Measuring the coherence between the Smart Specialization Strategy and regional innovative capabilities

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Abstract

The implementation of the Smart Specialisation Strategy (S3) has required regions in the EU to identify the technological domains where they will focus innovation policy. Choosing the best-suited domains involves a challenging assessment of the technological domains in which the region demonstrates superior innovative capabilities and that are going to facilitate diversification into new sectors. Given that regional specialization shows a high degree of path dependence, successful diversification can be achieved only in domains that are closely related to the existing knowledge base. The aim of this paper is to provide a first empirical assessment of the coherence between the technological domains chosen by Italian regions and those in which they show actual capabilities in research and innovation, as measured by their patenting activity in recent years. The paper develops a methodology to characterize the technological domains of the S3 and compare them to the actual innovation capabilities of the region.

Keywords: smart specialization strategy; innovative capabilities; regional development; regional innovation policy.

Introduction

The design and implementation of the Smart Specialisation Strategy (S3 from now on) has called for an effort from regional authorities aimed at identifying the specialisation domains where they are expected to concentrate the allocation of resources and target their innovation policy (Foray et al., 2012; McCann and Ortega-Argilés, 2013). Choosing the specialisation domains has been a challenging task for regional authorities for several reasons (Iacobucci, 2014). The major challenge was presented by the novelty of the design process. According to the EU guidelines (Foray et al., 2012), the design of S3 had to follow a bottom-up approach in which ‘entrepreneurial discovery’ was one of the main features. The second major challenge for regional authorities was the fact that specialization had to refer to technological domains rather than to industrial sectors. The emphasis on technology rather than on products or services is the result of the theoretical underpinnings of the S3 strategy: the emphasis is on linking *research* and *innovation*, and on the diversification of regional productions.

Smart specialisation strategies are meant to identify priorities for future regional development trajectories. In principle, they should originate from an effective matching of the opportunities in terms of ‘knowledge and technological specialization’. Consequently, the specialization domains chosen by regions are expected to satisfy the following criteria: i) the region is expected to show an effective strength in terms of research and innovation; ii) the chosen domains are expected to provide opportunities for the development of new products and services.

The underlying idea is that targeting the most promising technological domains will facilitate product innovation and the diversification of existing specialization through the creation of new technologies and production. Moreover, it is also expected to contribute to the technological upgrading of existing sectors through a more effective matching between the creation of new knowledge and its application (McCann and Ortega-Argilés, 2015).

In principle, the choice of technological domains should originate from an analysis of the region’s economic, technological and research specializations, aimed at identifying those with the greatest potential. As mentioned before, one of the major practical challenges in the design of S3 was the shift of emphasis from industrial sectors to technological domains. Although this shift was the logical consequence of the theoretical approaches underlying S3, at the practical level it posed several difficulties.

One of the obstacles is the absence of a map linking technological domains and industrial sectors. This map would be extremely useful for recognising the technological domains that are more relevant, taking into consideration the industrial specialization of a region, as well as being helpful for identifying the technological upgrading opportunities of existing sectors. It would be

even more significant for the understanding of what new production opportunities may originate from an investment in a specific technological domain. In the absence of this map, regions have relied on a bottom-up process for the identification of such links. In particular, those links were suggested by firms, researchers and technology experts during several rounds of focus groups and other consultation practices that were at the basis of the ‘entrepreneurial discovery’ process (Foray et al., 2009). The underlying logic is that firms and researchers directly involved in the development of technology and products are better equipped than policy makers in the selection of the most promising domains in which it would be worthwhile to invest public and private funds. Notwithstanding the validity of this argument, we believe that the choice of the technological specialization domains cannot rely on a ‘pure’ bottom-up approach. The many requests arising from researchers and firms must be selected and mediated according to the main aims of the S3: to make it a coherent strategy, rather than a collection of different (and potentially conflicting) interests.

Another obstacle that regions have had to face is the lack of data that are suitable for the analysis. Indeed, most of the available economic data are organized according to the classification codes of economic activities (NACE). Industry classification systems are mainly based on the description of products or services and may not be appropriate when trying to identify the technologies that are useful in a specific production. This problem is even greater if we consider that products are becoming increasingly complex and that their production makes use of knowledge originating from many heterogeneous technological domains. This tendency is evident when looking at the growing relevance of the so-called transversal or key technologies: i.e. technologies that may have important applications in many sectors, sometimes very distant from the one in which they had been originally developed.

An additional practical problem that regions have had to address in the identification of technological specialization domains was the absence of a codified system for their classification. Consequently, in the S3 documents the specialization domains (as well as the more detailed sub-domains) are presented using the natural language. This choice allowed regions to be somewhat flexible (and sometimes ‘creative’) in the identification of domains. However, it also presents several drawbacks. The first is the lack of ‘control’ regarding the content that is actually considered within a specific label. The second is that different labels could be used to refer to the same technological domain. The third is that it reduces comparability and hinders the possibility of performing quantitative analysis of S3.

Starting from these premises, this paper has two main objectives: the first is to describe in a more rigorous and controlled way the technological specialization domains chosen by regions in their S3 documents; the second is to provide a quantitative analysis of the coherence between the chosen

technological specialization domains and the actual strength of regions in those domains. More specifically, we seek to answer to the following questions: have regions chosen technological domains according to their actual innovation capacity? Have they selected technological domains in which they are increasing their specialisation?

To overcome the problem about the taxonomy of technological domains, we rely on the International Patent Classification system (IPC). This system is adopted by patent offices around the world to classify the technological domains to which a patent refers. Indeed, it is a widely known and universally adopted technology classification system, thus referring to technological domains instead of to industrial domains.

We focus our analysis on Italian regions. In particular, for each region we associated the specialisation domains declared in the S3 documents with the corresponding IPC codes. Specifically, we used the most detailed description of technologies provided in the S3 documents and linked them to the 3-digit IPC codes.

In order to measure the degree of specialization in specific technological domains, we calculated several indicators of technological specialization based on patent applications between 2002 and 2012 whose inventors are located in a specific region. Moreover, we also computed an index measuring whether a certain region is increasing its specialization in a certain technological domain. Our final measures of coherence attempt to quantify the degree of overlapping between the technological domains chosen by regions and those where regions are actually specialised, as proxied by their patenting activity.

The analysis allows us to measure the degree of coherence between the technological domains chosen by regions and those domains in which they show an absolute or relative strength in the patenting activity.

The paper is organized as follows. Section 2 presents a discussion of the rationale behind the identification of technological domains within S3 and the questions that this has posed for S3 design. Section 3 presents the data and the methodology applied. Section 4 discusses the empirical results. Section 5 draws the main conclusions and suggests the principal research and policy implications.

Background literature and research hypotheses

The S3 approach represents a major novelty in EU regional policy. As a necessary condition for obtaining structural funds for the programming period 2014-2020, regions were asked to design a development and innovation strategy, the so-called Smart Specialization Strategy (S3), to be

approved by the EU Commission. In particular, the S3 approach required regions to select a few specialization domains in which to focus their innovation policy(Foray et al., 2012).

The S3 approach combines recent theoretical advances in innovation policy and regional development (Foray et al., 2009). At the design level, the S3 approach has proposed two main novelties. The first one is the emphasis on the *bottom-up approach* in choosing the specialization domains. In fact, the choice should be the result of an ‘entrepreneurial discovery’ process where the actors of the regional innovation system, most notably firms and universities, contribute to identifying the domains in which the region is more likely to achieve a competitive advantage. The second relevant novelty in S3 is that the specialization domains should refer to *technological domains* rather than to industrial sectors.

The shift from industrial to technological domains is the consequence of two theoretical arguments: i) the relevance of research and development as one of the main drivers for innovation; ii) the importance of the knowledge capabilities for diversifying regional productions. The former argument points to the increasing importance of investments in research and development (R&D) and of linking research and innovation, as opposed to investments in the mere application of existing knowledge to specific products and services. The latter argument originates from the conclusions of the new evolutionary economic geography (Lambooy and Boschma, 2001; Boschma and Frenken, 2011). According to this theory, ‘successful’ regions are those that are able to diversify their production over time according to changing conditions in markets and technologies. This diversification process is path-dependent and conditioned by the knowledge endowments of the region (Neffke et al., 2011). This knowledge base is represented by technological know-how and organizational routines which can be applied to several products and services. While products and services may change to face market needs, the knowledge base does not change rapidly over time, since it is the result of a much slower accumulation process. Therefore, a region’s diversification capability lies in its accumulated knowledge base rather than in specific products or services. For this reason, innovation policy should target the development of this knowledge base (technological domains) rather than specific products or services.

The need to identify technological domains rather than industrial sectors has posed two main challenges to regions. The first is the lack of suitable data and information about the knowledge base of a region. In fact, most of the data and information about firms (and production in general) has been collected and organized according to industry classification systems (NACE in the case of Europe). The second challenge is the absence of a shared methodology for identifying the technological domains which are more promising for innovation and diversification.

Both issues were expected to be partially overcome by the ‘entrepreneurial discovery’ process (Foray et al., 2012). Firms, researchers and technology experts involved in this process were expected to give suggestions to regional governments on the most promising technological domains and research projects in which to concentrate resources. The idea is that firms and researchers directly involved in the development of technology and products are better equipped than policy makers in both defining and selecting the most promising domains.

As a consequence of this process and of the absence of shared methodologies, in the S3 documents the technological domains are identified using the natural language (Iacobucci and Guzzini, 2016). For example, ‘home automation’ or ‘mechatronics’ at the level of specialization domains, or ‘tissue engineering for regenerative medicine’ at a higher level of detail. Indeed, regions have adopted a tree structure based on two, and sometimes three levels. The first level contains the indication of the specialization domains in relatively broad terms (i.e. ‘health and wellness’, ‘mechatronics’, ‘aerospace’, etc.). At this level, the specialization domains are limited in number (generally less than ten) even for large regions. The second level specifies the technological fields included in the general domain: for example, ‘biorobotics for rehabilitation’ within the ‘life science’ domain. Some regions used a three-level structure, with a more detailed description of the technological fields identified at the second level.

The use of the natural language in the definition of the specialization domains (level 1) and technological fields (level 2 and 3) has several drawbacks. First, the level of aggregation (or disaggregation) is not consistent across regions.[1]Second, different labels may be used to refer to the same technological domain. Third, the lack of a common general classification reduces comparability and hinders the possibility of performing quantitative analysis of S3.

The use of quantitative methods is relevant for several reasons. According to the S3 approach the choice of the specialization domains should be mostly based on the ‘entrepreneurial discovery’ process. However, the definition of the specialization strategy cannot rely on a ‘pure’ bottom-up approach. The many requests arising from researchers and firms have to be selected and mediated in order to develop a coherent strategy. This means that a more objective (i.e. quantitative) analysis of the specialization domains could help policy makers in choosing the technological domains which are more relevant for the region according to the aims of the S3.

To overcome the limitations imposed by the use of the natural language, it is necessary to use a homogeneous classification of technological domains. The most obvious response to this need is the

[1]For example, the maximum detail of specification may be very different, ranging from a broad technological domain (e.g. ‘micro and nano-electronics’) to a very specific one (e.g. ‘new polymer alloys obtained by combining polymers with non-polar saturated and unsaturated rubbers by extrusion in the molten state’).

use of the International Patent Classification (IPC), a system adopted by patent offices around the world to describe the technological fields a patent refers to. The IPC is a knowledge categorization system designed by experts with several hierarchical levels that has been refined over 35 years. Besides the advantage of being a classification of technologies rather than of products and services, IPC allows to relate in a direct way the technological domains chosen by regional governments and the patenting activity within the same region.

Patents represent one of the main outputs of the innovation process. Moreover, they indicate technological domains in which firms and research institutions are investing and accumulating knowledge. However, patents are not the only output of innovative activity and indeed may not give an exhaustive representation of the knowledge base of a region. In some sectors, patents are less relevant for protecting technological knowledge and therefore their use is limited. In addition, while patents represent a form of codified knowledge, most technological know-how is based on informal non-codified knowledge.

We think that these limitations are less relevant for our analysis. As previously discussed, one of the aims of the S3 is to promote a more effective link between research and innovation. For this reason, it emphasizes the need to target technological domains in which the region is able to develop new knowledge by increasing the investment in R&D. The number of patents granted in those domains is one of the main indicators of the capacity for developing new knowledge.

This paper is a first attempt at providing a classification of the technological domains contained in the S3 documents in terms of IPC codes and applying this classification to carry out a quantitative analysis aimed at assessing the coherence between the technological domains chosen by regions and those in which they show an effective competitive advantage, as measured by their patenting activity.

More specifically, the paper has the following aims. The first is to provide a systematic association between the technological domains contained in the S3 documents (at the highest level of detail) and the corresponding IPC code. Taking this association as a starting point, it develops a quantitative analysis based on patenting activity observed in the regions. The main aims of the empirical analysis are the following:

- Assessing to what extent regions have chosen technological domains in which they show an actual innovation capacity;
- Assessing to what extent regions have chosen technological domains in which they are increasing their specialisation.

Data and methodology

S3 data

The empirical analysis is based on the analysis of the S3 documents officially approved by 20 Italian regions. These documents have been analysed to extract the technological domains chosen by the regional authorities at the highest level of description. Since every region has defined them in a non-codified way, we first had to homogenize the taxonomy in order to have fully comparable information. The second step consisted of a systematic association between the most detailed description of technological domains provided in the S3 documents and the corresponding International Patent Classification (IPC) 3-digit codes[2]. This association was carried out in a semi-automated way by using the publicly available service IPCCAT (Categorization Assistant in the International Patent Classification).3 The automatic mapping was then revised by experts.

For example, the Campania region indicated 6 technological domains among which Aerospace. Under the latter domain the S3 document listed 35 specific technological sub-domains (at the most detailed level). An IPC code was associated to each of them, resulting in 5 unique different IPC codes (at three-digit level).Thus, we obtained a detailed map of the chosen technological domains and corresponding IPC codes(see Table 1 for an example).[4]

The S3 documents were mapped into 64 different IPC codes, with G06(Data processing systems or methods) being the code with the highest frequency across regions. Out of the 64 IPC codes,20 codes (31%) have a frequency equal to 1, suggesting a moderate level of diversification of the Italian regions in choosing their specialization domains.

Each Italian region k is characterized by a set of IPC codes S_k corresponding to the technological domains chosen within its S3 strategy. In other words, if an IPC code i is in the set S_k then the region k has indicated the corresponding technological domains in its S3 documents.

The use of IPC codes in characterising the specialization domains is important for detecting similarities or differences in the domains chosen by regions. Indeed, in some cases regions used the same (broad) label under which they comprised different technologies or used different labels to refer to the same technological domain.

[2]http://www.wipo.int/portal/en/
[3] www.wipo.int/ipccat/
[4] The list of all the technological domains indicated by Italian regions and the corresponding IPC classes are provided in the Appendix. Abruzzo is not included among the regions analysed because the S3 document indicates the general domains of specialization (namely, agrifood, life science, ICT/aerospace, fashion/design) but did not provide a detailed description of the technologies included in these domains. This made it impossible to determine the IPC classes associated to the specialization domains.

Patent data

We retrieved patent data using the OECD RegPat database (February 2016 version) which provides information about the IPC codes a patent belongs to and the address of its applicant(s) and inventor(s). We looked at the PCT patent applications from 2002-2012 with at least one of the inventors localised in Europe, this was in order to assign to each European NUTS2 region the corresponding number of patents. These data allow us to assess the dynamics of innovation and technological specialization within the European regions as measured by patents.

We computed the fractional count of PCT applications for each 3-digit IPC class (if a patent was classified in more than one IPC class, its fractional count is considered for every IPC class it belongs to) in each year and European NUTS2 region.

Specialization measures

In order to characterize the technological domains a region is specialized in, we refer to three types of patent-based measures: i) the relative specialization in an IPC class; ii) the positive trend in the relative specialization in an IPC class in the time window we are taking into consideration; iii) the absolute value in terms of number of patents in an IPC class. We describe these measures in detail.

Relative specialization measure

In order to measure the actual relative technological specialization at the NUTS2 level we used the Balassa Index, also known as Revealed Comparative Advantage (RCA) index. We defined the RCA as follows:

$$RCA_{k,i} = \frac{\dfrac{X_{ki}}{\sum_{k=1}^{K} X_{ki}}}{\dfrac{\sum_{i=1}^{I} X_{ki}}{\sum_{k=1,i=1}^{K,I} X_{ki}}}$$

where X_{ki} is the sum of the fractional count of PCT patents in the period 2002-2012 in region k belonging to IPC class i. Therefore, $RCA_{k,i}$ is the ratio between the patent share of region k in IPC class i and the patent share of IPC class i in the world. Since the Balassa index tends to have an asymmetric and skewed distribution, we computed a symmetric version of this index by applying the following transformation (Dalum et al., 1998):

$$RCA_{k,i}^{norm} = \frac{RCA_{k,i} - 1}{RCA_{k,i} + 1}$$

We dichotomized the $RCA_{k,i}^{norm}$ using the threshold 0, since values below 0 point at a negative relative specialization in a certain technological domain as identified by the 3-digit IPC class of a certain region, while values above 0 indicate a positive relative specialization. Hence, we obtain a $K \times N$ matrix (D_{bin}), where each cell is equal to 1 if the region k is positively specialized in the IPC class i. By way of example, we show an extraction of this matrix in Table 2.

Positive trend measure

Second, we seek to know whether a region is significantly increasing its technological specialization in a certain IPC class in the time window from 2002 to 2012. In order to do so, for each combination of region k and IPC class i we perform a regression of $RCA_{k,i}^{norm}(t)$, computed year by year, with the time variable t (i.e. *year - 2002 + 1*) as regressor. We say that region k is characterized by a positive growth trend in IPC class i when the coefficient of the variable t is positive and significant (at the 80% level). Hence, we say that the variable $trend_{k,i}$ is equal to 1 if the region k shows a positive growth trend in the IPC class i and 0 otherwise.

Absolute value measure

Finally, in order to have a measure of the absolute 'importance' of a region in a certain IPC class, we consider the fractional count of patents for each region in the period 2002-2012. The variable $NPat_{k,i}$ is equal to the fractional count of PCT applications of the region k in the IPC class i over the period 2002-2012. Please note that this measure identifies the number of patents with at least one of its inventors located in a specific European NUTS2 region. Then, we dichotomize this variable using the median of nonzero values across regions as threshold, namely $\underline{t}$.

Coherence indicators

In this paper, we aim to assess the extent to which Italian regions have chosen the S3 technological domains according to strength in terms of innovation capabilities as measured by patenting activity, i.e. the coherence between S3 innovation strategy and actual attributes in terms of innovative capacity. In order to do so, we compute several indexes for each region *k*:

a. number of technological domains (IPC classes) declared in the S3 documents;
b. number of technological domains (3-digit IPC classes) in which a region is specialized, as measured by the Balassa index;
c. index of coherence based on RCA: share of chosen S3 technological domains in which a region is actually specialized, according to its normalized RCA index

$$\mathrm{R_k} = \frac{\sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{I}(\mathrm{i} \in \mathrm{S_k}) \cdot \mathrm{I}\left(\mathrm{RCA}_{\mathrm{k,i}}^{norm} > 0\right)}{\sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{I}(\mathrm{i} \in \mathrm{S_k})}$$

d. number of technological domains (3-digit IPC classes) in which a region is significantly increasing its specialization (according to the above-mentioned positive trend measure);

e. index of coherence based on RCA and positive trend measures: share of chosen S3 technological domains in which a region is either i) actually specialized (according to its normalized RCA index) or ii) significantly increasing its specialization (according to its positive trend measure)

$$T_k = \frac{\sum_{i=1}^{N} I(i \in S_k) \cdot I\left((RCA_{k,i}^{norm} > 0) \vee (trend_{k,i} = 1)\right)}{\sum_{i=1}^{N} I(i \in S_k)}$$

f. number of technological domains (3-digit IPC classes) in which a region has a number of patents over the median of non-zero values across regions;

g. index of coherence based on the absolute value measure: share of chosen S3 technological domains in which a region is actually relevant (the absolute number of patents belonging to the last quartile at the European level)

$$A_k = \frac{\sum_{i=1}^{N} I(i \in S_k) \cdot I\left(NPat_{k,i} > \underline{t}\right)}{\sum_{i=1}^{N} I(i \in S_k)}$$

Empirical results

As expected from the logic of S3, regions have chosen a number of specialization domains, which is a subset of those in which they show a relative specialization (i.e. RCA>0); on the average the former are about one-third of the latter (see Table 3). However, there are large differences around the mean. The opposite cases are Toscana and Campania that show a similar number of technological fields with relative specialization (48 and 47 respectively): however, Toscana indicated only 6 technological domains in its S3 document, while Campania indicated 33 technological domains. Regions that show a ‘narrow’ focus in their S3 (compared with their actual span of specialization) are Marche, Sardegna, Molise, Provincia Autonoma di Bolzano, Umbria, Veneto and Sicilia. On the contrary, together with Campania there are other regions that opted for a larger span of specialization: Basilicata, Calabria and Provincia Autonoma di Trento.

Besides the large or narrow span of specialization chosen by regions, the question we are interested in addressing is whether the chosen domains are within the ones in which the region has a relative advantage (as measured by the RCA index). We referred to it as an indicator of ‘coherence’ between the observed and the chosen specialization. On average, the degree of ‘coherence’ is slightly less than 50%. Moreover, also in this case (as for the span of specialization) there are large

variations around the mean, from the lowest values of Toscana and Sardegna (0.17 and 0.25 respectively) to the highest values of Puglia and Veneto (0.64 and 0.62 respectively).

Based on the two indicators discussed above (i.e. the span of specialization and the degree of coherence) regions can be divided into four groups according to their distance from the mean values of the two indicators (see Figure 1). In theory we should expect a negative relation between the two indicators: the larger the span of specialization, the higher the risk of losing coherence in the choice of technological domains. For this reason, regions were expected to be distributed in the second and forth quadrant. This is true for about half of the regions. However, there are several regions that, despite a narrow span of specialization, show a low degree of coherence and a few regions that, despite the larger span of specialization, show a level of coherence above the mean.[5]

It is worth remembering that we are using the concept of coherence in a 'neutral' way. It does not imply any judgement on the choices made by regional governments. They may have chosen domains in which there is not an actual specialization because of their future potential or because they emerged from the entrepreneurial discovery process. However, whatever the criteria has been for including a specific technological domain, it is relevant to know to what extent the region already had shown a strength in it.

We have extended the analysis of coherence by considering other indicators that may characterize the technological strengths of a region besides the index of relative specialization (RCA). Specifically, we have chosen two indicators.

The first is the trend in patenting; we look at those technological domains in which the RCA indicator has increased in the period before the design of the S3. The second is an index of 'absolute' strength (see previous section). A region may not have a relative specialization in a technological domain but nevertheless its choice could be justified by the fact that it is increasing the innovative activity in that area or has a critical mass of R&D activity and patents in it. This latter index is highly dependent on the size of the region and on its innovation capabilities. Large regions with a large and diversified knowledge base enjoyed a greater degree of freedom in choosing their specialization domains, as they reach a critical mass of accumulated technological knowledge in a large number of technological domains. This is not the case of small regions or regions with a low level of innovation performance (most of the Southern regions in the Italian case) that had to make their choices from among a much smaller set of promising technological domains.

[5] The latter result is not unexpected if we consider that the number of technological domains chosen by regions is only one third of those in which they showed a relative specialization.

Table 3 shows the technological domains in which regions have increased the relative specialization during the period before the design of the S3. The number of these technological domains is much smaller than those in which the region is specialized. Moreover, out of the 73 IPC classes in which the Italian regions have increased their specialization in the period 2002-2012 only 12 were included as specialization domains in S3. Half of these IPC classes were already considered in the previous indicator of coherence, as they were already comprised within those IPC classes in which the regions showed a relative specialization. As a result, the inclusions of the 'trend' indicator resulted in a significant increase in the coherence indicator only in a few regions (see *Table 3*).

The situation changed significantly when we consider the absolute strength of regions in patenting activity, as measured by having a number of patents above the median of EU regions. As previously mentioned, in this case the size of the regions matters, as they have a large number of technological domains in which they show absolute strength. On the other hand, we find small or less-developed regions that have none or only a few domains in which they show a significant patenting activity (see *Table 4*). This produces a dichotomous distribution of the coherence indicator. The largest and most-developed regions (such as Lombardy, Emilia Romagna, Veneto, Piemonte, etc.) show a coherence indicator equal to 1 or just above 1, as they had the possibility of choosing from a large number of technological domains where they have significant patenting activity. On the opposite front, there are the small or less-developed regions (Basilicata, Calabria, Molise, Sardegna and Valle d'Aosta) that had none of several of the technological domains with a significant patenting activity.

We should expect a positive relation between the span of specialization (i.e. the number of technological domains in which a region has chosen to specialize) and the share of IPC classes in which the region shows an absolute strength. The logic behind this expectation is that if a region does not already possess a critical mass in a technological domain it would be more difficult to obtain a significant competitive advantage in that domain. As a result, we expect that investment will be concentrated in fewer domains, as this will raise the likelihood of overcoming the initial weakness.

As shown in

Figure 2, this expectation is satisfied in general, but has some exceptions. Specifically, there are a few regions that, despite the low number of domains in which they show absolute strength, have nonetheless chosen a large span of specialization, thus resulting in a low level of the coherence indicator.

As a robustness check of the results obtained, we repeated the analysis using EPO applications instead of PCT applications. Figures 3 and 4 replicate figures 1 and 2 using EPO applications.

Conclusions and further development

The main aim of this paper is to provide a first assessment of the coherence between the technological domains chosen by regions for the implementation of their Smart Specialization Strategy and those in which they show an actual strength. The latter has been measured in several ways: an index of relative specialization (which is independent of the size of the region and the number of patents), the trend in knowledge accumulation, and the absolute strength in a technological domain.

To construct those indicators and to relate them to the domains actually chosen by regions, it was necessary to define them in a homogeneous way. In fact, regions used the natural language to indicate their specialization domains. To this aim we used the classification of technology provided by the IPC, i.e. the international classification codes of patents. We associated the specialization domains indicated by regions to the corresponding IPC codes, using the highest detail of description provided in the S3 documents. As a result, we obtained a codified map of the specialisation domains selected by regions for their S3. The use of IPC codes offered not only the possibility of defining the technological domains chosen by regions in a codified and homogeneous way, but also allowed us to relate this choice to the knowledge base observed in the region, as resulting from the patenting activity of firms and research centres located in the region.

In general, the set of technological domains included by regions in the S3 is lower than those in which regions show some kind of strength. In this sense, regions have fulfilled the basic requirement of S3 in choosing a narrow set of technological domains in which to specialize. However, there are also relevant differences between regions that choose a narrow span of specialization and those that choose a large number of technological domains.

A large span of specialization may not be a problem for large and well-developed regions that have reached a high level of the ‘coherence’ index by choosing domains in which they are specialized or in which they in any case already show a position of absolute strength.

On the contrary, smaller or less-developed regions were expected to reduce their span of specialization, as they have a much reduced set of technological domains in which they show

absolute strength or in which they are have a relative specialization or a positive trend in knowledge accumulation. This expectation is not always verified. Thus, it results in a high variation of the coherence indicators, even when all the measures of relative and absolute strength in knowledge production are considered.

It is worth remembering that we are using the concept of coherence in a ‘neutral’ way. It does not imply any judgement on the choices made by regional governments. They may have chosen domains in which there is not an actual specialization because of their future potential or because these domains emerged from the entrepreneurial discovery process. This analysis is intended as a way of improving the awareness of regions on the implication of their choices. In fact, the analysis will allow regions to more fully understand the present situation of the technological domains that they have chosen in terms of absolute and relative strength. It seeks to help them in implementing the strategy and in providing a more meaningful measure of its results.

The analysis will also be useful in predicting those results. We would expect that the strategy is more likely to produce effective results in those technological domains in which a region already shows absolute and relative strength. On the contrary, it would be much more difficult to obtain effective results in those technological domains where the region has not shown absolute or relative strength.

This analysis has several limitations. The most important limitation is the use of patents as a measure of the technological specialization and innovative capacity of a region. The use of patents may undervalue knowledge production and innovation in industry sectors that use other forms of knowledge protection or that are characterized by the presence of small firms.

However, one of the most important aims of the S3 is to strengthen the link between research and innovation. It also aims at increasing product innovation as a way of strengthening the diversification of regions towards more innovative and knowledge-based productions; which are expected to result in a higher growth of productivity. In both cases, patents represent an important indicator for measuring the efficacy of the S3 in the attainment of these goals.

The methodology developed in the paper opens several promising developments. Having defined the specialization domains in a homogeneous and comparable way allows a better comparison of the choices made by region and an opportunity to evaluate the degree of ‘connectivity’ that may be attained between regions that have chosen similar or complementary domains.

Another development is to identify, for each region, those domains in which they still have an absolute or relative strength and those that have been chosen for their promising trend but that at present show a situation of relative weakness. This should allow regions to better target their policy. A third development would be to measure to what extent regions have chosen domains with a high

or low degree of technological relatedness, given that this is expected to influence the overall innovative performance of the region.

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Tables and figures

Table 1 - An example of IPCs associated to regional domains as declared in the S3 documents

Region	Regional Domains	Corresponding IPC classes
Lombardia	Aerospace	G09 B64 B81 G02 A23 A61 B82 Y02 H02 G21 A62 A99 G06 H01 B44 D01 H04 C22 B60 B63 B01
	Agrifood	
	Green manufacturing	
	Health	
	Artistic and cultural industries	
	Advanced manufacturing	
	Sustainable mobility	

Table 2 - Indicators of coherence between regional S3 technological domains and regional technological specialization

Region (in alphabetical order)	**Number of IPC codes in which the region is specialized (RCA>0)**	**Number of IPC codes chosen by the region in the S3**	**Share of IPC chosen in the S3 in which the region shows a relative specialization**
Basilicata	29	13	0.31
Calabria	39	17	0.59
Campania	47	33	0.55
Emilia-Romagna	52	15	0.47
Friuli Venezia Giulia	43	16	0.44
Lazio	45	17	0.47
Liguria	50	16	0.50
Lombardia	70	19	0.42
Marche	52	10	0.30
Molise	25	5	0.40
Piemonte	59	15	0.47
Provincia autonoma di Bolzano	44	9	0.33
Provincia autonoma di Trento	48	22	0.50
Puglia	46	11	0.64
Sardegna	44	8	0.25
Sicilia	40	10	0.60
Toscana	48	6	0.17
Umbria	46	10	0.40
Valle d’Aosta	25	9	0.33
Veneto	56	13	0.62

Figure 1 - Regions by span of specialization and degree of coherence (differences from the mean)

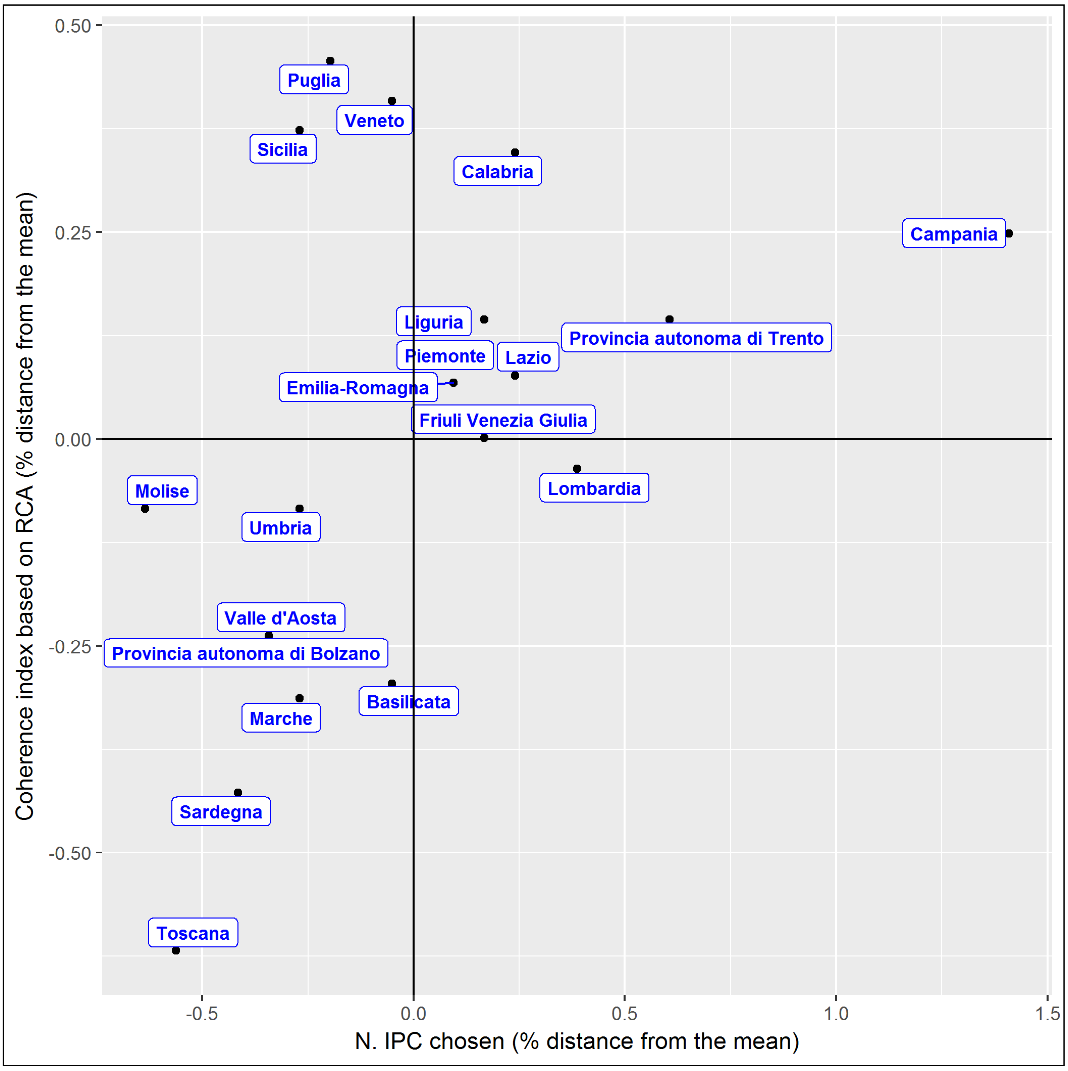

Table 3- Indicators of coherence between regional S3 technological domains and those in which the regions showed a positive trend

Region (in alphabetical order)	Number of IPC classes with a positive trend	Share of IPC chosen in the S3 in which the region shows a positive trend	Share of IPC chosen in the S3 in which the region shows a relative specialization OR a positive trend	Improvement from specialization
Basilicata			0.31	
Calabria	2	0.06	0.59	
Campania	4	0.06	0.58	0.06
Emilia-Romagna	4	0.13	0.53	0.14
Friuli Venezia Giulia	4	0.06	0.50	0.14
Lazio	5	0.06	0.53	0.12
Liguria	2		0.50	
Lombardia	8		0.42	
Marche	6	0.10	0.40	0.33
Molise	1		0.40	
Piemonte	8	0.07	0.53	0.14
Provincia autonoma di Bolzano	2		0.33	
Provincia autonoma di Trento	5	0.05	0.50	
Puglia	4	0.09	0.64	
Sardegna	2		0.25	
Sicilia	4	0.10	0.60	
Toscana	4		0.17	
Umbria	4		0.40	
Valle d’Aosta			0.33	
Veneto	4		0.62	

Table 4- Share of IPC codes in which the region has a number of patents near the EU median

Region	**Number of IPC in which the region is over the European median**	**Number of IPC codes chosen by the region in the S3**	**Share**
Basilicata	0	13	0.00
Calabria	2	17	0.06
Campania	28	33	0.36
Emilia-Romagna	109	15	1.00
Friuli Venezia Giulia	47	16	0.75
Lazio	87	17	1.00
Liguria	34	16	0.37
Lombardia	119	19	1.00
Marche	41	10	0.30
Molise	0	5	0.00
Piemonte	105	15	0.93
Provincia autonoma di Bolzano	6	9	0.00
Provincia autonoma di Trento	9	22	0.05
Puglia	13	11	0.27
Sardegna	2	8	0.00
Sicilia	5	10	0.30
Toscana	102	6	1.00
Umbria	7	10	0.00
Valle d’Aosta	2	9	0.00
Veneto	106	13	0.92

Figure 2 - Span of specialization and share of IPC codes in which the region shows absolute strength

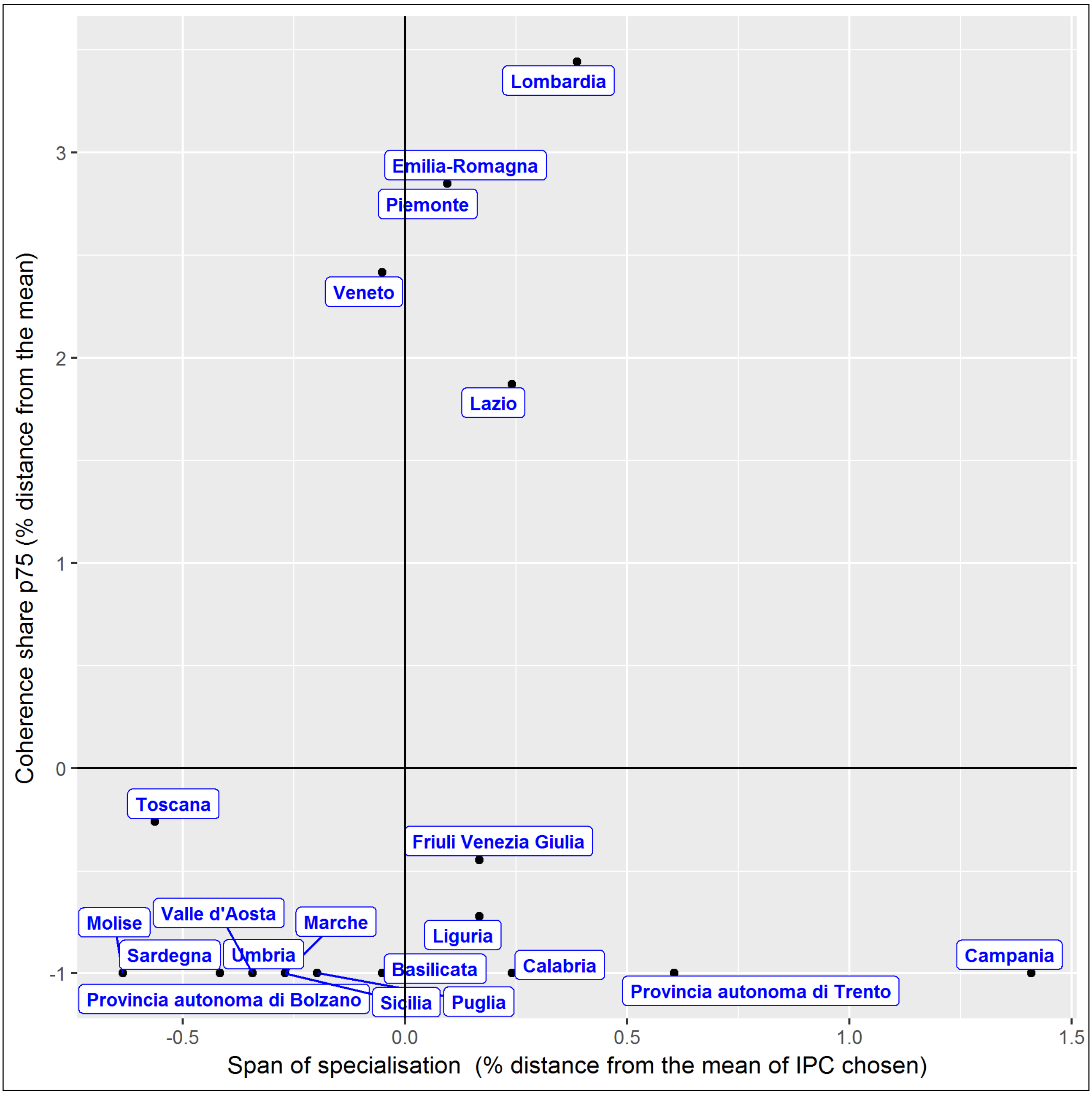

Figure 3 - Regions by span of specialization and degree of coherence (percentage difference from the mean) - EPO applications

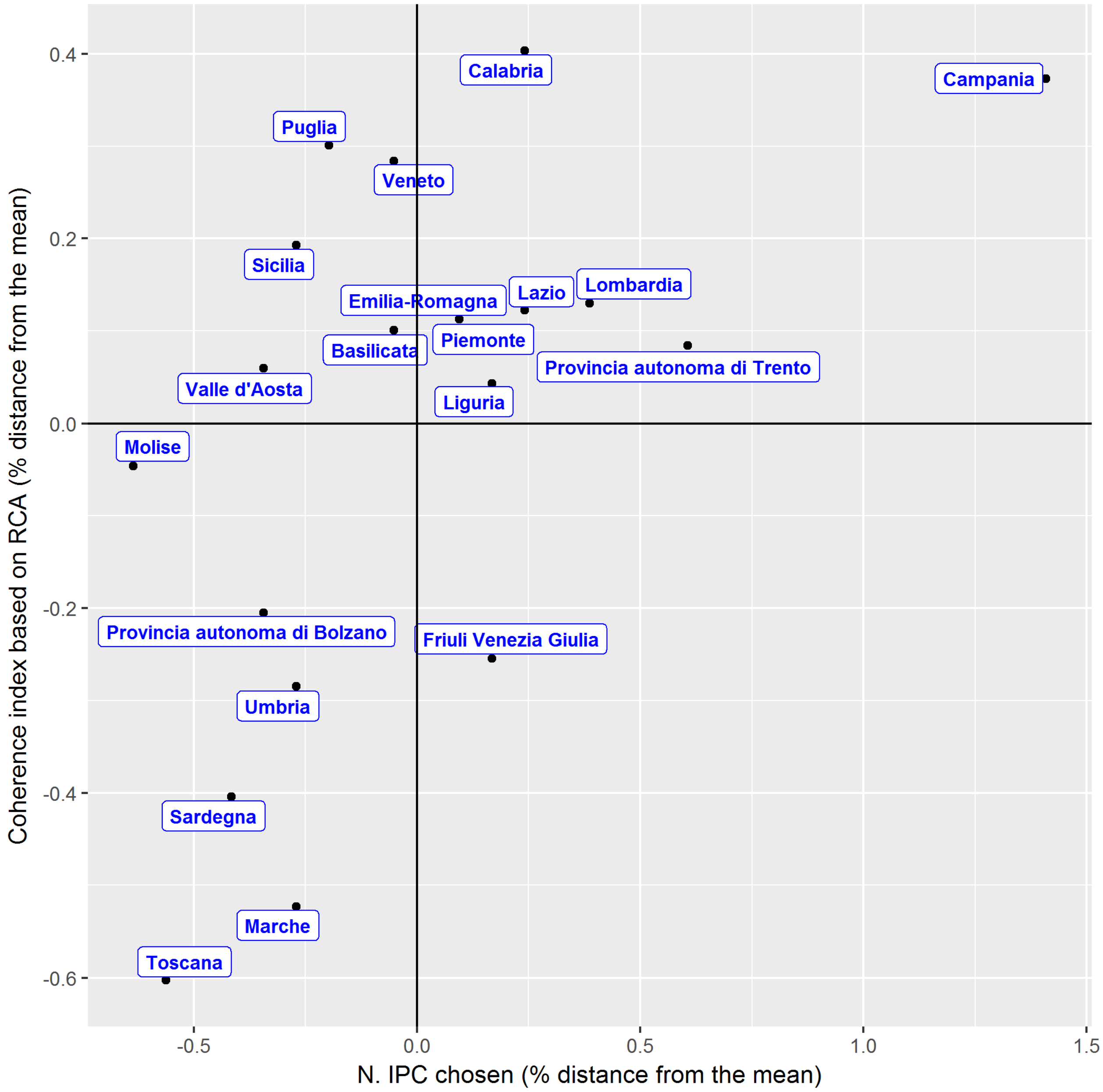

Figure 4 - Span of specialization and share of IPC in which the region shows absolute strength - EPO applications