologies with a potential for S3 and a RCA (2)	0,10	0,09	0,32
Degree of S3 (2/1)	0,11	0,09	0,33
Number of unexplored related technologies (1-2)	-0,15	-0,11	-0,36

Source: OECD (2016), Eurostat, and author's computations

Now, we devote our attention to table 7 where it is possible to observe the descriptive statistics concerning the computation of indicator (11)[15], which mirrors regions' evolution in terms of S3 between 2009 and 2013. Actually, there are 267 regions for which this index is computed. Its average is equivalent to 0.16. Moreover, it is possible to conclude that the highest score in terms of evolution is responsibility of Noord-Holland that presents a value equivalent to 0.37. Oppositely, the regions that present the lowest scores are Noord-Brabant, in Netherlands, and Centru and Sud-Est, both in Romania.

Table 7. S3 evolution (2009-2013)

	2009-2013
N	267
mean	0,17
max	0,37
min	0
std dev	0,08

Source: author's computations

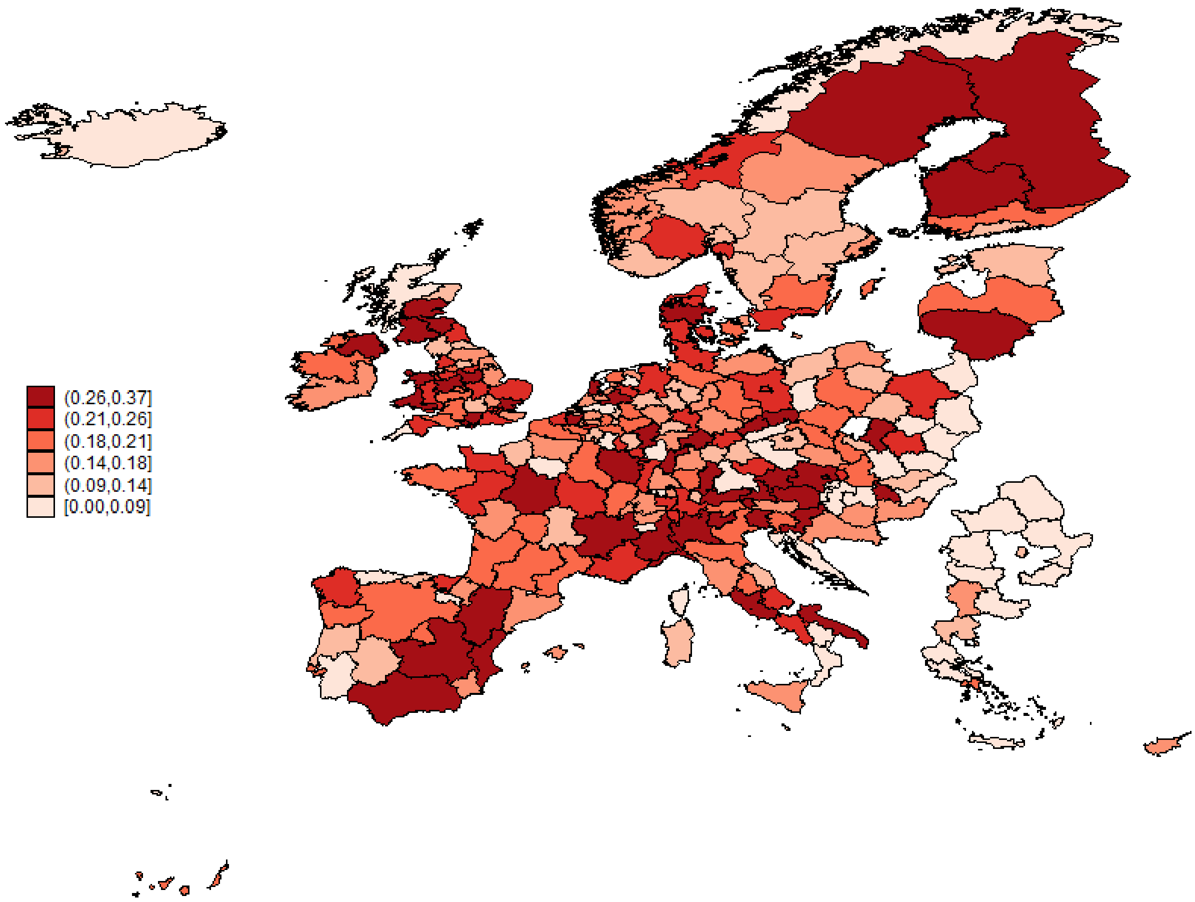
When observing the geographical distribution of the European regions' scores concerning this indicator (figure 2), it is possible to verify that regions leading the ranking are a bit more widespread across the continent than in our static indicator (see figure 1). When we compare to our static indicator, there is a lower predominance of leading results at the core of Europe. Reversely, there are also some southern (like in Spain) and eastern European regions which, for the indicator at stake, present scores that are among the best possible ones. Oppositely, it is also possible to observe some central European regions whose scores in terms of this indicator are very modest.

---

[14] For GDP pc there is no data concerning 1990, which justifies the lower number of observations when compared to patents.

[15] Only the standard version of the index is approached, because as it can be observed in appendix V, both versions (standard and restrictive) do not lead to substantially different results.

Figure 2. S3 evolution (2009-2013)



Source: author's computations

Finally, resorting to our static indicator for 2000 and 2012, we perform a cluster analysis exercise. For each of these years, our sample of regions is split in two different non-overlapping groups that basically correspond to those with the highest (leaders) and lowest (followers) scores in terms of S3[16]. Depending on the category that is attributed to each region in both periods, we categorize different territories as S3 persistent leaders (leaders both in 2000 and 2012), S3 recent leaders (followers in 2000 and leaders in 2012), S3 persistent followers (followers both in 2000 and 2012), and S3 recent followers (leaders in 2000 and followers in 2012). We also normalize the S3 index for both years, such that the maximum recorded each year is attributed the value 1, being all other values adjusted accordingly. The cluster analysis indicates 0.35 as the threshold for the degree of S3 in 2000. Those regions that present a degree of S3 bellow this threshold are considered to be S3 followers, while those that have a degree of S3 above this value are assumed to be S3 leaders. For 2012 the threshold is fixed at 0.33.

Figure 3 shows the representation of the different regions, and their classifications, according to the established thresholds resulting from the cluster analysis as previously described. In appendix VI it is possible to observe in detail the values attributed to the different regions, as well as where they stand according to the four defined categories. At the top right hand side of the graph (S3 persistent

---

[16] The groups are created resorting to partition cluster analysis methods. More precisely, the method applied in order to create distinct groups of observations is the k-means.

leaders) is clearly observable the dominance of German regions, being also possible to find some Italian, Finish and Austrian territories, among others. Resorting to the examples of the regions with the highest scores in 2000 (Länsi-Suomi - West Finland) and 2012 (Veneto), it is possible to understand that their persistency leading the S3 process is due to the fact they persistently have specializations (RCA>1) in most of the technologies that are assumed to have potential for S3. In the case of Länsi-Suomi (FI19), this region in 2000 was assumed to have potential for S3 in 31 different technologies, having specializations in 27 of them. Among those technologies with potential for S3, the most relevant one (with the highest RCA) was by far related to "working or preserving wood or similar material; nailing or stapling machines in general". Concerning 2012, the same region presented specializations in 22 out of the 35 technologies with potential for S3 in that region. However, the most relevant technology (among those with potential for S3) was associated with "working cement, clay, or stone", with the previously leading technology ("working or preserving wood or similar material; nailing or stapling machines in general") having substantially decreased in importance. Regarding Veneto (ITH3), in 2000 this region had specializations in 22 out of the 30 technologies assumed to have potential for S3, while in 2012 this territory achieved a specialization in 25 out of the 31 technologies with potential for S3. Concerning areas of specialization, in 2000, among those technologies with potential for S3, it was clear the region's specialization in technologies related to "hydraulic engineering; foundations; soil-shifting". However, in 2012, in spite of keeping a specialization in this technology, the performance of the region was clearly remarkable in technologies in the field of "working cement, clay, or stone".

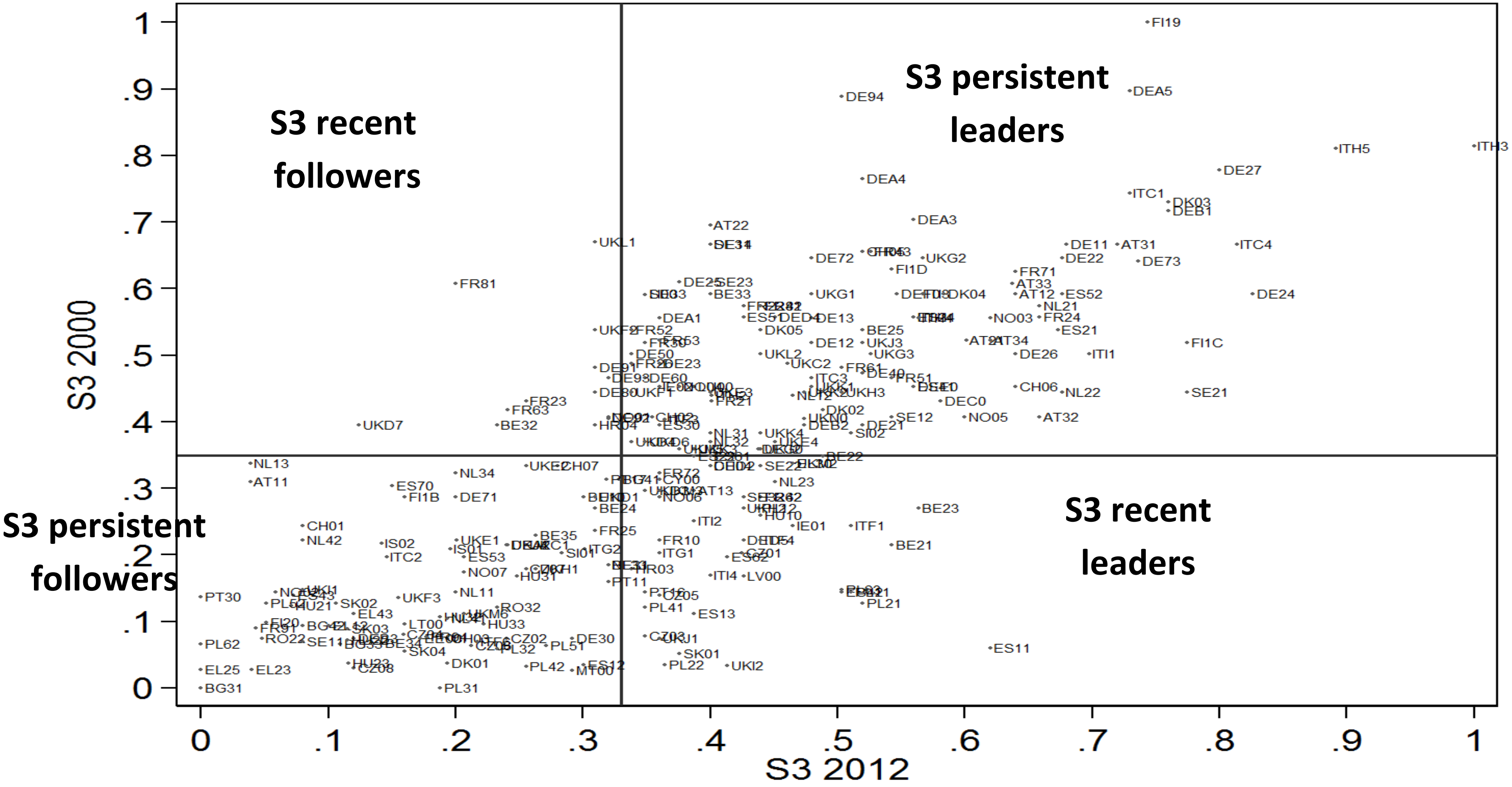
In what concerns the bottom left hand side of the chart (S3 persistent followers), several regions belong to southern and eastern European countries. As it is possible to observe in table 8, countries like Bulgaria, Czech Republic, Greece, Hungary, Portugal, Romania, and Slovakia clearly present most of their regions as being S3 persistent followers. However, it is also possible to find Austrian, German, Finish, French, British, Swedish and Dutch regions under the persistent followers' category. This fact suggests that regional heterogeneity in terms of S3 is not only verified among regions from different countries, but it is also observable within countries. A good instance to illustrate this situation is the case of Finland, where in Helsinki-Uusimaa (FI1B), in 2000, among the 32 technological fields assumed to have a potential for S3 in the region, specializations are only achieved in 8 of them. The situation in 2012 was even worse (4/31), justifying therefore the persistent categorization of this region as a S3 follower. Regions like Severozapaden (BG31) present even more disappointing scores, given that both in 2000 and 2012 this region had no specializations in any of the technologies assumed to have potential for S3. Actually, those technological areas that are assumed to have potential for S3 simply do not exist in the region. Reversely, other technologies related to fields such as "conveying; packing; storing; handling thin or filamentary material", "agriculture; forestry; animal husbandry; hunting; trapping; fishing", "heating; ranges; ventilating", "machines or engines in general; engine plants in general; steam engines", and "machines or engines for liquids; wind, spring, or weight motors; producing mechanical power or a reactive propulsive thrust, not otherwise provided for" are present in the region, and constitute its main areas of specialization. This can be the sign that in Severozapaden is taking place a process of radical innovation that our indicator is not able to capture.

In terms of recent leaders, in figure 3 is clearly highlighted the situation of Galicia (ES11), as one of the regions showing one of the most outstanding evolutions in terms of S3, between 2000 and 2012. This region evolved from a normalized degree of S3 in 2000 equivalent to 0.06, to more than 0.6 in

2012. This was possible due to the fact that this territory acquired specializations in several technologies considered to have a potential for S3, such as “heat exchange in general”, “cleaning”, and “ships or other waterborne vessels; related equipment”, among many others. In 2012 Galicia had specializations in 16 out of 32 technologies considered to have S3 potential in the region. Oppositely, in 2000, for most of the technologies with a potential for S3, the region did not have any specialization, being the only exceptions those technological areas related to “Locks; keys; window or door fittings; safes” and “doors, windows, shutters, or roller blinds, in general; ladders”.

The top left hand side of the chart (S3 recent followers) is clearly the area where less regions are allocated, suggesting to be quite uncommon regions that are considered to be leaders in terms of S3 at given point in time, to substantially worsen their position in the ranking. Among those regions exhibiting one of the most remarkable drops in their relative position in terms of S3, between 2000 and 2012, it is possible to find Merseyside (UKD7) and Languedoc-Roussillon (FR81). In the first case this regression in terms of S3 can be explained by fact that while in 2000 Merseyside presented specializations in several (11) technologies considered to have potential for S3, this number shrank to less than 5 in 2012. For instance, the technology related to “layered products”, which, among those considered as priorities in 2000, was the most relevant one (highest RCA), completely disappeared from the region in 2012, in spite of still being considered as a technological field with potential for S3. Regarding Languedoc-Roussillon, in 2000 this region had specializations in 18 out of the 32 technological areas with potential for S3. Among the most prominent technologies (those with higher degrees of RCA), it was possible to find technological areas related to “Life-saving; fire-fighting”, “working cement, clay, or stone”, and “ships or other waterborne vessels; related equipment”. In 2012 Languedoc-Roussillon presented specializations only in 5 of the technologies that were assumed to have potential for S3 in the region. In spite of the fact that both technological areas associated with “working cement, clay, or stone”, and “ships or other waterborne vessels; related equipment” kept being considered as technologies with potential for S3 in 2012, the region lost its specialization in these fields, among many others.

Figure 3. Distribution of European regions according to their degree of S3 both in 2000 and 2012



Source: author's computations

Table 8. Distribution of European regions according to their categories, by country

Countries	S3 persistent leaders	S3 recent leaders	S3 persistent followers	S3 recent followers	N regions
Austria	78 %	11 %	11 %	0 %	9
Belgium	18 %	27 %	45 %	9 %	11
Bulgaria	0 %	0 %	100 %	0 %	4
Croatia	0 %	50 %	0 %	50 %	2
Cyprus	0 %	100 %	0 %	0 %	1
Czech Republic	0 %	38 %	63 %	0 %	8
Denmark	80 %	0 %	20 %	0 %	5
Estonia	0 %	0 %	100 %	0 %	1
Finland	60 %	0 %	40 %	0 %	5
France	57 %	17 %	13 %	13 %	23
Germany	74 %	5 %	11 %	11 %	38
Greece	0 %	20 %	80 %	0 %	5
Hungary	0 %	14 %	86 %	0 %	7
Iceland	0 %	0 %	100 %	0 %	2
Ireland	50 %	50 %	0 %	0 %	2
Italy	58 %	26 %	16 %	0 %	19
Latvia	0 %	100 %	0 %	0 %	1
Lichtenstein	100 %	0 %	0 %	0 %	1
Lithuania	0 %	0 %	100 %	0 %	1
Luxembourg	100 %	0 %	0 %	0 %	1
Malta	0 %	0 %	100 %	0 %	1
Netherlands	42 %	8 %	50 %	0 %	12
Norway	43 %	14 %	29 %	14 %	7
Poland	0 %	50 %	50 %	0 %	12
Portugal	0 %	25 %	75 %	0 %	4
Romania	0 %	0 %	100 %	0 %	2
Slovakia	0 %	25 %	75 %	0 %	4
Slovenia	50 %	0 %	50 %	0 %	2
Spain	38 %	38 %	25 %	0 %	16
Sweden	63 %	25 %	13 %	0 %	8
Switzerland	43 %	14 %	43 %	0 %	7
United Kingdom	51 %	16 %	24 %	8 %	37

Source: author's computations

Finally, for each one of the regional categories discussed above, we compute the correlation between the degree of S3 and, as previously, patents (absolute values and per capita) and GDP per capita. As we can observe by the results displayed in table 9, the existing correlation between the S3 score of the regions and their endowment in terms of patents is very low, suggesting the absence of a clear relationship between these two variables, regardless the type of region at stake. Actually, these results are in line with those obtained when it is considered the full sample of regions (see table 6). Concerning GDP per capita, there are two surprising facts, when these results are compared with those obtained for the full sample of regions. The first one concerns the group of regions that are assumed to be S3 persistent leaders. Actually, as it can be observed in table 9, for these regions the correlation between their level of GDP per capita and their S3 score is close to zero, indicating that these two variables are not correlated at all for this group of regions. It seems that for these regions that present higher scores in terms of S3, their level of GDP per capita becomes dissociated from their rank in terms of S3. The second puzzling fact is related to the regions that are assumed to be S3 recent followers, group for which there is a negative and moderate correlation between S3 scores and levels of GDP per capita. However, in this case the results should be observed with caution, as the number of regions (and therefore observations) included within this group is low. Moreover, most of the regions are located very close to the frontier with the persistent leaders (see figure 3), which can explain the negative sign of the existing verified correlation.

Table 9. Correlation between different sets of variables and the degree of S3 by types of regions (2012 and 2000)

Types of Regions	Variables	Patents	Patents pc	GDP pc (PPP)
S3 Persistent Leaders	N	226	216	211
	Degree S3	0,08	-0,04	-0,04
S3 Recent Leaders	N	98	94	90
	Degree S3	-0,01	0,10	0,41
S3 Persistent Followers	N	166	147	135
	Degree S3	0,05	0,06	0,37
S3 Recent Followers	N	26	24	24
	Degree S3	0,01	0,04	-0,29

Source: OECD (2016), Eurostat, and author's computations

6. S3 in the light of policies and institutions

The above discussed outcomes can certainly, at least in part, be explained by differentiated policy and institutional approaches to innovation. As pointed out by Kroll et al. (2016), Germany constitutes a perfect example of a country where, overall, strategic innovation policy (which is translated into formal innovation strategies) has already a long tradition. Moreover, the consultation of the stakeholders, the existence of decentralized policy processes, as well as priority setting approach to innovation policy, certainly contribute to the fact that most German regions are considered, according to our analysis, S3 persistent leaders (see table 8). Actually, according to Kroll (2015), the conditions experienced by Germany for starting the development of RIS3 were more appropriate than those verified in other EU countries. A similar situation can be observed in Austria, where, for instance, the region of Lower Austria (AT12 - Niederösterreich) is commonly considered (including by the EU) as a best practice case to illustrate the adoption of a S3 strategy (see Kroll et al., 2014 for further details).

Oppositely, in cases such as Greece, or most of the eastern European countries, the innovation policy has not had a tradition based on the principles that are similar to those of S3, reason why, probably, such countries, according to our analysis, still present disappointing scores. In the case of Greece, Kroll et al. (2014) points out the fact that regional authorities were newly set up (they were only set up in 2012), suffering also from lack of technical and professional experience designing regional innovation policies based on S3. Beyond these facts, in Greece, historically, very small budgets have been allocated to R&D and innovation policy. Moreover, according to the authors, even for the national government the development of regional innovation policies is something new, thereby constituting a challenge. For all these reasons, it is also difficult to include private companies in the development of any regional innovation strategy. On the one hand, they do not regard regional authorities as institutions able to support them in business (regional authorities are seen as old administrations working on regulatory matters). On the other hand, as their business strategies are rarely based on R&D and innovation, they have little interest to take part in the process (Kroll et al., 2014).

Concerning eastern European countries, for instance, Karo and Kattel (2015) perform an analysis of the different R&D policies and institutions of CEE (Central and Eastern European) countries and to what extent such institutional framework can influence their approach to S3. Generally, the authors argue that “bottom-up public-private coordination” is missing in these countries. According to the authors, what prevails in these countries are old (state led) policy routines that are expected to persist over time. In this sense, it is foreseen that it will take time to implement a new approach to R&D and innovation policy. Therefore, this fact can explain the low scores of these countries in terms of S3. This case can be illustrated, for instance, resorting to Estonia (a S3 persistent follower), a country (and region) where innovation policy has been characterized by horizontal policy measures (contrasting with the vertical ones defended by the S3), and a weak private sector that is not involved in the policy making process (Karo and Kattel, 2015). Nevertheless, among the CEE countries, it is interesting to highlight the case of Slovenia, whose neo-corporatist features are assumed to have favored the coordination of the state and private sector interests, in a way that both actors have been involved in the policy making process (including in field of R&D and innovation). Curiously, among the CEE countries, Slovenia is the only one where it is possible to find a region as a S3 persistent leader (see table 8).

In the literature it is also possible find other remarkable examples of regions pointed out as S3 persistent leaders. One interesting case is the Basque Country (ES21), which in the 1980s was considered an old industrial region, where traditional and declining industries (steel and shipbuilding, for instance) were the pillar of the economy, while nowadays it constitutes a success story case, due to its ability to transform and renew its economic structure. Actually, this was only possible due to the regional authorities that through the political commitment to a regional innovation policy, together with the application of a policy of active intervention in the industrial and institutional landscape, were able to keep mature industries in an innovation track (Morgan, 2016). Such policy, among other aspects, is based on an innovation model that relies on the principle of “collective entrepreneurship”, according to which public and private sector work in coordination, being also fostered the cooperation among different agents of the private sector (Morgan, 2016). It is therefore not difficult to understand that, even before the adoption of any S3, some of its principles were already guiding the Basque Country regional development policies, thereby constituting an arguable explanation for the high S3 scores presented by this region.

In western Norway, in Vestlandet (NO05) (more precisely in Møre and Romsdal - NO053) , which is also a S3 persistent leader, Asheim and Grillitsch (2015) highlight the success of S3 in this territory, emphasizing the importance of a DUI (learning-by-doing, by-using and interacting) mode of innovation for such outcome. More precisely, according to the qualitative work carried out by the authors, Møre and Romsdal S3 strategy is based on the exploitation of the resources derived from the ocean, on which all the community has a shared and common view about its importance. Furthermore, it is also stated that due to the collaboration between different sorts of stakeholders (namely industries and different types of higher education institutions), whose initiatives are actively supported by the governmental authorities, the region has outstanding opportunities for related diversification. Finally, the limited regional diversity in this territory is counterbalanced by searching for knowledge outside of the region, which makes clear that even in specialized regions, S3 logic can be applied and successfully implemented.

Concerning regions whose category indicates a change of status between 2000 and 2012 (either S3 recent leaders or S3 recent followers), it is also possible to illustrate some cases where this happened, trying to grasp to what extent such changes are related to the policies pursued by such territories. Starting by the S3 recent leaders, one interesting example is the case of Poland, one of the countries that has more regions falling under such category (see figure 11). Kroll et al. (2014) points out that, for instance, the region of Greater Poland (Wielkopolska – PL41), like other Polish regions, benefits from a regional development policy whose decision-making and implementation is carried out by the regional authorities. Moreover, in such territory regional innovation policies are not new, once their existence can be dated back to the beginning of the 2000s. Moreover, the current regional innovation strategy (2010-2020) included for the first time the participation of stakeholders (companies, cluster, and research institutions). Overall, in spite of the fact that this and other Polish regions are used with the designing and implementation of regional innovation policy strategies, some of the S3 principles were not well consecrated in such strategies (Kroll et al., 2014), being implemented only now, reason why further developments can be expected in the future.

Finally, regarding S3 recent followers, it is possible to resort to the German regions of Braunschweig (DE91), Hannover (DE92), and Lüneburg (DE93) in order to try to illustrate some causes underlying the categorization of these regions as they are categorized. According to Kroll et al. (2016), the region of Lower Saxony (DE9), where these three regions are located, oppositely to what is verified in other German regions, up to 2012, was characterized by the absence of any formal innovation strategy. Up to that moment, the existing innovation planning was carried out informally, and in a very centralized way, at the ministerial level. Even after 2012, the authors criticize the adopted strategies by their inability to meet the principles underlying S3, namely in what concerns the participation of the stakeholders. “In general, Lower Saxony's approach towards RIS3 was less than proactive” (Kroll et al., 2016, p.1464). This case also shows that S3 differences among regions are not exclusively country specific, but also region specific. Germany, a country that overall presents strong capacities in terms of R&D, also has some regions that due to their approach to innovation policy can present low S3 scores, namely when their policies seem to disregard the principles underlying S3.

7. Conclusions

The concept of S3 has been growing in importance over the last years, becoming a regional innovation policy concept, whose aim is to foster R&D and innovation investments in activities that are considered to have more potential for the economic development of the regions. This concept's operationalization requires an exercise of vertical prioritization, which should be done through the application of an EDP. Nevertheless, it is still missing a framework of analysis in order to quantitatively deal with S3, at the same time most of its principles and orientations are respected. We have proposed to resort to the concept of related technological diversity, in order to frame this policy concept. Under such framework, two indicators of S3 are suggested, namely one that measures the situation of a given region in terms of S3 at a given moment in time, and the other that evaluates S3 evolution over time. Moreover, the indicators are conceived being as much as possible in harmony with most of the principles consecrated in the literature regarding the S3 policy.

Testing these indexes resorting to data on patents suggests that the process of S3 is more developed in regions located at the core of the European continent, as well as in northern European regions. In contrast, the regions located in southern and Eastern Europe persistently present lower scores than other European regions. In terms of evolution between 2009 and 2013, the best and the worst scores seem to be more widespread across the European continent. Nevertheless, it still exists a concentration of regions with scores well below the average in Eastern Europe. This aggregation of outstanding and poor results around certain geographical areas can lead us to suspect about the existence of spillover effects associated with this policy concept. Is spite of the existing dichotomy between northern and central European regions, and southern and eastern European regions, through our analysis it was also possible to find remarkable dissimilarities across regions belonging to the same country. Therefore, this fact suggests that S3 should not be only dependent on national policies, but an important part of it can be potentially explained by region-specific factors.

Sharing our sample into different groups of regions according to their relative degree S3 in 2000 and 2012, indicates that the lion's share of the European territories fall either under the category of S3 persistent leaders or S3 persistent followers. This fact seems to suggest that substantial changes in the relative degree of S3 do not occur very often. Moreover, if changes occur, it is even rarer to find regions considered as S3 recent followers (regions whose relative degree of S3 worsened substantially between 2000 and 2012). This fact can be the sign that a given region, after achieving a good position in terms of S3 hardly leaves that status.

Although the S3 policy concept should be able to be applied to every region, our indicators, at least the way they were computed (using patent data), have the limitation that they can only be estimated for regions and years with patents, at least, in more than one technology. Therefore, further research on the topic should be focused on the development of more inclusive S3 indicators. Other interesting strand of research to be developed in the future is to understand the determinants of S3. According to our results, GDP per capita and the institutional framework existing within each specific region should be seriously considered as elements with some explanatory power over the degree of S3 of the different territories. However, this topic needs to be further investigated.

Finally, with this piece of research based on the technological topography of the regions, we have tried to infer some conclusions concerning the situation of the different European territories in terms of S3. In this sense, this exercise has nothing to do with the S3 strategies that are being proposed by the regions and to what extent they are being successfully implemented. Actually, its purpose is the creation of a proxy for S3 based on the principle of technological related diversification. Nevertheless, in the future, it would be worth to grasp to what extent the regional S3 strategies of the different territories are in line with technological related diversification logic that was adopted in the context of this research.

References

Asheim, B. and Grillitsch, M. (2015), “Smart specialisation: Sources for new path development in a peripheral manufacturing region”, Papers in Innovation Studies, Paper No. 2015/11

Balassa, B. (1965), “Trade Liberalisation and “Revealed” Comparative Advantage”, The Manchester School, 33, 99-123

Barca, F. and McCann, P. (2011), “Methodological note: outcome indicators and targets – towards a performance oriented EU cohesion policy”, retrieved online on May 21, 2013 at theURL:http://ec.europa.eu/regional_policy/sources/docgener/evaluation/doc/performance/improve_inno_resear_en.pdf

Boschma, R. (2014), “Constructing regional advantage and Smart specialisation: Comparison of two European policy concepts”, Scienze Regionali, Italian Journal of Regional Science, 13(1), pp. 51–68.

Boschma, R. and Frenken, K. (2011), “Technological relatedness and regional branching”, in H. Bathelt, M.P. Feldman and D.F. Kogler (eds.) “Beyond Territory, Dynamic Geographies of Knowledge Creation, Diffusion and Innovation”, Routledge, London.

Boschma, R. and Giannelle, C. (2014), “Regional Branching and Smart Specialization Policy”, S3 Policy Brief Series No. 06/2014

Boschma, R., Martin, V. and Minondo, A. (2015), “Neighbor regions as the source of new industries”, Papers in Evolutionary Economic Geography, 15.08, March 2015

Boschma, R., Minondo, A. and Navarro, M. (2012), “Related variety and regional growth in Spain”, Papers in Regional Science, Volume 91 number 2, pp. 241-256

Boschma, R., Rigby, D. and Balland, P. A. (2016), “Relatedness, knowledge complexity and technological opportunities of regions: A framework for smart specialization”, Presentation at the 3rd Geography of Innovation Conference 2016

Boschma, R. and Wenting, R. (2007), “The spatial evolution of the British automobile industry”, *Industrial and Corporate Change*, 16(2): 213-238

Camagni, R. and Capello, R. (2013), “Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies” Growth and Change, Vol. 44 No. 2, pp. 355–389

Caragliu, A. and Del Bo, C. (2013), “Smart Specialization Strategies and Smart Cities: an Evidence-based assessment of EU Policies” Working Paper n. 2013-17, Dipartimento di Economia, Management e Metodi Quantitativi - Università Degli Studi di Milano

David, P., Foray, D. and Hall, B. (2009), “Measuring Smart Specialisation: The concept and the need for indicators” Working document available at CEMI - the Chair of Economics and Management of Innovationhttp://cemi.epfl.ch/files/content/sites/cemi/files/users/178044/public/Measuring%20smart%20specialisation.doc (accessed 5 March 2015)

Essleztbichler, J. (2013), “Relatedness, industrial branching and technological cohesion in US metropolitan areas”, *Regional Studies*

European Commission (2014), “Guidance on Ex ante Conditionalities for the European Structural and Investment Funds - PART II”, European Commission

Evangelista, R., Meliciani, V. and Vezzani, A. (2015), “The Specialisation of EU Regions in Fast Growing and Key Enabling Technologies”, JRC Technical Reports, European Commission

Foray, D., David, P.A. and Hall, B.H. (2009), “Smart Specialization – The Concept”, Knowledge Economists Policy brief No. 9, European Commission, Brussels, June

Foray, D. (2013), “The economic fundamentals of smart specialisation”, Ekonomiaz, Vol. 83 No. 2, pp. 83-102.

Foray, D., David, P. and Hall, B., (2011), “Smart Specialization – From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation”, MTEI Working Paper, November 2011

Foray, D., Goddard, J., Beldarrain, X., Landabaso, M., McCann, P., Morgan, K., Nauwelaers, C. and Ortega-Argiles, R. (2012), “Guide to Research and Innovation Strategies for Smart Specialization (RIS 3)”, European Union Regional Policy, March 2012

Frenken, K., Van Oort, F. and Verburg, T. (2007), “Related variety, unrelated variety and regional economic growth”, Regional Studies, 41(5): 685-697

Hidalgo, C. A., Klinger, B., Barabási, A. L. and Hausmann, R. (2009), “The product space conditions the development of nations”, Science 317 (5837), 482–487

Iacobucci, D. (2014), “Designing and implementing a smart specialization strategy at regional level: Some open questions”, Scienze Regional – Italian Journal of Regional Science, 13(1), 107–126

Karo, E. and Kattel, R. (2015), “Economic development and evolving state capacities in Central and Eastern Europe: can “smart specialization” make a difference?”, Journal of Economic Policy Reform, 18:2, 172-187

Klepper, S. (2007), “Disagreements, spinoffs, and the evolution of Detroit as the capital of the U.S. automobile industry”, *Management Science*, 53: 616-631

Kroll, H. (2015), “Efforts to Implement Smart Specialization in Practice—Leading Unlike Horses to the Water”, European Planning Studies, 23, 2079-2098

Kroll, H., Böke, I., Schiller, D. and Stahlecker, T. (2016), “Bringing owls to Athens? The transformative potential of RIS3 for innovation policy in Germany's Federal States”, European Planning Studies, 24:8, 1459-1477

Kroll, H., Muller, E., Schnabl, E. and Zenker, A. (2014), “From smart concept to challenging practice – how European regions deal with the commission’s request for novel innovation strategies”, (Working Papers Firms and Region No. R2/2014), Karlsruhe: Fraunhofer ISI.

Maraut, S., Dernis, H., Webb, V., Spiezia, V. and Guellec, D. (2008), „The OECD REGPAT Database: A Presentation“, OECD STI Working Papers, 2008/02

Mccann, P. and Ortega-Argilés. R. (2013), “Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy”, Regional Studies

Montresor, S. and Quatraro, F. (2015), "Key Enabling Technologies and Smart Specialization Strategies. European Evidence from patent data", IPTS Working Papers on Corporate R&D and Innovation No. 05/2015, EC, JRC-IPTS

Moodysson, J., Trippl, M. and Zukauskaite, E. (2015), “Policy Learning and Smart Specialization Balancing Policy Change and Policy Stability for New Regional Industrial Path Development”, Papers in Innovation Studies, Paper no. 2015/39

Morgan, K. (2016), “Collective entrepreneurship: the Basque model of innovation”, European Planning Studies, 24:8, 1544-1560

Neffke, F. (2009), “Productive Places. The Influence of Technological Change and Relatedness on Agglomeration Externalities”, PhD thesis, Utrecht University, Utrecht.

Neffke, F., and Svensson Henning, M. (2008), “Revealed relatedness: Mapping industry space”, DRUID Working Paper No. 08-18

OECD (2016), REGPAT database, February 2016

Rodriguez-Pose, A. and Wilkie, C. (2015), “Institutions and the Entrepreneurial Discovery Process for Smart Specialization”, Papers in Evolutionary Economic Geography, 15.23

Rodrik, D. (2004), “Industrial Policy for the twenty-first century”, working paper, Kennedy School of Management, Harvard University, Cambridge MA

Appendix I - Total number of patents by IPC class

Year	N patents by IPC class	Year	N patents by IPC class	Year	N patents by IPC class	Year	N patents by IPC class	Year	N patents by IPC class
1964	1	1981	57 546	1990	118 194	1999	248 877	2008	199 285
1966	5	1982	60 976	1991	121 170	2000	276 198	2009	200 434
1968	3	1983	69 610	1992	121 837	2001	284 466	2010	207 914
1969	2	1984	78 454	1993	128 141	2002	264 376	2011	211 595
1975	2	1985	84 223	1994	137 515	2003	232 555	2012	205 630
1977	10 691	1986	92 290	1995	142 469	2004	218 491	2013	200 143
1978	29 397	1987	105 327	1996	163 162	2005	187 875	2014	41 728
1979	43 210	1988	114 214	1997	183 136	2006	195 841	2015	17
1980	52 444	1989	121 474	1998	209 823	2007	210 518	**Total**	**5 631 258**

Source: OECD (2016) and author's computations

Appendix II – Comparison of the relatedness results for IPC classes and subclasses with Boschma et al. (2012)

In the case of IPC classes, assuming that pairs of technologies whose degree of proximity is equal or larger than 0.25, such assumption leads us to obtain 1786 technology-pairs that are related to each other, corresponding to 22% of all possible technology-pairs. Regarding IPC subclasses, with the application of the same criterion, 6610 related technology-pairs were achieved (equivalent to 3,24% of all possible combinations of IPC subclasses). As we are following Boschma et al. (2012) concerning the threshold to be applied in the degree of proximity in order to consider two technologies as related to each other, aggregating technologies according to IPC classes seems to be more adequate, than the IPC subclasses approach. As it is possible to observe in the table below, with the IPC subclasses approach the obtained results are quite distant from Boschma et al. (2012)[17], reason why the rest of the analysis will be performed considering different technological fields aggregated according to IPC classes typology. In the sense that this method is based on the co-occurrence of a specialization (RCA>1) in two different technological fields, regardless their features, normally it is identified as relatedness ex-post (Boschma et al., 2012). This process to determine the existence of relatedness between two different technologies contrasts with the ex-ante approach, according to which it is assumed that two technologies are related if their IPC codes have in common a given set of symbols. For instance, in the case of IPC classes it is assumed that they are related if they belong to the same section[18].

Approach	N technologies /products	N possible combinations	N related combinations	Related combinations (%)
Boschma et al. (2012)	**1244**	**773146**	**107275**	**13,88 %**
IPC classes	129	8256	1786	21,63 %
IPC subclasses	639	203841	6610	3,24 %

Source: Boschma et al. (2012) and author's computations

---

[17] The use of IPC subclasses would require, probably, the use of a lower threshold for the degree of proximity, such that a higher percentage of related technologies could be achieved (as Boschma et al. (2012) achieve when they perform similar computations using data on traded products). However, as when applying the same criterion of Boschma et al. (2012) resorting to IPC classes, our percentage of technology-pairs that are assumed to be related is just slightly higher than in the case of Boschma et al. (2012), we deem that the use of IPC classes should be more adequate than the IPC subclasses for the purpose of this work.

[18] During our analysis only the ex-post approach will be adopted, because, as we will conclude in Appendix II, the ex-ante approach seems to be less adequate.

Appendix III – Descriptive statistics for the total number of technological fields (IPC classes) with a potential for S3 in our sample of regions, by year and relatedness method

	IPC classes					
	Ex-ante			Ex-post		
	2012	2000	1990	2012	2000	1990
N	277	258	225	277	258	225
mean	40,1	41,0	40,6	33,1	33,4	33,8
max	109	93	105	57	59	64
min	9	12	14	9	27	16
std dev	12,0	12,1	13,6	4,4	3,4	5,3

Source: author's computations

In the table above it is possible to observe, for our sample of regions, the number of technological fields that met the potential for S3 criterion for those years for which the indicator was computed, when assuming ex-ante and ex-post relatedness. As it is possible to conclude, the ex-ante approach does not seem to be adequate for our purpose, given that under such framework, there are some regions for which almost all IPC classes are considered to have a potential for S3 (which is not a very reasonable assumption). Actually, as it can be observed in the table below, the correlation between the outcome of relatedness when computed by the different methodologies (ex-ante and ex-post) is very low, which indicates that there are substantial differences between these two methodologies when attributing relatedness to the considered pairs of technologies.

	Correlation between the N terms of the outcome of the relatedness results when computed from an ex-ante perspective and from an ex-post approach
N	7379
Correlation	0,14

Source: author's computations

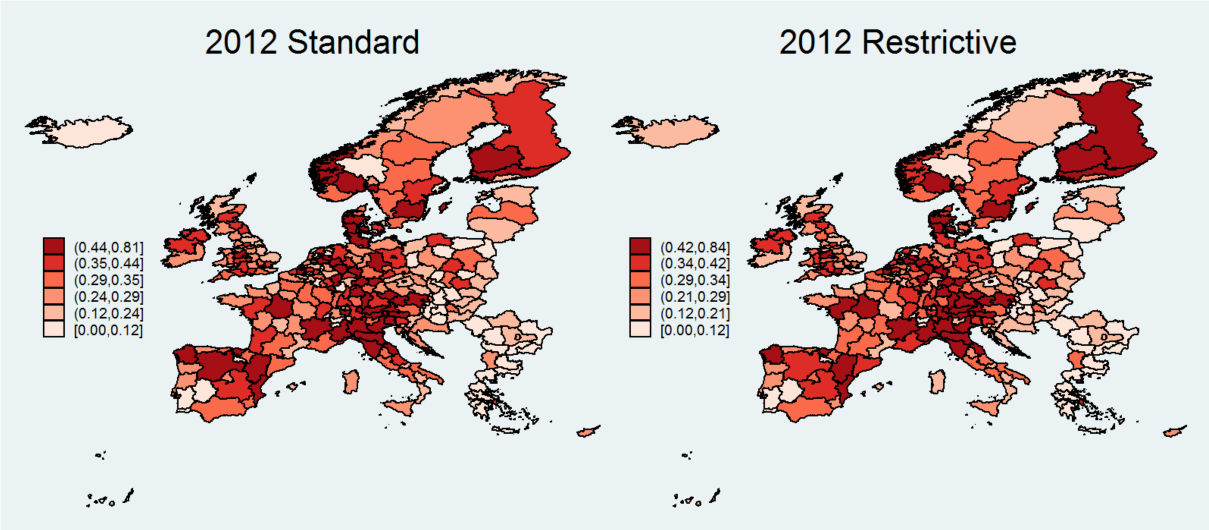
Therefore, our analysis will be carried out resorting exclusively to the ex-post approach. Moreover, the first table also allows us to conclude that the choice of technologies whose relatedness density was included in the third quartile seems to constitute a balanced criterion, once other choices would risk to lower the minimum or to increase the maximum, assuming therefore that some regions would have too little or too much technological fields with a potential for S3.

Appendix IV – Comparison of standard and restrictive versions of the Degree S3 by year

As it is possible to observe below, through the comparison of the two versions of the index (standard and restrictive), it becomes clear that they do not differ much in terms of their average, standard deviation, minimum and maximum. Moreover, the regions for which the maximum and the minimum are registered are almost always also the same in both cases. Therefore, the concerns that led us to create a restrictive version of (8) seem not to have a big impact in our results.

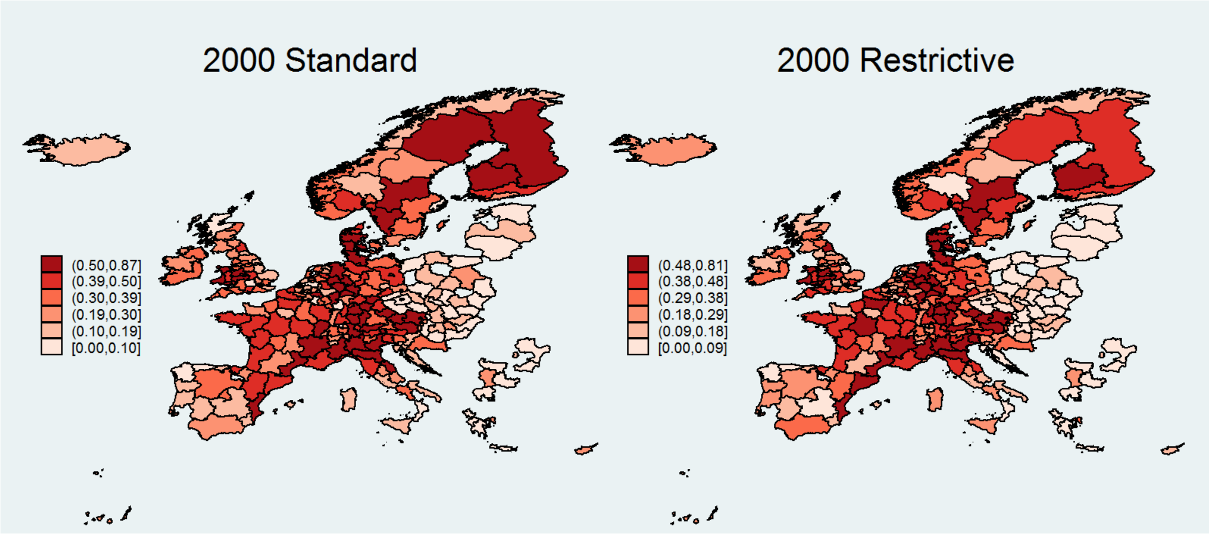
	Standard			Restrictive		
	2012	2000	1990	2012	2000	1990
N	277	258	225	277	258	225
mean	0,29	0,30	0,27	0,28	0,29	0,27
max	0,81	0,87	0,74	0,84	0,81	0,74
min	0	0	0	0	0	0
std dev	0,16	0,18	0,18	0,16	0,18	0,18

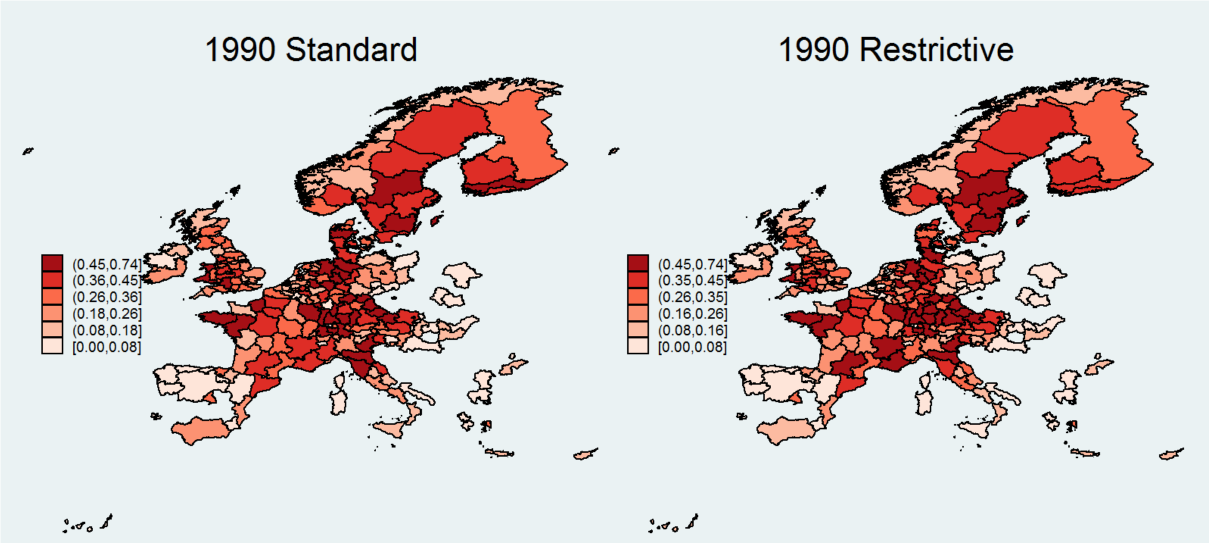
Source: author's computations



2012 Standard

2012 Restrictive

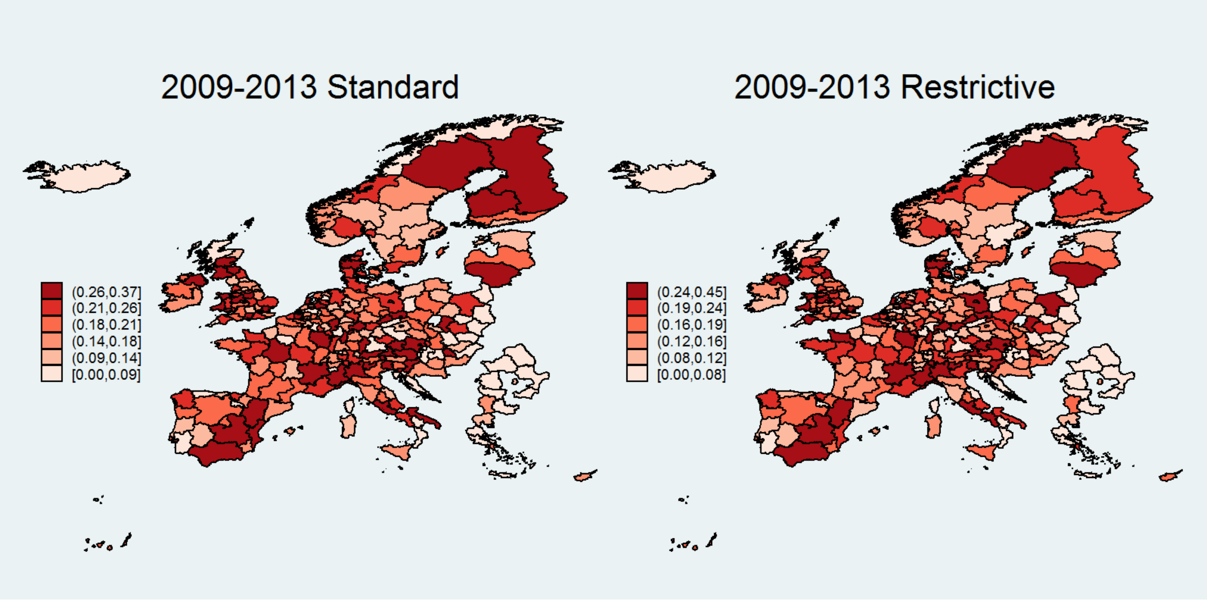

2000 Standard
(0.50,0.87]
(0.39,0.50]
(0.30,0.39]
(0.19,0.30]
(0.10,0.19]
[0.00,0.10]
2000 Restrictive
(0.48,0.81]
(0.38,0.48]
(0.29,0.38]
(0.18,0.29]
(0.09,0.18]
[0.00,0.09]


1990 Standard
(0.45,0.74]
(0.36,0.45]
(0.26,0.36]
(0.18,0.26]
(0.08,0.18]
[0.00,0.08]
1990 Restrictive
(0.45,0.74]
(0.35,0.45]
(0.26,0.35]
(0.16,0.26]
(0.08,0.16]
[0.00,0.08]

Appendix V – Comparison of standard and restrictive versions of the S3 evolution (2009-2013)

	Standard	Restrictive
N	267	267
mean	0,17	0,16
max	0,37	0,45
min	0	0
std dev	0,08	0,08

Source: author's computations



Appendix VI

S3 Persistent Leaders			
Region code	**Region name**	**Normalized degree S3 - 2000**	**Normalized degree S3 - 2012**
AT12	NIEDERÃ?STERREICH	0,59	0,64
AT21	KÃ?RNTEN	0,52	0,60
AT22	STEIERMARK	0,70	0,40
AT31	OBERÃ?STERREICH	0,67	0,72
AT32	SALZBURG	0,41	0,66
AT33	TIROL	0,61	0,64
AT34	VORARLBERG	0,52	0,62
BE25	PROV. WEST-VLAANDEREN	0,54	0,52
BE33	PROV. LIÃ?GE	0,59	0,40
CH02	ESPACE MITTELLAND	0,41	0,35
CH05	OSTSCHWEIZ	0,66	0,52
CH06	ZENTRALSCHWEIZ	0,45	0,64
DE11	STUTTGART	0,67	0,68
DE12	KARLSRUHE	0,52	0,48
DE13	FREIBURG	0,56	0,48
DE14	TÃ?BINGEN	0,67	0,40
DE21	OBERBAYERN	0,39	0,52
DE22	NIEDERBAYERN	0,65	0,68
DE23	OBERPFALZ	0,49	0,36
DE24	OBERFRANKEN	0,59	0,83
DE25	MITTELFRANKEN	0,61	0,38
DE26	UNTERFRANKEN	0,50	0,64
DE27	SCHWABEN	0,78	0,80
DE40	BRANDENBURG	0,47	0,52
DE50	BREMEN	0,50	0,34
DE60	HAMBURG	0,47	0,35
DE72	GIEÃ?EN	0,65	0,48
DE73	KASSEL	0,64	0,74
DE94	WESER-EMS	0,89	0,50
DEA1	DÃ?SSELDORF	0,56	0,36
DEA3	MÃ?NSTER	0,70	0,56
DEA4	DETMOLD	0,77	0,52
DEA5	ARNSBERG	0,90	0,73
DEB1	KOBLENZ	0,72	0,76
DEB2	TRIER	0,39	0,47
DEC0	SAARLAND	0,43	0,58
DED4	CHEMNITZ	0,56	0,45
DEE0	SACHSEN-ANHALT	0,45	0,56
DEF0	SCHLESWIG-HOLSTEIN	0,59	0,55
DEG0	THÃ?RINGEN	0,36	0,44
DK02	SJÃ?LLAND	0,42	0,49
DK03	SYDDANMARK	0,73	0,76
DK04	MIDTJYLLAND	0,59	0,58
DK05	NORDJYLLAND	0,54	0,44
ES21	PAÃ⍰S VASCO	0,54	0,67
ES24	ARAGÃ?N	0,56	0,56
ES30	COMUNIDAD DE MADRID	0,39	0,36
ES41	CASTILLA Y LEÃ?N	0,45	0,56
ES51	CATALUÃ?A	0,56	0,43

ES52	COMUNIDAD VALENCIANA	0,59	0,68
FI19	LÃ?NSI-SUOMI	1,00	0,74
FI1C	ETELÃ?-SUOMI	0,52	0,78
FI1D	POHJOIS- JA ITÃ?-SUOMI	0,63	0,54
FR21	CHAMPAGNE-ARDENNE	0,43	0,40
FR22	PICARDIE	0,57	0,43
FR24	CENTRE	0,56	0,66
FR26	BOURGOGNE	0,49	0,34
FR30	NORD - PAS-DE-CALAIS	0,52	0,35
FR41	LORRAINE	0,57	0,44
FR43	FRANCHE-COMTÃ?	0,66	0,53
FR51	PAYS DE LA LOIRE	0,47	0,54
FR52	BRETAGNE	0,54	0,34
FR53	POITOU-CHARENTES	0,52	0,36
FR61	AQUITAINE	0,48	0,50
FR71	RHÃ?NE-ALPES	0,63	0,64
FR82	PROVENCE-ALPES-CÃ?TE D'AZUR	0,57	0,44
IE02	SOUTHERN AND EASTERN	0,45	0,36
ITC1	PIEMONTE	0,74	0,73
ITC3	LIGURIA	0,47	0,48
ITC4	LOMBARDIA	0,67	0,81
ITF3	CAMPANIA	0,40	0,36
ITH1	PROVINCIA AUTONOMA DI BOLZANO/BOZEN	0,56	0,56
ITH2	PROVINCIA AUTONOMA DI TRENTO	0,44	0,40
ITH3	VENETO	0,81	1,00
ITH4	FRIULI-VENEZIA GIULIA	0,56	0,56
ITH5	EMILIA-ROMAGNA	0,81	0,89
ITI1	TOSCANA	0,50	0,70
ITI3	MARCHE	0,59	0,57
LI00	Liechtenstein	0,59	0,35
LU00	LUXEMBOURG (GRAND-DUCHÃ?)	0,45	0,39
NL12	FRIESLAND (NL)	0,44	0,47
NL21	OVERIJSSEL	0,57	0,66
NL22	GELDERLAND	0,44	0,68
NL31	UTRECHT	0,38	0,40
NL32	NOORD-HOLLAND	0,37	0,40
NO03	SÃ?R-Ã?STLANDET	0,56	0,62
NO04	AGDER OG ROGALAND	0,45	0,38
NO05	VESTLANDET	0,41	0,60
SE12	Ã?STRA MELLANSVERIGE	0,41	0,54
SE21	SMÃ?LAND MED Ã?ARNA	0,44	0,78
SE23	VÃ?STSVERIGE	0,61	0,40
SE31	NORRA MELLANSVERIGE	0,67	0,40
SE33	Ã?VRE NORRLAND	0,59	0,35
SI02	ZAHODNA SLOVENIJA	0,38	0,51
UKC2	NORTHUMBERLAND AND TYNE AND WEAR	0,49	0,46
UKD4	LANCASHIRE	0,37	0,34
UKD6	CHESHIRE	0,37	0,35
UKE3	SOUTH YORKSHIRE	0,44	0,40
UKE4	WEST YORKSHIRE	0,37	0,45
UKF1	DERBYSHIRE AND NOTTINGHAMSHIRE	0,44	0,34
UKG1	HEREFORDSHIRE, WORCESTERSHIRE AND WARWICKSHIRE	0,59	0,48
UKG2	SHROPSHIRE AND STAFFORDSHIRE	0,65	0,57
UKG3	WEST MIDLANDS	0,50	0,53

UKH3	ESSEX	0,44	0,50
UKJ2	SURREY, EAST AND WEST SUSSEX	0,36	0,44
UKJ3	HAMPSHIRE AND ISLE OF WIGHT	0,52	0,52
UKK1	GLOUCESTERSHIRE, WILTSHIRE AND BRISTOL/BATH AREA	0,45	0,48
UKK2	DORSET AND SOMERSET	0,44	0,47
UKK3	CORNWALL AND ISLES OF SCILLY	0,36	0,39
UKK4	DEVON	0,38	0,44
UKL2	EAST WALES	0,50	0,44
UKM5	NORTH EASTERN SCOTLAND	0,36	0,38
UKN0	NORTHERN IRELAND	0,41	0,47

S3 Recent Leaders

Region code	Region name	Normalized degree S3 - 2000	Normalized degree S3 - 2012
AT13	WIEN	0,30	0,39
BE21	PROV. ANTWERPEN	0,22	0,54
BE22	PROV. LIMBURG (B)	0,35	0,49
BE23	PROV. OOST-VLAANDEREN	0,27	0,56
CH04	ZÃ?RICH	0,33	0,40
CY00	KYPROS / KIBRIS	0,31	0,36
CZ01	PRAHA	0,20	0,43
CZ03	JIHOZAPAD	0,08	0,35
CZ05	SEVEROVYCHOD	0,14	0,36
DED2	DRESDEN	0,33	0,40
DED5	LEIPZIG	0,22	0,43
EL30	ATTIKI	0,34	0,47
ES11	GALICIA	0,06	0,62
ES13	CANTABRIA	0,11	0,39
ES22	COMUNIDAD FORAL DE NAVARRA	0,35	0,39
ES42	CASTILLA-LA MANCHA	0,14	0,50
ES61	ANDALUCÃ�A	0,35	0,40
ES62	REGIÃ?N DE MURCIA	0,20	0,41
FR10	Ã?LE DE FRANCE	0,22	0,36
FR42	ALSACE	0,29	0,44
FR62	MIDI-PYRÃ?NÃ?ES	0,29	0,44
FR72	AUVERGNE	0,32	0,36
HR03	JADRANSKA HRVATSKA	0,18	0,34
HU10	KOZEP-MAGYARORSZAG	0,26	0,44
IE01	BORDER, MIDLAND AND WESTERN	0,24	0,47
ITF1	ABRUZZO	0,24	0,51
ITF4	PUGLIA	0,22	0,44
ITG1	SICILIA	0,20	0,36
ITI2	UMBRIA	0,25	0,39
ITI4	LAZIO	0,17	0,40
LV00	LATVIJA	0,17	0,43
NL23	FLEVOLAND	0,31	0,45
NO06	TRÃ?NDELAG	0,29	0,36
PL11	LODZKIE	0,14	0,51
PL12	MAZOWIECKIE	0,27	0,44
PL21	MALOPOLSKIE	0,13	0,52
PL22	SLASKIE	0,03	0,36
PL41	WIELKOPOLSKIE	0,12	0,35
PL63	POMORSKIE	0,15	0,50
PT16	CENTRO (P)	0,14	0,35

SE22	SYDSVERIGE	0,33	0,44
SE32	MELLERSTA NORRLAND	0,29	0,43
SK01	BRATISLAVSKY KRAJ	0,05	0,38
UKD3	GREATER MANCHESTER	0,30	0,35
UKH2	BEDFORDSHIRE AND HERTFORDSHIRE	0,27	0,43
UKI2	OUTER LONDON	0,03	0,41
UKJ1	BERKSHIRE, BUCKINGHAMSHIRE AND OXFORDSHIRE	0,07	0,36
UKM2	EASTERN SCOTLAND	0,34	0,47
UKM3	SOUTH WESTERN SCOTLAND	0,30	0,36

S3 Persistent Followers

Region code	Region name	Normalized degree S3 - 2000	Normalized degree S3 - 2012
AT11	BURGENLAND (A)	0,31	0,04
BE10	RÃ?GION DE BRUXELLES-CAPITALE / BRUSSELS HOOFDSTEDELIJK GEWEST	0,29	0,30
BE24	PROV. VLAAMS-BRABANT	0,27	0,31
BE31	PROV. BRABANT WALLON	0,19	0,32
BE34	PROV. LUXEMBOURG (B)	0,07	0,14
BE35	PROV. NAMUR	0,23	0,26
BG31	SEVEROZAPADEN	0,00	0,00
BG33	SEVEROIZTOCHEN	0,07	0,11
BG41	YUGOZAPADEN	0,31	0,33
BG42	YUZHEN TSENTRALEN	0,09	0,08
CH01	RÃ?GION LÃ?MANIQUE	0,24	0,08
CH03	NORDWESTSCHWEIZ	0,07	0,19
CH07	TICINO	0,33	0,28
CZ02	STREDNI CECHY	0,07	0,24
CZ04	SEVEROZAPAD	0,08	0,16
CZ06	JIHOVYCHOD	0,06	0,21
CZ07	STREDNI MORAVA	0,18	0,26
CZ08	MORAVSKOSLEZSKO	0,03	0,12
DE30	BERLIN	0,07	0,29
DE71	DARMSTADT	0,29	0,20
DEA2	KÃ?LN	0,22	0,24
DEB3	RHEINHESSEN-PFALZ	0,07	0,12
DK01	HOVEDSTADEN	0,04	0,19
EE00	EESTI	0,07	0,17
EL12	KENTRIKI MAKEDONIA	0,09	0,10
EL23	DYTIKI ELLADA	0,03	0,04
EL25	PELOPONNISOS	0,03	0,00
EL43	KRITI	0,11	0,12
ES12	PRINCIPADO DE ASTURIAS	0,03	0,30
ES43	EXTREMADURA	0,14	0,07
ES53	ILLES BALEARS	0,20	0,21
ES70	CANARIAS	0,30	0,15
FI1B	HELSINKI-UUSIMAA	0,29	0,16
FI20	Ã?LAND	0,10	0,05
FR25	BASSE-NORMANDIE	0,24	0,31
FR91	GUADELOUPE	0,09	0,04
FR94	RÃ?UNION	0,08	0,18
HU21	KOZEP-DUNANTUL	0,12	0,07
HU22	NYUGAT-DUNANTUL	0,07	0,12
HU23	DEL-DUNANTUL	0,04	0,12
HU31	ESZAK-MAGYARORSZAG	0,17	0,25

HU32	ESZAK-ALFOLD	0,11	0,19
HU33	DEL-ALFOLD	0,10	0,22
IS01	CAPITAL REGION	0,21	0,20
IS02	OTHER REGIONS	0,22	0,14
ITC2	VALLE D'AOSTA/VALLÃ?E D'AOSTE	0,20	0,15
ITF6	CALABRIA	0,07	0,22
ITG2	SARDEGNA	0,21	0,30
LT00	LIETUVA	0,10	0,16
MT00	MALTA	0,03	0,29
NL11	GRONINGEN	0,14	0,20
NL13	DRENTHE	0,34	0,04
NL33	ZUID-HOLLAND	0,19	0,32
NL34	ZEELAND	0,32	0,20
NL41	NOORD-BRABANT	0,10	0,19
NL42	LIMBURG (NL)	0,22	0,08
NO02	HEDMARK OG OPPLAND	0,14	0,06
NO07	NORD-NORGE	0,17	0,21
PL31	LUBELSKIE	0,00	0,19
PL32	PODKARPACKIE	0,06	0,23
PL42	ZACHODNIOPOMORSKIE	0,03	0,26
PL51	DOLNOSLASKIE	0,06	0,27
PL52	OPOLSKIE	0,13	0,05
PL62	WARMINSKO-MAZURSKIE	0,07	0,00
PT11	NORTE	0,16	0,32
PT17	LISBOA	0,31	0,32
PT30	REGIÃ?O AUTÃ?NOMA DA MADEIRA	0,14	0,00
RO22	SUD-EST	0,07	0,05
RO32	BUCURESTI - ILFOV	0,12	0,23
SE11	STOCKHOLM	0,07	0,08
SI01	VZHODNA SLOVENIJA	0,20	0,28
SK02	ZAPADNE SLOVENSKO	0,13	0,11
SK03	STREDNE SLOVENSKO	0,09	0,12
SK04	VYCHODNE SLOVENSKO	0,05	0,16
UKC1	TEES VALLEY AND DURHAM	0,22	0,26
UKD1	CUMBRIA	0,29	0,31
UKE1	EAST YORKSHIRE AND NORTHERN LINCOLNSHIRE	0,22	0,20
UKE2	NORTH YORKSHIRE	0,33	0,26
UKF3	LINCOLNSHIRE	0,14	0,16
UKH1	EAST ANGLIA	0,18	0,26
UKI1	INNER LONDON	0,15	0,08
UKJ4	KENT	0,22	0,24
UKM6	HIGHLANDS AND ISLANDS	0,11	0,21

S3 Recent Followers

Region code	Region name	Normalized degree S3 - 2000	Normalized degree S3 - 2012
BE32	PROV. HAINAUT	0,39	0,23
DE80	MECKLENBURG-VORPOMMERN	0,44	0,31
DE91	BRAUNSCHWEIG	0,48	0,31
DE92	HANNOVER	0,41	0,32
DE93	LÃœNEBURG	0,47	0,32
FR23	HAUTE-NORMANDIE	0,43	0,26
FR63	LIMOUSIN	0,42	0,24
FR81	LANGUEDOC-ROUSSILLON	0,61	0,20

HR04	KONTINENTALNA HRVATSKA	0,39	0,31
NO01	OSLO OG AKERSHUS	0,41	0,32
UKD7	MERSEYSIDE	0,39	0,12
UKF2	LEICESTERSHIRE, RUTLAND AND NORTHAMPTONSHIRE	0,54	0,31
UKL1	WEST WALES AND THE VALLEYS	0,67	0,31