RELATED VARIETY IN THE DEVELOPMENT OF LESS DEVELOPED REGIONS

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ABSTRACT

PYLAK K., WOJNICKA-SYCZ E., RELATED VARIETY IN THE DEVELOPMENT OF LESS DEVELOPED REGIONS. The aim of the paper is to analyse the role of related variety in the development of European regions and to elaborate recommendations for innovation policy in less developed regions concerning RIS3 strategies. In the paper we define two types of related variety: explicit (pecuniary) and tacit (competency-driven). Multidimensional analysis revealed that related variety does not induce growth, but plays a crucial role in building global value chains. Our findings show companies should produce as much as possible within their own industry, which would induce the growth of productivity and R&D activities in the sector. Although domestic demand induces value added growth, there are some limitations in this demand and participation in global value chains becomes inevitable. However, the paper provides strong evidence that the most developed regions are specialised in high-tech or medium high-tech industries that are not ubiquitous in the economy. Thus, to induce the growth of regions, smart specializations have to be more knowledge-intensive, but at the same time they have to be very different from specialisations of other regions, allowing the region to gain an advantage. Therefore, RIS3 strategies should enhance less ubiquitous industries or suggest sub-industries, branches of current specialisations that are niches and have potential to be an engine of growth. Application of the Ordinary Least Squares Method revealed that the share of medium-high-technology sectors induces GDP growth and thus high GDP per capita. This relatedness is valid for all regions, thus these sectors can be taken into account primarily during the preparation of RIS3 strategies for less developed regions.

KEYWORDS

Related variety; global value chains; development; less developed regions; specialisations;

JEL CLASSIFICATION: E2, O2, O31, O32, R3, R5

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1. INTRODUCTION

How do regions develop? How do regions learn to develop? How do regions learn to absorb, benefit from and, above all, how do they become convinced practitioners of the knowledge economy? How do regions learn to deal with the dynamics of constantly renewed, evolving, applied and embodied knowledge – especially analytic knowledge? Evolutionary economic geography tells us that regions can construct competitive advantage and thus develop (Asheim, Boschma, & Cooke, 2011; Cooke & Leydesdorff, 2006). Nevertheless, there is an ambiguity in the understanding of how regional advantage is constructed /can be constructed in different contexts and how it impacts development. In general, agglomeration economies (Frenken, Van Oort, & Verburg, 2007) can be grouped into urbanisation and into localisation economies. Urbanisation economies are profiled by concentrated demand, density of economic activity and variety, forming the basis for Jacobs' externalities, (unrelated variety). Localisation economies are specialised economies of scale (Marshall's) resulting from co-locating of businesses in the same or related sectors due to a specialised labour market, suppliers' and the facilitating potential of knowledge spillover (Henderson, 2003; Marshall, 1890). However, there is no unequivocal opinion of how each one of these two types of economies, as development drivers, impacts the renewal of less developed regions.

Thus, while many findings are essential for constructing a regional advantage, a number of questions are still to be researched; e.g. we need to understand (1) less developed regions' cross-over to the knowledge economy, facilitation or not by a related variety or whether there was a kind of 'fresh start' (*development discontinuities and related variety*); we also need to understand (2) how, why, in what situations related variety continuities have not led to upscale specialisation but, rather, to the opposite, i.e. in loss of productivity and knowledge economy absorptiveness. We observe such phenomena in a number of European regions that today face grave development crises such as Greece, Portugal, Spain as well as in development-challenged 'pockets' in very advanced economies (*development reversals and related variety*); we also need to understand (3) why and how, in certain types of regions, the dynamics of existing specialisations in a related variety do not appear to function effectively towards growth and upscale renewal *(slow growth and related variety).*

Thus the aim of the paper is to analyse the role of related variety in the development of European regions and to elaborate recommendations for innovation policy in less developed regions concerning RIS3 strategies. The paper is structured as follows. The next section explores and clarifies the theoretical background on related variety and global value chains. The third section lays out the empirical design, including hypotheses, data and measurement process. The fourth section presents and discusses the empirical results of analysis, regarding the country and regional level and the role of related variety. In addition, this section discusses possible future research, considering the results in terms of theoretical and practical aspects. The fifth offers a conclusion.

2. BACKGROUND

The notion of related variety, defined by Boschma and Iammarino (2009) as '*industrial sectors that are related in terms of shared or complementary competences'*, focuses more on knowledge networks than on business networks. This approach indicates not only location and spillover externalities, but also social and knowledge values that can be measured (Ter Wal & Boschma, 2009; Walter, Lechner, & Kellermanns, 2007). Frenken et al. (2007) defined related variety as the variety of 5-digit industries in 2-digit class assuming that all these industries have to have the same knowledge pool and create externalities, i.e. synergy and growth in regions. It is worth noting that Hidalgo, Barabási, Winger, and Hausmann (2007) created their product space theory based on an assumption that a similar knowledge pool is required to produce products or services that are mostly commonly sold outside the country. This approach, fitted to individual clusters and to value chains (i.e. supplier – buyer relationships or company – scientists) takes into account all strengths of the abovementioned measures and techniques, and especially allows the related industries to be matched even between different classes.

In the literature, it is widely debated which approach, the related or unrelated variety, is more appropriate for constructing regional advantage (Asheim et al., 2011; Boschma & Frenken, 2011a; Frenken et al., 2007). Although a number of studies tended to 'glorify' one of the two approaches

(Boschma, Heimeriks, & Balland, 2014; Boschma & Iammarino, 2009; Boschma, Minondo, & Navarro, 2012, 2013; Desrochers & Leppala, 2011; Henderson, 2003), there is evidence of relatedness between them, whereby urbanisation economies benefit some localisation industries, and localisation economies can add to the diversification potential of urbanisation economies (Feser, 2002; Jofre-Monseny, 2009; Jofre-Monseny, Marín-López, & Viladecans-Marsal, 2013). Some findings question the positive impact of related variety on employment growth (Brachert, 2011) and of unrelated variety on economic growth (Frenken et al., 2007). Research on the emergence of new industries in a region shows relatedness to previously existing industries and indicates strong path dependency and relatedness in regional economies (Boschma et al., 2012, 2013; Neffke, Henning, & Boschma, 2011). Thus, upscale path renewal seems to be in general supported by the continuities (and their renewal potential) that related variety contexts imply and that we are seeking 'specialisation (-s) in related variety' (Boschma & Frenken, 2011b; Boschma & Iammarino, 2009; Boschma et al., 2012). However, while related variety contexts in general correlate with constructed regional advantage, research indicates that their upscale driver impact is conditional on baseline functional and knowledge aspects in regions (Breschi, Lissoni, & Malerba, 2003; Frenken et al., 2007; Garcia-Vega, 2006; Hartog, Boschma, & Sotarauta, 2012) and may vary according to different factors like type, maturity, size, knowledge-intensity of the sectors etc.

However, product spaces, developed by Hidalgo et al. (2007), reflect related variety of products and industries and at the same time fit in building global value chains (GVC), which covers 80% of world trade (Barrientos, 2014) and is still growing (Beugelsdijk, Pedersen, & Petersen, 2009). The latter approach, complementary to knowledge pool relatedness, indicates 'functional dependency' and 'productive dependency' (Caceres, Martinez-Roman, & Romero, 2013), which is more explicit and pecuniary. But it is still an efficient mechanism for the learning of organisations (Gereffi, 1999; Pietrobelli & Rabellotti, 2011). Contrary to this, there is a vertical specialisation of global value chains, which means a decrease in host-home and inter-firm trade (Beugelsdijk et al., 2009) and thus more production within the links in the chain and fewer suppliers' tiers. Hence, a few countries concentrated export volume at the sectoral level (Cattaneo, Gereffi, & Staritz, 2010) with less developed regions mostly in the bottom of the value chains, in a so-called 'global value chains trap' (Hu, 2012; Huang & Fu, 2013; Lei, 2012), but still they can benefit from global value chains through accessing knowledge and enhancing learning and innovation (Pietrobelli & Rabellotti, 2011). If so, global value chains become more vulnerable to the risk of crisis, because elimination of one unit in the global chain induces reduction of many relations within the sector, between different countries. Nevertheless, the most resilient economies are the ones whose economies have a more diversified structure, but conversely not every diversification is appropriate. The public service sector tends to be more resilient than the private service sector, while the manufacturing and construction industries seem to be the least resilient (Martin, 2012). If we want to change a global value chain to be more specialised or more diversified, we have to keep in mind that the change of global value chains depends on three factors: (1) the complexity of transactions, (2) the ability to codify transactions, and (3) the capabilities in the supply-base (Gereffi, Humphrey, & Sturgeon, 2005).

In the end, in the literature there is a growing number of surveys confirming the positive impact of global value chains on economic growth through productivity, technology diffusion and output growth (Pietrobelli & Saliola, 2008), although local upgrading opportunities depend on the way value chains are governed (Humphrey & Schmitz, 2002) and where in the chain a given country or region is (Hu, 2012). This statement is crucial because only countries with relatively high number of capabilities to export similar products are able to produce high incomes (Hausmann & Hidalgo, 2011), or, in other words, the most developed countries have the most complex export portfolio. Nevertheless, diversified exporting of ubiquitous products is strongly correlated with GDP per capita and GDP growth (Hidalgo & Hausmann, 2009).

3. EMPIRICAL DESIGN

3.1. HYPOTHESES

The different findings on the role of related variety in the economy show its positive impact on growth, even when related variety is counted differently (Boschma & Iammarino, 2009; Boschma et al., 2012; Frenken et al., 2007; Hidalgo et al., 2007), although mostly export data was used. Thus the comparative advantage of regions in global value chains reflects the competitiveness of the whole economy, while also having some limitations. We have to agree with Boschma and Iammarino (2009) and Boschma et al. (2012) that export profiles of regions do not reflect the entire regional economy, especially since some industries are not export-oriented. In addition, using export data we lack both local and domestic demand and industry specialisations counted by location quotients (Lehtonen & Tykkyläinen, 2014), which can be missing in an export profile.

Thus in the paper we want to examine the interior of the region and related variety within the regional economy. We use the approach of location quotients (Lehtonen & Tykkyläinen, 2014), product spaces (Hidalgo et al., 2007) and input-output analysis (Flegg & Tohmo, 2011) as pecuniary ways to find related industries. Nevertheless, based on the existing results, we assume positive influence of related variety, and thus we hypothesize that:

H.1. The larger the related variety, the higher participation in global value chains by the region.

H.2. The larger the related variety, the higher performance of the region.

Performance will be measured by different variables, including gross domestic product (GDP), gross value added (GVA), employment growth, but also different innovation indicators. Detailed description of explained and explanatory variables will be provided in the next section.

3.2. DATA AND MEASUREMENT

To confirm the hypotheses, a multi-step research process should be carried out. First we indicate and measure related variety within countries, regions and industries. Then we match regions' related variety and its evolution with the industries that led/lead renewal in the regional economy. In the next step we seek to understand whether related variety is part of the development process and, if so, how. In the end we discuss whether the development has also given rise to a radically renewed related variety pool, and, if so, how dense and knowledge intensive these pools are. Then we indicate recommendations for policy makers, including preparation of RSI3.

3.2.1. DOMESTIC AND GLOBAL VALUE CHAINS

Related variety can play a crucial role in the creation and development of value chains both domestic and foreign, because although at the core related variety is about competence sharing (Boschma & Iammarino, 2009), the competencies required for product or service, along with materials and intermediates, make up the whole. We assumed that the more related the industries, the more transactions between these industries will be. If a producer from one industry buys products from other industry, he needs them for the production process as a material, intermediate or equipment. The same if the producer wants to sell his products to other industries. Thus transactions between industries can reflect the related variety in its direct, pecuniary way. Therefore, we can name this related variety as an explicit type. It can be accounted from both client and suppliers.

To assess domestic and global value chain levels in economies, we use input-output data provided by the World Input-Output Database (www.wiod.org). We use this data because it is updated annually and we can also analyse the impact of the related variety on the dynamics of different variables. From the WIOD tables we can obtain information for any industry (on the 2-digit NACE codes level), and what output quantity it buys and sells from/to other industries. In other words, we claim that the output transferred to other industries can be a proxy for related variety in a pecuniary way, including foreign transactions that can reflect global value chains (Beugelsdijk et al., 2009). As a result, we get the level of related variety for each country and each industry:

$$RV_{ij} = \frac{O_{osij}}{O_{tij}} \tag{1}$$

where:

RV_{ij} related variety of 2-digit NACE industry *i* in country *j*

O_{osij} output sold to / bought by industry *i* to/from different industries in country *j*

O_{tij} total output of sector *i* in country *j*

For each industry (within the country) we calculated a set of indicators referring to related variety and global value chains, and embeddedness as a complementary issue, described in table 1. We analysed both producer-driven and buyer-driven value chains (Gereffi, 2001), including indicators of suppliers from the same and other sectors domestic and foreign, value added, domestic buyers from other sectors, final domestic consumption, gross fixed capital formation and export.

Table 1. Indicators referring to embeddedness, related variety and global value chains used in analysis

Indicator	Description
% of suppliers (domestic)	Industry embeddedness in domestic economy (domestic suppliers from the same and other sectors)
% of suppliers from the same sector (domestic and foreign)	Industry sectoral embeddedness
% of suppliers from the same sector (domestic)	Industry sectoral embeddedness in domestic economy
% of suppliers from different sectors (domestic and foreign)	Related variety push factor (extent to which industry is supported by intermediates from other related domestic and foreign sectors)
% of suppliers from different sectors (domestic)	Related variety push factor in domestic economy (extent to which industry is supported by intermediates from other related domestic sectors)
% of buyers in different sectors (domestic)	Related variety pull factor (extent to which industry supports as an intermediate other related domestic sectors)
% of suppliers (foreign)	Global value chain participation (extent to which industry is supplied by foreign suppliers from the same or other industries)
% of suppliers from different sectors (foreign)	Global value chain participation within related variety (extent to which industry is supplied by foreign suppliers from other related industries)
% of suppliers from the same sector (foreign)	Global value chain participation within sector (extent to which industry is supplied by foreign suppliers from the same industry)
% value added	Income growth potential of the industry (extent to which industry is able to create value added)
% consumed domestically	Domestic demand (extent to which outputs of the industry are consumed domestically by final consumers)
% gross fixed capital formation	Current investments (extent to which industry is investing in fixed capital annually)
% exported outputs (basic sectors)	Product competitiveness (extent to which outputs of the industry can be sold outside the country)
% of sector in the economy	Market share of the industry

Due to only having data on the industry level, the indicators and analysis can be done for the separate industries, although tracing precise global value chains is also possible (Pietrobelli & Saliola, 2008). Nevertheless, we want to confirm the role of related variety within the country and outside as far as the value added, consumption, capital formation, export and market share is concerned. Particularly, we want to analyse relationships with export shares because at the regional level there is hardly any data available, although all the findings from the country level will be valid as a background for regional analyses.

3.2.2. EXPLICIT RELATED VARIETY INDEX

Based on the level of the related variety shares within individual industries in a given country, we can compose indicators for regions. To analyse the role of the related variety in the development process, regional related variety indexes must be prepared for each region. To assess the regional related variety index we have to count the average of the related variety for every industry existing in a region proportionally to market shares of individual industries measured by number of persons employed (Hartog et al., 2012). We found full data for 257 European regions and calculated averages for the period of 2008-2011. Thus, we can calculate the **related variety index** for every region from the Eurostat structural business statistics (SBS) database in such a way:

$$RV_r = \sum_{i=1}^{n} s_i \times RV_{ir\to c} \qquad (2)$$

where:

RV_r regional related variety index of region *r*

i number of 2-digit NACE industries in the economy of region *r*

s_i share of industry *i* in the economy of region *r* (by number of persons employed)

$RV_{ir\to c}$ related variety of industry *i* in country *c* (region *r* belongs to country *c*)

In other words, related variety index reflects the structure of economy by its relatedness. Thus it reflects the share of outputs from all industries sold / bought to/ by other industries. Its maximum value can reach 1, when every industry sells / buys all of its output to / from other industries.

In analogous way, we calculated the related variety indexes for high technology sectors, medium-high-technology sectors, medium-low technology sectors, low technology sectors, KIS market services, LKIS low intensive-services, knowledge intensive (KI) industries (high and medium high tech and KIS sectors). It is worth noting that these indexes show not only the related variety of given sectors, but also the level of specialisation of the region in these sectors (the more persons employed in these industries, the higher the index is).

3.2.3. TACIT RELATED VARIETY INDEX

The second dimension of the related variety is the competency similarity between industries. In this approach we assume employees can work in different industries sharing common competencies; thus if two sectors appear in many regions, it means they are related in a tacit (competency) way. This approach is in line with the proximity indicator developed by Hidalgo et al. (2007), adjusted to the regional level (Boschma & Iammarino, 2009; Boschma et al., 2012, 2013). Because this approach uses an indirect method of assessing related sectors (based on the assumption that similar knowledge is required to produce products usually exported together), it will reflect the tacit dimension of related variety. We measure the tacit related variety indexes as regional economic complexity indexes (RECI) (Hausmann & Hidalgo, 2010, 2011; Hausmann & Klinger, 2007; Hidalgo, 2009; Hidalgo et al., 2007; Hidalgo & Hausmann, 2009) based on the number of employees in individual sectors, not on export as in the abovementioned approach. Nevertheless, we adopt this approach to our analysis in the following way.

If we define M_{rs}, as a matrix that is *1* if region *r* has employees in sector *s*, and *0* otherwise, we can measure the diversity of regions and the ubiquity of industries by summing the rows or columns of that matrix. Formally, we define:

$$Diversity = k_{r,0} = \sum_s M_{rs} \tag{3}$$

$$Ubiquity = k_{s,0} = \sum_r M_{rs} \tag{4}$$

To generate a more accurate measure of the number of competences available in a region, or required by a sector, the information that diversity and ubiquity carry can be used by each to correct the other. For regions, this requires a calculation of the average ubiquity of the industries that it possesses, the average diversity of the regions that also have these sectors and so forth. For industries, this requires a calculation of the average diversity of the regions that have them and the average ubiquity of the other industries in these regions. This can be expressed in the following way:

$$k_{r,N} = \frac{1}{k_{r,0}} \sum_s M_{rs} \times k_{s,N-1} \tag{5}$$

$$k_{s,N} = \frac{1}{k_{s,0}} \sum_r M_{rs} \times k_{r,N-1} \tag{6}$$

In the next step, the equation (6) is inserted into (5):

$$k_{r,N} = \frac{1}{k_{r,0}} \sum_s M_{rs} \frac{1}{k_{s,0}} \sum_{r'} M_{r's} \times k_{r',N-2} \tag{7}$$

$$k_{r,N} = \sum_{r'} k_{r',N-2} \sum \frac{M_{rs} M_{r's}}{k_{r,0} k_{s,0}} \tag{8}$$

Then, it is rewritten to achieve:

$$k_{r,N} = \sum_{r'} \widetilde{M}_{rr'} k_{r',N-2} \tag{9}$$

where

$$\widetilde{M}_{rr'} = \sum \frac{M_{rs} M_{r's}}{k_{r,0} k_{s,0}} \tag{10}$$

Then equation (9) is satisfied when $k_{r,N} = k_{r,N-1} = 1$, which is the eigenvector of $\widetilde{M}_{rr'}$, which is associated with the largest eigenvalue. Since this eigenvector is a vector of ones, it is not informative. Then the eigenvector associated with the second largest eigenvalue is taken. This is the eigenvector that captures the largest amount of variance in the system and is our measure of regional economic complexity. Hence, we define after Hausmann and Hidalgo (2010), the Regional Economic Complexity Index (RECI) as:

$$RECI = \frac{\vec{K} - \langle \vec{K} \rangle}{stdev(\vec{K})} \tag{11}$$

where $\langle \quad \rangle$ stands for an average, $stdev$ stands for the standard deviation and $\vec{K}$ stands for an eigenvector of $\widetilde{M}_{rr'}$ associated with the second largest eigenvalue.

Analogously the Regional Sector Complexity Index (RSCI) can be defined as:

$$RSCI = \frac{\vec{Q} - \langle \vec{Q} \rangle}{stdev(\vec{Q})} \tag{12}$$

where $\vec{Q}$ stands for an eigenvector of $\widetilde{M}_{ss'}$ associated with the second largest eigenvalue.

Adopting this approach to regional economic performance we counted these indexes twofold. First, we took all the employment and granted *1* in matrix M_{rs}, when region *r* had at least one employee in sector *s*, and *0* otherwise. Second, we wanted to analyse specialisation industries and their relatedness between regions. This approach is used by the abovementioned authors (see Hausmann & Hidalgo, 2010; Hausmann & Hidalgo, 2011; Hausmann & Klinger, 2007; Hidalgo, 2009; Hidalgo et al., 2007; Hidalgo & Hausmann, 2009). They used Balassa (1964) definition of Revealed

Comparative Advantage (RCA), but in our approach RCA will be used to reflect more employment in a sector than its 'fair' share within the global market, thus it reflects a kind of specialization in this sector:

$$RCA_{rs} = \frac{E_{rs}}{\sum_r E_{rs}} \div \frac{\sum_s E_{rs}}{\sum_{r,s} E_{rs}} \tag{13}$$

where:

RCA_{rs} is the Revealed Comparative Advantage that region *r* has in sector s,

E_{rs} stands for number of employees in sector s within region *r*.

Then we filled the matrix M_{rs} with *1*, if the region *r* has more employees in sector s than average for all the analysed regions, so the Revealed Comparative Advantage is larger than *1*:

$$M_{rs} = \begin{Bmatrix} 1\ if\ RCA_{rs} > 1 \\ 0\ otherwise \end{Bmatrix} \tag{14}$$

The matrix M_{rs} shows which regions are specialised in what sectors and is necessary to construct measures of regional complexity indexes of specialisation industries. RECI for RCA > 1 for region *r* shows how specialization industries of this region are related to other sectors in the context of labour resources.

Finally, as a complementary analysis, we measured the spatial autocorrelation using a global Moran's Index to see if the RECI pattern is clustered, dispersed, or random. This is crucial for finding patterns of similarity and learning possibilities through knowledge spillovers (Xie & Wang, 2013). Due to the lack of data for some variables for all NUTS2 regions it was impossible to use spatial regression methods. However global and local Moran indexes were calculated for the major variables reflecting related variety.

Moran's index is a measure of spatial autocorrelation. Spatial autocorrelation is the correlation between the values of one variable measured at different points in space. Spatial autocorrelation determines the degree of relationship of the variable for a given spatial unit to the value of the same variable in another unit (location). The consequence of the existence of such a relationship is a spatial clustering of territorial units. Positive autocorrelation is a spatial concentration of high or low values of the observed variables, and negative autocorrelation is the incidence of low values of variables next to the high. Global spatial autocorrelation – the global Moran index – examines the interrelationships between objects, and the local Moran index allows the identification of spatial agglomeration effects; that is, it shows if it is statistically significant that the units around a given spatial unit have similar values of the variable – high or low (Sheng, Yin, & Wei, 2009). To calculate the Moran index at first a weight matrix defining the neighbourhood relationships between regions must be prepared. The most common is the matrix of direct neighbourhood based on the criterion of the common border. In the paper the weight matrixes of queen contiguity were used which define a location's neighbours as those with either a shared border or vertex (in contrast to a rook weights matrix, which only include shared borders) (Bai, Ma, & Pan, 2012).

3.2.4. RELATED VARIETY IMPACT ON REGIONAL PERFORMANCE

In the next step, we analyse correlations between the related variety indexes (explicit and tacit) of regions and their performance. We primarily consider productivity growth, the associated increasing returns and how they contribute to the overall regional income as proxies indicating the probably gradual but radical transformation of a lagging economy into a knowledge-based economy. Nevertheless, in the analysis we include wide spectrum of performance indicators provided by Eurostat for regions:

- population in 1,000 persons and population density (to analyse the agglomeration economies);

- GDP in EURO per INH;
- GDP in PPS per INH;
- real growth of GDP in PPS per inhabitant;
- gross value added at basic prices per worker [1,000 Euros per worker];
- real growth rate of regional gross value added (GVA) at basic prices;
- average compensation [1,000 euro per worker];
- growth of average compensation;
- gross fixed formation / 1000 hours worked;
- employment growth rate in the whole economy, and in knowledge intensive sectors individually;
- % of population with first and second stage of tertiary education (levels 5 and 6);
- R&D expenditure in total as % of GDP, including the government, higher education and business sectors;
- total R&D personnel in all sectors (% of total employment - in full time equivalents), including government, higher education and business sector;
- Human Resources in Science and Technology (HRST) (% of active population), including education, occupation and core.

Apart from analysing correlations between all the variables, we also analysed cause-effect relations within the processes of development using Ordinary Least Squares Method. Thereby, it was possible to find a real impact of related variety on regional performance and to describe functioning models.

The last step involved selecting regions at the two poles – with the most related variety in the economy and the least – and then choosing within these two groups regions that have managed to reach the highest and lowest levels of economic growth, resulting in four groups of regions. These groups were estimated by cluster analysis using variables in the cause-effect processes, indicated by models from the former step. We analysed if the groups differ as far as the role of related variety in the development process is concerned.

As a result, it was possible to match regions' related variety and evolution with the industries that led/lead to regional economic renewal. First we seek to understand whether related variety is part of the path renewal process and, if so, how. Secondly we discuss whether path renewal has also given rise to radically renewed related variety environments, and, if so, how dense and knowledge intensive these environments are.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. EXPLICIT RELATED VARIETY AND GLOBAL VALUE CHAINS WITHIN COUNTRIES

Analysis of input-output data on 40 countries revealed correlations between related variety indicators and performance of the entire countries and participation in global value chains (see Table 2).

Explicit related variety, as it was defined in the latter section, induces a decrease in gross value added in a given sector, which means that the more production is supplied by other industries, the less the gross added value of the sector is. What is more, these more related, complex products are consumed domestically less frequently, but are exported to a greater extent (0.362) under the condition that the suppliers are from abroad. This is a very important statement for the analysis of global value chains and it fits the findings of Hausmann and Hidalgo (2011) that countries can export products requiring more capabilities.

The share of suppliers from abroad reflecting the level of global value chains (GVC) is correlated to export, which we describe as product competitiveness, at the rate of 0.685. This means the more foreign suppliers, the more exported products there are, but, as we see, it is better for export when the suppliers are from the same industry (0.607) than from other industries (0.448), although in both cases relatedness is statistically significant. Thus the products belong to global value chains on both the suppliers' and clients' sides. At the same time, products with foreign suppliers inputs are consumed domestically less frequently (-0.414). Therefore, in a general sense we can speak about rather sustainable global value chains. Of course, within the global chains there are different incentives to attract suppliers and buyers, and the value chains can be asymmetric (Antras & Chor, 2013). Nevertheless, in general, the entire value chain becomes more global from both sides. We have to keep in mind that even with more domestic suppliers from other sectors, products are exported more frequently.

On the other hand, the bigger the domestic demand, the higher income growth potential (value added) is (corr. 0.536), according to Keynesian theory, because demand induces higher prices. It is worth noting, that domestic demand is the only variable inducing growth of value added in individual sectors; thus we can define it as an endogenous growth potential. We have to keep in mind, however, that the analyses are conducted for separate industries and relations between sectors are not taken into account. In a global perspective, global value chains drive not only multinationals' growth (Cao, Jiang, & Cheng, 2012), but also economic growth (Hidalgo et al., 2007), despite the fact that they can be seen as a weaker or less productive way to create GDP. Most of all, they are seen as one way to grow when the domestic demand is fulfilled. From the companies' point of view, global value chains can be seen as a way to overcome growth constraints, compete in distant markets (Giuliani, Pietrobelli, & Rabellotti, 2005) and participate in the global division of labour (Hu, 2012).

In addition, neither related variety, global value chains, nor embeddedness of the industry is correlated positively with domestic consumption, which means different products can be consumed within the country, but more likely they would consist of intermediates from the same sector (because exported products are more likely to be produced by related industries).

Table 2. Analysis of the correlation between the variables describing the explicit related variety and global value chains

By all countries	Average	Standard deviation	Share of suppliers (domestic) (as % of total output)	Share of suppliers from the same sector (domestic and foreign) (as % of total output)	Share of suppliers from the same sector (domestic) (as % of total output)	Share of suppliers from different sectors (domestic and foreign) (as % of total output)	Share of suppliers from different sectors (domestic) (as % of total output)	Share of buyers in different sectors (domestic) (as % of total output)	Share of suppliers (foreign) (as % of total output)	Share of suppliers from different sectors (foreign) (as % of total output)	Share of suppliers from the same sector (foreign) (as % of total output)	Share of value added (as % of total output)	Share of consumed domestically (as % of total output)	Share of gross fixed capital formation (as % of total output)	Share of exported outputs (basic sectors) (as % of total output)	Share of sector in the economy (as % of total output)
Share of suppliers (domestic) (as % of total output)	0,382	0,126	–	0,328*	0,516*	0,530*	0,823*	0,148*	-0,174*	-0,189*	-0,048	-0,648*	-0,300*	0,125*	-0,001	-0,068*
Share of suppliers from the same sector (domestic and foreign) (as % of total output)	0,113	0,103	0,328*	–	0,781*	-0,170*	-0,136*	-0,080*	0,333*	-0,093*	0,724*	-0,496*	-0,414*	-0,048	0,299*	0,206*
Share of suppliers from the same sector (domestic) (as % of total output)	0,072	0,072	0,516*	0,781*	–	-0,196*	-0,063*	0,144*	-0,095*	-0,219*	0,135*	-0,314*	-0,264*	0,020	-0,121*	0,263*
Share of suppliers from different sectors (domestic and foreign) (as % of total output)	0,416	0,136	0,530*	-0,170*	-0,196*	–	0,747*	-0,034	0,442*	0,606*	-0,053	-0,764*	-0,306*	0,106*	0,362*	-0,341*
Share of suppliers from different sectors (domestic) (as % of total output)	0,310	0,108	0,823*	-0,136*	-0,063*	0,747*	–	0,077*	-0,140*	-0,075*	-0,146*	-0,547*	-0,174*	0,132*	0,079*	-0,253*
Share of buyers in different sectors (domestic) (as % of total output)	0,313	0,207	0,148*	-0,080*	0,144*	-0,034	0,077*	–	-0,271*	-0,144*	-0,285*	0,098*	-0,308*	-0,109*	-0,427*	-0,127*
Share of suppliers (foreign) (as % of total output)	0,147	0,116	-0,174*	0,333*	-0,095*	0,442*	-0,140*	-0,271*	–	0,830*	0,633*	-0,630*	-0,400*	-0,054	0,688*	-0,141*
Share of suppliers from different sectors (foreign) (as % of total output)	0,106	0,091	-0,189*	-0,093*	-0,219*	0,606*	-0,075*	-0,144*	0,830*	–	0,094*	-0,492*	-0,251*	0,001	0,448*	-0,208*
Share of suppliers from the same sector (foreign) (as % of total output)	0,041	0,065	-0,048	0,724*	0,135*	-0,053	-0,146*	-0,285*	0,633*	0,094*	–	-0,441*	-0,365*	-0,099*	0,607*	0,037
Share of value added (as % of total output)	0,440	0,165	-0,648*	-0,496*	-0,314*	-0,764*	-0,547*	0,098*	-0,630*	-0,492*	-0,441*	–	0,536*	-0,054	-0,533*	0,179*
Share of consumed domestically (as % of total output)	0,299	0,283	-0,300*	-0,414*	-0,264*	-0,306*	-0,174*	-0,308*	-0,400*	-0,251*	-0,365*	0,536*	–	-0,225*	-0,508*	0,088*
Share of gross fixed capital formation (as % of total output)	0,055	0,128	0,125*	-0,048	0,020	0,106*	0,132*	-0,109*	-0,054	0,001	-0,099*	-0,054	-0,225*	–	-0,167*	0,291*
Share of exported outputs (basic sectors) (as % of total output)	0,260	0,266	-0,001	0,299*	-0,121*	0,362*	0,079*	-0,427*	0,688*	0,448*	0,607*	-0,533*	-0,508*	-0,167*	–	-0,219*
Share of sector in the economy (as % of total output)	0,030	0,026	-0,068*	0,206*	0,263*	-0,341*	-0,253*	-0,127*	-0,141*	-0,208*	0,037	0,179*	0,088*	0,291*	-0,219*	–

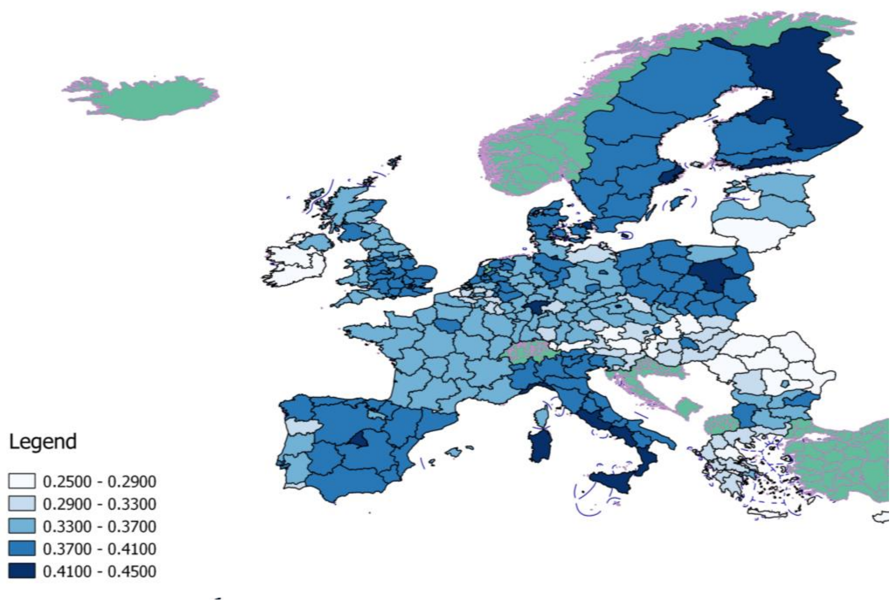
Source: own elaboration. Note: '*' denotes 5% significance level.

We also analysed different correlations with dynamics of related variety, global value chains and performance indicators, but there were no important relations (although statistically significant), which means these variables do not induce speed of processes.

In the next section we will go deeper into the regional level and calculate different measures of the related variety for regions.

4.2. RELATED VARIETY LEVEL WITHIN REGIONS

Explicit related variety level was analysed by four variables: 1) Average level of buyers in different sectors (domestic); 2) Average level of suppliers from different sectors (domestic and foreign); 3) Average level of suppliers from different sectors (domestic); 4) Average level of suppliers from different sectors (foreign). While the first variable refers to the pull factor of related variety (the buyers side), the next three refer to the push factor (the supplier side of the market), but in different scopes (domestic or foreign or both).



Map 1. Related variety pull factor (extent to which industry supports as an intermediate other related domestic sectors) – average level of buyers in different sectors (domestic) in analysed regions

Source: Self prepared in QGIS.

If we analyse the extent to which industries sell their outputs as intermediates to other domestic industries (pull factor), we see that the majority of regions with high related variety are in capitals and central parts of countries. In-depth analysis showed that this is caused by service sectors, selling much of their outputs to other sectors, which confirms the findings of Marrocu, Paci, and Usai (2013) that diversity has a positive impact on knowledge-based services in urban areas of 'old' Europe. One can conclude that the related variety pull factor works in highly developed and dense regions, but in-depth analysis showed this related variety refers to outputs of service sectors, especially low knowledge intensive service sectors (see Table 3), which are absorbed by manufacturing. Thus in these regions service sectors can play a crucial role in development, which is widely confirmed in the literature (Pylak & Majerek, 2014 (forth.)). The table shows that KIS market services have both higher shares of buyers and suppliers from other services, which confirms their intermediate role in the economy (Strambach, 2008).

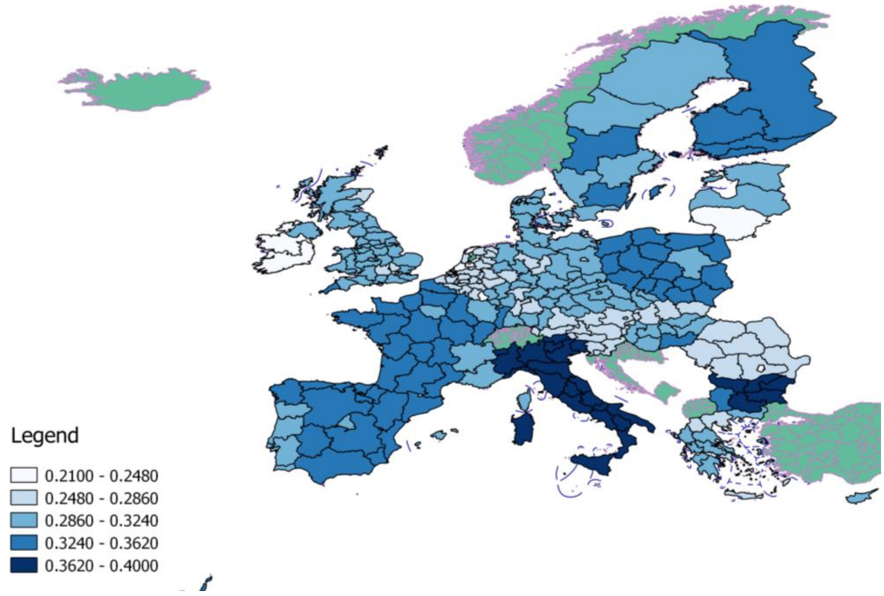
The average level of suppliers from different sectors, in turn, reflecting the related variety push factor, refer mostly to low and medium-low technology sectors as far as domestic suppliers are concerned (0.50 and 0.48 respectively), and to high technology sectors when foreign supplier are concerned (0.43). This conclusion may be combined with country analysis, where foreign suppliers induced export activities, which can be combined here with high technology products to be exported. Also, if there are fewer foreign suppliers from other sectors in high-tech sectors, there are also fewer buyers from other sectors (0.40), which can reflect isolation and non-ubiquity of these sectors (Hausmann & Hidalgo, 2011) and fit within the Marshallian externalities theory (Henderson, 2003), also indicating and confirming specialisation of value chains in these sectors (Beugelsdijk et al., 2009).

Table 3. Correlations between explicit and tacit related variety indexes

				REGIONAL EXPLICIT RELATED VARIETY INDICATORS				REGIONAL TACIT RELATED VARIETY INDICATORS	
	Variables	Average	Standard deviation	Average level of buyers in different sectors (domestic)	Average level of suppliers from different sectors (domestic and foreign)	Average level of suppliers from different sectors (domestic)	Average level of suppliers from different sectors (foreign)	Regional Economy Complexity indicator (all sectors' employment)	Regional Economy Complexity indicator (sectors with RCA > 1)
Regional explicit related variety indicators	Average level of buyers in different sectors (domestic)	0,34	0,04	–	0,172125	0,373897*	-0,195485	-0,061054	-0,480949*
	Average level of suppliers from different sectors (domestic and foreign)	0,39	0,04	0,172125	–	0,744995*	0,590696*	0,198347*	0,438202*
	Average level of suppliers from different sectors (domestic)	0,29	0,03	0,373897*	0,744995*	–	-0,098190	0,265634*	0,415809*
	Average level of suppliers from different sectors (foreign)	0,10	0,03	-0,195485	0,590696*	-0,098190	–	-0,025410	0,150765
Regional tacit related variety indicators	Regional Economy Complexity indicator (all sectors employment)	0,29	1,08	-0,061054	0,198347*	0,265634*	-0,025410	–	0,463670*
	Regional Economy Complexity indicator (sectors with RCA > 1)	0,15	1,16	-0,480949*	0,438202*	0,415809*	0,150765	0,463670*	–
Average level of buyers in different sectors (domestic)	High technology sectors related variety level	0,00	0,00	-0,057448	0,490378*	0,273567*	0,400661*	-0,011843	0,150731
	Medium-high-technology sectors related variety level	0,01	0,01	0,019056	0,065805	0,334646*	-0,306619*	0,104871	0,240294*
	Medium-low technology sectors related variety level	0,02	0,01	-0,165869	0,405570*	0,523443*	-0,028112	0,476563*	0,741284*
	Low technology sectors related variety level	0,02	0,01	-0,265650*	0,450471*	0,505789*	0,060227	0,284026*	0,727277*
	KIS market services related variety level	0,02	0,01	0,468892*	-0,376166*	-0,403350*	-0,073285	-0,263871*	-0,629581*
	LKIS low intensive-services related variety level	0,17	0,03	0,719233*	-0,002189	0,133067	-0,164225	-0,184636	-0,514062*
	KI industries (high and medium high tech and KIS sectors) related variety level	0,03	0,01	0,480662*	-0,300094*	-0,253552*	-0,140996	-0,232432*	-0,536158*
	Share of not KI industries (medium and low tech and LKIS sectors)	0,21	0,03	0,660213*	0,370570*	0,609202*	-0,184062	0,129701	0,043049
Average level of suppliers from different sectors (domestic and foreign)	High technology sectors related variety level	0,01	0,00	-0,005113	0,384119*	0,117642	0,430747*	0,029458	0,052457
	Medium-high-technology sectors related variety level	0,03	0,02	-0,023176	0,286708*	0,271021*	0,099895	0,208557*	0,383064*
	Medium-low technology sectors related variety level	0,03	0,02	-0,101148	0,530033*	0,498469*	0,187776	0,401704*	0,737481*
	Low technology sectors related variety level	0,05	0,02	-0,318644*	0,515751*	0,481301*	0,187236	0,287564*	0,765348*
	KIS market services related variety level	0,01	0,01	0,435897*	-0,297008*	-0,394393*	0,033971	-0,209809*	-0,662378*
	LKIS low intensive-services related variety level	0,14	0,02	0,297598*	0,234591*	0,008079	0,340202*	-0,247213*	-0,372366*
	KI industries (high and medium high tech and KIS sectors) related variety level	0,05	0,02	0,156798	0,224860*	0,107584	0,205322*	0,106654	0,081973
	Share of not KI industries (medium and low tech and LKIS sectors)	0,22	0,03	-0,054677	0,772169*	0,574577*	0,456946*	0,217857*	0,616147*

Source: own elaboration. Note: '*' denotes 5% significance level.

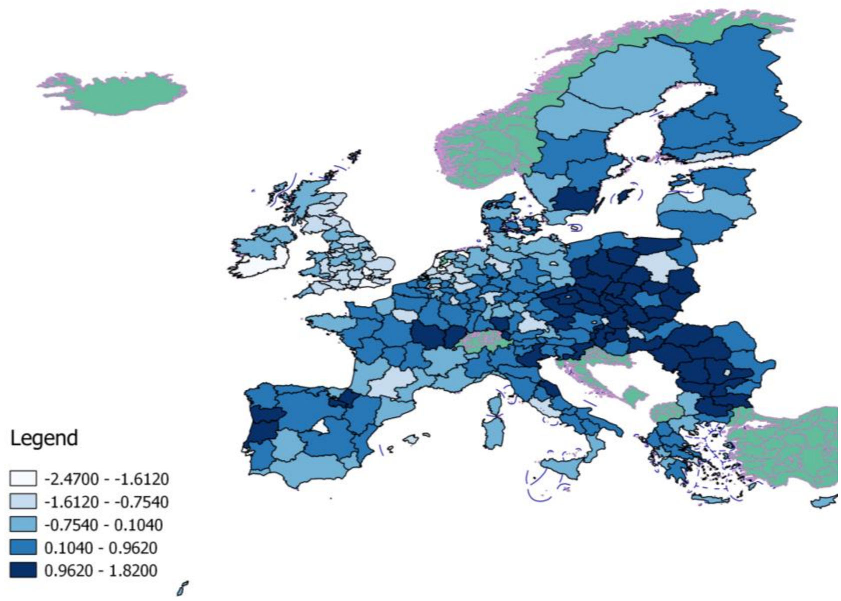
The related variety push factor decomposes mostly in regions that are not central, although the country component of the indicator formula can be seen (see map 2).



Map 2. **Related variety push factor (extent to which industry is supported by intermediates from other related domestic and foreign sectors) – % of suppliers from different sectors (domestic and foreign) in analysed regions**

Source: Self prepared in QGIS.

After explicit related variety pull and push indicators, we analysed the tacit related variety indicators for the entire economy and for specialisation industries. It is easy to notice that the latter indicator strengthens the correlations of the first one, thus the findings are sharper and differentiate the regional results to a greater extent (standard deviation is 1.16 vs. 1.08), although correlation between these two indicators is relatively high (0.46).



Map 3. **Regional Economic Complexity Index (RECI) for sectors with RCA > 1 in analysed regions**

Source: Self prepared in QGIS.

RECI indicators have a statistically significant correlation with the share of suppliers in the economy, especially for sectors with RCA > 1 (0.44), but are negatively correlated with the share of buyers from other sectors. When we analyse sectors, we can see that RECI covers both the suppliers' and buyers' side of medium low and low technology sectors and is opposite to KIS and LKIS sectors. Thus this means a large number of regions specialise in medium low and low technology industries (and therefore RECI (RCA > 1) grows), which represent a large share of their economies and are largely related to the domestic market, confirming the findings of Hu (2012).

This finding confirms the role RECI can play in describing relatedness of sectors. First, more related and common industries increase the RECI value; thus it is crucial to find out if it induces regional growth (which will be done in the next section). Second, competencies sharing between industries and regions can be hampered, and thus gaining capabilities to develop more knowledge intensive industries can be problematic. To analyse this issue we used a global Moran's index for spatial autocorrelation.

The analysis pointed out the existence of a statistically significant positive autocorrelation of RECI (sectors with RCA > 1); however it was not significant for the indicators of explicit related variety average level of domestic buyers in different sectors and average level of domestic suppliers from different sectors. The global Moran index for Regional Economy Complexity indicator was statistically significant for neighbourhood matrixes of queen contiguity even of the 3rd order which implies similar values of the indicator in a given region and neighbouring regions even in the 3rd circle of surrounding regions. The statistically significant (p-value 0.001) global Moran index for neighbourhood matrix of the 2nd order including lower orders equalled 0.46, while for the neighbourhood matrix of the 3rd order including lower orders 0.37 (p-value 0,02) and for the neighbourhood matrix of the 3rd order without lower orders 0.34 (p-value 0,03). This implies that the values of the indicator are the most similar in the case of the closest neighbours. It also means large clusters of similar values of the RECI (RCA>1) indicator in Europe. Figure 1 presents the Moran scatter plot for the Regional Economic Complexity Indicator (RCA>1) for the neighbourhood matrix of the 2nd order including lower orders.

The Moran scatter plot visualizes the type and strength of spatial autocorrelation in a data distribution. The slope of the scatter plot corresponds to the value for Moran's I. It is a measure of global spatial autocorrelation or overall clustering in a dataset. The four quadrants of the scatter plot describe an observation's value in relation to its neighbours; starting with the x-axis, followed by y: High-high, low-low (positive spatial autocorrelation) and high-low, low-high (negative spatial autocorrelation).

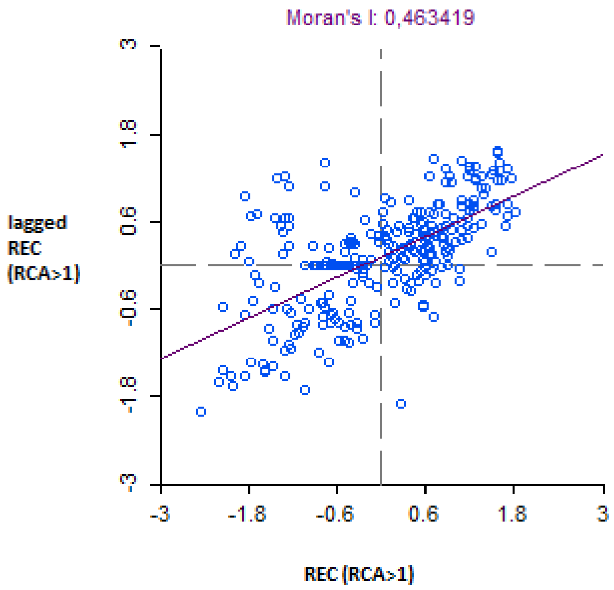
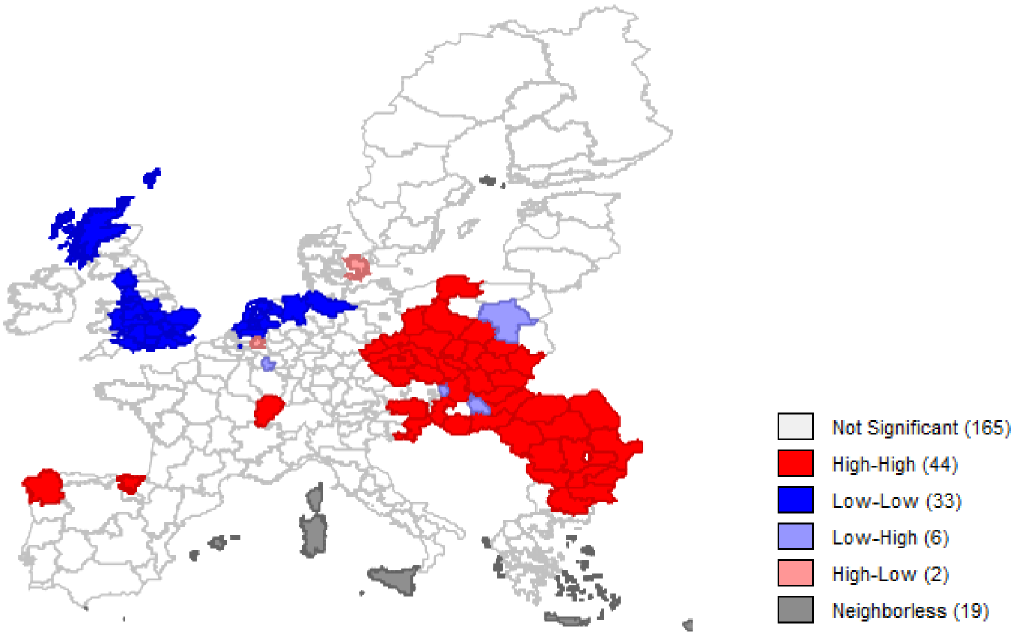


Figure 1. **Global Moran index for Regional Economic Complexity Indicator (RCA>1) (neighbourhood matrix of queen contiguity of the 2nd order including lower orders)**

Source: Calculations in GeoDa

The global Moran index significant for neighbourhood matrix even of the 3rd order implies large clusters of regions of similar values of the RECI (RCA > 1). It was confirmed by the analysis of local

Moran index for the weights matrix of neighbourhood of the 1st order which is presented on the Map 4.



Map 4. Local Moran Index cluster map for Regional Economic Complexity Indicator (RCA>1)

Source: Self prepared in GeoDa.

As the map shows, statistically significant clusters of regions with a high value of the indicator surrounded by regions of similarly high values of the indicator are present in large parts of Central and South-East Europe, as well as some northern regions of Spain and a French region near Switzerland, while regions with a low value of the indicator surrounded by regions of low values are located mainly in England, Scotland and on the North Sea coast of continental Europe.

This finding confirms that although the pecuniary exchange of outputs can be borderless, competency sharing (or hampering) can take place in some European regions. We indicated both positive and negative examples of clusters that limit themselves to either specialisation or diversification. While the first positive clusters are enhancing growth by specialisations based on not ubiquitous industries, the second clusters can be a real problem in terms of providing an appropriate level of convergence. A study on the least developed regions of Eastern Poland performed on the level of sub-regions based on spatial econometrics showed that interactions with sub-regions located among their 10 closest neighbours implied that interactions with the most developed sub-regions of the capital and surrounding territories induced growth in Eastern Poland's sub-regions, while interactions with neighbours from Eastern Poland lowered the growth potential (Wojnicka-Sycz, 2013a).

To confirm the role of RECI in explaining the role of related variety in development, we analysed the level of RECI for the entire economy and for specialisation industries and GDP per capita (see figure 2). The figure shows that many developed regions specialise in less ubiquitous industries and lots of less developed regions specialise in more ubiquitous industries and this correlation is high (0.591). The correlation of GDP per capita with RECI for the entire economy is only 0.259; thus this may mean the specialisation in not ubiquitous industries can play a crucial role in development. This statement, however, will be analysed more deeply in the next section.

In addition, when we consider the two most developed countries (circled in blue), we see that the first one (with the highest GDP per capita) is specialised in less ubiquitous industries and thus is less diversified, while the second case shows the region specialised in industries of similar ubiquity and thus nearly as diversified. This may mean that the structure of the economy is less relevant for development and that specialisations are crucial, because subtraction of two RECI indicators is not strongly correlated with GDP per capita (0.275) either.

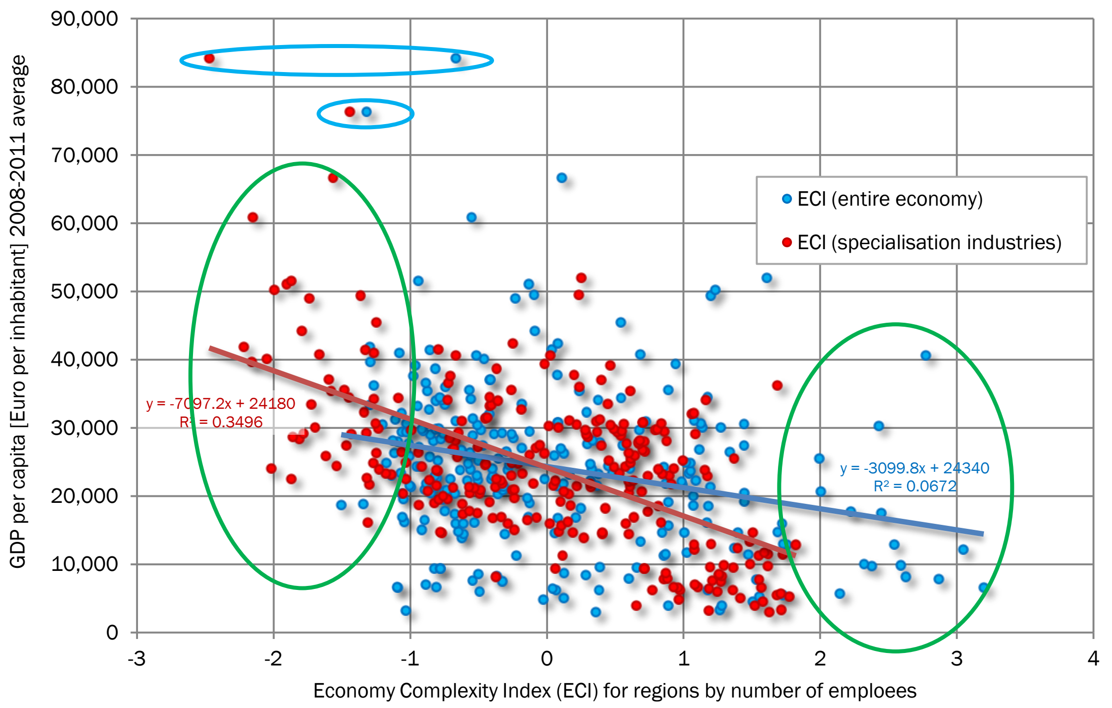


Figure 2. **Correlation between Economy Complexity Index (ECI) for regions by number of employees in the entire economy and specialization industries and GDP per capita [Euro per inhabitant] 2008-2011 average**

If the possibility for growth lies in the not ubiquitous industries, we have to analyse the RSCI for knowledge intensive industries. Figure 3 and 4 presents both RSCI in regional economies' industries and industries that are regional specialisations:

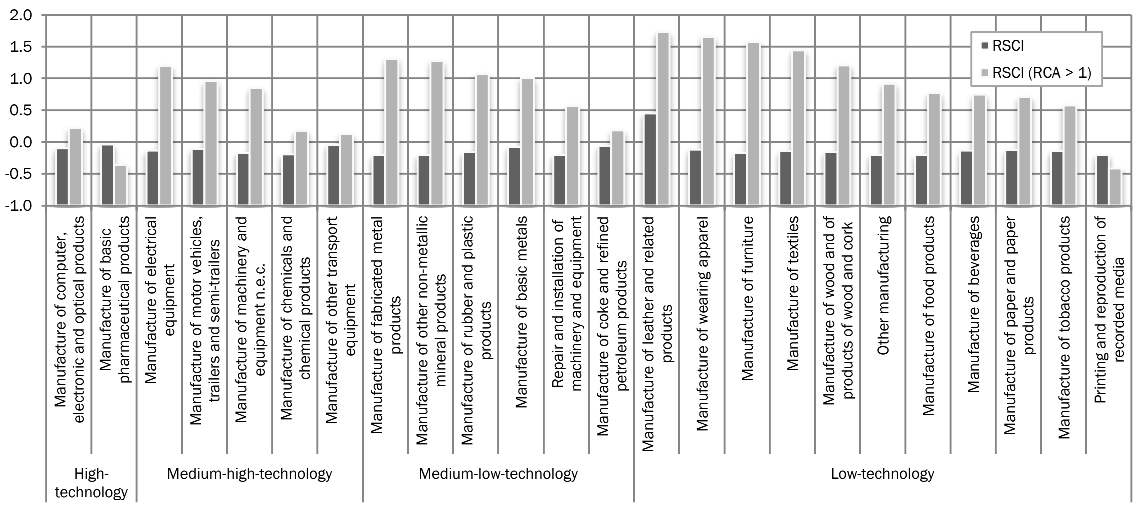


Figure 3. **Regional Sector Complexity Index (RSCI) for industries existing in regions and industries that are regional specialisations – knowledge intensive manufacturing sectors**

The first conclusion from these figures is that most of the industries are present in every region, which means most regions can produce or participate in the production of outputs of every sector, including high-tech sectors. But, when specialisation industries are concerned, the more knowledge intensive the sector, the fewer regions can obtain an advantage. In other words, regions mostly specialise in low-technology sectors.

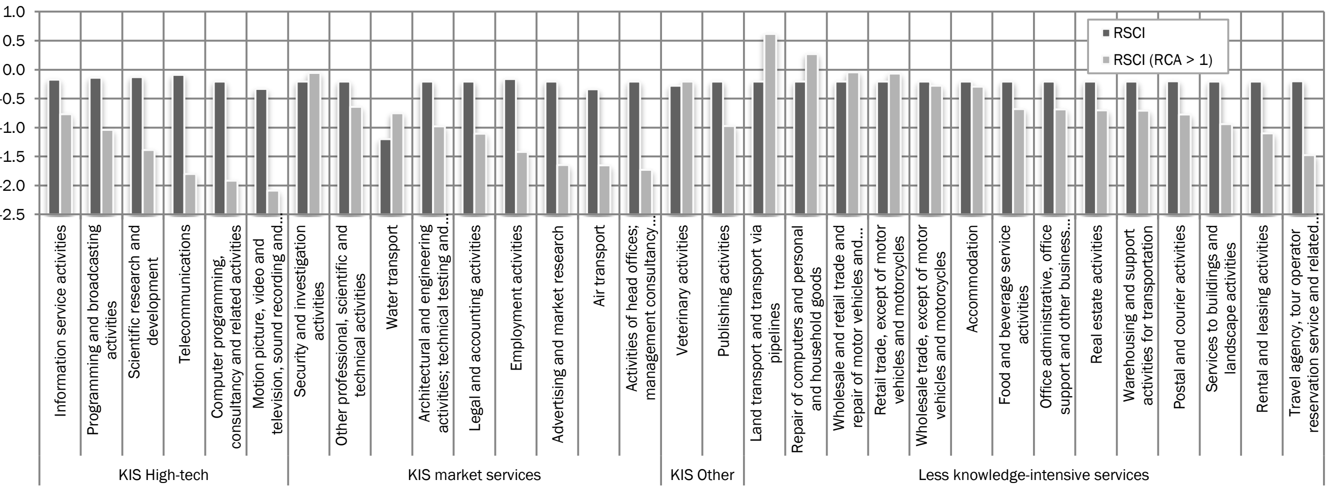


Figure 4. Regional Sector Complexity Index (RSCI) for industries existing in regions and industries that are regional specialisations – knowledge intensive services sectors.

The same relatedness can be observed as far as the service sectors are concerned. Although every region has the majority of service sectors, they can specialise the most in less-knowledge intensive services. It is worth noting that far fewer regions specialise in service sectors compared to industry specialisations. This conclusion can have a negative impact on development potential of regions.

4.3. TRACING THE IMPACT OF RELATED VARIETY ON REGIONAL PERFORMANCE

To confirm the hypothesis of the positive impact of related variety on economic wellbeing, especially economic growth and the innovativeness of regions, varied models explaining output and innovativeness measures with variables reflecting related variety were estimated. Related variety was expressed by measures referring to the whole economy of regions as well as particular sectors of the economy such as high technology, medium high technology, medium low technology, low technology, total knowledge-intensive services, knowledge-intensive high-technology services, knowledge-intensive market services (except financial intermediation and high-technology services), other knowledge-intensive services, total less knowledge-intensive services, less knowledge-intensive market services, other less knowledge-intensive services, knowledge intensive industries (high and medium high tech and KIS sectors), and industries that are not knowledge intensive (medium and low tech and LKIS sectors). The share of sectors was expressed by the number of employees. As output-economic performance measures were analysed: population in 1,000 persons, population density, GDP in EURO per capita, GDP in PPS per capita, real growth of GDP in PPS per capita, real growth of GDP in PPS per capita in quota, gross value added (GVA) at basic prices per worker [1,000 Euros per worker], real growth rate of regional gross value added (GVA) at basic prices, average compensation [1,000 euro per worker], growth rate of average compensation of employees, gross fixed formation / 1000 hours worked. As variables reflecting regional innovativeness were taken: share of population with first and second stage of tertiary education (levels 5 and 6), R&D expenditure in total as % of GDP, R&D expenditure in the government sector as % of GDP, R&D expenditure in the higher education sector as % of GDP, R&D expenditure in the business sector as % of GDP, total R&D personnel in all sectors (% of total employment – in full time equivalents), total R&D personnel in government sectors (% of total employment – in full time equivalents), total R&D personnel in higher education sectors (% of total employment – in full time equivalents), total R&D personnel in business sectors (% of total employment – in full time equivalents), Human Resources in Science and Technology (HRST) (% of active population), Human Resources in Science and Technology (HRST) – Education (% of active population), Human Resources in Science and Technology (HRST) – Occupation (% of active population), Human Resources in Science and Technology (HRST) – Core (% of active population).

Table 4. Models of related variety factors influence on regional performance using Ordinary Least Squares Method

Explanatory variables	Explained variable: GDP in EURO per inhabitant	GDP in EURO per inhabitant	Real growth of GDP in PPS per inhabitant	Human Resources in Science and Technology - Occupation (% of active population)	Gross value added at basic prices per worker [1,000 Euros per worker] (logarithm)	R&D expenditure in the business sector as % of GDP (logarithm)
Share of Medium-high-technology sectors	655.2 (0.0002)	525.4 (0.0026)	0.225705 (<0.00001)			
Share of Other knowledge-intensive services	740.7 (<0.00001)					
Regional Economy Complexity indicator (sectors with RCA > 1)	-6,863.08 (<0.00001)	-4,233.19 (0.00023)				
Share of total knowledge-intensive services	.	733.1 (<0.00001)	-0.231016 (<0.00001)			
Average level of buyers in different sectors (domestic)			76.6178 (<0.00001)			
Average level of suppliers from different sectors (domestic)			-51.8299 (<0.00001)			
Medium-high-technology sectors related variety level (buyers)			-232.279 (<0.00001)			
Medium-low technology sectors related variety level (buyers)			-107.992 (<0.00001)			
Low technology sectors related variety level (buyers)			71.1314 (0.0074)			
KIS market services related variety level (buyers)			-92.1595 (<0.00001)			
LKIS low intensive-services related variety level (buyers)			-44.872 (0.00006)			
High technology sectors related variety level (average level of suppliers from different sectors: domestic and foreign)				3,208.09 (0.00007)		
GDP in PPS per INH				0.0007 (<0.00001)		
Share of high technology sectors				-13.9532 (0.0003)		
R&D expenditure in total as % of GDP (logarithm)					0.463157 (0.0077)	
Regional Economy Complexity indicator (sectors with RCA > 1) (logarithm)					-0.180738 (<0.00001)	
High technology sectors related variety level (average level of suppliers from different sectors: domestic and foreign) (logarithm)						-3.18 (0.001)
Share of Medium-high-technology sectors (logarithm)						0.72 (0.0002)
Share of high technology sectors (logarithm)						3.57 (0.0004)
% of population with first and second stage of tertiary education (levels 5 and 6)						0.076 (<0.00001)
R^2	0.72	0.73	0.59	0.71	0.57	0.54

Source: own elaboration. Note: * In each equation satisfactory were values of RESET test for specification, test for heteroscedasticity and test for normality of residuals' distribution; in each model also constant was present.

Only 6 of the many estimated models were satisfactory and are presented in table 3. It means only 6 variables are explained by explanatory variables taken into account. These models were estimated using the Ordinary Least Squares Method. In some cases logarithms of the values of variables were used. The data was of a cross-sectional character.

The first model showed that increase in the share of medium high-tech sectors by 1 percentage point caused increase in GDP in euro per inhabitant by 655.2 with other variables constant. Also, the increase in the share of other knowledge intensive services caused an increase of GDP per capita by even more, that is 740.7, while an increase in the index of the Regional Economy Complexity Indicator (for sectors with an RCA higher than 1) by one caused a decrease of GDP in euro per inhabitant by 6,863. It means that related variety of specialisation industries reflecting similar competences in a region induce a much lower GDP per inhabitant, which confirms our above findings. This model explained 72% of variation of the explained variable GDP per capita.

The second model showed similar relationships, that is the positive impact of the increase of the share of medium high-tech sectors in the economy and the negative impact of the increase of the Regional Economy Complexity Index on GDP per capita and also the positive impact of the increase of the share of total knowledge-intensive services on GDP in Euro per inhabitant in European regions, with other variables constant. This means KIS are also important for growth, but their role is confirmed in other papers (see for example: Desmarchelier, Djellal, & Gallouj, 2013; Evangelista, Lucchese, & Meliciani, 2013; Marrocu et al., 2013; Pylak & Majerek, 2014 (forth.)). This model explained 73% of the variation of GDP per capita in the regions.

The third model explained real growth of GDP in PPS per inhabitant in the European NUTS 2 regions and is crucial for explaining the development process of regions. The model showed that an increase in the measure of the average level of domestic buyers' explicit related variety in different sectors by 1 caused an increase of GDP growth in PPS per inhabitant by 76.7 percentage points with other variables constant, and a similar increase by 71.1 percentage points caused an increase of the related variety level of low technology sectors calculated based on the share of buyers in different sectors. This means low technology sectors induce GDP growth only when their outputs are sold to other sectors within the region, thus outputs of these sectors should fall within the scope of wide value chains to induce GDP growth. Nevertheless, the share of suppliers from other sectors should be the lowest (see also table 3) in these sectors; thus they should produce mostly within their industries, confirming the positive role of Marshallian externalities in the economy (Frenken et al., 2007; Henderson, 2003).

Where the medium high-tech sectors are concerned, GDP growth can be induced by their share growth in the economy with other variables constant, which means specialisation in these sectors with the proviso that they are not related to other sectors (this related variety had the strongest negative effect).

The role of service sectors is unambiguous. Although increase of both the share of total KIS and the explicit related variety indicator referring to buyers from other sectors within KIS market services and less knowledge intensive services caused a decrease in the real growth per capita in a given region, in model 1 the share of total KIS caused an increase in the GDP per capita, with other variables constant. It may mean that the quickest growing regions in Europe should have a medium level of KIS, but most importantly, KIS should play a supporting and enhancing role for medium high-tech industries (Pylak & Majerek, 2014 (forth.)), which is possible in more developed regions (which is shown in model 1). This may explain the negative effects of entire service sectors and KIS in all the regions. Also, the negative effect caused by the share of KIS selling to other sectors can be explained by the necessity of focusing on specialisation industries by KIS. Model 3 explained 59% of the variation of the explained variable real GDP growth in PPS per inhabitant, which in fact means a weak goodness of fit of the model.

The 4th model showed that a higher index of the related variety level of high technology sectors measured by the average level of domestic and foreign suppliers from different sectors caused a strong increase of Human Resources in Science and Technology (HRST) occupations as a percentage of the active population, with other variables constant, GDP in PPS per inhabitant in a region also had a small positive influence on HRST occupations, while the increase in the share of high technology sectors in a region caused a decrease in HRST occupations as a percentage of the active population. In this case related variety of high-tech sectors increased the innovative potential of a region, although the negative effect of a growing share of high-tech industries is hardly explainable. Probably the share of these industries can cause a relatively lower demand for HRST, because of knowledge sharing and technology transferring. This model explained 71% of variation of the explained variable, indicating a satisfactory goodness of fit.

The 5th model showed that an increase of the Regional Economy Complexity indicator (calculated for sectors with RCA>1) by 1% caused a decrease of Gross Value Added at basic prices per worker by 0.18%, while the increase of the share of R&D in the GDP by 1% caused an increase of GVA per worker by 0.46%. This means that innovativeness and R&D is crucial for productivity, as neoclassical and new growth theory states, rather than related variety (Solow, 1988; Wojnicka-Sycz, 2013b). The more similar industries are in regions, the lower their productivity level, which can be explained by an increased level of competitiveness between industries and lower prices. This model however explained 57% of the variety of GVA per worker, which indicates a weak goodness of fit.

The 6th model showed that an increase in the related variety of high technology sectors measured by the share of domestic and foreign suppliers in the output caused a decrease of the share of business R&D in the GDP by 3.2%, with other variables constant, while an increase of the share of medium-high tech and high tech sectors in the regional economy had a positive impact on the share of business R&D in the GDP. This means the more suppliers of high-tech companies there are, the weaker the need for conducting their own R&D activities is; nevertheless it is obvious and confirmed that high-tech companies are devoting more resources to these activities than others. The increase of the share of the population with a tertiary level of education by one percentage point caused an increase of the share of business R&D in the GDP by 7.8%. The impact of related variety on regional innovativeness is thus ambiguous and depends on the measure of innovativeness. High tech related variety has a positive influence on the share of HRST occupations in the active population (model 5), but negative on the share of business R&D in the GDP. The reason for the latter negative impact of higher related variety may be the need for some kind of monopoly needed for a firm to be able to place innovations on the market, giving it an advantage and rewarding research and development efforts (Hausmann & Rodrik, 2003; Schumpeter, 1939). This monopoly is acquired, for example, by intellectual property rights. Firms are more likely to engage in R&D if the economy is specialized, rather than too diversified. The 6th model explains, however, only 54% of the variety of the explaining variable, indicating a weak goodness of fit.

4.4. RELATED VARIETY WITHIN GROUPS OF REGIONS

The last step of our analysis is finding out if different grouping are gaining different effects. Thus we took all the explanatory variables from the previous section that were inducing performance and all the explained variables that were induced in the six models and identified four groupings by cluster analysis.

The four groupings were named according to their development level (measured by GDP per capita). It is notable that although the higher GPD level, the lower GDP growth is, in the group of medium less developed regions, real growth is the lowest. In turn, this group is specialised in less ubiquitous industries than the medium high developed group (see figure 5).

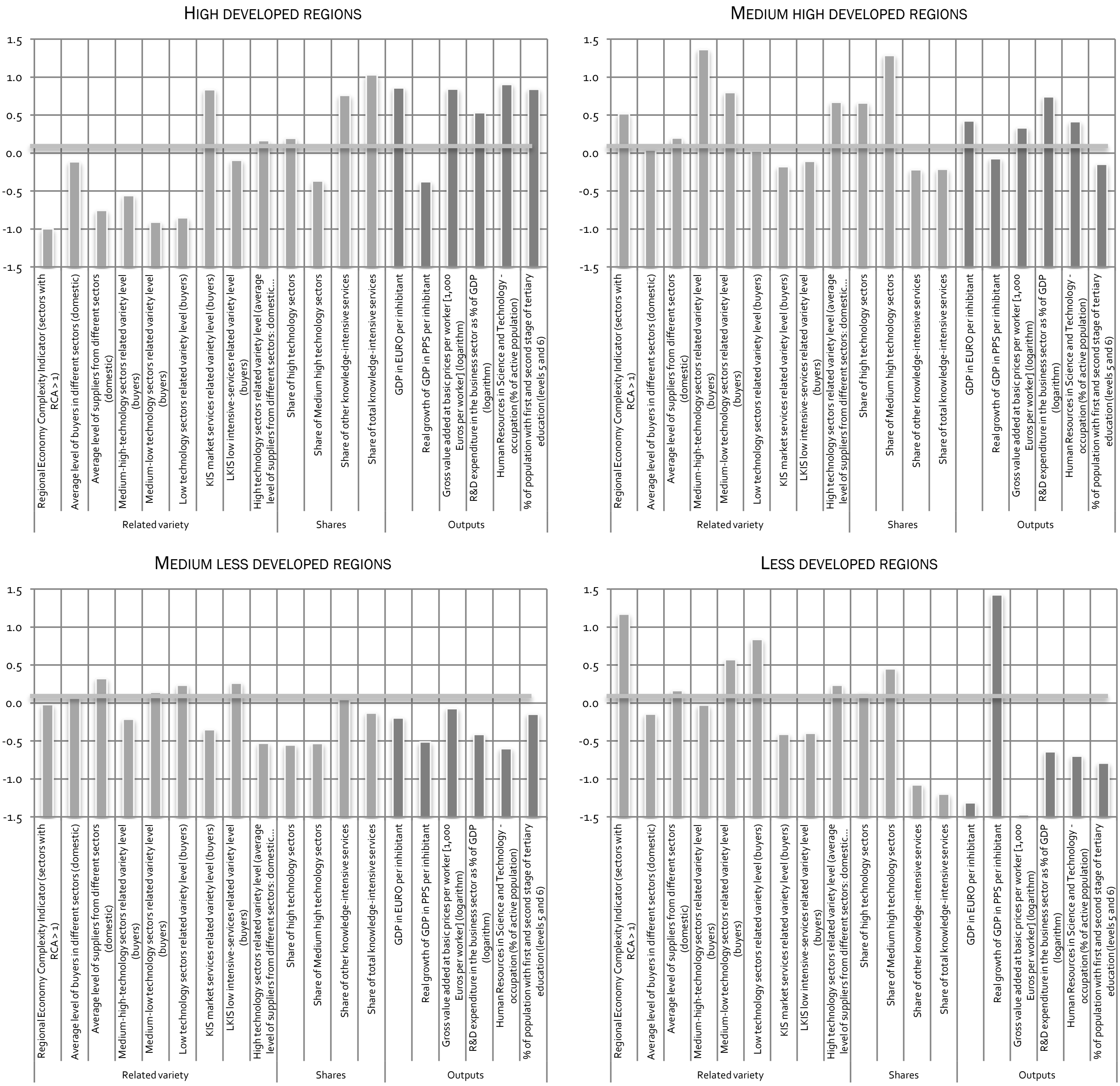


Figure 5. Averages of variables of four groups selected using cluster analysis

Thus the group of medium less developed regions deserves further research as their specialisations are not working effectively and GDP growth is the smallest.

We can also indicate some interesting features of each group, like KIS orientation and a big share of KIS outputs selling to other sectors in high developed regions, which proves the group consists of knowledge hubs, especially when these regions also have the highest share of HRST and tertiary educated people. A different specificity of groups was confirmed in Pylak and Chaniotou (2013).

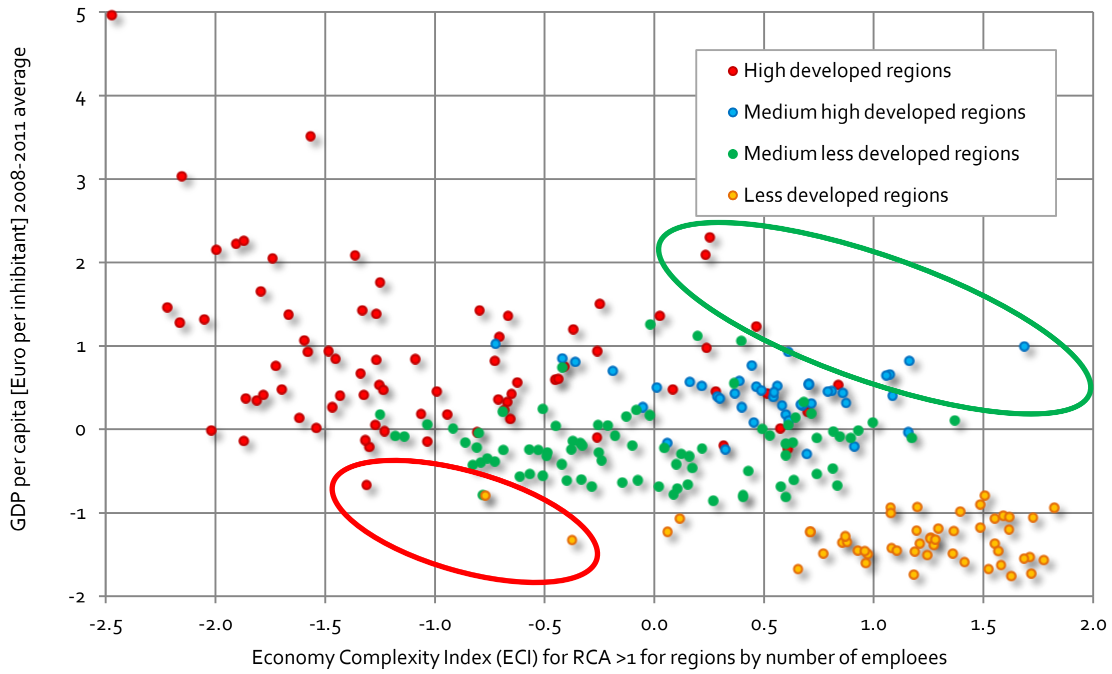


Figure 6. **Correlation between Regional Economy Complexity Indicator (sectors with RCA > 1) and GDP in euro per inhabitant within four groups referring to different level of development (variables standardised)**

The same can be noted as far as the medium high developed regions are concerned. They can be called high technology-driven regions due to the highest level of these industries in the economy, but one can note that less developed regions have a relatively high share of these industries. These differences between groups should be studied further research so that their influence on regional performance can be determined.

In this study we want to indicate specific regions that act and benefit from the complexity of their economies, as well as those that don't (see figures 6-8). In figure 7, we can indicate a few regions that, despite the high level of ECI (RCA > 1), achieve a high level of GDP per capita (circled in green), thus positively exploiting their complexity (for example Vorarlberg, Vestlandet, Agderog Rogaland). There are also negative examples of regions (circled in red), that do not exploit their not ubiquitous specialisation industries (like Közép-Magyarország, Mazowieckie, Bucuresti–Ilfov).

The same indication can be done as far as the GVA level is concerned. Here we can also indicate regions that exploit their complexity (Vorarlberg, Vestlandet, Agderog Rogaland) and that are not exploiting their specialisation potential (like for instance Közép-Magyarország, Yugozapaden, Mazowieckie, Bucuresti–Ilfov). As we can see, the good and bad examples concerning GDP per capita and GVA per worker are similar.

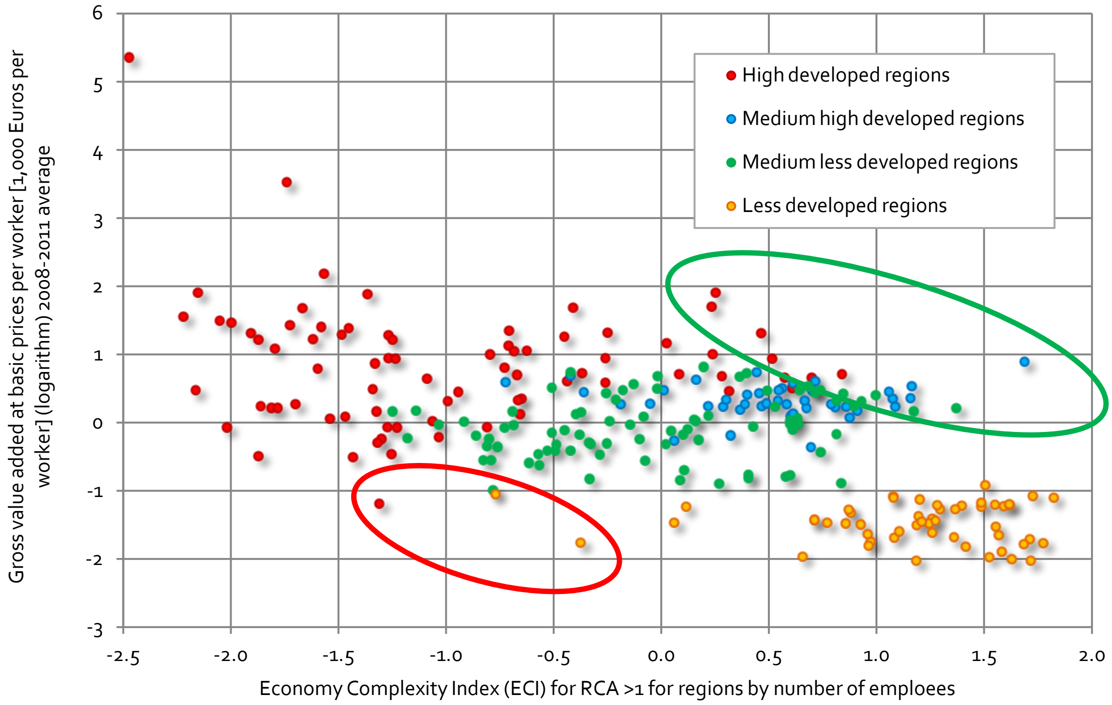


Figure 7. **Correlation between Regional Economy Complexity Indicator (sectors with RCA > 1) and gross value added at basic prices per worker [1,000 Euros per worker] (logarithm) within four groups referring to different level of development (variables standardised)**

As far as real growth of GDP is concerned (see figure 8), good examples are circled in green (for instance Yugozapaden, Bucuresti–Ilfov, Mazowieckie). These are the same examples as the bad ones concerning exploitation of their specialisation, and, in addition, they are capitals of less developed countries (Bulgaria, Romania and Poland). Therefore, it is crucial to analyse these case studies in further research and find out if these regions are only starting to benefit their specialisation or if they are making some mistakes in the appropriate exploitation of their current position or entering into the 'global value chains trap' (Hu, 2012).

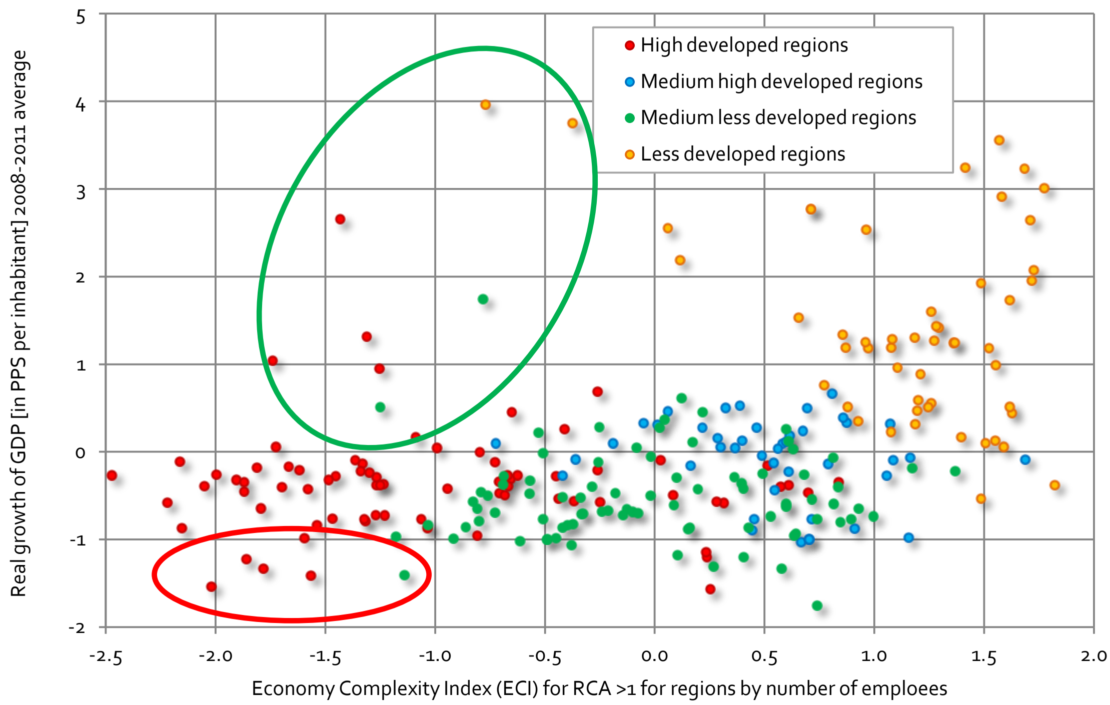


Figure 8. **Correlation between Regional Economy Complexity Indicator (sectors with RCA > 1) and real growth of GDP [in PPS per inhabitant] within four groups referring to different level of development (variables standardised)**

The bad examples of GDP growth are for example very specialised regions like: West Midlands, Oslo og Akershus, Bedfordshire and Hertfordshire, Surrey, East and West Sussex, Outer London. These cases also require further analysis.

5. CONCLUSION

Multidimensional analysis revealed that on the country level related variety plays a crucial role in building global value chains, thus hypothesis 1 is confirmed. Global competitiveness, however, induces more complex products for export, made by a country, mainly with foreign suppliers from both the same and other sectors. On the other hand, for a growth of sectoral value added, it is crucial to keep as much as possible of the value chain within the country, strengthening Marshallian externalities (Henderson, 2003) and especially to consume outputs domestically. Although domestic demand induces value added growth, there are some limitations in this demand, and participation in global value chains becomes inevitable.

On the regional level both explicit (pecuniary) and tacit (competency-driven) related variety indicators were analysed. In general, both groups of indicators show related variety does not induce growth. This means hypothesis 2 is not confirmed at all. Nevertheless, the study shows how different internal specialisations compare with export-driven related variety, which induces growth (Boschma & Iammarino, 2009; Boschma et al., 2012; Hidalgo et al., 2007). In turn, our study shows that although smart specializations have to be more knowledge-intensive, and thus have higher potential for growth, at the same time they have to be the most different from specialisations of other regions (so as to rich the lowest level of RECI for RCA >1). As far as the related variety of suppliers from different sectors is concerned, our findings show companies should produce as much as possible within their own industry, which would induce the growth of productivity and R&D activities. Nevertheless, we should keep in mind both domestic demand potential and global value chains' sophistication.

The analysis revealed a high correlation between explicit and tacit related variety (0.44), which means that the more suppliers from other sectors there are, the more often sectors of these suppliers and buyers appear in the economy of regions, especially as far as specialization industries are concerned. This confirms the correctness of the assumptions of our analysis. But while pecuniary related variety does not show spatial correlations, competencies are more likely to be shared between proximal regions. This causes another problem that some regions are facing. Moran's index revealed clusters of similarly high values of RECI (RCA > 1), which means these regions are specialised in industries that are very common in the European economy. Therefore, once they may experience interregional spillovers, hampering the development (Bai et al., 2012), they are in a difficult position to learn developmental specialisation. These regions are located in Central and South-East Europe, which means they need to benchmark their specialisations from farther west, at least to Germany or further.

The analysis has shown that the impact of related variety of the economy on regional economic performance and innovativeness is ambiguous, while it has confirmed other relations of strong theoretical basis like the importance of R&D for productivity, and thus high-tech industries (Hartog et al., 2012) or KIS play a crucial role. If we agree with the huge role of KIS in the development of high-tech sectors (Djellal, Gallouj, & Miles, 2013; Doloreux & Shearmur, 2012, 2013) and the rarity of both high-tech and KIS in regions in the extent that can generate specialisation, the development potential of regions can be at risk. Nevertheless, further analysis revealed some exceptions; for example, there are some examples of less knowledge intensive services that are also not ubiquitous. Also, analysis of the RSCI indicators of different industries showed there are examples of less knowledge-intensive sectors that are not ubiquitous either (like the following sectors: chemical and other transport equipment (medium-high tech), and printing and reproduction of recorded media (low tech)). Application of Ordinary Least Squares Method revealed that the share of medium-high-technology sectors induces GDP growth and thus a high GDP per capita. This relatedness is valid for all regions, thus these sectors can be taken into account primarily during the preparation of RIS3 strategies. Medium high-tech industries positively influence growth of regions, and poor regions may be more capable of developing such industries than high tech ones, but related variety of these medium high-tech industries in a region decreases GDP growth. This may mean that quickly growing regions could have a few not ubiquitous medium high-tech industries holding a high share in employment, and beginning to act as engines of growth and modernisation in the economy (because of the high share of buyers from other sectors). Also, these quickly growing regions have relatively high related variety of low tech industries, which means both these outputs are widely sold to other sectors, and the share of these products in the economy is high.

Our research also has great implications for political decisions. RIS3 strategies have to be tailored precisely to decrease RECI (RCA>1) in the less developed regions, because their specialisations are very common, and industries with which they are trying to build comparative advantage are located in many regions, including a large cluster in Central and South-East Europe. RIS3 strategies should enhance these industries that are less ubiquitous in the European economy or suggest sub-industries, branches of current specialisations that are niches. However, this requires conducting analysis on a more detailed level than in this survey. It may correspond to the stages theory of growth, which states that economies transform from traditional to modern, but economic take-off must initially be led by a few individual sectors or niches (through path creation and adoption). Hence quickly growing regions are traditional with some modernisation taking place, for example in the form of quickly growing low and medium high tech branches. RIS3 strategies can focus on other issues like, for example, exporting highly not low-processed products of traditional industries or clusters of interlinked industries which partially embrace the logic of related variety, but are connected with some kind of specialisation allowing for the generation of suitable potential – critical mass for innovating and being competitive may be more promising in terms of growth enhancing policy.

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