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SMART SPECIALIZATION STRATEGY: ANY *RELATEDNESS* BETWEEN THEORY AND PRACTICE?

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Smart Specialization Strategy: any *relatedness* between theory and practice?

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Abstract

The smart specialization strategy (S3) has been at the core of European Cohesion Policy supporting regions to identify the technologies and economic sectors that might comprise sustainable growth paths. Most regions have included S3 in their development policies and devoted a share of available EU resources to their Regional Operational Programmes for the period 2014-2020. This paper provides one of the first attempts in the literature to assess empirically whether the choices made by European regions in selecting their S3 sectors are consistent, directly and indirectly, with their current specialisation patterns. The latter refer to the regional economy as a whole and not just to the manufacturing sector. Previous contributions that have focused on patent data may be biased because of the concentration of patenting within manufacturing. Analysis of S3 strategies draws from the EC official S3 website, where all regions were compelled to disclose their industrial and technological targets. Results show that regional strategies are heterogeneous. There are a few regions that have chosen a new S3 path rooted both in current sectors within which they enjoy comparative advantage and on related activities. However, overall, regions have not selected sectors highly associated with their current specialization or closely related to it, indicating a limited potential for S3 to activate successful growth trajectories that leverage existing capabilities.

Keywords: Smart Specialization Strategy, regional development, capabilities, revealed comparative advantage, relatedness
Jel codes: L52, O18, R11, R58

1. Introduction

The European Union (EU) has assigned a central role to the Smart Specialisation Strategy (S3) within the development agenda of the Europe 2020 program promoting smart, sustainable and inclusive growth (Foray et al. 2009; Foray et al. 2012; McCann and Ortega-Argiles 2015). The Regional Operational Programme 2014-2020, and especially the European Regional Development Funds (ERDF) initiative, have incorporated S3 policy in their agendas, devoting significant financial resources to implement the bottom-up, entrepreneurial discovery approach envisaged by the new program. Over the period 2014-2016, all EU regions defined their S3 sectoral policy targets after long negotiation with local stakeholders and EC officers. These priorities are currently being implemented through public calls and other administrative procedures: financial resources must be spent by 2023 following the *n*+3 rule of the 2014-2020 EU programmes.

The economic literature has devoted significant attention to S3 and to related regional policies (Foray 2015; Foray et al. 2015; McCann 2015; Nauwelaers et al. 2014; Rodriguez-Pose et \al. 2014). The fundamental logic of the S3 programme is outlined in Barca (2009), Foray et al. (2009) and by the European Commission (2012): a platform of place-based economic development that strengthens existing knowledge-based foundations of local competitive advantage, that leverages those capabilities to diversify into related technological and economic domains and seeks inter-regional synergies across Europe while reducing competitive overlap. Early overviews of the structure of the S3 program are offered by McCann and Ortega-Argiles (2014, 2015) and by Kroll (2015).

Almost immediately, the operationalization of the S3 programme, and its "bottom-up" process of identifying regional targets of economic transformation through an "entrepreneurial discovery logic" (Foray 2019) were criticized (see the recent review by Aranguren et al. 2019). Early concerns focused on operationalization and the risks of ineffective implementation, especially in peripheral regions that face additional developmental constraints (Boschma 2014; Morgan 2015; Iacobucci and Guzzini, 2016). Quality of governance questions, weak regional innovation systems, the lack of capacity in specific knowledge-based sectors, and concerns with local/regional markets and potential integration into global value chains have been highlighted (see Capello and Kroll 2016; McCann and Ortega-Argiles 2016). Broader issues with the appropriate spatial scale of policy actions, of regional "lock-in" and the complex interplay between tangible and intangible knowledge production assets, and their territorial distribution, have also been raised. Hassink and Gong (2019) remain ardent skeptics, prompting renewed defense by Foray (2019).

From our point of view, it is important to remark that the current debate, although very intense, has remained mostly speculative, with very limited evidence-based analysis (though see D'Adda et al. 2019a and Gianelle et al 2019 as exceptions). Because S3 policy will run for a few more years, it is currently not possible to evaluate its overall impact on the knowledge, innovation and production structure of regions and, more generally, on their economic development.[1] However, it is possible to examine whether the choices already made by regional policy makers in defining smart specialization strategies are coherent with

[1] A simulation of the potential impact of S3 on three Hungarian regions using a Geographic Macro and Regional model has been recently proposed by Varga et al (2020). This interesting exercise is based on the regions' industrial characteristics rather than on their actual S3 targeted sectors.

the theoretical inspiration of S3 and related EC recommendations. Assessment of the cohesion of policy implementation and policy design is also useful to guide similar policies in the future, for instance in the regional operational programmes 2021-2027, that are now being defined. In this paper, we explore the coherence (or *relatedness*) between S3 policy implementation and the theoretical foundations that support this programme as outlined by Foray et al. (2009) and Foray (2015).

In order to define more precisely our research question, we start by reconsidering the EU guidelines to the smart strategy definition. In the official S3 platform of the European Commission (EC) it is clearly stated that the regional S3 "should prioritise domains, areas and economic activities where regions or countries have a competitive advantage or have the potential to generate knowledge-driven growth". The identification and selection of such domains, areas, or activities has been a particularly difficult and challenging task for local authorities for a number of reasons (effectively discussed in Capello and Kroll 2016), which may result in risky choices. In order to test whether and to what extent this has been the case we articulate our research question into two main hypotheses:

H1. Regions selected their S3 targets in domains/areas/activities in which they *currently* exhibit revealed comparative advantage (RCA).

H2. Regions seek to generate knowledge-driven growth by developing new RCA in S3 target sectors that are related to their existing patterns of RCA.

A necessary condition to answer our research questions is to have a homogeneous and structured account of S3 policy choices identified by European regions. McCann and Ortega-Argiles (2016) provide a relatively aggregate overview using the Eye@RIS3 database. As remarked by D'Adda et al. (2019b), drilling into the details is not an easy task, given the absence of a codified system for the classification of S3 targets, because each region has specified its domain (and optional sub-domains) in a flexible and creative way so that comparisons across regions and a simple quantitative evaluation of S3 are impossible. However, to overcome these drawbacks the EC has recently classified each S3 domain according to three dimensions: the economic, the scientific and the policy dimension. It is now possible to gather information on the economic sectors selected by each region for their S3 policy. Although a lot of emphasis has been assigned to the role of smart specialization strategy in driving innovation, with most extant empirical work devoted to assess the technological coherence of S3 policy by means of patent data, the EC has recognized that S3 targets have a scope that goes far beyond the "pure" technological domain represented by patents. The reclassification of S3 targets into economic sectors has the advantage of considering the entire economy including service sectors, whose weight has steadily increased in most regional European economies, and to overcome the old-fashioned idea that knowledge could be accumulated and innovation could be realized almost exclusively in manufacturing firms or research institutions. This is crucial given that several regions, as we will see in Section 2, based their S3 policy on service activities like tourism, culture, archaeological heritage and health.

The second necessary element to test our research hypotheses is a representation of the *current* pattern of regional economic specialization. We provide that representation by computing the revealed comparative advantage (RCA) index, based on employment, across 2-digit economic sectors from the EU Labour Force Survey database, as in Balland and Boschma (2019).

Testing H2 is more challenging as we have to deal with the *potential* notion of knowledge-driven growth. To operationalize this idea, we use the concept of *relatedness density* proposed by Hidalgo et al. (2007) and widely developed in Neffke et al. 2011; Boschma et al. (2015), Balland et al. (2019) and Rigby et al. (2019). In the context of our analysis, relatedness density measures the degree to which an S3 target sector utilizes economic capabilities that are readily available within a region. Higher relatedness density implies that a target sector is a better "fit" within a region and might be read as an indicator of potential growth through diversification. The importance of relatedness for regional innovation and economic development is highlighted by Boschma (2005) and Frenken (2007). At this time, we have relatively strong empirical evidence that knowledge production within regions accumulates in a path dependent fashion around existing technological capabilities (Rigby and Essletzbichler 1997; Kogler et al. 2013; Boschma and Iammarino 2009; Boschma et al. 2015; Rigby 2015).

For the purpose of our analysis, it is important to question whether the regional selection process that identifies S3 target sectors is systematically associated with structural factors such as the stage of economic development or institutional quality within the region. In this regard, it is important to bear in mind that for the local policy-makers the inclusion of a specific sector in the S3 means that it becomes eligible for EU funds to support private investment. Therefore, the behaviour of local authorities is likely to be influenced by local economic conditions and especially by stakeholder pressure. For example, on the one hand, we may expect less developed regions to be more general in their S3 definition given the shortage of investment opportunities in their economic system. On the other hand, highly developed regions may have more choices and thus they can identify more narrow strategies, but at the same time they may face a larger number of requests by the local stakeholders.

The rest of this paper is organised as follows. Section 2 deals with the construction and the description of the database with an emphasis on the data used to identify S3 target sectors. Section 3 tests the first hypothesis on the relationship between the selected S3 sectors and the *current* regional productive specialisation. The second hypothesis is tested in Section 4 where we provide an empirical measure of proximity for the European economic space and on this basis, we assess the relatedness density of S3 target sectors. In Section 5 we discuss the main results. Finally, in Section 6 we provide some concluding remarks and policy implications.

2. Data

2.1 The Smart Specialization Strategy[2]

Smart specialization strategy has been implemented at different territorial levels in Europe, as shown in Table 1.[3] In some countries, S3 has been carried out at the national

[2] The data presented in this section have been collected from the EC official S3 web site: https://s3platform.jrc.ec.europa.eu/home. The registration in the S3 platform is compulsory, therefore we assume that it gives a full coverage of all the regional strategies realised. The key objective of the S3 Platform is the development of mutual trans-regional learning and to provide several benchmarking tools (McCann and Ortega-Argilés (2016). For a detailed description of the Platform see Sörvik and Kleibrink (2015).

level, in others at the regional Nuts-1 or Nuts-2 levels, while in Finland and Sweden it is implemented at Nuts-3. The choice to perform S3 at the national level seems reasonable for small countries while it is more surprising for large countries like Hungary and Bulgaria. The latter choice might reflect more centralised modes of governance. In total we collected data on the S3 for 205 territorial units (from now on we refer to them as "regions", regardless of the Nuts level).[4] McCann and Ortega-Argiles (2016) list a series of resources that different EU regions have been able to exploit as they craft S3 policy options.

As we have seen from the EC guidelines, each region was supposed to build its S3 on a limited number of *priorities*, namely the economic activities where the region has a competitive advantage or the potential to generate knowledge-driven growth (Foray, 2015). The process of selecting these priorities must follow the so-called "Entrepreneurial Discovery Process" through focus groups organised by the regional S3 authorities with local stakeholders (Aranguren et al, 2019). The regions' proposals were subject to long examination by EC officers before being formally approved over the years 2014-2016. The key idea of the strategy is to concentrate the managerial and financial resources available in the region on a few well-defined priorities and avoid policy dilution (Gianelle et al, 2019).

Appropriate implementation of the smart specialization strategy might begin with analysis of the number of priorities selected by the regions in their S3. From Table 2 and Graph 1 it emerges that the number of these priorities varies significantly between regions. The average number of priority targets is 6, though the range runs from a minimum of 2 in three small regions in Greece, Finland and Sweden to a maximum of 15 in Galicia. Thus, a first consideration is that the number of priorities pursued by many regions seems higher than we would have expected, although the S3 foundations don't provide very clear guidance on this issue. In Table 3 we report the average number of priorities across EU countries. The highest number is shown by Ireland (14) followed by Slovenia (9), while the lowest number of priorities (4) is found in Bulgaria and Luxembourg.

We might have expected a higher number of priorities by richer, well-developed regions that are more likely to face a higher number of requests by local stakeholders. But, at the same time, a less developed area, where private investments are scarce, may choose to be more flexible, enlarging the number and the scope of its priorities and thus trying to catch all investment opportunities. However, based on this first descriptive evidence, any clear relationship between regional development status and the number of priority targets is hard to find.

What is also remarkable is that the nature of the selected priorities is extremely variable.[5] Some of them are labelled in a very general way: *Bio-Economy and Sustainability*; *Humans and Technology*; *Energy*; *ICT*. In other cases, S3 priorities have been defined more narrowly: *Construction based on wood material*; *Surface coating technologies*; *Wind energy*; *3d printing and*

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[3] S3 has been also adopted in non-EU countries like Norway, Albania, Bosnia, Serbia, Turkey, Ukraine. We limit our analysis to the 28 EU countries, including also UK that was part of the EU when the S3 was designed.

[4] In six countries (Austria, Denmark, Germany, Greece, Poland and Portugal) the S3 carried out at the regional level has been complemented with national projects effective to the whole country.

[5] Iacobucci and Guzzini (2016) analyse the S3 priorities implemented by the Italian regions and remark that they are very general covering broad areas. See also Sörvik and Kleibrink (2015).

friction welding. Again, if a priority is intended to identify a region's competitive advantage then the narrow definition seems easier to defend. Indeed, it is hard to conceive that a region may have a comparative advantage (or disadvantage) in a field like *Humans and technology* proposed by the Austrian region Vorarlberg.

To allow for comparison of the different strategies, the EC has classified each S3 priority according to three dimensions: economic, scientific and policy.[6] For the aim of the present paper we will focus on the economic dimension that is based on 82 Nace 2-digit sectors. As we have already noted, the nature of the selected priorities is extremely diverse and therefore also the number of the economic sectors involved presents a high degree of dispersion. The average number of sectors classified in each priority is 4.7 with a standard deviation equal to 4.4. The maximum number of sectors is found in Poland's national strategy (35 sectors), followed by the Nuts-3 Finnish region Päijät-Häme and the Italian region Marche. In these regions the priorities are very general and involve a large number of economic sectors: *Innovative technologies and industrial processes*; *Circular economy*; *Natural resources and waste management*. At the other extreme, there are 224 narrowly defined priorities which are associated with only one economic sector. For instance: *Fisheries and aquaculture* in the Greek region of Notio Aigaio; *Dairy production* in the Dutch region Friesland; *Aeronautics industry* in Centru, Romania; *Logistics* in the Denmark region Sjælland; *Healthcare* in Lombardia, Italy.

In order to map the S3 choices onto the *current* regional RCA we have considered for each region the entire set of S3 targeted sectors regardless of the priorities in which they are supposed to be implemented, this constitutes a sort of regional "unified" S3 strategy. In the regional integrated strategy we have included all the Nace sectors selected at least once in the original priorities.[7] The final result is a dual matrix of 169 territorial areas and 82 Nace 2-digit economic sectors where the characteristic element x_{ri} takes the value 1 if sector i is included in the S3 strategy of region r and 0 otherwise.

In general, the higher the number of target sectors included in the region's strategy the lower the degree of concentration in the specialization areas of the regional S3. At the same time, it is important to remark that each region must allocate a significant part of its ERDF resources (like firms' financial incentives) to the priorities and sectors indicated in the S3. Therefore, a rational behaviour by regional policy-makers is to define priorities in a generic fashion to include several economic sectors in its strategy. This way the region increases its chances to meet private firm investment.

Table 4 reports the descriptive statistics on the number of economic sectors included in S3 for the 169 territorial units. The average number of target sectors is 22 (out of 82) with a high variation from a maximum of 58 to a minimum of five sectors. The regions with the highest number of sectors are in Finland and Sweden where we have aggregated the S3 defined at the Nuts3 level to the corresponding Nuts2. Interestingly, many sectors are also included in Calabria, a region of the Italian Mezzogiorno, and in the north of the

[6] The economic dimension is classified according to the NACE rev 2, the scientific dimension with the NABS 2007 and the policy on the EU objectives.

[7] We have excluded the national priorities if the S3 is carried out by the regional authorities to avoid the overlapping of different decision levels. Moreover, for Finland and Sweden the Nuts3 strategies have been added at the corresponding Nuts2 level.

Netherlands, regions that are quite different in terms of the institutional and economic context. Looking at the entire distribution reported in Map 1, a clear geographic pattern does not emerge (i.e. north vs south, east vs west, poor vs rich, country specific), which may help in explaining the choice to restrict or enlarge the S3 definition and thus the number of included sectors. The distribution of the number of target sectors across the regions is reported in Graph 2.

It is also interesting to analyse which economic sectors have been selected more frequently in the regional S3. In Table 5 we can see that 134 regions (out of the 169 considered) have chosen *Human health activities* in their strategy; other service activities like *Information service*, *Computer programming*, and *Scientific R&D* appear also very popular. The highest ranked manufacturing sectors targeted are *Food products* (6th) and *Machinery and equipment* (8th). Interestingly, 84 regions have selected the *Creative, arts and entertainment activities* (11th), which are thus considered a key driver of local development. The fact that most target sectors are service activities does highlight the issue of whether patents can capture the policy objectives of regions under the S3 programme.

2.2 The regional production structure

The analysis of the regional production structure is based on the Structural Business Statistics (SBS) provided by Eurostat. More specifically we use employment data for the year 2016 classified by Nace rev2 economic sectors.[8] Four macro sectors (A *Agriculture*; K *Financial and insurance services*; O-P *Public administration, education, health*; R-T *Arts, entertainment, recreation*) are not covered by SBS, thus employment data have been retrieved from Eurostat Regional Accounts.

We end up with a full matrix of 243 regions (mainly Nuts2) and 74 Nace sectors (a mixed of 1, 2 and 3 digit). This is a very detailed picture of the production space at the regional level in Europe and on its basis we compute the indices of the regional specialization and production relatedness. It is worth noting that 82 is the number of Nace sectors considered in the EU classification of S3, whereas 74 is the maximum number of sectors for which employment data is available in the SBS database. Finally, 64 is the number of sectors at the intersection between the set of S3 sectors and the set of SBS sectors with employment data.

3. The association between S3 and local production specialisation

The purpose of this section is to examine the degree of association between the S3 and the *current* production specialisation of different EU regions. We aim to investigate whether the sectors indicated in the regional strategies are those in which regions exhibit a comparative advantage. To answer this question, we first construct a list of 64 sectors for which we have employment data spanning 166 regions. These sectors are matched to the S3 target sectors. A balanced panel of sectors covering all regions is important to our

[8] The SBS survey presents missing data which vary from year to year, thus we have filled the missing observations for 2016 using other closed years (2015, 2014, 2017). In few cases we have also estimated Nuts 2 for the missing sectors using the sectoral shares at the higher territorial levels. Three small countries Cyprus, Luxembourg and Malta have been excluded due to the lack of data.

methodology where we calculate the relatedness of each region's S3 priorities to its existing employment structure.[9]

Secondly, for the 166 territorial units considered we have computed the standard Balassa index or Revealed Comparative Advantage (RCA) index:

$$RCA_i^r = \frac{s_i^r / \sum_i^N s_i^r}{\sum_r^R s_i^r / \sum_r^R \sum_i^N s_i^r}$$

where $\mathrm{RCA}_i^r > 1$, when region *r* employs more workers in sector *i* than the average region.

Finally, we transform the RCA values into a binary matrix where the elements x_{ri} take the value 1 if region *r* has a comparative advantage (is specialized) in sector *i* and 0 otherwise. The specialisation index is a relative measure, it means that, by construction, each region must exhibit some sectors with a positive specialisation and similarly each sector must appear as a specialisation activity for some regions. However, there are important differences across regions and sectors, that deserve a closer look. In Table 6 we report the regions which display higher and lower number of sectors with relative specialisation. The five territorial units with a wider sectoral coverage are, as expected, national countries, namely Hungary (in 38 sectors out of 64 it has a RCA) followed by Czech Republic, Slovenia and Slovakia with 36 and Croatia with 35. At the other end of the distribution we find small regions with a production structure highly specialised in only a few sectors: two Greek regions mainly devoted to tourism and related activities (Notio Aigaio and Ionia Nisia), the French Languedoc-Roussillon and Nord-Est in Romania.

In Table 7 we look at the pattern of specialization of sectors across regions, what is often termed the ubiquity of a sector. The most ubiquitous activities are *Manufacture of food products* (98 out of 166 regions have RCA in this sector) followed by two construction related activities *Construction of buildings* (95) and *Specialised construction activities* (83). Other ubiquitous activities are R*estaurant and bar services* (85) and the macro area of *Public Administration, education and health* (86). The least ubiquitous activities, those concentrated in few specific areas, are *Air transport* (RCA in only 24 regions), *Motion picture*, *TV production, music* (27) *Telecommunications* (32) and *Postal and courier activities* (32).

We have now two comparable binary matrices describing the smart specialization strategies and the actual production specialisation of each region and we can evaluate the degree of association between the two matrices as a test of hypothesis H1. In Table 8 we report the correlation coefficients between the S3 and RCA matrices at the country level. The first remarkable result is that for European countries as a whole the association is very low (sample correlation equal to 0.13). To test association between the regional distribution of S3 and its RCA counterpart we also computed the Pearson's chi-squared test. It is worth recalling (Guilford, 1936) that for the case of two binary variables the Pearson correlation coefficient is equal to the mean square contingency coefficient ϕ (with $\phi = \sqrt{\chi^2/n}$ where c^2 is Pearson's chi-squared test and n=64 is the number of sectors). In 107 out of 166 regions the null hypothesis of the test (no association) is not rejected at conventional significance

[9] The full list of the 166 territorial units and the 64 economic sectors are reported, respectively, in Table A1 and Table A2 in the Appendix.

levels.[10] This means that, on average, there is little association between the S3 target sectors and the actual production specialisation of most countries. This is a novel and relevant result in understanding the effective implementation of the smart specialisation strategy in Europe. The differences across countries are remarkable; the highest association is found in Greece (0.32) followed by Finland and Ireland. The weakest associations between S3 targets and existing sectors that exhibit RCA are found in Bulgaria and the Czech Republic that exhibit weakly negative correlations. There is no clear correlation between S3 targets and sectors of existing specialization in all the large economies including Germany, UK, France and Italy.

Looking at the association at the regional level (Table 9) we observe a positive and statistically significant association in some Greek regions. Indeed, four out of the six regions with the highest correlation coefficients belong to Greece. Among the top ten regions we find two from Poland and one from Romania, France and Spain. Very differentiated as country of origin is also the ranking of the regions with lowest association. The regional distribution of the correlation coefficients is reported in Graph 3. In general, as also displayed in Map 2, there is not a clear pattern to explain the variability in the correlation coefficients. The association is quite low with a certain degree of territorial disparity which seems quite erratic.

Thus, we have the first important result, which seems to provide evidence in contrast with what is stated in H1. On average, regional policy-makers have not selected for their smart strategy those sectors where their region enjoys comparative advantage. Clearly this result strongly contrasts with the S3 theoretical background.

To assess whether there are regularities in the policy-makers decision regarding their regional S3 sectors, we have done a simple econometric analysis, by regressing the correlation coefficient between S3 and RCA sectors on GDP per inhabitants in PPS in 2016 and the European Quality of Government Index (EQI) for the year 2013[11]. Institutional quality is a multi-dimensional concept consisting of three indexes: high impartiality, quality of public service delivery and low corruption. Estimation results indicate that policy-makers' decisions do not seem to be associated with regional structural characteristics in any significant way.

4. S3 and production relatedness

As highlighted in the introduction and stated in both the scientific and the EC documents, the key idea of the smart specialization strategy is to strengthen the areas where the region has (i) a comparative advantage or (ii) the potential to generate knowledge-driven growth. As the first goal is concerned, we established in the previous section that implementation of the strategy did not consistently target sectors with a well-established RCA. In order to test whether the selected S3 sectors are related to current patterns of specialization in regions we measure the *relatedness density* of these sectors within each region. We compute relatedness density following Hidalgo et al. (2007).

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[10] Similar results are obtained by estimating the conditional probability of selecting an S3 sector given the current RCA on the basis of logit models.

[11] This index has been developed by the Quality of Government Institute of Gothenburg University (Charron et al 2015).

First, we find the proximity matrix for the 64 sectors considered in our analysis. Proximity or relatedness between any two sectors, *i* and *j*, is given by the minimum of the pairwise conditional probability of a region being specialized in the production of sector *i* (*j*) given that it is also specialized in the production of sector *j* (*i*):

$$\varphi_{i,j} = min\{P(RCAs_i|RCAs_j), P(RCAs_j|RCAs_i)\}$$

The parameter $\varphi_{i,j}$ provides a measure of the strength of co-specialization between sectors *i* and *j* and it is computed using all 243 EU regions for which sectoral employment data are available in order to maximize the information on economic co-specialisation.[12] The resulting matrix represents the European production space, which is depicted in Graph 4 as a network. For the sake of visualization, we have aggregated different parts of the economy into 13 macro-sectors. The graph shows the relevance and centrality of services sectors across most EU regions. Economic sectors that cluster together are more highly related than those which are relatively distant in Graph 4. We interpret the relatedness between sectors as an indication of whether they share capabilities in terms of production requirements. Thus, if a region has the capabilities to produce output in one industry *i* it is also likely to possess the capabilities to produce output in industry *j* if the industries *i* and *j* are related to one another. Looking at the European production space matrix we notice that the highest value (0.74) of co-specialisation is found for the couple S15 *Man. of rubber and plastic products* and S18 *Man of fabricated metal products*. Also, the pair S34 *Retail Trade* and S40 *Accommodation* has a high relatedness (0.71). Among the total of 2016 pairs, we have only one case of fully disconnected sectors - S1 (Agriculture) and S51 (Activities of head offices) – with a zero proximity value. Only 155 pairs (7.6% of total cases) show a proximity higher than 0.5, while 445 pairs (22%) are below the 0.2 probability of co-specialisation. It is also interesting to compute for each of our 64 sectors its average value of proximity with respect to all other sectors (the row average of the symmetric matrix). The ten sectors with highest and lowest values of relatedness are reported in Table 10. Notably, the highest value of proximity is shown by S19 *Man. of computer and electronic products* followed by five service sectors. The most isolated sector in the European production space appears S42 *Publishing activities*.

Second, having obtained the sectoral relatedness matrix in production space, we calculate the *relatedness density* of each S3 sector within the regions in which they are targeted. Relatedness density provides a measure of how close, in terms of relatedness, a target sector is to the economic core of a region. The higher a sector's relatedness density to the economic core of a region, the lower the cost to the region of developing competitive advantage (RCA) in that sector. This is because as relatedness density to a target sector increases within a region, the more likely the pool of capabilities, skills and knowledge required in that sector are already available in the region. Relatedness density for sector *j* in region *r* is computed as:

$$\varpi_j^r = \frac{\sum_{i \neq j}^{N} I_i^r \phi_{i,j}}{\sum_{i \neq j}^{N} \phi_{i,j}}$$

[12] For robustness we have also computed the production space using the data for the 166 regions covered by the S3. Results are very similar, the correlation between the two matrices is 0.94.

where I_i^r is an indicator function taking the value of 1 if $RCA_i^r > 1$.

We computed the average relatedness density for S3 target sectors within each territorial unit. Average relatedness density values by country are reported in Table 11, whereas Table 12 reports the top and bottom 10 regions exhibiting the highest and lowest average values of relatedness density to their S3 target sectors. Map 3 depicts the geographical distribution of these relatedness density values. As expected, territorial units represented by whole countries exhibit the highest values of the average relatedness density. At the country level the portfolio of specializations is in general wider than at the regional level, thus it is more likely for a given sector to be surrounded by a large number of related sectors. Among the top territorial units, Île de France stands out as the Nuts2 region having the highest relatedness density (0.56) to its S3 priority targets. Surprisingly, perhaps, among the ten regions with the lowest relatedness density to their S3 target sectors, five belong to France signalling a remarkable discrepancy between the S3 priority sectors and the economic core of these regions. Most of the other regions with relatively low levels of relatedness density to their S3 target sectors are predominantly found in Southern and Eastern Europe, where the production space is very modestly characterized by co-specializations.

Overall, the average relatedness density of the S3 target sectors, ranging from 0.15 to 0.61, is equal to 0.35 across the European regions. This evidence, coupled with the modest degree of connectivity of the European production space, raises some concerns on the ability of the smart specialisation target sectors to activate successful growth trajectories leveraging existing capabilities.

As done in the previous section for the association between S3 and current RCA, we assess whether the S3 relatedness density is significantly correlated with regional structural traits as proxied by per capita GDP and EQI. Estimation results indicate a positive and significant correlation with the former and a negative one with the latter. Although significant, the size of both effects is small: a 1% increase in per capita GDP would yield a 0.0017 increase in S3 average relatedness density (which amounts to an increase of 0.48% if we consider the regional average of 0.354), while a reduction of 0.00169 is associated with a unit increase in EQI.

5. Discussion

The main results presented here indicate that S3 policy choices, by and large, have not tended to target sectors in which regions have an existing comparative advantage or the potential to develop comparative advantage as indicated by relatedness density measures. We have shown that the implementation of S3 has taken a different from that suggested by the EC in its guidelines and from that which recent work in evolutionary economic geography might have predicted. That may be because the private sector has not played a very active role in the entrepreneurial discovery process as argued by Aranguren et al. (2019). This finding does not imply any negative kind of judgement on the choices made by regional policy-makers, or that the policy will result in ineffective outcomes. However, growth strategies that are unrelated to a region's existing assets are risky and do see inconsistent with the bottom-up policy framework at the heart of the smart specialization programme.

In order to single out which possible trajectories could emerge from the evidence we have provided so far by testing our two hypotheses of interest, we represent H1 and H2 in Graph 5. This graph allows us to identify four possible scenarios, in terms of their degree of potentiality and riskiness, to provide useful insights for the design and implementation of the future regional operational programmes in the EU. More specifically, in Q1 we have a set of 61 regions (see also Graph 6 and Map 4) that have a chosen a "virtuous path" as their targeted S3 sectors are related in both actual and potential terms with their current specialization patterns. These regions have a good chance of developing new trajectories of comparative advantage. Regions in quadrant Q2 (20 territorial units), are "out of the beaten path", as they are trying to diversify their productive specialization into related sectors without shoring up existing sectors that have comparative advantage. Taking a quite different path, the regions in quadrant Q4, (the largest subset with 66 regions) have chosen a "conservative" or safe path as their S3 strategy is shaped by existing specialisation. This scenario might bolster existing strengths, in line with EC recommendations, but it also risks negative forms of lock-in if the sectoral base of these regions is too narrow and comparative advantage cannot be maintained. Finally, we identify a set of 19 regions in quadrant 3 that have designed their S3 policy targets with little regard to existing patterns of specialization or to sectors that are closely related to these specializations. This unrelated diversification scenario must rely almost entirely on external capabilities, or on a broad transformation of local capabilities and therefore could be very risky for a region.

6. Conclusions

Smart specialisation is only just over a decade old and it is, therefore, still relatively early for a comprehensive evaluation. Nonetheless, it is possible to assess how regions and countries have interpreted the conceptual framework of S3 and how they have moved from theory to practice. Most countries and regions have, as a matter of fact, included the Smart Specialisation Strategy in their development policies and devoted a share of available EU resources to their Regional Operational Programmes for the period 2014-2020. The S3 programme has attracted a lot of attention from policy-makers and academics (see the latest contributions by Hassink and Gong 2019 and Foray 2019) because it represents one of the largest experiments of place-based development policy centred on the selection of local priority sectors. In this paper, we have attempted to assess empirically how much the choices made by European regions in selecting S3 target sectors are consistent with the aim to "prioritise domains, areas and economic activities where regions or countries have a competitive advantage or have the potential to generate knowledge-driven growth".

Our analysis of regional strategies draws from the EC official S3 website, where all regions disclose their industrial and technological targets, and from the Structural Business Statistics (SBS) provided by Eurostat on employment in manufacturing and services. These two information sets allow us to examine the degree of association between S3 and *current* production specialisation, both in terms of competitive advantage and of relatedness, for most EU regions.

Results show that regional strategies are, as expected, heterogeneous, since they reflect differences in production structures, development stage, innovative capabilities, institutional setting and many other distinctive factors. Nonetheless, it is fair to say that this heterogeneity does not appear easily linked to any of these elements. More generally, we find that S3 practice has taken many different routes with respect to the guiding principles stated in the EC guidelines. In other words, a number of regions have only partially targeted sectors in which they have, on average, an existing competitive advantage or the potential to develop one as indicated by relatedness density measures.

These findings do not necessarily imply a negative assessment either on policy-makers or on the policy itself, but they certainly confirm that the implementation phase of S3 has been particularly complex and difficult (Capello and Kroll, 2016), shaping extremely diverse responses. We summarise these responses across four different trajectories of existing capabilities and related possibilities. These different trajectories are characterised by strengths and weaknesses as much as opportunities and risks. They certainly lead to further reflections on S3 policy from both a theoretical and practical perspective for potential future adjustments and improvements.

In the work presented here, regions were treated as independent units without taking into account their spatial, economic or technological connectivity and thus their opportunities to exploit proximate external capabilities (Balland and Boschma 2020). Clearly, we have more work to do to assess inter-regional interdependencies, within and between nations. The duplication of S3 policy targets across many regions raises a number of questions, but also permits interesting research designs given that not all regions chasing the same industrial targets are likely to be equally successful. In the end, the overall effectiveness of S3 policy might prove difficult to assess given the impact of the COVID-19 pandemic and different national responses to it.

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Table 1. Territorial levels of S3 in the EU countries

Territorial level		n. units	Territorial level		n. units
Nuts 0, country level			**Nuts 2 level**		
BG	Bulgaria	1	AT	Austria	9
CY	Cyprus	1	DK	Denmark	5
CZ	Czech Republic	1	EL	Greece	13
EE	Estonia	1	ES	Spain	16
HR	Croatia	1	FR	France	22
HU	Hungary	1	IT	Italy	21
IE	Ireland	1	PL	Poland	16
LT	Lithuania	1	PT	Portugal	5
LU	Luxembourg	1	RO	Romania	7
LV	Latvia	1			
MT	Malta	1			
SI	Slovenia	1			
SK	Slovakia	1			
Nuts 1 level			**Nuts 3 level**		
BE	Belgium	3	FI	Finland	21
DE	Germany	16	SE	Sweden	27
NL	Netherlands	4			
UK	United Kingdom	7			
				Total	205

Table 2. S3 priorities in the EU regions

Regions with highest number of priorities		
ES11	Galicia	15
DE4	Brandenburg	13
EL23	DytikiEllada	13
Regions with lowest number of priorities		
EL25	Peloponnisos	2
FI1D3	Pohjois-Karjala	2
SE214	Gotlandslän	2
	Total number of priorities	1288
	Average	6.0
	St. Dev.	2.4

Table 3. S3 priorities in the EU countries
(average number)

AT	Austria	5.3
BE	Belgium	7.3
BG	Bulgaria	4.0
CY	Cyprus	8.0
CZ	Czech Republic	6.0
DE	Germany	7.2
DK	Denmark	5.3
EE	Estonia	7.0
EL	Greece	6.3
ES	Spain	7.8
FI	Finland	4.4
FR	France	5.7
HR	Croatia	5.0
HU	Hungary	8.0
IE	Ireland	14.0
IT	Italy	5.5
LT	Lithuania	6.0
LU	Luxembourg	4.0
LV	Latvia	5.0
MT	Malta	8.0
NL	Netherlands	6.5
PL	Poland	5.4
PT	Portugal	7.3
RO	Romania	6.8
SE	Sweden	5.4
SI	Slovenia	9.0
SK	Slovakia	5.0
UK	United Kingdom	6.3

Table 4. Regions per number of sectors included in S3

Regions with highest number of sectors included		n. sectors
FI1C	Etelä-Suomi	58
FI1D	Pohjois- ja Itä-Suomi	52
SE12	Östra Mellansverige	51
ITF6	Calabria	48
NL1	Northern Netherlands	48
Regions with lowest number of sectors included		
DK03	Syddanmark	7
ITC4	Lombardia	7
UKN	Northern Ireland	6
UKF	East Midlands (UK)	5
Number of regions considered		169
Number of 2-digit sectors considered		82
Average number of sectors included		22.6
St. Dev.		10.3

Table 5. Nace sectors included in 169 regional S3

Sectors most included in S3		n. regions
Q86	Human health activities	134
J63	Information service activities	127
J62	Computer programming, consultancy	125
D35	Electricity, gas, steam and air conditioning supply	116
M72	Scientific research and development	114
Sectors less included in S3		
B07	Mining of metal ores	5
G47	Retail trade	5
B05	Mining of coal and lignite	4
G45	Wholesale, retail trade, repair of motor vehicles	4
B06	Extraction of crude petroleum and natural gas	2
Number of regions considered		169
Number of 2-digit sectors considered		82
Average number of inclusions		46.6
St. Dev.		32.4

Table 6. Sectoral RCA in the EU regions

Regions with the highest number of sectors with RCA		
HU	Hungary	38
CZ	Czech Republic	36
SI	Slovenia	36
SK	Slovakia	36
HR	Croatia	35
Regions with the lowest number of sectors with RCA		
EL42	Notio Aigaio	9
EL62	Ionia Nisia	9
FRJ1	Languedoc-Roussillon	9
RO21	Nord-Est	9
Number of regions considered		166
Number of sectors considered		64
Average number of RCA sectors		21.6

Table 7. Regions' RCA in the economic sectors

Sectors with RCA in regions - highest number		
C10	Manufacture of food products	98
F41	Construction of buildings	95
OPQ	P.A., education, health	86
I56	Food and beverage services	85
F43	Specialised construction activities	83
Sectors with RCA in regions - lowest number		
H53	Postal and courier activities	32
J61	Telecommunications	32
J59	Motion picture, TV production, music	27
H51	Air transport	24
Number of regions considered		166
Number of sectors considered		64
Average number of regions' RCA		56.0

Table 8. Association between S3 and RCA in the EU countries
(correlation coefficient)

Country		Corr. coeff.
AT*	Austria	0.08
BE*	Belgium	0.19
BG	Bulgaria	-0.15
CZ	Czech Republic	-0.03
DE*	Germany	0.10
DK*	Denmark	0.15
EE	Estonia	0.03
EL*	Greece	0.32
ES*	Spain	0.16
FI*	Finland	0.25
FR*	France	0.06
HR	Croatia	0.06
HU	Hungary	0.18
IE	Ireland	0.24
IT*	Italy	0.12
LT	Lithuania	0.07
LV	Latvia	0.02
NL*	Netherlands	0.09
PL*	Poland	0.12
PT*	Portugal	0.15
RO*	Romania	0.21
SE*	Sweden	0.12
SI	Slovenia	0.17
SK	Slovakia	0.02
UK*	United Kingdom	0.01
	Europe	0.13

* average of regional correlations

Table 9. Association between S3 and RCA in the EU regions
(correlation coefficient)

Regions with highest corr. coeff.		
EL42	Notio Aigaio	0.61
EL65	Peloponnisos	0.50
RO42	Vest	0.47
EL43	Kriti	0.46
PL81	Lubelskie	0.43
EL41	Voreio Aigaio	0.42
PL52	Opolskie	0.41
AT11	Burgenland (AT)	0.41
FRI1	Aquitaine	0.41
ES21	País Vasco	0.41
Regions with lowest corr. coeff.		
FRM0	Corse	-0.14
BG	Bulgaria	-0.15
FRB0	Centre	-0.16
FRG0	Pays de la Loire	-0.17
PL22	Slaskie	-0.17
UKJ	South East (UK)	-0.19
NL1	Northern Netherlands	-0.20
ITC4	Lombardia	-0.22
UKD	North West (UK)	-0.25
AT22	Steiermark	-0.28

Table 10. Minimum conditional probability of sectoral co-specialization in the European regions

ID	NACE_R2	Description	Average probability
Top 10 sectors with high co-specialisation			
S19	C26	Manufacture of computer, electronic and optical products	0.366
S39	H53	Postal and courier activities	0.358
S36	H50	Water transport	0.357
S59	N79	Travel agency, tour operator	0.356
S34	G47	Retail trade, except of motor vehicles and motorcycles	0.355
S40	I55	Accommodation	0.355
S17	C24	Manufacture of basic metals	0.351
S35	H49	Land transport and transport via pipelines	0.349
S18	C25	Manufacture of fabricated metal products	0.348
S25	C32	Other manufacturing	0.344
Bottom 10 sectors with low co-specialisation			
S29	F41	Construction of buildings	0.269
S9	C16	Manufacture of wood and of products of wood and cork	0.268
S21	C28	Manufacture of machinery and equipment n.e.c.	0.267
S13	C20	Manufacture of chemicals and chemical products	0.259
S10	C17	Manufacture of paper and paper products	0.244
S48	K	Financial, insurance services	0.231
S49	L	Real estate activities	0.215
S41	I56	Food and beverage service activities	0.210
S16	C23	Manufacture of other non-metallic mineral products	0.209
S42	J58	Publishing activities	0.165

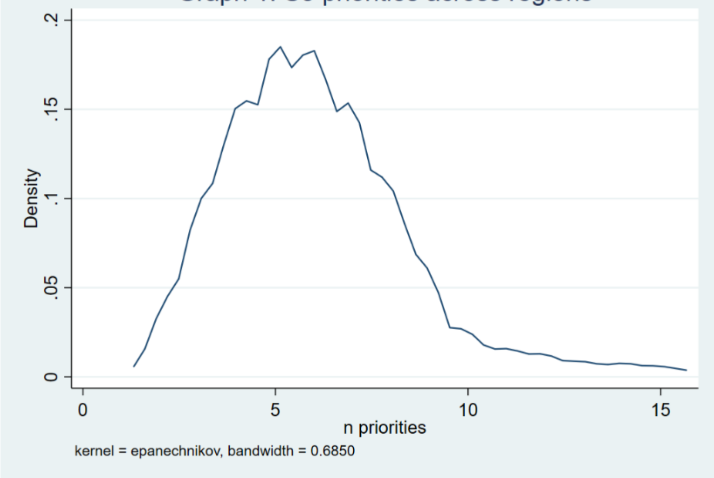
Table 11. Relatedness density in the EU countries

Country		average density	normalised density
AT*	Austria	0.41	0.52
BE*	Belgium	0.32	-0.27
BG	Bulgaria	0.37	0.14
CZ	Czech Republic	0.57	1.98
DE*	Germany	0.43	0.65
DK*	Denmark	0.34	-0.16
EE	Estonia	0.54	1.71
EL*	Greece	0.23	-1.09
ES*	Spain	0.35	-0.01
FI*	Finland	0.38	0.26
FR*	France	0.24	-1.05
HR	Croatia	0.57	1.94
HU	Hungary	0.61	2.35
IE	Ireland	0.47	1.01
IT*	Italy	0.35	-0.05
LT	Lithuania	0.49	1.20
LV	Latvia	0.51	1.38
NL*	Netherlands	0.33	-0.24
PL*	Poland	0.41	0.49
PT*	Portugal	0.32	-0.27
RO*	Romania	0.32	-0.30
SE*	Sweden	0.37	0.10
SI	Slovenia	0.58	2.06
SK	Slovakia	0.60	2.25
UK*	United Kingdom	0.41	0.54
	Europe	0.35	0.00

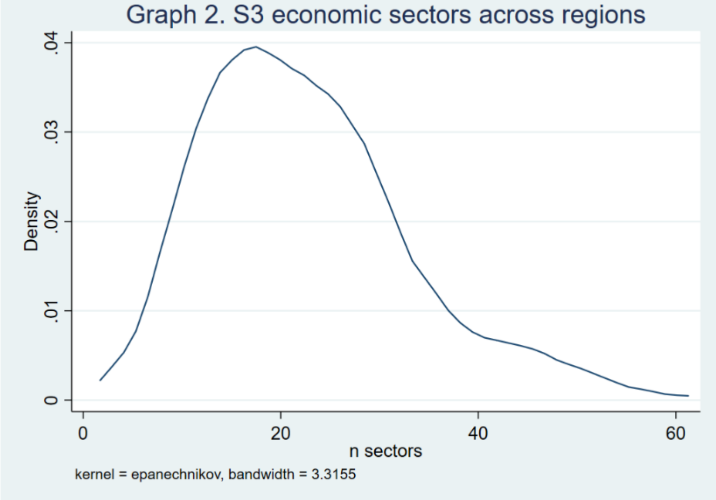
* average of regional relatedness density

Table 12. Relatedness density in the EU regions

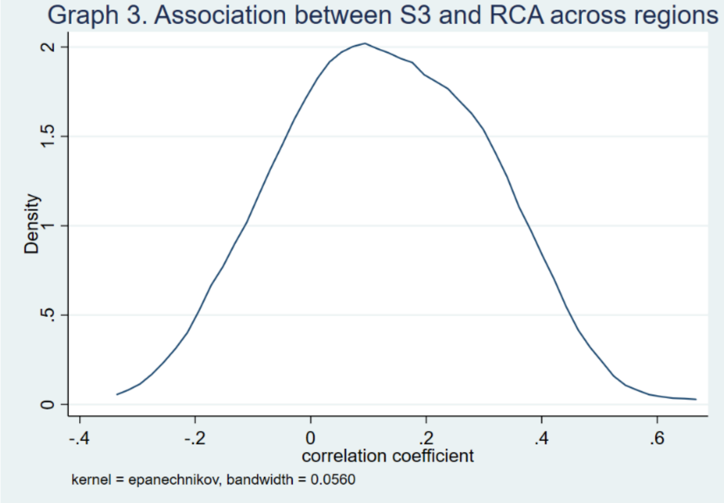
	Region	average relatedness density	normalised relatedness density
Top 10 regions with high relatedness density			
HU	Hungary	0.61	2.35
SK	Slovakia	0.60	2.25
SI	Slovenia	0.58	2.06
CZ	Czech Republic	0.57	1.98
HR	Croatia	0.57	1.94
FR10	Île de France	0.56	1.82
PL51	Dolnoslaskie	0.55	1.78
EE	Estonia	0.54	1.71
PL21	Malopolskie	0.54	1.69
DE7	Hessen	0.53	1.59
Bottom 10 regions with low relatedness density			
FRJ2	Midi-Pyrénées	0.18	-1.62
ITF6	Calabria	0.17	-1.68
FRF3	Lorraine	0.16	-1.72
EL42	Notio Aigaio	0.16	-1.74
EL62	Ionia Nisia	0.16	-1.78
EL61	Thessalia	0.16	-1.78
RO21	Nord-Est	0.16	-1.79
FRH0	Bretagne	0.16	-1.79
FRD1	Basse-Normandie	0.16	-1.80
FRJ1	Languedoc-Roussillon	0.15	-1.88



Graph 1. S3 priorities across regions

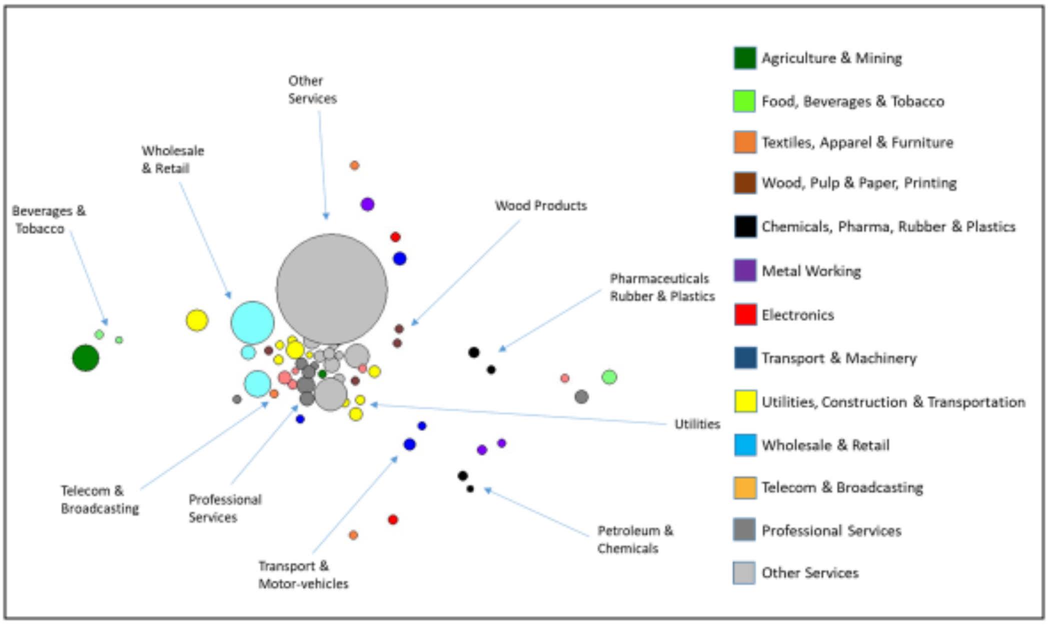


Graph 2. S3 economic sectors across regions

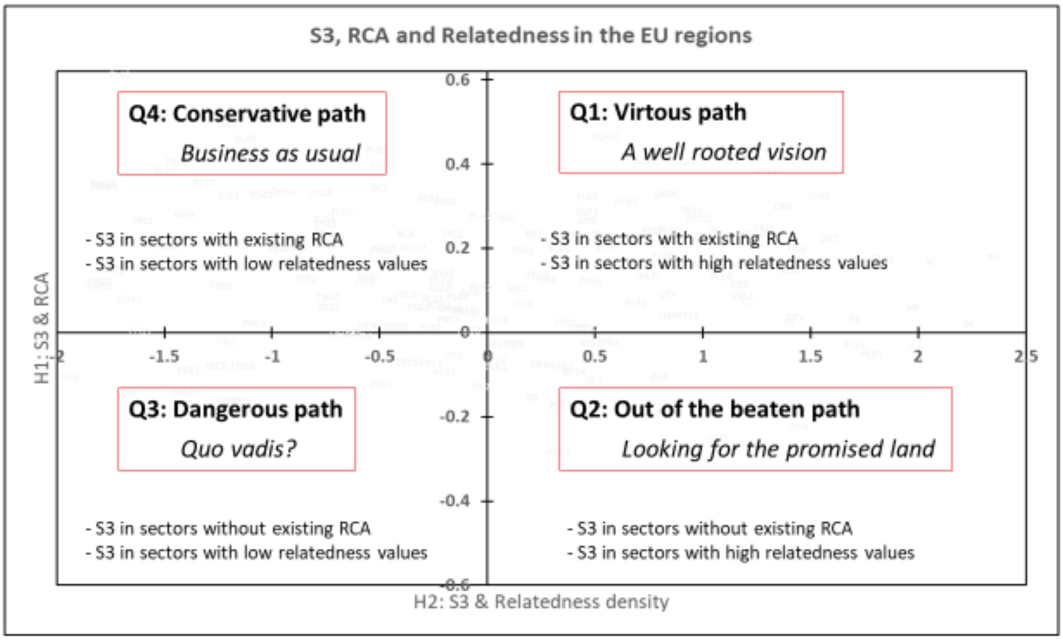


Graph 3. Association between S3 and RCA across regions

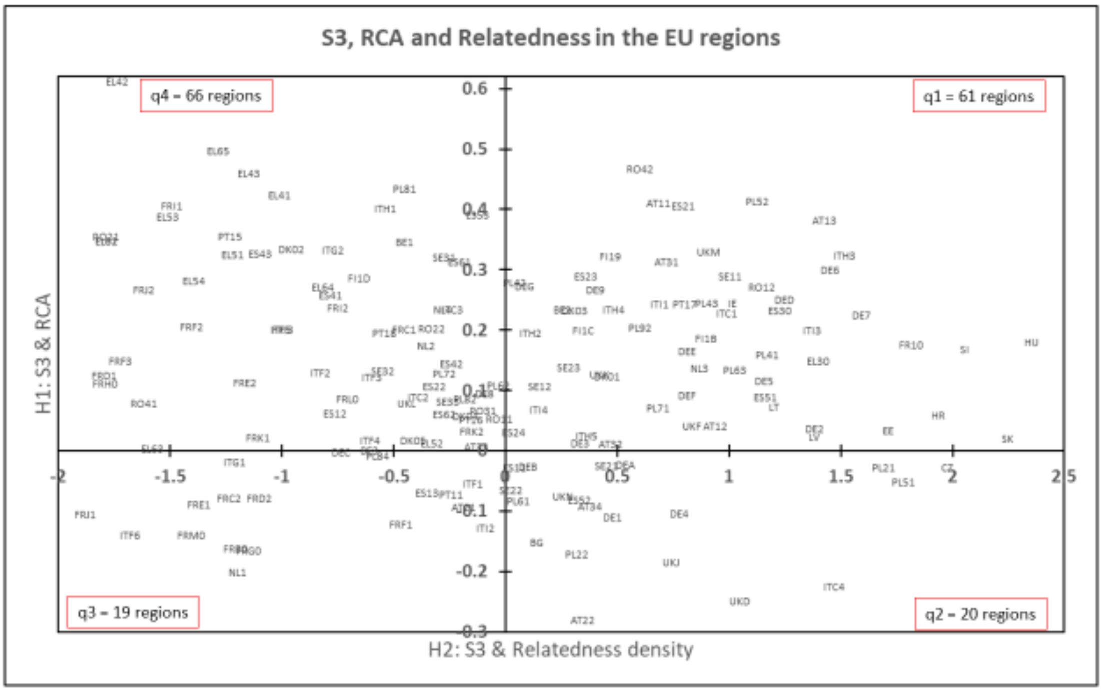
Graph 4. Production relatedness in Europe (64 sectors grouped in 13 macrosectors)



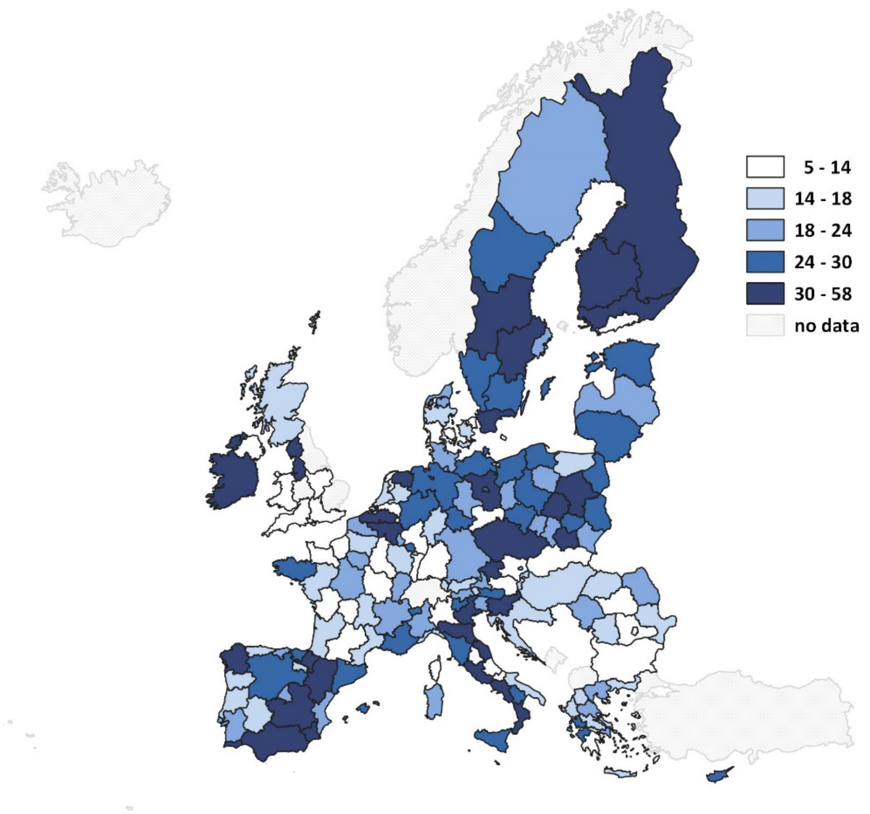
Graph 5. Relationship between implemented S3, actual specialisation and relatedness



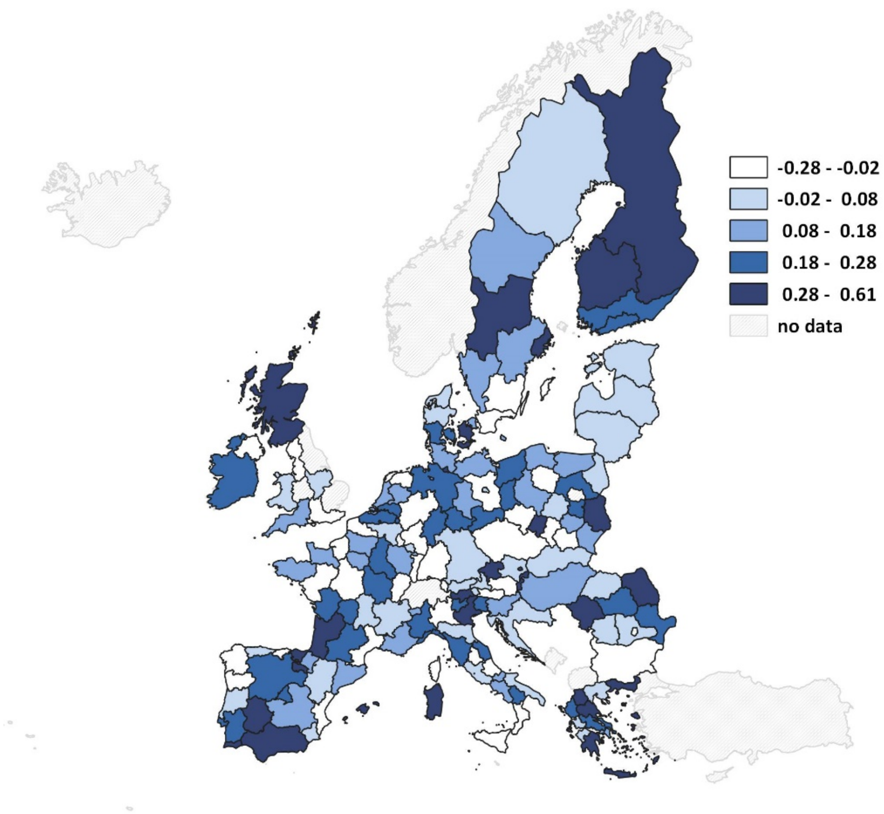
Graph 6. S3, production specialisation and relatedness in the European regions



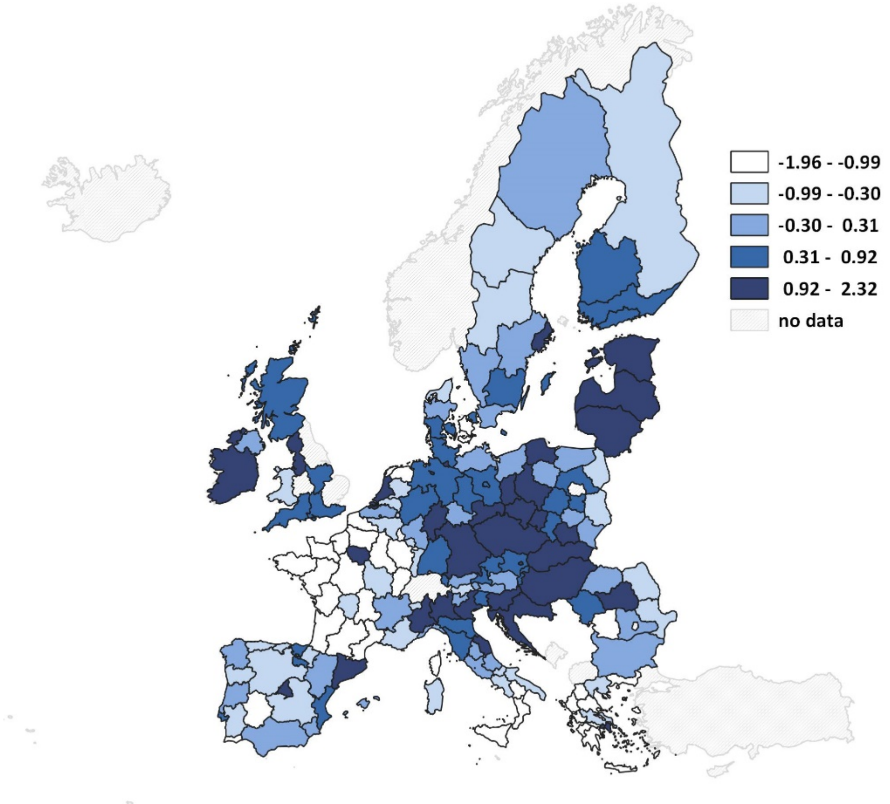
Map 1. Number of sectors included in S3 in the EU regions



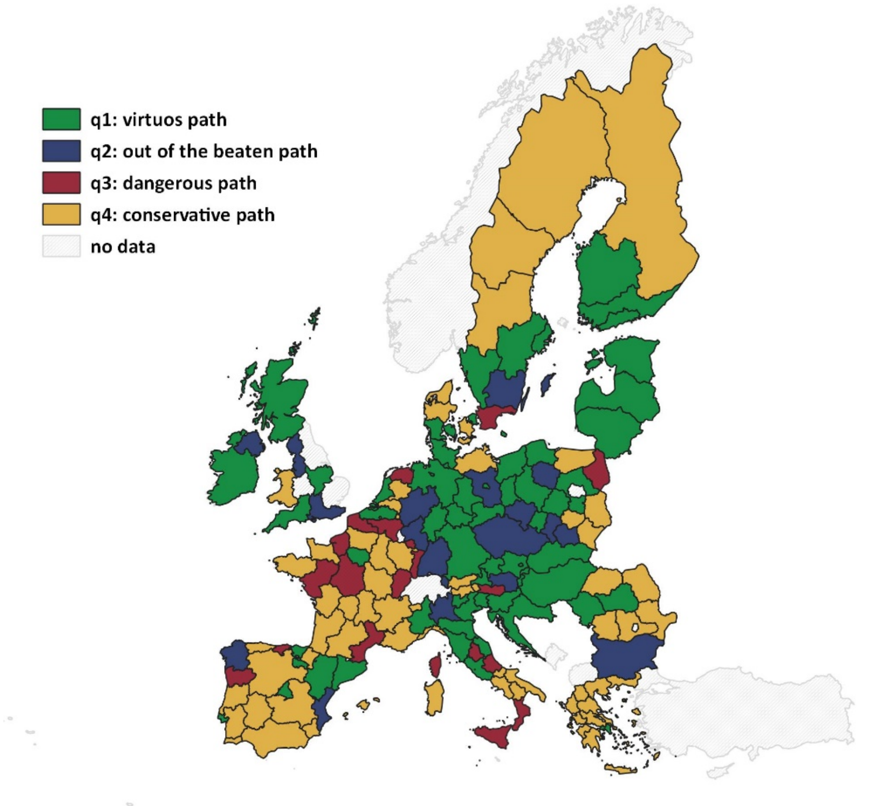
Map 2. Correlation coefficient between S3 and RCA



Map 3. Relatedness density in the European regions (normalised average values)



Map 4. Scenarios for S3, specialisation and relatedness in the European regions (see Graph 5)



Appendix 1. List of territorial units considered

NUTS-ID	Region/Country Name	NUTS-ID	Region/Country Name
AT11	Burgenland (AT)	FRI2	Limousin
AT12	Niederösterreich	FRI3	Poitou-Charentes
AT13	Wien	FRJ1	Languedoc-Roussillon
AT21	Kärnten	FRJ2	Midi-Pyrénées
AT22	Steiermark	FRK1	Auvergne
AT31	Oberösterreich	FRK2	Rhône-Alpes
AT32	Salzburg	FRL0	Provence-Alpes-Côte d'Azur
AT33	Tirol	FRM0	Corse
AT34	Vorarlberg	HR	Croatia
BE1	Brussels-Capital Region	HU	Hungary
BE2	Flemish Region	IE	Ireland
BE3	Région Wallonne	ITC1	Piemonte
BG	Bulgaria	ITC2	Valle d'Aosta/Vallée d'Aoste
CZ	Czech Republic	ITC3	Liguria
DE1	Baden-Württemberg	ITC4	Lombardia
DE2	Bayern	ITF1	Abruzzo
DE3	Berlin	ITF2	Molise
DE4	Brandenburg	ITF3	Campania
DE5	Bremen	ITF4	Puglia
DE6	Hamburg	ITF5	Basilicata
DE7	Hessen	ITF6	Calabria
DE8	Mecklenburg-Vorpommern	ITG1	Sicilia
DE9	Niedersachsen	ITG2	Sardegna
DEA	Nordrhein-Westfalen	ITH1	Provincia Autonoma di Bolzano/Bozen
DEB	Rheinland-Pfalz	ITH2	Provincia Autonoma di Trento
DEC	Saarland	ITH3	Veneto
DED	Sachsen	ITH4	Friuli-Venezia Giulia
DEE	Sachsen-Anhalt	ITH5	Emilia-Romagna
DEF	Schleswig-Holstein	ITI1	Toscana
DEG	Thüringen	ITI2	Umbria
DK01	Hovedstaden	ITI3	Marche
DK02	Sjælland	ITI4	Lazio
DK03	Syddanmark	LT	Lithuania
DK04	Midtjylland	LV	Latvia
DK05	Nordjylland	NL1	Northern Netherlands
EE	Estonia	NL2	Eastern Netherlands
EL30	Attiki	NL3	Western Netherlands
EL41	Voreio Aigaio	NL4	Southern Netherlands
EL42	Notio Aigaio	PL21	Malopolskie
EL43	Kriti	PL22	Slaskie
EL51	Anatoliki Makedonia, Thraki	PL41	Wielkopolskie
EL52	Kentriki Makedonia	PL42	Zachodniopomorskie
EL53	Dytiki Makedonia	PL43	Lubuskie
EL54	Ipeiros	PL51	Dolnoslaskie
EL61	Thessalia	PL52	Opolskie
EL62	Ionia Nisia	PL61	Kujawsko-Pomorskie
EL63	Dytiki Ellada	PL62	Warminsko-Mazurskie
EL64	Sterea Ellada	PL63	Pomorskie
EL65	Peloponnisos	PL71	Lódzkie
ES11	Galicia	PL72	Swietokrzyskie
ES12	Principado de Asturias	PL81	Lubelskie
ES13	Cantabria	PL82	Podkarpackie
ES21	País Vasco	PL84	Podlaskie
ES22	Comunidad Foral de Navarra	PL92	Mazowieckie
ES23	La Rioja	PT11	Norte
ES24	Aragón	PT15	Algarve
ES30	Comunidad de Madrid	PT16	Centro (PT)
ES41	Castilla y León	PT17	Lisboa
ES42	Castilla-La Mancha	PT18	Alentejo
ES43	Extremadura	RO11	Nord-Vest
ES51	Cataluña	RO12	Centru
ES52	Comunidad Valenciana	RO21	Nord-Est
ES53	Illes Balears	RO22	Sud-Est
ES61	Andalucía	RO31	Sud - Muntenia
ES62	Región de Murcia	RO41	Sud-Vest Oltenia
FI19	Länsi-Suomi	RO42	Vest
FI1B	Helsinki-Uusimaa	SE11	Stockholm
FI1C	Etelä-Suomi	SE12	Östra Mellansverige
FI1D	Pohjois- ja Itä-Suomi	SE21	Småland med öarna
FR10	Île de France	SE22	Sydsverige
FRB0	Centre	SE23	Västsverige
FRC1	Bourgogne	SE31	Norra Mellansverige
FRC2	Franche-Comté	SE32	Mellersta Norrland
FRD1	Basse-Normandie	SE33	Övre Norrland
FRD2	Haute-Normandie	SI	Slovenia
FRE1	Nord - Pas-de-Calais	SK	Slovakia
FRE2	Picardie	UKD	North West (UK)
FRF1	Alsace	UKF	East Midlands (UK)
FRF2	Champagne-Ardenne	UKJ	South East (UK)
FRF3	Lorraine	UKK	South West (UK)
FRG0	Pays de la Loire	UKL	Wales
FRH0	Bretagne	UKM	Scotland
FRI1	Aquitaine	UKN	Northern Ireland

Appendix 2. List of 64 sectors included in the S3 analysis

ID	NACE_R2	Description
S1	A	Agriculture
S2	B	Mining
S3	C10	Manufacture of food products
S4	C11	Manufacture of beverages
S5	C12	Manufacture of tobacco products
S6	C13	Manufacture of textiles
S7	C14	Manufacture of wearing apparel
S8	C15	Manufacture of leather and related products
S9	C16	Manufacture of wood and of products of wood and cork, except furniture;
S10	C17	Manufacture of paper and paper products
S11	C18	Printing and reproduction of recorded media
S12	C19	Manufacture of coke and refined petroleum products
S13	C20	Manufacture of chemicals and chemical products
S14	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
S15	C22	Manufacture of rubber and plastic products
S16	C23	Manufacture of other non-metallic mineral products
S17	C24	Manufacture of basic metals
S18	C25	Manufacture of fabricated metal products, except machinery and equipment
S19	C26	Manufacture of computer, electronic and optical products
S20	C27	Manufacture of electrical equipment
S21	C28	Manufacture of machinery and equipment n.e.c.
S22	C29	Manufacture of motor vehicles, trailers and semi-trailers
S23	C30	Manufacture of other transport equipment
S24	C31	Manufacture of furniture
S25	C32	Other manufacturing
S26	C33	Repair and installation of machinery and equipment
S27	D	Electricity, gas, steam and air conditioning supply
S28	E	Water, sewerage, waste
S29	F41	Construction of buildings
S30	F42	Civil engineering
S31	F43	Specialised construction activities
S32	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
S33	G46	Wholesale trade, except of motor vehicles and motorcycles
S34	G47	Retail trade, except of motor vehicles and motorcycles
S35	H49	Land transport and transport via pipelines
S36	H50	Water transport
S37	H51	Air transport
S38	H52	Warehousing and support activities for transportation
S39	H53	Postal and courier activities
S40	I55	Accommodation
S41	I56	Food and beverage service activities
S42	J58	Publishing activities
S43	J59	Motion picture, video and television programme production, sound recording
S44	J60	Programming and broadcasting activities
S45	J61	Telecommunications
S46	J62	Computer programming, consultancy and related activities
S47	J63	Information service activities
S48	K	Financial, insurance services
S49	L	Real estate activities
S50	M69	Legal and accounting activities
S51	M70	Activities of head offices; management consultancy activities
S52	M71	Architectural and engineering activities; technical testing and analysis
S53	M72	Scientific research and development
S54	M73	Advertising and market research
S55	M74	Other professional, scientific and technical activities
S56	M75	Veterinary activities
S57	N77	Rental and leasing activities
S58	N78	Employment activities
S59	N79	Travel agency, tour operator and other reservation service and related activities
S60	N80	Security and investigation activities
S61	N81	Services to buildings and landscape activities
S62	N82	Office administrative, office support and other business support activities
S63	OPQ	Public administration, education, health
S64	RST	Arts, entertainment and recreation

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