Related Variety of Regional Smart Specialization Strategies

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Abstract:

Purpose: The paper seeks to find the related variety of smart specialization strategies in European regions.
Design/Methodology/Approach: We apply the product space methodology of Hidalgo et al. (2007) to identify the most frequent occurrences of specialization in industry, scientific or policy domains in regional innovation strategies and construct a matrix of their co-occurrences.
Findings: Although to some extent regions utilize unrelated variety, i.e., homogeneous industry sections, scientific or policy domains, most regions benefit from cross-linkages between sections and domains (related variety). This latter variety may be grouped into two interconnected domains: (1) quality of life and well-being, including high-tech products that facilitate various spheres of social and economic life; (2) sustainable urban development with smart cities, green transportation, and energy conservation and effectiveness.
Practical Implications: Tracing the related variety of smart specializations may facilitate an understanding of the localization and urbanization economies that benefit regions and the mechanisms behind entrepreneurial discovery processes. Moreover, the results can show the extent to which regions can differentiate themselves from others.
Originality/Value: The product space methodology has not been applied to smart specializations to date. Based on this methodology and network analysis, the study provides the most common related varieties present in regional strategy documents, which can be analyzed in more detail in future research.

Keywords: related variety, related diversification, unrelated variety, smart specializations, regional innovation strategies

JEL codes: R58, O52

Paper Type: Research study

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1. Introduction

The identification of smart specializations (SS) became the basis of EU regional policy implemented under the Europe 2020 Strategy. Having defined specializations was also a condition for applying for and benefiting from European funds, which forced many regions to carry out entrepreneurial discovery processes in a copycat fashion (Di Cataldo *et al.,* 2021). These processes themselves led by the regions has been ambiguously evaluated in the literature (D'Adda *et al.,* 2019; Gianelle *et al.,* 2020a; 2020b; Iacobucci and Guzzini, 2016), with better and worse practices found, such as too much routine in a number of underdeveloped regions, or novel approaches in southern regions (Kroll, 2015). Assessments of SS's effectiveness in inducing regional development have also been equivocal, pointing to concerns about translating theory into practice (Gianelle *et al.,* 2020a; McCann and Ortega-Argilés, 2015; 2016) and the much longer time frame for achieving strategy goals (Klikocka, 2019).

Nevertheless, smart specializations were intended to be an instrument to guide regions in taking distinctive and more strategic approaches to their development policies (McCann and Ortega-Argilés, 2014). Each 'smart specialization' defined by a region in an entrepreneurial discovery process refers to one or more scientific and technological areas in which a region or country can benefit more than other regions or countries (Foray, 2015). These benefits primarily relate to economies of scale, including the reduction of marginal unit costs using shared knowledge resources in the labor market, supplier market, or technology market. These benefits are therefore directly associated with localization economies, which relate to: 1) easy flow of skills and knowledge between actors, allowing new ideas to emerge and improving existing products, production processes and organizations; 2) easy access to skilled labor and specialized public goods and services; 3) financial savings due to the possibility of cooperation and subcontracting part of production to partners; 4) lower transportation costs for materials and semi-finished products (Fritsch and Slavtchev, 2010; Henderson, 2003). Thus, these are benefits typical of concentrations of specialized firms – industrial districts (Marshall, 1890), or clusters (Porter, 2003).

Yet, smart specializations can also bring urbanization economies associated with concentrated demand, high density of economic activity, as the flow of people and knowledge may involve formally unrelated industries and result from close proximity (Jacobs, 1969). These benefits are also invaluable when a region attracts entirely new investors, encouraged by the large market and available resources, especially human resources, so that the development of smart specializations can be transferred to entirely new sectors of the economy (Foray, 2015; 2014). These two types of economies provide the foundation for related variety (Beaudry and Schiffauerova, 2009; Caragliu *et al.,* 2016) and reflect the advantages it can bring to a region and the importance of tracking the main patterns and understanding the phenomenon of the entrepreneurial discovery process.

This study seeks to explore the related variety of smart specializations in European regions. Through network analyses in the industrial, scientific and policy domains, we found two main related varieties: (1) quality of life and well-being, including high-tech products that facilitate different spheres of social and economic life; (2) sustainable urban development with smart cities, green transport, and energy conservation. To a certain extent, however, these two related varieties are connected as the latter variety contributes to the quality of life and prosperity, especially for those living in urban areas. This is also reflected in the results of the study. The remainder of the paper is as follows. In the next section, we provide the data and methods of analysis. Then, in the next section, we present the empirical results separately for industries, scientific disciplines, and policy objectives. In the last section, we discuss the results and conclude with further research avenues.

2. Data and Methods

The aim of the analysis is to identify related variety of specializations occurring in European regions. In practice, this boils down to determining the co-occurrence of smart specializations in particular regions in their innovation strategy documents. These RIS3 (Research and Innovation Strategies for Smart Specializations) strategies have been compiled on the s3platform and are available at https://s3platform.jrc.ec.europa.eu. Each strategy (and the specializations selected within it) was characterized by three categories: 1) eighteen economic domains (A–R), divided into 82 divisions, corresponding to three-character NACE codes; 2) thirteen scientific domains (01–13), divided into 110 scientific disciplines; and 3) eleven regional policy objectives (A–K), divided into 73 sub-objectives. A detailed list of the three categories, along with an indication of the codes appearing in the analyses, can be found on s3platform.

The analysis involves identifying the most frequent links within each category (economic, scientific, and political), indicating the relatedness of the specialization of European regions. Hence, the research approach involves the analysis of the three categories separately using network analysis techniques. The analysis proceeds in the following steps. Each region in each category is assigned *1* if its specializations fall within a particular industry, scientific discipline, or policy objective, and *0* otherwise. The level of co-occurrence of specialization in one industry, discipline, or objective relative to the others was then calculated based on the work of Hausmann and Klinger (2007) and Hidalgo *et al.* (2007) concerning 'product space methodology'. They define proximity (co-occurrence) $\phi_{i,j}$ between category i and category j as the minimum between the conditional probability of a region specializing in category i (industry, scientific domain, policy objective) given its specialization in category j, and the conditional probability of a region specializing in category j given its specialization in category i:

$$\phi_{i,j} = min\big(P(x_i|x_j), P(x_j|x_i)\big)$$

The conditional probability was calculated by dividing the number of co-occurrences of a given two categories in regional strategies by the maximum of the number of occurrences of both categories separately. For the sake of clarity, probabilities below half were discarded. As a result of such analysis, a matrix of co-occurrence in regional specializations of a given category was created. In addition, each category was characterized by the relative level of occurrence of the category in strategic documents measured as follows:

$$\lambda_i = \frac{l_i}{\sum_{j=1}^{n} l_j}$$

where the number of occurrences of category i in strategic documents, l_i, (also within the same document in case it describes several specializations of the same region), divided by all occurrences of the category in strategic documents.

As a result, the three categories (industries, scientific disciplines, policy objectives) were depicted as nodes of a size determined by the relative level of occurrence of a given category in strategic documents, while the linkages between the categories represent the category co-occurrence matrix (the thickness of the line reflects the level of proximity calculated as above) (Bukalska *et al.,* 2021).

3. Empirical Results

3.1 Related Variety of Industry Divisions in Innovation Strategies

First, the industry divisions in which regions in Europe most often specialize altogether were analyzed (Figure 1). Typically, regions specialize to a large extent in homogeneous industry sections (e.g., E.36 – water supply; sewerage; waste management and remediation activities – section E, construction – section F, transportation – section H, or some professional, scientific, and technical activities – section M). Relatively many regions indicate their various specializations within manufacturing (section C) of low technology. These include specializations in the tobacco products (C.12), textile (C.13), clothing (C.14) and leather (C.15) industries, as well as wood (C.16), paper (C.17), printing and reproduction of recorded media (C.18), and furniture (C.31).

Specializations in these industries are related to raw material specializations, i.e., industries engaged in basic processing of raw materials, also characterized by relatively low technological advancement, such as the refining industry (C.19), the chemical industry (C.20), the rubber and plastics industry (C.22), the mineral industry (C.23), the metal industry (C.24), metal products industry (C.25) and supportive activities of repair and installation of machinery and equipment (C.33).

Figure 1. *Network analysis of related variety of economic industries in regional specializations*
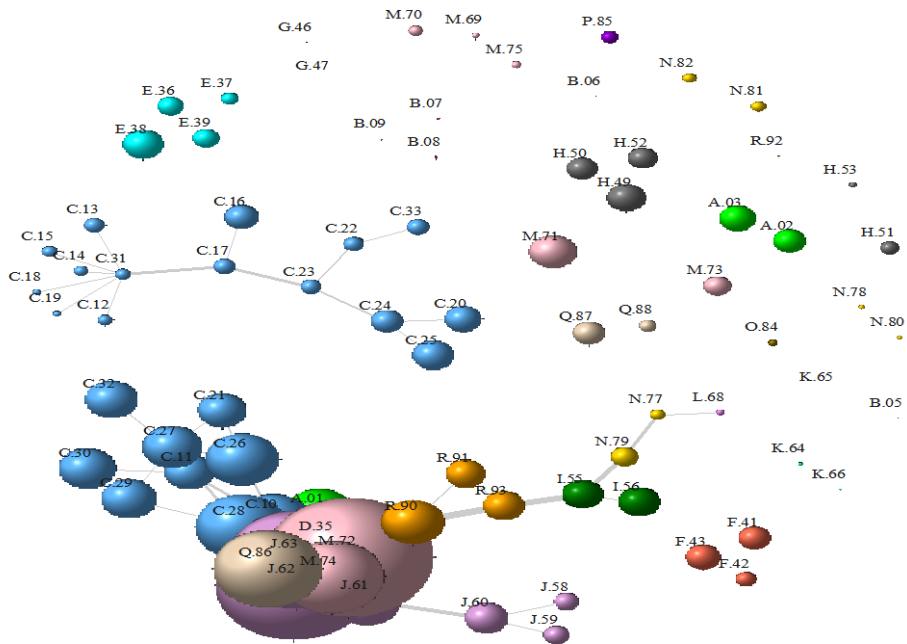
Note: *The size of the nodes indicates the degree of occurrence of an industry in regional specializations, the thickness of the lines indicates the level of co-occurrence of two industries in regional specializations. The colors are used to distinguish the different sections of industries in the economy. The list of codes used in the graphs can be found on s3platform.*
Source: *Own elaboration using R (Csardi and Nepusz, 2006) based on s3platform database (https://s3platform.jrc.ec.europa.eu).*

However, given the nature of regional specializations, an interdisciplinary approach to identifying them through related diversity (Foray *et al.,* 2009), i.e., facilitating the creation of innovations at the nexus of different economic and scientific activities, may bring significant benefits to regions. Such diversity can be seen in case of the core cluster, that most often links regional specializations in regional strategies. It also has the strongest linkages comprising various high technology industries, both industrial and service. The linkages between industries in this case have mainly a technological and process dimension – technologies created within one industry are used in others, strengthening synergies and innovation potential (Balland *et al.,* 2018; Foray, 2015; Kogler *et al.,* 2017).

Within manufacturing, we can distinguish the pharmaceutical industry (C.21), electronics, computers, and optics industry (C.26), electrical equipment (C.27), machinery and equipment industry (C.28), and transportation vehicles industries (C.29 and C.30). Interestingly, in addition to knowledge-intensive industries, this

cluster also comprises food and beverages industries (C.10 and C.11), which are linked to agriculture (A.01), machinery and equipment (C.28), and the health care industry (Q.86). Together, these industries form specializations in improving the quality of life, as they are additionally linked to creative activities related to culture and entertainment (R.90), publishing activities (J.58), production of films, videos and TV programs, sound recordings and music (J.59) and programming and broadcasting activities (J.60); and the whole tourism cluster described below. The remaining industries form, in a way, a scientific and technical backup, as they refer to scientific and research activities (M.72 and M.74) and all information and communication technologies (remaining industries in section J).

The variety can also be seen in the case of tourism cluster that links tourism agents (N.79) with accommodative (I.55) and food services (I.56) along with arts, entertainment, and recreation (R) services. Interestingly, the tourism cluster is also related to rental services (N.77) and real estate agency services (L.68), so it can refer to individual tourism i.e., rooms for rent, Airbnb and agritourism. This cluster tends to occur only in less developed regions, which choose these specializations based on market linkages, i.e., a common range of customers rather than technological background.

3.2 Related Variety of Scientific Disciplines in Innovation Strategies

Another category considered is the scientific fields and disciplines covered by regional specializations. The strategic documents analyzed include 13 scientific fields, divided into 109 scientific disciplines. As shown in Figure 2, almost half of the scientific disciplines are used within regional specializations to a small extent (small nodes), but on the other hand, the regions employing these disciplines are specialized in them (they do not combine these disciplines with others, which is illustrated by the linkages only within the clusters of disciplines in a given domain). These separately clustered domains are environment (02), space exploration and exploitation (03), education (09), and political and social systems, structures, and processes (11).

Interestingly, the related variety of scientific disciplines is evident to a greater extent than in the case of industries, not only in terms of occurrence in the regions, but also in terms of the range of scientific disciplines. The greatest representation can be noted in industrial production and technology (06), also forming kind of sub-clusters around manufacturing of tobacco (06.43), textiles (06.44), wearing apparel (06.45), leather (06.46), wood (06.47) and paper (06.58), as well as coke and refined petroleum products (06.50), chemicals and chemical products (06.51), rubber and plastic products (06.53) and other non-metallic mineral products (06.54). This therefore, reflects the separate manufacturing industry cluster identified in Figure 1, although it is linked to the core interdisciplinary cluster for scientific disciplines.

**Figure 2**. *Network analysis of related variety of scientific disciplines in regional specializations*
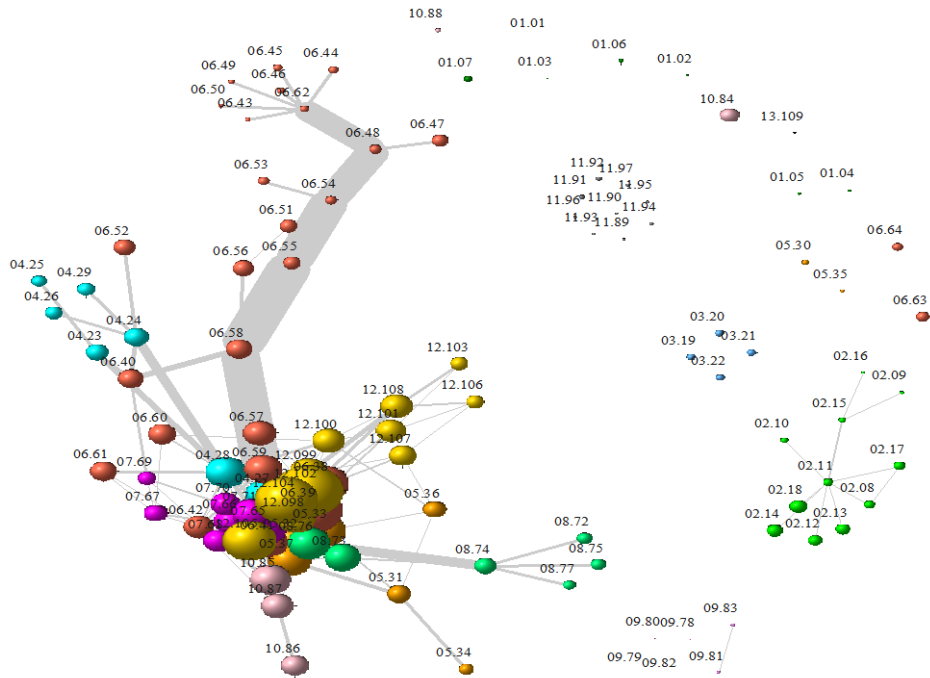
Note: The size of the nodes indicates the degree of occurrence of a scientific discipline in regional specializations, the thickness of the lines indicates the level of co-occurrence of two disciplines in regional specializations. The colors are used to distinguish the different scientific fields. The list of codes used in the graphs can be found on s3platform.
Source: Own elaboration using R (Csardi and Nepusz, 2006) based on s3platform database (https://s3platform.jrc.ec.europa.eu).

Interestingly, the core of the cluster of scientific disciplines is formed by agricultural, forestry, fisheries, animal, and dairy sciences (12,098), which are related to various agricultural sciences (08), health sciences (07) and culture, recreation, religion, and mass media (10), indicating a focus on improving quality of life. Emphasis is also placed on smart cities and sustainable urban development forming a subcluster of civil engineering (04.23), building construction and planning (04.24), general land use planning (04.25), protection from harmful impacts in land use planning (04.26), water supply (04.29), and waste recycling (06.40) related to transportation science concerning the manufacture of motor vehicles, trailers and semi-trailers (06.60), other transportation equipment (06.61), and machinery and equipment (06.59). This strain of knowledge is supplemented with energy disciplines on energy conservation (05.31), energy efficiency consumption (05.32), energy production and distribution efficiency (05.33), hydrogen and fuel gas (05.34), other power and storage technologies (05.36), and renewable energy sources (05.37).

Figure 3. *Network analysis of related variety of policy objectives in regional specializations*
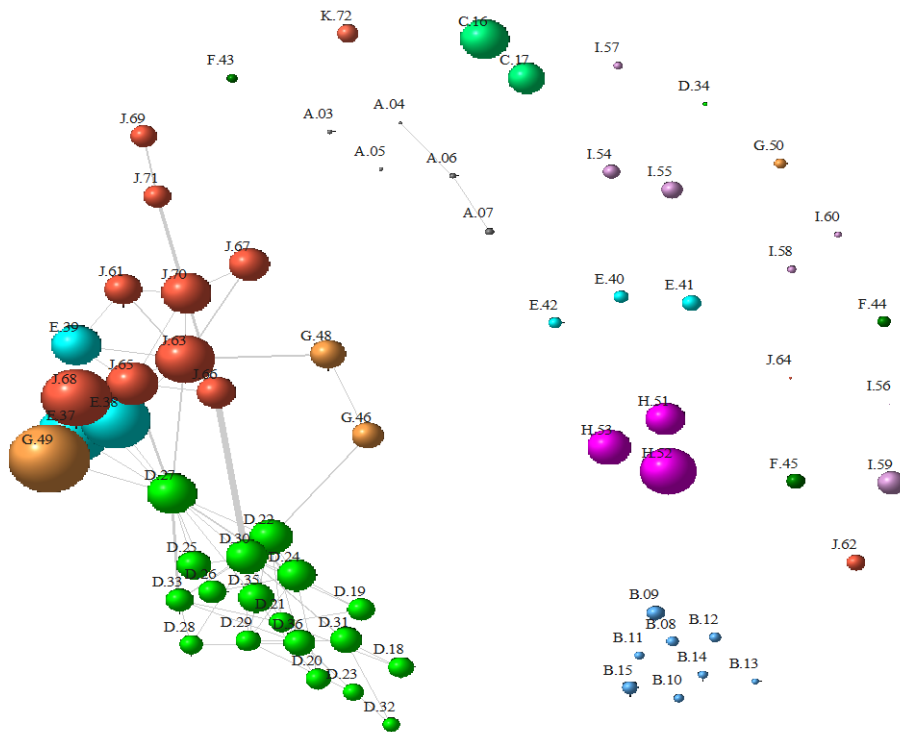
Note: The size of the nodes indicates the degree of occurrence of a political objective in regional specializations, the thickness of the lines indicates the level of co-occurrence of two objectives in regional specializations. The colors are used to distinguish different groups of political objectives. The list of codes used in the graphs can be found on s3platform.
Source: Own elaboration using R (Csardi and Nepusz, 2006) based on s3platform database (https://s3platform.jrc.ec.europa.eu).

3.3 Related Variety of Policy Goals in Innovation Strategies

An analogous situation occurs in the implementation of regional policy objectives by regional specializations (Figure 3). In this case, also part of the objectives is implemented separately by regions (specializing in them simultaneously). This is true for all the service innovation (H) policy objectives, in which many regions specialize. Also, all blue growth policy objectives (B) form a separate cluster with small nodes, indicating that there are only a few regions specializing in these policy objectives. The same is true for aeronautics and space (A), to some extent. Surprisingly, cultural, and creative industries (C) are very common but separated from the main core, contradicting the industrial domain presented above.

The main core is formed by only four types of policy goals, with most of them related to digital transformation (D), including high-performance computing,

artificial intelligence, big data, broadband and sustainable networks, industrial digitization, e-commerce, e-government, e-inclusion, ICT trust, internet of things, new media, robotics, and smart systems integration. Moreover, we can easily identify some interrelationships between this type of policy and other types of policies that have, however, similar areas of interest. For example, eHealth (D.27) clusters with aging populations (G.46), public health and well-being (G.49), and food safety and security (G.48); intelligent inter-modal & sustainable urban areas (e.g., smart cities) (D.30) links with smart green & integrated transport systems (J.66); cleaner environment and efficient energy networks and low-energy computing (D.22) are combined with sustainable innovation, especially in resource efficiency (J.65), sustainable energy and renewables (J.68), smart, green and integrated transport systems (J.66) and eco-innovation (J.63). There are also links to some key enabling technologies (KET) such as advanced manufacturing systems (E.37), advanced materials (E.38) and industrial biotechnology (E.39). Thus, the policy objectives can be considered to emphasize digital transformation, green technologies, sustainable development, and improved quality of life.

4. Discussion and Conclusion

The purpose of the study was to point out the related variety of regional smart specializations to explore in which industries, scientific disciplines and policy objectives regions specialize the most and seek to maximize their potential and obtain synergies (Foray, 2015; Foray *et al.,* 2009). Although to some extent regions utilize unrelated variety (Castaldi *et al.,* 2015; Frenken *et al.,* 2007), i.e., homogeneous industry sections, scientific or policy domains, most regions benefit from cross-linkages between sections and domains. These multi-faceted domains seek to enhance quality of life and well-being by improving food and health and providing creative, cultural, tourism and entertainment services. There is also a tangle with high-tech industries in the production of various life-enhancing machinery and equipment, such as computers, electronics, and precision instruments. Moreover, key enabling technologies such as advanced manufacturing systems, advanced materials, and biotechnology reinforce these domains and lead to regional branching (Montresor and Quatraro, 2017), which is the essence of SS and thus may indicate its potential effectiveness.

The second related variety of smart specialization domains focus on sustainable urban development, including smart cities, smart and green transportation, particularly prominent in scientific disciplines and policy objectives. Energy efficiency, sustainable energy, and renewables are very relevant here, and intertwine across these domains to enhance their effectiveness. Likewise with digital transformation, which is a key part of the main core of policy objectives, forming altogether a major part of the related variety of smart specialization.

Thus, it was possible to delineate two broad related variety of domains in which many regions specialize. A perverse question can be raised as to whether the related

variety of specialization domains determines innovative resources that identify growth-generating advantages (Di Cataldo and Monastiriotis, 2020; McCann and Ortega-Argilés, 2015), since most regions specialize in them. In this situation, the advantage on which SS were supposed to be built does not become an advantage but only a direction in which the region follows and begins to compete with many regions with similar goals. This in turn leads to an unequal battle between regions where stronger, more reputable, better managed units with higher levels of income and thus investment and other resources may win. This certainly deserves detailed further research.

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