Clusters, export variety and the economic performance of regions: an investigation of the Portuguese case.

Daniela Filipa da Silva Braziela Coutinho

danieladasilvabraziela@hotmail.com

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Supervisor

Ester Gomes da Silva

Biographic Notes

Daniela Filipa da Silva Braziela Coutinho was born on 9th of January of 1992, in Santo Ildefonso – Porto.

She holds an undergraduate degree in Languages and International Relations from the Faculty of Arts and Humanities of University of Porto between 2010 and 2013. During her Bachelor Degree she was congratulated with a Merit Award from University of Porto due to her outstanding academic record.

In 2013 Daniela she joined the Master in International Economics and Management in Faculty of Economics of University of Porto (FEP), in which the present dissertation is written.

During her academic experience (quando?) Daniela Coutinho was also Co-President of the Group of Students of International Relations of University of Porto and member and team leader of AIESEC in FEP.

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Abstract

Regional agglomeration forces, variety and economic growth are closely intertwined. Even though the concept of regional agglomeration has been evolving over time, most studies emphasize the existence of important benefits from clustering, highlighting the importance of local knowledge spillovers as sources of competitiveness and economic growth. Building on this literature, in this work an attempt is made to analyze the relationship between the export structure of Portuguese regions and growth, focusing specifically on the role played by diversity. The empirical analysis uses until now unexplored data on Portuguese regional exports at the NUT 3 level between 2005 and 2013.

The results show that variety differs widely across Portuguese regions, being higher in regions such as Algarve, Grande Porto e Região Autónoma da Madeira and lower in Baixo Alentejo, Pinhal Interior Sul, Serra da Estrela e Douro. Related variety is also very heterogeneous, with Ave, Baixo Vouga, Cávado, Grande Porto and Tâmega presenting the highest levels of related variety, while Alto Alentejo, Alto-Trás-os-Montes, Baixo Alentejo and Pinhal Litoral Sul have the lowest levels. Unrelated variety is also not homogenous: Grande Porto, Oeste and Dão-Lafões have the highest levels, whereas Pinhal Interior Sul and Baixo Alentejo present the lowest). A distinctive pattern emerges, where variety figures are usually higher in coastal regions.

Econometric results show that the impact of variety on economic growth depends on the type of variety involved. Related variety has a positive and statistically significant effect on regional growth, whereas unrelated variety has a positive but insignificant effect. It seems therefore that a diversified regional structure in complementary industries translates into a significant growth bonus..

Key words: Agglomeration economies; Knowledge spillovers; Export variety; Regional growth.

JEL – Codes: D62, O18, R11

Resumo

Economias de aglomeração, variedade e crescimento económico constituem conceitos intrinsecamente ligados. Apesar do conceito de economias de aglomeração ter evoluído ao longo do tempo, a maioria dos estudos enfatiza a existência de importantes benefícios resultantes da concentração no espaço de atividades económicas, enaltecendo a importância da difusão local de conhecimento como força de crescimento económico e de competitividade. Partindo desta literatura, neste trabalho analisamos a relação entre a estrutura regional das exportações e o crescimento económico, abordando especificamente o papel desempenhado pela diversidade. A análise empírica utiliza dados até ao momento não explorados sobre as exportações regionais portuguesas, ao nível NUT3, entre o período compreendido entre 2005 e 2013.

Os resultados revelam a existência de uma significativa desigualdade regional em termos de variedade relacionada e não relacionada no território português, sendo que regiões como o Ave, o Baixo Vouga, o Cávado e o Grande Porto apresentam maiores níveis de variedade relacionada, enquanto o Alto Trás-os-Montes, o Baixo Alentejo e o Pinhal Litoral Sul apresentam os resultados mais baixos. Paralelamente, a variedade não relacionada também apresenta grande heterogeneidade: Grande Porto, Oeste e Dão-Lafões têm os maiores níveis de variedade relacionada, enquanto o Pinhal Interior Sul e o Baixo Alentejo têm os resultados mais baixos.

Resultados econométricos revelam que a influência da variedade sobre o crescimento económico depende do tipo de variedade considerada. Por um lado, os resultados da estimação sugerem a existência de uma relação positiva e estatisticamente significativa entre a variedade relacionada e o crescimento económico, enquanto a variedade não relacionada apresenta um impacto positivo, mas não estatisticamente significativo.

Palavras-Chave: Economias de aglomeração; Difusão de conhecimento; Variedade das exportações; Crescimento regional.

JEL – Codes: D62, O18, R17

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1. Introduction: motivation and research goals

Knowledge spillovers are widely recognized as major sources of growth and convergence since the emergence and consolidation of 'new growth theory'. In contrast with the traditional neoclassical growth model (Solow, 1956), in which technology was seen as an exogenous force, under this stream of research innovation and knowledge are directly related to the endogenous forces of the economy, through a Schumpeterian process of profit-driven research. The basic point regards the non-rivalry of knowledge: ideas are non-rival and thus can be used in simultaneous by a large number of actors without congestion. Ideas can flow both within a nation and outside its borders, but an important part of knowledge has a non-codified nature and is thus transmissible only in a person-to-person basis (Keller, 1996). In this context, knowledge spillovers at the local and regional levels are particularly worthy of attention. In fact, according to some studies, the majority of knowledge spillovers occurs within *clusters*, due to the working of economic agglomeration mechanisms (Grossman and Helpman, 1994; Jones and Romer, 2009).

But to what extent knowledge spillovers are dependent upon the diversity or, in contrast, the specialization of regions? There remains a discussion on whether regional diversification (Jacobs' externalities) associated with spillovers of creativity, innovation and brand-new ideas lead to regional economic growth, or if this result is more likely to happen with industry specialization, as firms are expected to learn more with other focal firms of its industry (localization or *Marshall-Arrow-Romer* externalities). Thus, there is an ongoing debate in the literature on whether firms get more knowledge and become more innovative if they learn from other firms of their industry or if they learn from firms from different industries (Boschma and Iammarino, 2009; Boschma *et al*, 2011).

Furthermore, Jacobs' externalities (i.e., knowledge spillovers that take place in regions with diversified industries) are not always assumed to occur, because for this to happen some complementarities must exist among sectors. Thus, a debate has emerged regarding the roles played by related and unrelated variety in local, regional and national growth (Boschma and Iammarino, 2009). The composition of the economy and the extent of input-output linkages between and within industries are now at the center of the debate.

Being theoretically grounded on this literature, this study attempts to investigate the role played by the regional composition of economic activity, analyzing the extent to which diversification matters for regional growth. It is our purpose to study if variety has an influence on regional growth patterns, using yet unexplored data from the Portuguese Statistics office for the 2005-2013 period.

The thesis is structured as follows. Chapter 2 provides a survey of the literature on the relationship between agglomeration economies and regional growth, distinguishing between theoretical and applied research. Chapter 3 is dedicated to the description of the methodology used in the empirical work, and to the computation of variety indices. In Chapter 4 an investigation is made of the relationship between the sectorial composition of regional exports and labor productivity growth, using data at the NUTS 3 level. Chapter 5 concludes, summarizing and discussing major findings and providing some clues for future research.

2. Agglomeration economies and regional economic growth: a survey of the literature

2.1. Agglomeration economies: major theories and concepts

Regional agglomeration can be defined as the spatial concentration of economic activities, which can take place in the form of industry clusters or employment centers inside cities or communities. Agglomeration leads to important economies, i.e., a number of significant benefits occur when companies and economic actors locate near each other in urban areas and industrial clusters (Glaeser, 2010).

Traditionally, three major types of agglomeration economies are considered: *localization economies*, which reflect increasing returns of activities within a single industry; *urbanization economies*, which are related to increasing returns from a diversity of activities that have impact at the regional level (Delgado *et al*., 2014) and Jacobs' externalities, in which knowledge spills between industries that share some sort of technological complementarities (Paci and Usai, 2000; Panne, 2004; Boschma and Iammarino, 2009).

The debate on the impact of agglomeration economies on economic growth has its early roots in Marshall's "Principles of Economics" (1920), which introduced the notion of *industrial district,* an agglomeration of several alike small businesses that are concentrated in the same locality. Marshall's work inspired recent contributions in the field, as those developed by Venables (2008), Ellison *et al*. (2010) and Neffke *et al*. (2011).

Marshall believed that the concentration of specialized activities generated external economies, due to the combined influence of three main factors (Sachs and McCord, 2008):

- Backward and forward linkages associated with large local markets;
- Greater access to specialized skills;
- Knowledge spillovers.

Clustering occurred because a firm locating near other firms would be able to purchase a significant variety of cheaper inputs from a close firm specialized in that input and they would both benefit from this nearby relation. In other words, input-output linkages were amplified because firms benefited from being closely located to their suppliers and buyers, being able to reduce transport costs (Marshall, 1920). On the other hand, agglomeration created a labor market pooling, since greater variety of opportunities lead to job specialization, a better job search and match between firms' requirements and workers' abilities (Marshall, 1920). These conditions created a more competitive and innovative environment inside clusters and lead to scale economies.

A final reason behind industry agglomeration was the spread of ideas, skills and know-how, transferred due to face-to-face contacts between suppliers, producers and buyers. Knowledge spillovers emerged more easily because workers learned quicker from each other in an industrial cluster environment, promoting the spread of knowledge and leading to innovation and quality improvement (Marshall, 1920).

Following Marshall's seminal work, a substantial amount of research has focused on the role played by economies of agglomeration on sustaining competitiveness, employment and regional growth. In 1984, Piore and Sabel introduced the idea of *industrial divide*, "a critical moment in our industrial development when the dominant logic of strategy, organization and technology is being challenged" (Starkey and Barnatt, 2007: 271), which combined the notions of flexibility and specialization, giving rise to the *flexible*

specialization theory. This theory emphasized the virtues of vertical disintegration, which would lead to the reduction of fixed costs and to an increase in product variety. Vertical disintegration was accompanied by the intensification of competition, forming a "flexible network of small, independent and service companies specialized to produce a differentiated range of image outputs: a "transaction-rich network of firms" (Starkey and Barnatt, 2007: 272). Economies of scale, flexible automation, product differentiation, small specialized production and networking were the key factors underlying this theory (Giuliani, 2005).

The *flexible specialization theory* represented a major breakthrough in the field of regional studies and, as Marshall in the beginning of the 20th century, constituted the basis of a number of important developments. One of the most relevant ones was accomplished by the French group GREMI (*Group for Research and Studies on Mediators of Inflammation*), which introduced the concept of *innovative milieu* to describe how industrial agglomerations were able to lead to change, due to the dynamic competence and coherence among the several players (Giuliani, 2005). Thereby, the economic literature started to acknowledge the existing linkage between regional agglomeration and innovation and this opened the way for the emergence of more recent contributions, such as Michael Porter's theory on industrial clusters. In his "Competitive Advantage of Nations" (1990), Porter sees clusters as "geographic concentrations of interconnected companies and institutions in a particular field (…), encompassing an array of linked industries and other entities important to competition" (Porter, 1998: 3). Clusters are seen as crucial because they can leverage national, regional and state economies and increase competitiveness around the world. The existence of intertwined clusters in a region is the source of important competitive advantage: clusters can influence costs, along the traditional view of cost-competitiveness (e.g., Ricardian and Heckscher-Ohlin models), but they can also generate quality improvements, giving rise to higher levels of innovation and differentiation.

More precisely, according to Porter (1998), clusters may impact competitiveness in three different ways:

1) Increasing the productivity of companies located in the area of the cluster;
2) Driving the direction and pace of innovation that would strengthen future productivity growth;

3) Stimulating the creation of new businesses, which would enlarge and reinforce the cluster itself.

In a nutshell, by being part of a cluster, firms become more productive because they have access to a pool of inputs, technology, information, suppliers, buyers and policy measures that, as a whole, are crucial to their competitiveness.

Paul Krugman's contribution on "New Economic Geography", inspired by Dixit and Stiglitz contribution on monopolistic competition (Dixit and Stiglitz, 1977), is also a major landmark in the analysis of the spatial concentration of industries. This stream of research focuses on the national and worldwide location of firms and attempts to explain why some areas grow (whereas others fall behind) and why specific specialization emerges in distinct regions (Pressman, 2012). Under the headings of "New Economic Geography" an attempt is thus made to understand the location of firms across and within countries. Krugman tries to single out the factors that influence the agglomeration of economic activities in particular regions, which according to his view were not appropriately pointed out in previous research (Pressman, 2012).

Investigating the patterns of spatial concentration, Krugman (1991) identified historical accident, an internal advantage combined with increasing returns, and cumulative or circular causation as the main influencing factors. In Krugman's view there is a role for randomness, since the location of some industries is in some cases arbitrary and there is no apparent economic explanation behind it, only some sort of historical accident. Based on the observation of the US manufacturing belt, Krugman (1991) concluded that even though strong economies of scale, low transportation costs and a large share of *footloose* production are crucial factors to spatial location, history is also extremely relevant and sometimes constitutes the main reason for the location of some of the most important clusters in the world. Thus, the author highlights the role played by factors apart from economic ones, questioning, at the same time, the conventional vision of constant returns' models .

However, location is not always arbitrary, and in some cases is connected with local advantages. For example, economies of scale and government policies can be major influences determining firms' location. Krugman argues that once a set of firms are located in a region, a pool of knowledge, skills and synergies starts to arise and leads to the development of economies of scale and to transport cost reduction, which increases

its attractiveness. This process of progressive reinforcement of already "strong" regions would ultimately give rise to movements of polarization.

While Michael Porter based his work on a macroeconomic perspective, Krugman studies the importance of clusters to economic growth and to international trade from a microeconomic view, taking the firm as the appropriate unit of analysis. Krugman's seminal contribution to the understanding of spatial dynamics is however difficult to treat analytically, requiring a high number of numerical simulations to develop results (Krugman, 1991).

More recently, Duranton and Puga (2003) presented another explanation for agglomeration economies, focusing on three types of micro-foundations, related to *sharing*, *matching* and *learning* mechanisms. The former are related "with sharing indivisible facilities, sharing the gains from the wider variety of input suppliers that can be sustained by a larger final-goods industry, sharing the gains from the narrower specialization that can be sustained with larger production and sharing risks" (Duranton and Puga, 2003: 1197), which diminishes the cost of using shared facilities. At the same time, matching raises the benefits generated by the spatial proximity between workers and firms, which contributes to a better match between supply and demand and to productivity gains (Melo and Graham, 2012). Finally, learning refers to the creation, exchange and accumulation of knowledge between workers and firms (Duranton and Puga, 2003), which also leads to productivity gains and innovation growth.

Duranton and Puga's contribution can be understood as a "description of the processes through which the sources of agglomeration economies materialize" (Melo and Graham, 2003: 32), whereas Marshall's focus was on the sources of agglomeration economies. Either way, both frameworks emphasize the forces that are most commonly accepted as the ones that better explain the existence of industry agglomeration.

To these agglomeration sources, mostly related to the supply side, Baptista and Swann (1998) add the benefits that can arise from the strong local demand generated by the geographic concentration of several different industries. Moreover, if firms settle near to consumers they will be able to understand better their needs and act accordingly.

Michael Porter's theory of competitive advantage provides, on the other hand, a rather comprehensive view, encompassing both supply and demand factors as potential sources of agglomeration. Porter describes the four determinants that form as a whole

the *diamond of competitive advantage*: *Factor Conditions* (nation's factors of production that are needed to succeed in certain industries); *Demand Conditions* (the composition of the home market demand for a certain industry value proposal); Related and Supporting Industries (the existence or absence of related industries that can compete in international markets); and Firm Strategy, Structure and Rivalry (the governing conditions regarding the formation and organization of the industries, as well as the nation's domestic competition). These determinants work as a system and are crucial for the firms' success and to the development of the industries included in the cluster as a whole.

As in Baptista and Swann (1998) Porter's *diamond model* stresses the role played by demand conditions for the success of an industry. Thus, "nations gain competitive advantage in industries where the home demand gives their companies a clear or earlier picture of emerging buyer needs, and where demanding buyers pressure companies to innovate faster and achieve more sophisticated competitive advantages that their foreign rivals" (Porter, 1990: 82). Even though the size of demand continues to be pointed out by the economic literature as a key factor, Porter emphasizes instead the extent of demand sophistication as a factor of success of clusters.

On the other hand, factor advantages can also be pinpointed as an important reason for industry agglomeration. Thus, some regions have better natural environments for the establishment of certain industries, which leads to natural cost advantages. In this case conglomeration can also arise because more than one industry can be attracted to a certain natural advantage, which creates a dynamic and innovative environment (Ellison *et al*, 2010).

Finally, broad urbanization factors can also account for agglomeration: "there is some sort of public goods that can be shared more economically in a larger city or cluster" (Strange, 2008: 3). Thus, the existence of several shared infrastructures, such as telecommunications and transportations, increase productivity because firms can take advantage from a pool of related services, which generates local externalities that benefit all. Consumers are also benefited because of an increased access to public goods. The value of the rent can be pointed as another reason for agglomeration. In this case firms are not able to stay inside of the cities due to lack of space or to high price rents so they move spatially to a better location where they create industry clusters (Strange, 2008).

Table 1 presents a summary of the major theories surveyed above, along with the main factors explaining agglomeration. .

Table 1: Major theoretical concepts regarding agglomeration economies

Concept	Main contributions	Brief Description	Sources of agglomeration
Industrial District	Alfred Marshall (1920)	Agglomeration of several alike small businesses in the same locality.	Knowledge spillovers, larger markets for specialized skills, backward and forward linkages associated with large local markets.
Flexible specialization theory	Piore and Sabel (1984)	Vertical disintegration can lead to the reduction of fixed costs and to an increase in product variety connected with competition growth.	Economies of scale, flexible automation, product differentiation, small specialized production and networking.
Innovative Milieu	GREMI	Industrial agglomerations as sources of economic change.	Dynamic competence and coherence among the several players.
Industrial Clusters	Michael Porter (1990)	Clusters are crucial to the world economy because they can leverage national and regional areas and increase competitiveness around the world. Four factors are identified as crucial for regions' competitiveness and success. These factors are not considered individually, but as a dynamic whole.	Regions' set of unique characteristics and their interactions. Factor Conditions; Related and Supporting Industries; Firm Strategy, Structure and Rivalry
New Economic Geography	Paul Krugman (1991)	Focuses on the national and worldwide location of firms in an attempt to explain why some areas grow (whereas others fall behind) and why specific specialization emerges in distinct regions.	Historical accident, increasing returns, processes of cumulative and circular causation.
Clusters and local Demand	Baptista and Swann (1998) Michael Porter (1990)	Clusters benefit from a sophisticated and strong local demand because they have access to larger markets and understand better consumers' needs.	Sophisticated and strong local demand.

2.2. Agglomeration and sustainable growth

As indicated in the previous section, agglomeration economies may become important drivers of productivity and constitute major sources of economic growth. Clusters can promote regional competitiveness and growth and, at the same time, benefit all economic agents involved (e.g., suppliers, firms and buyers). According to Porter's characterization, the reasons for the positive relation between regional agglomeration and growth are:

- Productivity increases due to firms' access to specialized inputs, institutions and information;
- Higher innovation rates in result of increasing competition within clusters;
- Better production performance as a result of an improvement of the regional strategic planning due to the existence of an entrepreneurial environment. (Stejskal and Hajek, 2012)

Clusters also foster competitiveness since they "influence structural changes, they revitalize industrial sectors, and deliver the necessary frame for research, innovation and regional development" (Cornelia, 2012:9). Therefore, agglomeration plays an important role in the modern economy and is the source of several economic gains, with clusters "becoming increasingly perceived as tools to engage the economic growth, innovation and competitiveness" (Vlăsceanu and Vorocenci, 2014: 149).

Notwithstanding, not all clusters remain competitive, attractive and profitable in the long-term. According to Spencer et al. (2010), the maintenance of high performance levels over time depends on the cluster's degree of specialization, its scale and scope, the intensity of contact among firms and industries, the qualification of the employers and employees, the quality of infrastructures and the strength of the knowledge spread. Thus, the relationship between agglomeration economies and growth is not automatic: s several factors influence clusters*'* ability to generate and sustain economic growth.

In this regard, the factors underlying the formation of competitive advantage of clusters are also crucial to assure its success over time (Porter, 1989). A firm that has a weak competitive advantage can benefit from being located in an innovative and competitive environment, whereas a firm located in a non-competitive cluster can lose competitive advantage. Porter's theory stresses the importance of clusters' dynamism and the firms' on-going necessity to innovate and search for new competitive advantages. This is an

inherently dynamic process that can be applied to every determinant of competitive advantage, such as the degree of competition and specialization, the extent of backward and forward linkages, the scale and scope of the cluster and the existing pool of knowledge. As a consequence, the success of a particular cluster is not definitive and the existence of agglomeration economies is not a guarantee of success.

In this respect, it is worth mentioning a certain bias in the literature, which tends to give a lot of attention to successful clusters, whereas the failing ones are often neglected. Several reasons can account for clusters' failure, though: lack of investment in innovation and technology; the presence of negative externalities, such as little or too much entry of new competitors or high levels of pollution (Asheim et al., 2008); lack of coordination among firms; weak links between institutions, infrastructures and public policies; governmental failures and lack of connection to world networks *(*Glavan, 2007; Chorincas, 2009; Uyarra and Ramlogan, 2012).

Countries' tacit capabilities also influence clusters' success, because they cannot be transferred internationally (Spencer *et al.* 2010; Boschma *et al.*, 2012). In this regard, intangible capabilities such as knowledge, firm networks or skills are especially important. Regions' specific assets and the extent of tacit knowledge are crucial for industries' success because they cannot be easily imitated. Thus, regional diversification in technologically related industries is a source of competitiveness: firms in these industries will spill important knowledge, crucial for the region dynamism and ongoing search for high performance (Boschma and Frenken, 2011).

Public institutions and policies can also play an important role in determining the maintenance of clusters' competitiveness over time. Some studies have criticized the capacity of policy makers to legislate according to firms' needs (Cornelia, 2012; Porter, 2007). According to Porter (2007), policymakers often provide targeted support to firms, hurting competition and influencing negatively their performances. Porter also states that different levels of support given by policymakers to specific economic sectors may affect negatively competition and regional development as a whole. The problem here is how to assure that the "right sectors" are chosen and to design correct incentives that do not translate into inefficiency. This is one of the most controversial issues surrounding the debate on the potentialities and shortcomings of industrial policy. In this account, it seems that policymakers still know little about the processes of

transitional development and of its dynamics at the regional level and for this reason the implementation of regional policy is still at its infancy (Cornelia, 2012).

2.3. Diversification vs. specialization as strategies for regional economic growth

Should regions specialize in certain products or technologies to benefit locally from economies of scale, share labor markets and forward and backward linkages, or should they diversify in order to have access to inter-industry and intra-industry knowledge spillovers? This question summarizes the specialization-diversity debate, theoretically grounded on the concepts of Marshall-Arrow-Romer (i.e., localization economies) and Jacobs' externalities (Panne, 2004; Boschma *et al*, 2012).

As indicated earlier, the concept of Marshall-Arrow-Romer (MAR) externalities regards knowledge spillovers that occur between firms of the same industry. MAR externalities can be considered as localization economies (or specialized externalities) because they create intra-industry knowledge spillovers, and "firms are expected to learn mainly from other local firms in the same industry" (Boschma and Iammarino, 2009: 290). Specialized regions can benefit from MAR externalities, having access to local externalities due to the presence of specialized suppliers, a market pool of specialized workers and to the existence of a flow of specialized knowledge spillovers. All of these externalities contribute to firms' competitiveness and innovation, particularly the flow of specialized knowledge among firms, generally through its employees, which leads often to the creation of new products, new production processes and management strategies (Boschma and Iammarino, 2009; Van Oort, 2011). On the other hand, the specialization strategy also leads to increasing returns to scale because the production of a relatively small amount of products or services will be reflected in declining production costs and in an increase of regional productivity levels (Panne 2004). Lastly, the proximity relative to specialized suppliers also leads to the reduction of transaction costs, thus inducing competitiveness (Van Oort, 2011).

Diversified regions, on the other hand, may benefit from knowledge spillovers across industries, giving rise to new combinations (*Neue Kombination*) in the spirit of Schumpeter's (1912) early writings on the role played by innovation as a growth factor. Such spillovers, which are also taken into account by *new growth theory*, are usually related to Jacobs' externalities (cf. Frenken *et al.*, 2007). The exchange of knowledge

across complementary industries facilitates search and experimentation in innovation, stimulating the emergence of new products and ideas (Panne, 2004; Boschma and Iammarino, 2009). In other words, knowledge spillovers across industries are more likely to occur when there is some cognitive proximity among industries: the cognitive distance cannot be too large nor too small in order to assure that firms in distinct industries can actually learn from each other (Boschma and Iammarino, 2009). It is worth mentioning, however, that the existence of complementarities among sectors is a necessary but not a sufficient condition to assure growth. In fact, "regional absorptive capacity is needed to understand and transform it into regional growth" (Boschma and Iammarino, 2009: 294). Hence, firms must be prepared to absorb new forms of knowledge in order to innovate; otherwise the new knowledge will be lost and will not be reflected in productivity gains and regional growth.

At the same time, the existence of a diversified structure, based on activities that *do not* share close complementarities, may protect a region against external shocks, giving rise to the so-called 'portfolio effect' and determining lower unemployment rates (Boschma and Iammarino, 2009).

The debate on the importance of diversity vs. specialization as regional growth strategies has been accompanied by the development of a number of analytical concepts. With regard to diversity, the investigation has been carried out using the concept of *variety*, defined as "the number of actors, activities and objects required to describe the economic system" (Saviotti and Frenken, 2008: 205). Total variety can be decomposed in two major parts: *related* and *unrelated variety*. Related variety can be defined as a type of diversification that occurs in sectors that share complementary competences, thus proxying Jacobs' externalities. Increases in related variety are expected to lead to higher levels of innovation and competitiveness within the regions: "related variety improves the opportunities to interact, copy, modify, and recombine ideas, practices and technologies across industries "(Frenken *et al*, 2007: 687).

Unrelated variety, in turn, regards diversification in sectors that do not possess substantial economic input-output linkages (Boschma and Iammarino, 2009), giving rise to the aforementioned portfolio effect.

Although riskier and more difficult, this type of variety can also lead to knowledge spillovers, enhancing more radical innovation because bits of knowledge that were

previously unrelated can generate new technologies and innovative products (radically new combinations). Because of the differences between the knowledge that is spread, which in some cases cannot be recombined, unrelated variety has a higher probability of failure, but, when successful, it originates major technological breakthroughs (Saviotti and Frenken, 2008; Castaldi *et al*, 2013).

With regard to the concept of specialization, it is usually measure in applied work by several metrics. The measurement of specialization of a particular region can be computed simply the sum of deviations of the importance that the sector *j* has in the region *r* and the importance that this same sector assumes in the pattern of the region *p* (Palan, 2010; Ellison *et al*., 2010) The Krugman Specialization Index is also widely used. This index computes the share of employment that has to be repositioned in order to accomplish an industry structure correspondent to the average structure of the reference group, which can be a country or a wider geographical area. In the same context, the Theil Index computes the degree of specialization of a region comparing the sectoral employment shares of a country in relation to the employment shares of the reference group in order to compute the degree of specialization of a region regarding the nation and regional employment (Palan, 2010). Another measure is the Los-index. This index measures the technological relatedness between industrial sectors analysing their similarity, using information on their input combinations from national input-output tables. Hence, the Los-Index can be seen as a proxy of localization economies, since it considers the regional concentration of a single industry and the degree of technological relatedness across industries (Frenken *et al.*, 2007).

2.4. Empirical studies on the impact of agglomeration economies on growth

Several studies attempted to identify which type of economic agglomeration is more important as a source of regional growth. In this study we will not explore this debate, since our focus is on the diversity component. Moreover, it is worth mentioning that the concept of regional growth may have several interpretations and that different types of externalities may impact growth differently. Regional growth is often used to mean either value-added growth, labor or multi-factor productivity growth, employment or unemployment growth, which actually represent very different things.

Taking labor productivity as an indicator of growth, a positive relationship is usually expected with regard to Jacobs' externalities (*proxied* by related variety) and localization economies. Regarding the former, an increase in related variety may be reflected in process innovation, leading to higher productivity growth. This is more prone to happen in the short-run than in the long-run (Saviotti and Frenken, 2008). Localization economies can also be reflected into higher labor productivity and value-added growth, due to the effects mentioned above (e.g., specialized suppliers, a market pool of specialized workers, a flow of specialized knowledge spillovers, reduction of transaction costs).

With regard to employment, there may be some contradictory influences. If related variety leads to labor-saving process innovation, it can be reflected in lower employment rates (Frenken *et al*, 2007; Boschma and Iammarino, 2009; Boschma *et al*, 2011, Van Oort *et al* 2013). On the other hand, because regions with higher related variety may experience also an increase in product innovation, especially in the long-run, that can be translated into higher employment rates (Frenken *et al*, 2007; Boschma *et al*, 2011; Van Oort *et al* 2013).

On the other hand, unemployment growth is expected to be negatively related to unrelated variety because the presence of several sectors with few input-output linkages makes the region less vulnerable to demand shocks. In contrast, if a region is highly specialized, that can result in higher unemployment rates, due to a greater vulnerability to external shocks in demand (Frenken *et al*, 2007).

How do empirical results match the theoretically expected relationships? Several studies have investigated empirically the relationship between agglomeration economies and regional economic growth. In our survey we give special attention to the studies approaching the effects of diversity on growth, since this is our focus of analysis. As can be seen in Table 2, most studies use regions as the geographical unit of analysis, employing entropy coefficients to measure variety. Moreover, in many cases the econometric method chosen is pooled OLS.[1]

With regard to urbanization economies, proxied by population density, the surveyed evidence shows somewhat mixed results. Frenken *et al.* (2007) and Boschma and Iammarino (2009) find that population density has no significant impact on employment

[1] An exception is Hartog et al (2012), which applies the Generalized Method of Moments (GMM).

growth; whereas Hartog *et al.* (2012) results show a negative impact. In contrast, Boschma *et al.* (2011) find that population density has a positive impact on regional Spanish productivity growth; while Van Oort *et al.* (2013) conclude that larger urban areas have a stronger effect on productivity growth than medium-sized areas.

Related variety, on the other hand, is often identified as a significant source of regional growth. Frenken *et al.* (2007), using data on Dutch regions, show that related variety influences positively employment growth, corroborating the view that Jacobs' externalities are important sources of regional growth. A similar result is found by Boschma and Iammarino (2009) for Italian regions, and by Boschma *et al.* (2011) for Spanish regions.

On the other hand, Frenken *et al.* (2007) find that related variety is significant but negatively related to productivity growth, contrary to what would be theoretically expected (this contradictory finding is not explained by the authors). In contrast, Boschma and Iammarino (2009) and Van Oort *et al.* (2013) find a positive relationship between related variety and productivity growth, as would be expected.

With regard to unrelated variety, Boschma and Iammarino (2009) find a positive and significant impact in the two specifications using value-added growth as the dependent variable. However, Van Oort *et al.'s* (2013) results show a positive relationship between unrelated variety and unemployment growth, which contradicts the predicted *portfolio* effect.

Moreover, Boschma and Iammarino (2009) and Boschma *et al.* (2011) find that related variety has a positive and robust impact on regional value-added growth, while Jacobs' externalities and unrelated variety are always insignificant. Thus, according to Boschma and Iammarino (2009), variety *per se* does not impact regional economic growth: it does it only when it occurs among cognitively related sectors. This finding is also evidenced by Boschma *et al.* (2011). Using different relatedness measures, such as Porter's (2003) cluster classification and Hidalgo *et al.* (2007) proximity index, the authors find strong evidence supporting that related variety is positively associated to regional growth, whereas unrelated variety seems to have no impact.

Hartog *et al.* (2012), in turn, find that related variety as a whole has no significant impact on regional growth. Only high-tech related variety has a significant and positive effect on regional employment growth.

Summarizing: several studies show that related variety influences positively regional economic growth (Frenken *et al*,2007;, Boschma and Iammarino, 2009, Boschma *et al.*, 2011), although there may be substantial differences across sectors: Hartog et al. (2012) find that related variety affects regional economic growth only in the case of high-tech industries. With regard to unrelated variety, the evidence is weaker. Frenken *et al.* (2007) show that unrelated variety affects negatively unemployment growth, but several other studies (e.g., Boschma and Iammarino (2009) and Boschma et al. (2011)) do not confirm this relationship.

Moreover, the surveyed studies show that related variety and unrelated variety have different impacts according to the dependent variables chosen. Generally, related variety is positively related to regional employment growth, labor-productivity and value-added growth. Unrelated variety, on the other hand, is often found to have a non-significant impact on labor-productivity, employment or regional value-added growth; although in some cases it is shown to be negatively related to unemployment growth, in line with the aforementioned *portfolio* effect. Finally, the effect of urbanization economies is very diverse, depending on the country/ regional units under analysis, being difficult to establish a definitive conclusion regarding their influence on regional growth based on the evidence produced so far.

Table 2: Empirical studies focusing on the relationship between agglomeration economies and regional economic growth

Author (s)	Geographical Scope	Time Period	Measures of variety	Method	Main Control Variables	Independent variables	Dependent variables	Main results*
Frenken *et al*, 2007	The Netherlands NUTS 3 level	1996-2002	Entropy coefficient: RV[1] at 5-digit level. UV at 2-digit level (Sector employment)	Pooled OLS	Investment, R&D, Capital-labour growth, Human Capital, Wage level, Business growth, Dwellings Growth	• Related Variety (RV) • Unrelated Variety (UV)	Employment Growth,	• RV **(+)** • UV non-significant
							Productivity Growth,	• RV **(-);** • UV non-significant
							Unemployment Growth	• UV (-)
							Inactivity Growth	• Variety non significant
Boschma and Iammarino, 2009	Italy NUTS 3 level	1995-2003	Entropy coefficient: RV at 3-digit level UV at 1-digit level (Sector level)	Pooled OLS	Employment Growth Labor Productivity	• Related Variety (RV) • Unrelated Variety (UV) • Population Density	Regional employment growth	RV (+) UV non-significant
							Regional value-added growth	• RV (+) • UV (+) (portfolio effect)
							Labor-productivity growth	• RV (+) • UV non significant
Boschma *et al*, 2011	Spain NUTS 3 level	1995-2007	Entropy coefficient: RV at 6-digit level (Product level) UV at 1-digit level (Sector level)	Pooled OLS	Labor Productivity, Human Capital, Level of employment	• Related Variety (RV) • Unrelated Variety (UV) • Population Density	Regional value-added growth	RV (+) UV (-)
							Regional employment growth	RV (+) UV (-)
Hartog, 2012	Finland NUTS 4 level	1993-2006	Entropy coefficient:	GMM	Density, Human capital, R&D	• Related Variety (RV)	Regional employment growth in high-tech	RV (+)

			RV at 5-digit level UV at 2-digit level (Sector level)		expenditures	• Unrelated Variety (UV) • Regional Population	sectors.	UV non significant
							Regional employment growth in low-and-medium-tech sectors	RV (-)
								UV non significant
Van Oort *et al* (2013)	15 European Countries NUTS 2 level	2000-2010	Entropy coefficient: RV at 4 and 3-digit level UV at 1 and 2-digit level (Sector level)	Pooled OLS ML spatial-lag model	R&D expenditures, Average educational level, Market potential	• Related Variety (RV) • Unrelated Variety (UV) • Population Density	Employment growth	RV (+)
								UV non significant
							Unemployment growth	RV non significant
								UV (+)
							Labor productivity	RV (+)
								UV (-)

Notes: RV acronym stands for "Related Variety", UV for "Unrelated Variety". Statistically significant results are signalized in grey.

3. Methodological considerations

3.1. Measurement of industry relatedness

Industries and products can be classified using international standard classifications such as the Standard Industrial Classification (SIC) and the Harmonized System (HS).
The Standard Industrial Classification is used to classify business establishments and other statistical units by type of economic activity. The Standard Industrial Classification (SIC code) is a standard series of six-digit codes that was created by the U.S. Government in order to catalogue the business activities. Thus, the SIC system divides the economy into 11 categories, which are further divided into 83 2-digit major groups, that are additionally subdivided into 416 3-digit industry groups and disaggregated into 1,005 4-digit industries (Worldwide Business Directory, 2015).

On the other hand, the Harmonized System (HS) is an international product nomenclature developed by the World Customs Organization, which is used to classify the products that are traded according to their form and functions. The Harmonized System includes about 5,000 commodity groups, which are identified by a six digit code. This code is defined according to a legal and logical structure and is supported by strict rules that allow a uniform classification. Currently, this system is used in about 200 countries and over 98% of the goods that are internationally traded are classified in terms of the Harmonized System (World Customs Organization, 2015).

Both SIC and HS nomenclatures constitute *ex ante* measures of relatedness, since products are grouped according to predetermined classifications of products. *Ex-ante* measures "enable to capture the whole range of possibilities by which products or industries can be related, like similarities in regulatory framework, complementarities in their use, the intensive use of a certain type of infrastructure, the use of advertisement to build trademarks" among other aspects (Boschma *et al*, 2011: 2). *Ex post* measures of relatedness don't have the same drawback as *ex ante* measures because they allow to capture a broader set of factors that affect the relatedness across products and industries, by taking into account the entire process. Notwithstanding, *ex post* measures also have some drawbacks, such as the difficulty to compare results across different spatial and territorial contexts. In practice, the choice of the measure applied is usually made taking into account the availability of data.

An example of an ex-post procedure is the cluster classification. The economic literature classifies clusters according to two main dimensions: scope and the relationship between the actors in the cluster. Thus, according to the scope, clusters can be distinguished considering the micro, meso and macro levels, depending on whether firms, industries or nations are being considered. With regard to the relationship between the actors located the cluster, attention is put on the innovative efforts when firms or sectors cooperate in the spread of innovations and to production linkages between firms or sectors (Hoen, 2000).

Table 3: Types of clusters

Scope/Level	Innovative Efforts	Production linkages
Micro	Dissemination of technology and knowledge between **firms**	Linkages between suppliers and buyers or creation of chains of firms
Meso	Spread of technology and knowledge across **sectors**	Backward and forward connections between sectors
Macro	Segregation of the **economy** in sectors that spread technology or knowledge	Segregation of the economy in sectors that create value-added or production chains

Source: Hoen (2000)

How can clusters be empirically identified? Roelandt *et al.* (1999) study the vertical relationships between firms and their interdependence based on synergies and linkages, presenting two empirical methods for identifying clusters: the Monographic Method and the Input-Output Method.

The Monographic Method is based on a cluster chart that is defined according to Porter's diamond model, combined with statistical analysis. This method can nevertheless be considered more qualitative than quantitative since it is mostly based on interviews, surveys and some case studies.

The Monographic Method has several advantages but it presents also some important shortcomings. First, this method allows the recognition of the existence of innovative linkages across different regions since it studies regional synergies. On the other hand, it emphasizes the importance of knowledge spillovers in an industry context, at the same time that illustrates the variety that exist in the economic scope of clusters. Moreover, the method also shows the role played by institutions on regional development and

helps to identify the need for specific clusters´ policies. Notwithstanding, the Monographic Method is mostly qualitative and therefore the economic use of the aforementioned clusters chart is limited. Furthermore, Porter's diamond model is constructed to identify competitiveness at a meso level, which means that other methods must be combined with that from Porter in order to identify clusters at macro and micro levels. With the Monographic Method the comparison across clusters is rather difficult since it is a method based on branch or industry level (OECD, 1999).

On the other hand, the Input-Output Method is based on the input-output table linkages in order to identify the sectors that use each other products and aggregate them into clusters. Unlike the previous method, this method is more quantitative and easier to apply because it can be used to study long periods of time and can be applied to almost every country. In fact, the input-out tables are available in almost every country and the data is easier to get and to analyze in comparison with the aforementioned model. However, this method presents also disadvantages, such as not focusing on the firm's linkages and knowledge spread, since it is limited to the analysis of input-output tables. Moreover, the method is excessively focused on the clusters that are easily detected by using hypothetical extraction technique (Hoen, 2000).

According to Kawaji *et al.* (2001) another method for identifying clusters can be considered, which is the Graph-Based Clustering Method. This is a hierarchical method because establishes the linkages between the clusters, which are represented by a dendrogram. Thus, the cluster are identified by cutting edges of the dendrogam with a threshold, which leads to the creation of families. Thus, when the suitable edge is given this method results in the production of accurate families, however this not happen in all the cases and can lead to the production of many too small clusters and scarce large clusters.

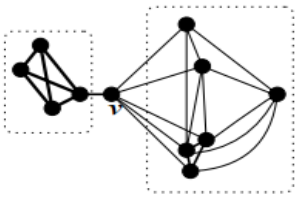

Figure 1: Example of a linkage graph (source Kawaji *et al.*, 2001).

Notwithstanding, this method has some disadvantages such as one sequence can be more familiar to other family member than to some of the members of its family because sequence similarities are not metric.

The aforementioned methods are the main methods used to identify clusters empirically. A different method has been developed by Porter (2003), which identifies the location linkages by the "locational correlation of employment across traded industries to reveal externalities and define clusters" (Porter, 2003: 562). In order to eliminate the spurious correlations and identify only the real correlations among industies, Porter uses detailed four-digit SIC industry definitions,detailed information on the products that belong to each industry and specific industry knowledge of industries. Porter considers as spurious correlations those in which no logical externality is expected between the industries, and the cases in which there is no substantial input-output flow. In his study, the author identifies 41 traded clusters in the U.S, with an average of 29 industries each. Porter's (2003) classification contains both manufacturing and services industries, grouping industries from different parts of the SIC classification, and creating in some casesa n overlap of industries across clusters.

More recently, Hidalgo *et al* (2007) presented another method for identifying industry relatedness. The authors developed a proximity indicator, which is based on the premise that if some products are listed several times together in the exports of countries, that happens because they share a set of capabilities, meaning that there is proximity when countries have comparative advantage in both products. Proximity is computed as follows:

$$\varphi_{ijt} = min\{P(X_{i,t} \mid X_{j,t}), \mathrm{P}(X_{j,t}|X_{i,t})\}$$

Where P(xi,t|xj,t) is the conditional probability of showing comparative advantage in the product *i* considering that the country also showed comparative advantage in the product *j*.Based on the aforementioned index, Hidalgo *et al* (2007) draw a product map measuring the extent of relatedness. Thus, the parts of the map that are more dense represent the products that are more related, while the peripheric areas represent the products that have few correlations among each other. Hence, the location of the

countries in this map indicates its pattern of specialization and diversification possibilities.

In this context, and considering our data, we are going to use two, four and six-digit HS industry definitions, with the detailed information on the products that belong to each industry and to each economic field for all the Portuguese NUTS 3. Thus, the database that were are going to analyze already has this detailed information regarding two, four and six-digit HS codes, which allows to identify relatedness between industries that exist in each region.

3.2. The use of entropy indices in the measurement of variety

A common procedure in the literature to calculate the impact of diversity externalities, consists in the computation of variety indices using entropy measures (e.g., Frenken et al., 2007; Boschma and Iammarino, 2009; Boschma *et al* (2011). Variety indices can be computed using ex-ante measures of industry relatedness, as it is done in this study. Considering regional (NUTS 3) exports data classified according to the HS nomenclature (six-digit), total variety (VARIETY) is computed as follows:

$$VARIETY = \sum_{i=1}^{N} p_i \log_2\left(\frac{1}{p_i}\right) \quad (1)$$

Where p_i stands for the share of six-digit product *i* in the total of regional exports. Thus, the more diversified the exports of a region, the higher the value of the entropy indicator.

Computations of related and unrelated variety are also made using entropy indices. Related variety (RELVAR) is computed as the weighted sum of the entropy measure at the six-digit level within each two-digit class, as follows:

$$RELVAR \sum_{g=1}^{G} P_g H_{g,} \quad (2)$$

Where

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} \log_2\left(\frac{1}{p_i/P_g}\right) \quad (3)$$

Thus, we compute the share of HS *i* product classification at six-digit level in the total of regional exports (p_i) and the share of each related variety group (two-digit class) in total regional exports(P_g).

Unrelated variety (UNRELVAR), in turn, is computed as the entropy measure at one-digit level, as in Boschma et al. (2011):

$$UNRELVAR = \sum_{j=1}^{N} p_j \log_2 \left(\frac{1}{P_j}\right) \quad (4)$$

Where P_j stands for the share of one-digit level exports in total exports.

4. An empirical assessment of the impact of export variety on regional growth

4.1. Portuguese regional variety indices: 2005-2013

The computation of variety indices is made for 2005, 2009 and 2013, using data from the Portuguese Statistical Office. Portugal is divided into 30 NUTS 3 subregions, 28 located in the mainland and the other two in the Autonomous Regions of Azores and Madeira.

Table 4 presents the results of total variety, which show considerable differences across regions. Thus, regions such as Grande Porto (7.87), Região Autónoma da Madeira (7.02) Algarve (6.81) and Ave (6.74), present considerably higher total variety than Baixo Alentejo (0.49), Pinhal Interior Sul (1.73), Serra da Estrela (2.42) and Douro (2.98). In the period under study total variety has increased in most regions, reflecting a broad diversification trend in regional economic activity. Nonetheless, not all regions registered an increase in total variety, and some of them even presented a decline. Alto Trás-os-Montes, Alto Alentejo, Beira Interior Norte and Grande Lisboa suffered a decline, representing a reduction in their extent of differentiation economic activities.

Table 4: Total variety (2005, 2009, 2013; Portuguese NUTS 3)

	Total variety			Av. Annual growth rates %		
	2005	**2009**	**2013**	**2005-09**	**2009-13**	**2005-2013**
Alentejo Central	3.96	4.23	4.70	2%	3%	2%
Alentejo Litoral	3.42	4.20	3.99	5%	-1%	2%
Algarve	4.69	5.90	6.81	6%	4%	5%
Alto Alentejo	4.02	4.59	3.01	3%	-10%	-4%
Alto Trás-os-Montes	4.11	3.21	2.95	-6%	-2%	-4%
Ave	6.54	6.72	6.74	1%	0%	0%
Baixo Alentejo	0.49	1.43	1.95	31%	8%	19%
Baixo Mondego	3.87	4.59	5.48	4%	5%	4%
Baixo Vouga	6.56	7.18	7.17	2%	0%	1%
Beira Interior Norte	4.06	3.92	3.44	-1%	-3%	-2%
Beira Interior Sul	3.98	3.76	3.72	-1%	0%	-1%
Cávado	4.73	5.49	6.47	4%	4%	4%
Cova da Beira	4.65	5.19	5.62	3%	2%	2%
Dão-Lafões	4.30	5.58	5.58	7%	0%	3%
Douro	2.98	3.70	4.81	6%	7%	6%
Entre Douro e Vouga	5.47	5.70	5.83	1%	1%	1%
Grande Lisboa	7.23	7.48	6.36	1%	-4%	-2%
Grande Porto	6.36	7.73	7.87	5%	0%	3%
Lezíria do Tejo	5.78	6.09	6.60	1%	2%	2%
Médio Tejo	4.74	5.58	5.96	4%	2%	3%
Minho-Lima	4.62	4.84	5.59	1%	4%	2%
Oeste	6.19	6.84	7.03	3%	1%	2%
Península de Setúbal	4.56	4.99	5.13	2%	1%	2%
Pinhal Interior Norte	5.52	5.93	5.83	2%	0%	1%
Pinhal Interior Sul	1.73	2.51	2.22	10%	-3%	3%
Pinhal Litoral	6.10	6.59	6.70	2%	0%	1%
Região Autónoma da Madeira	4.25	6.03	7.02	9%	4%	6%
Região Autónoma dos Açores	3.81	3.96	4.29	1%	2%	2%
Serra da Estrela	2.42	3.56	3.59	10%	0%	5%
Tâmega	5.80	5.90	5.90	0%	0%	0%
N	3,96	4,23	4,70			
Minimum	0,49	1,43	1,95			
Maximum	7,23	7,73	7,87			
Average	4,57	5,11	5,28			
Standard deviation	1,46	1,46	1,55			

On the other hand, the results on related variety reveal that there was a general increase in Portuguese related variety at the regional level between 2005 and 2013. There are, once again, considerable differences across regions. Regions such as Ave, Baixo Vouga,

Cávado, Grande Porto and Tâmega present higher values of related variety, meaning that there is greater diversification in inter-related industries in these regions than in the rest of the country. In contrast, regions such as Alto Alentejo, Alto-Trás-os-Montes, Baixo Alentejo and Pinhal Litoral Sul, present very low related variety values, all below 0.90.

Moreover, the evolution of related variety during the period 2005-2013 shows also great variation across regions (cf. Table 5). Alentejo Litoral, Algarve, Baixo Alentejo, Pinhal Interior Sul and Região Autónoma da Madeira show a considerable increase in related variety in the period under study, whereas regions such as Beira Interior Sul, Beira Interior Norte and Alto Alentejo show an above average decrease in related variety. The remaining NUTS 3 show a general, albeit small, increase in related variety, which reflects an overall increase in the degree of diversity in complementary industries over time.

The geographical differences across regions are more visible in Figures 2 and 3, in which becomes clear the difference between the regions located in the coastline and the regions located in the inner area of the country. Therefore, in general, the regions located in the country's coastline show higher related variety levels than the rest of the country. In fact, this regional asymmetry becomes more pronounced over time since in 2013 the northern coast of the country has more regions with related variety levels above 2.70 (cf. Figure 3), than in 2005 (cf. Figure 2). At the same time the regions with the lowest related variety levels, such as Alto Alentejo e Alto Trás os Montes are located in the inner area of the country.

Therefore, we can conclude that the regions located in the country´s coast line have a structure with a larger rate of related industries. On the other hand, the inner area of the country presents an economic structure with less diversification in complementary industries..

Table 5: Related Variety and Unrelated variety (2005, 2009, 2013; Portuguese NUTS 3)

Region	Related variety						Unrelated Variety					
	Levels			Av. Annual growth rates %			Levels			Av. Annual growth rates %		
	2005	2009	2013	2005-2009	2009-2013	2005-2013	2005	2009	2013	2005-2009	2009-2013	2005-2013
Alentejo Central	1.57	1.29	1.48	-5%	4%	-1%	1.79	2.14	2.24	5%	1%	3%
Alentejo Litoral	0.94	1.57	1.57	14%	0%	7%	1.39	1.86	1.63	6%	-3%	2%
Algarve	1.40	1.58	2.37	3%	11%	7%	2.04	2.46	2.58	5%	1%	3%
Alto Alentejo	0.79	1.27	0.51	13%	-20%	-5%	2.56	2.52	1.83	0%	-8%	-4%
Alto Trás-os-Montes	0.79	0.69	0.79	-3%	3%	0%	2.38	1.84	1.60	-6%	-3%	-5%
Ave	2.63	2.70	2.71	1%	0%	0%	2.26	2.38	2.52	1%	1%	1%
Baixo Alentejo	0.03	0.24	0.61	67%	%27	46%	0.32	0.91	1.02	30%	3%	16%
Baixo Mondego	0.99	1.65	1.60	14%	-1%	6%	2.01	1.97	2.67	-1%	8%	4%
Baixo Vouga	2.69	3.20	3.11	4%	-1%	2%	2.32	2.40	2.51	1%	1%	1%
Beira Interior Norte	1.14	1.05	0.91	-2%	-3%	-3%	1.72	1.76	1.54	1%	-3%	-1%
Beira Interior Sul	1.63	1.39	1.06	-4%	-7%	-5%	1.64	1.77	1.92	2%	2%	2%
Cávado	3.61	2.71	3.21	-7%	4%	-1%	1.51	1.69	1.95	3%	4%	3%
Cova da Beira	1.98	1.99	2.25	0%	3%	2%	1.96	2.30	2.45	4%	2%	3%
Dão-Lafões	1.36	1.73	1.68	6%	-1%	3%	2.00	2.48	2.59	6%	1%	3%
Douro	1.05	0.86	1.40	-5%	13%	4%	1.65	2.14	2.35	7%	2%	5%
Entre Douro e Vouga	1.98	2.18	2.18	2%	0%	1%	2.58	2.60	2.60	0%	0%	0%
Grande Lisboa	2.58	2.85	2.45	2%	-4%	-1%	2.58	2.58	2.22	0%	-4%	-2%
Grande Porto	2.22	2.95	3.09	7%	1%	4%	2.48	2.96	2.91	5%	-1%	2%
Lezíria do Tejo	1.21	1.63	1.92	8%	4%	6%	2.98	2.91	2.97	-1%	1%	0%
Médio Tejo	1.68	1.84	1.80	2%	-1%	1%	2.10	2.63	2.58	6%	-1%	3%
Minho-Lima	1.22	1.61	1.96	7%	5%	6%	2.06	2.04	2.18	0%	2%	1%
Oeste	2.05	2.36	2.43	4%	1%	2%	2.48	2.65	2.75	2%	1%	1%
Península de Setúbal	1.43	1,68	1.87	4%	3%	3%	2.02	2.17	2.25	2%	1%	1%
Pinhal Interior Norte	2.18	2.03	2.08	-2%	1%	-1%	2.18	2.69	2.66	6%	0%	3%
Pinhal Interior Sul	0.75	1.24	1.42	13%	3%	8%	0.86	1.16	0.68	8%	-13%	-3%
Pinhal Litoral	2.22	2.59	2.67	4%	1%	2%	2.56	2.53	2.54	0%	0%	0%
R. Autónoma da Madeira	1.11	2.01	2,58	16%	7%	11%	2.28	2.71	2.90	4%	2%	3%
R. Autónoma dos Açores	1.29	1.21	1.65	-2%	8%	3%	1.94	2.10	1.82	2%	-4%	-1%
Serra da Estrela	1.30	1.22	1.37	-2%	3%	1%	0.54	1.97	1.85	39%	-2%	17%
Tâmega	2.87	2.80	2.74	-1%	-1%	-1%	1.50	1.74	1.87	4%	2%	3%

N	1,57	1,29	1,48	1,79	2,14	2,24
Minimum	0,03	0,24	0,51	0,32	0,91	0,68
Maximum	3,61	3,20	3,21	2,98	2,96	2,97
Average	1,62	1,80	1,92	1,96	2,20	2,21
Standard deviation	0,76	0,71	0,73	0,59	0,47	0,54

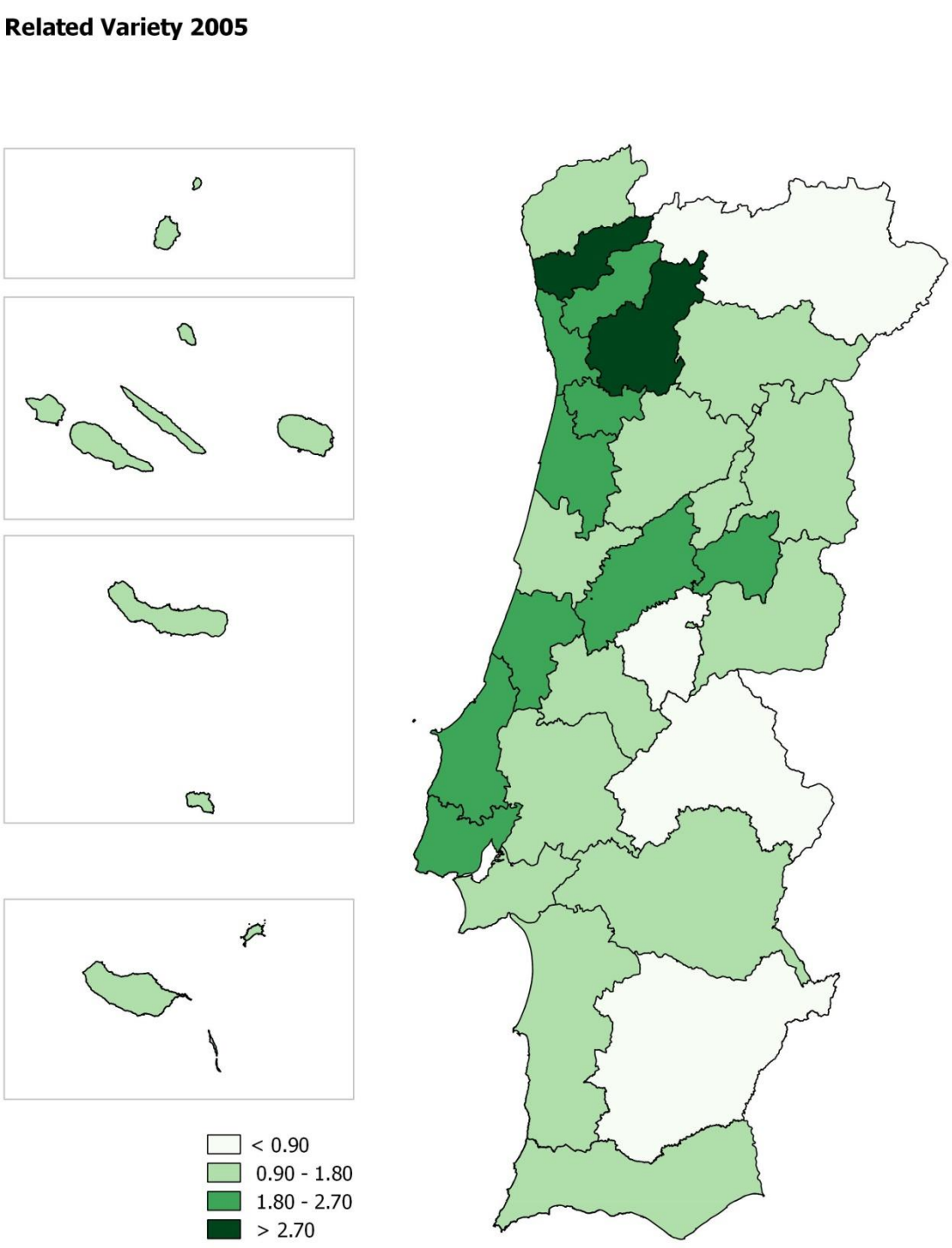

Figure 2: Related Variety, Portuguese NUTS 3, 2005

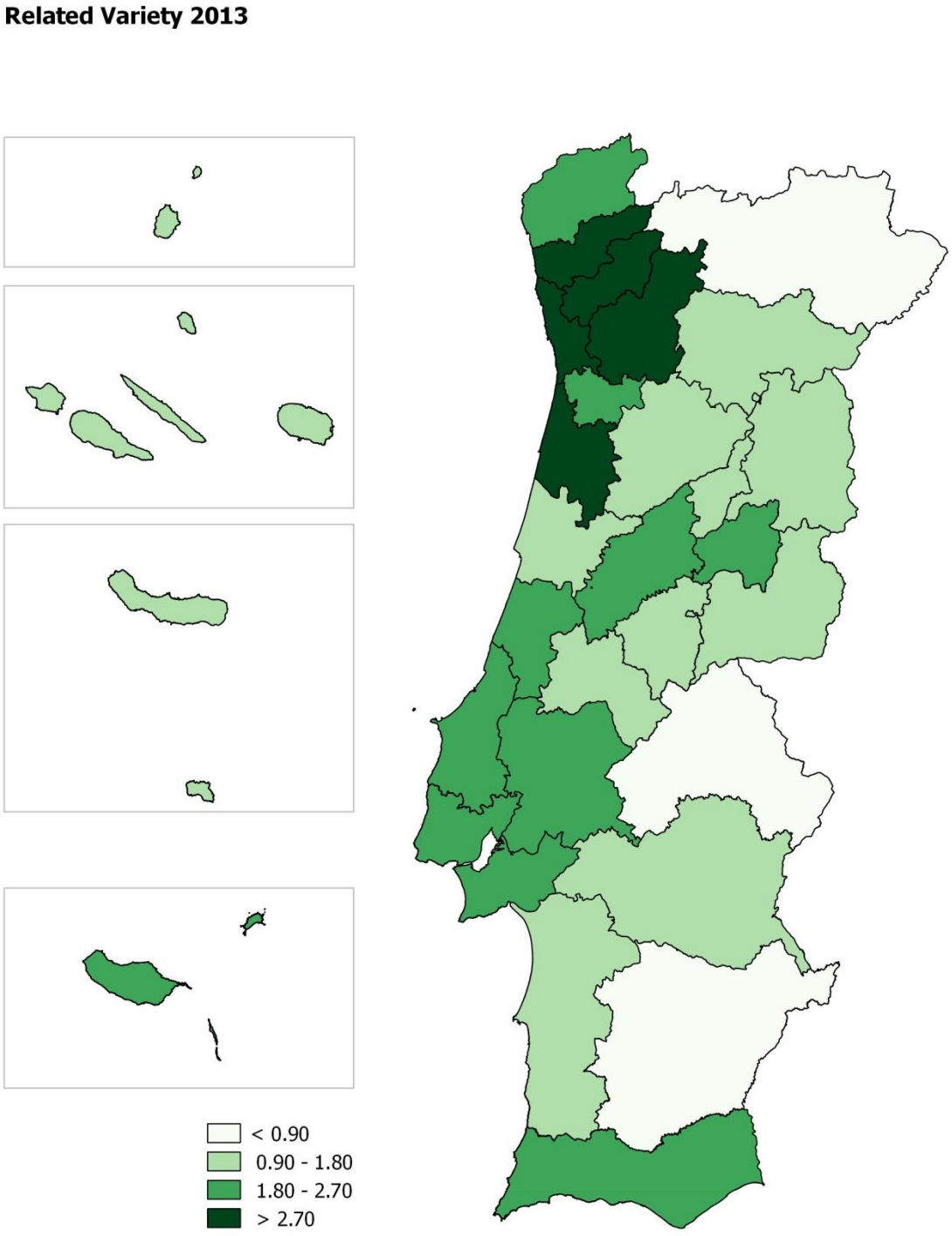

Figure 3: Related Variety, Portuguese NUTS 3, 2013

In line with the evolution of total and related variety, the results on unrelated variety show a general increase between 2005 and 2013. Once again, there are regional differences that must be taken into account. The regions of Grande Porto, Oeste and Dão-Lafões are those which present higher unrelated variety levels, which means that their industries do not show significant complementarities. In contrast, the regions of Pinhal Interior Sul and Baixo Alentejo have the lowest unrelated variety values, which means that they probably benefit less from the portfolio effect indicated earlier. Still, as can be seen more clearly in Figures 4 and 5, there is some homogeneity regarding unrelated variety across Portuguese regions, with the majority of territorial units showing values between 1.80 and 2.70.

Regarding the temporal evolution of unrelated variety, between 2005 and 2013 Serra da Estrela (17%) and Baixo Alentejo (16%) show above average positive growth, whereas regions such as Alto Trás-os-Montes (-5%) and Alto Alentejo (-4%) show a significant decline in this variety component.

On the other hand, as can be seen in Figures 4 and 5, there is a regional asymmetry bewteen the regions located in the portuguese coast line and the regions located in the rest of the country. Thus, the regions located in the coast line have, in general, higher unrelated variety levels than the regions in the inner country. Notwithstanding, this regional asymmetry is more pronouced in 2005 (cf. Figure 4) than in 2013 (cf. Figure 5), showing that the Portuguese territory is becoming more homogenous regarding the unrelated variety component. On the other hand, it is important to mention the regions located in the southern region, which have lower unrelated variety levels than the rest of the country, specially in 2005.

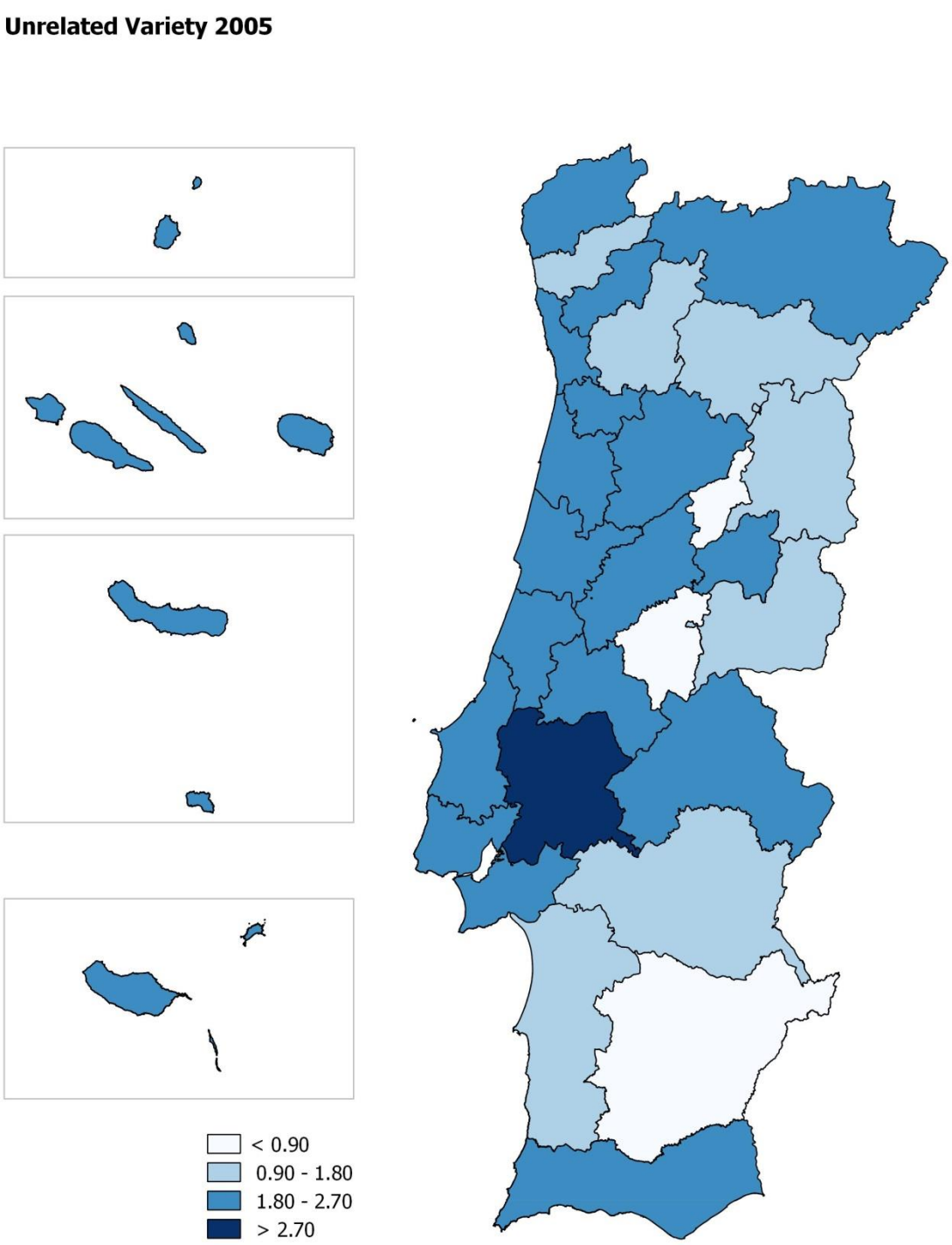

Figure 4: Unrelated Variety, Portuguese NUTS3, 2005

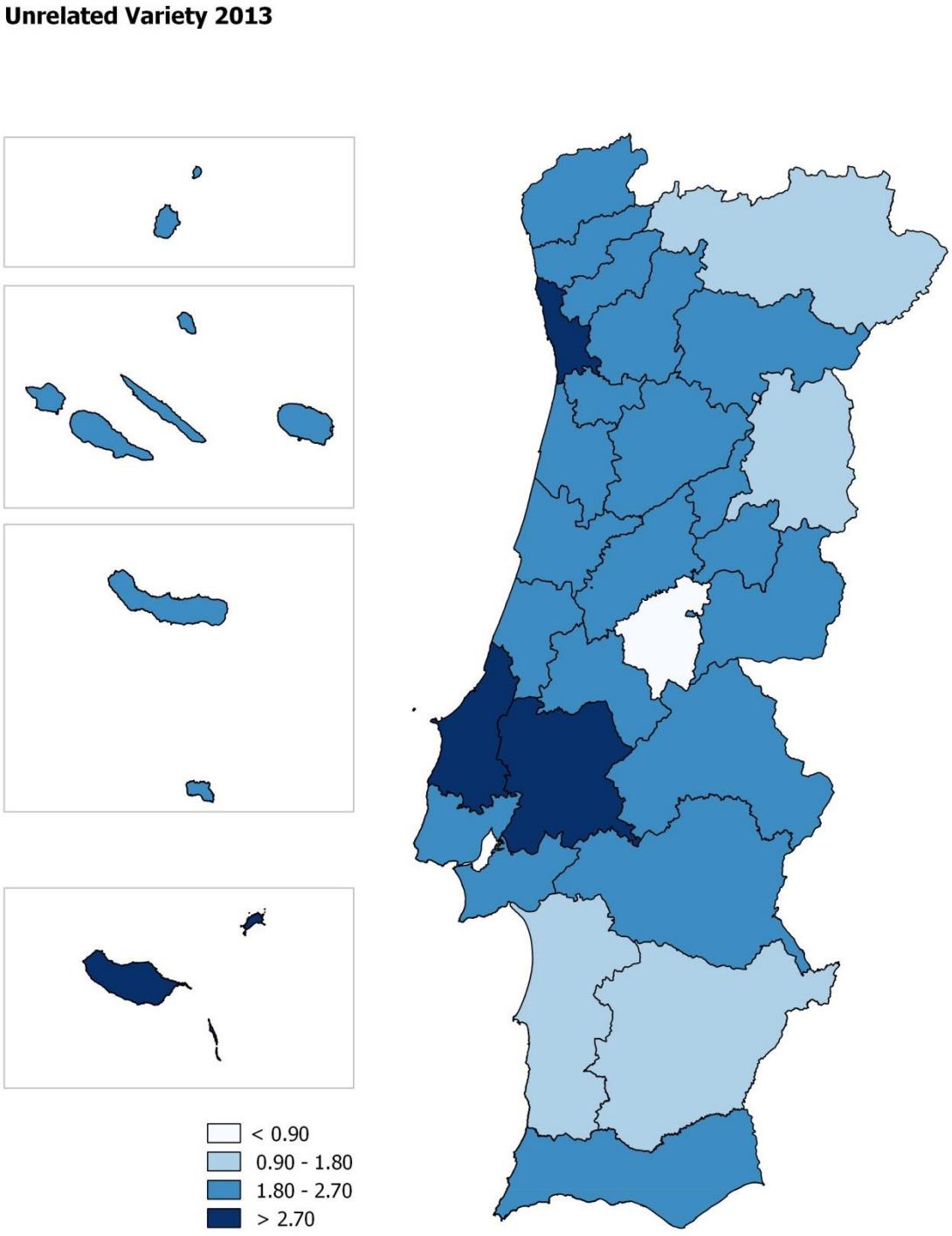

Figure 5: Unrelated Variety, Portuguese NUTS3, 2013

4.2. The model and data

Based on the theoretical discussion performed in Section 2, we estimate the following model:

$$VA_{growth_i} = \beta_0 + \beta_1 RV_{growth_i} + \beta_2 UV_{growth\,i_i} + \beta_3 X'_i + \varepsilon_i \qquad (5)$$

Where VA_{growth_i} , $RV_{growthi}$and $UV_{growth\,i}$ represent annual average growth rates in value added, related variety and unrelated variety in region i, respectively, X′ is a vector of control variables and ε_i.is the error term.

According to the aforementioned theoretical discussion, we expect a positive relationship between increases in related variety and value added growth, because an increase in diversification in complementary industries is capable of generating spillover effects that may translate into innovation and productivity growth. On the other hand, unrelated variety may affect growth, but, as seen before, this effect is more difficult, since it involves the combination of very different bits of information in order to generate more radical innovation.

The vector of control variables includes other factors that may influence regional growth, such as urbanization economies, human capital and labour-productivity. As seen before, urbanization economies, proxied by population density, may foster regional growth and thus a positive sign is expected for the coefficient associated to this variable. Human capital is measured as the fraction of population with a high school degree, proxying in this way the relative importance of skilled workforce. This is a variable commonly used in growth models, shown to have a significant positive impact on innovation capability, since high-skilled labor makes more easy to absorb knowledge transfer(Andersson and Ejermo, 2005). Finally, labor productivity or value-added per capita is included to proxy the usual catching up effect. Regions which have lower per capita income levels may benefit more from the introduction of already available technology and thus show higher growth rates. A negative sign is thus expected for the coefficient associated to this variable. All control variables are measured at the beginning of the period.

Table 6 provides a description of the variables used and of their data sources.

Table 6: Variables description and data sources

Variable	Acronym	Description	Source
Annual Growth Rate	AGR	Annual average growth rate of value added measured at 2005 constant prices	Computed using data from the Portuguese Statistical Office (INE)
Population Density	DENSITY.	Number of inhabitants per square kilometer	INE: Regional Statistical Yearbook
Labour Productivity	LPROD.	Ratio of value added (constant 2005 prices over employment	Computed using date from INE (Regional Statistical Yearbook)
Human Capital	HK	Fraction of population with a highschool degree in total population.	INE: Regional Statistical Yearbook

The geographic unit of analysis are the Portuguese regions, which are classified at the NUTS 3 level, according to Eurostat regional standard classification. The period of analysis is 2005–2013, which is divided in four-year intervals (2005-2009 and 2009-2013). Growth is measured as the average annual value-added or variety in each 4-year interval.

As Boschma *et al* (2011) makes clear, the use of regional exports data has some drawbacks since not all the industries in a region are exporting ones. There is some bias toward manufacturing activities, but as Boschma *et al* (2011: 10) emphasize "knowledge complementarities between sectors can be approximated by export structures of regions, since industries that are most open to international competition are also those that contribute most to new knowledge, innovation and economic growth".

4. 3 Empirical results

Table 8 presents some descriptive statistics regarding the variables included in the econometric specification (Equation 5).

On the other hand, regarding the coefficient of variation, average annual growth and labour productivity are the variables with higher and lower variation during the period of study. This can also be seen through the analysis of the maximum and minimum of the variables, which affects the mean and in consequence the coefficient of variation.

On the other hand, related and unrelated variety also have a high coefficients of variation during the period 2005 to 2013. Notwithstanding, the variables have heterogeneous coefficient of variation, showing the difference towards the means of the variables.

Table 7: Descriptive statistics

	Average Annual Growth	Related Variety	Unrelated Variety	Human Capital	Labour Productivity	Population Density
Mean	-0.068	0.037	0.022	126.609	25.3257	225.924
Median	-0.223	0.025	0.013	116.558	24.889	93.500
Maximum	3.672	0.674	0.385	243.796	44.504	1578.800
Minimum	-2.893	-0.204	-0.127	63.230	14.427	14.600
Std. Dev.	1.508	0.108	0.070	35.771	6.908	371.719
Coefficient of Variation	-2217.647	291.891	318.181	28.253	27.277	164.533

Given the substantial variation in several of the variables under analysis (especially in population density and value added growth rates) it is likely that some outliers exist.

Before estimating the model, and given the wide variation in some of the variables included, we thus checked for the existence of outliers. Using the influence statistics are discovering influential observations, or outliers. Thus, they are a measure of the difference that a single observation makes to the regression results, or how different an observation is from the other observations in an equation's sample. Therefore, Figure 6 reveals precisely the existence of significant outliers in observations 7, 29 and 32, which represent the Baixo Alentejo, Região Autónoma da Madeira e Serra da Estrela.

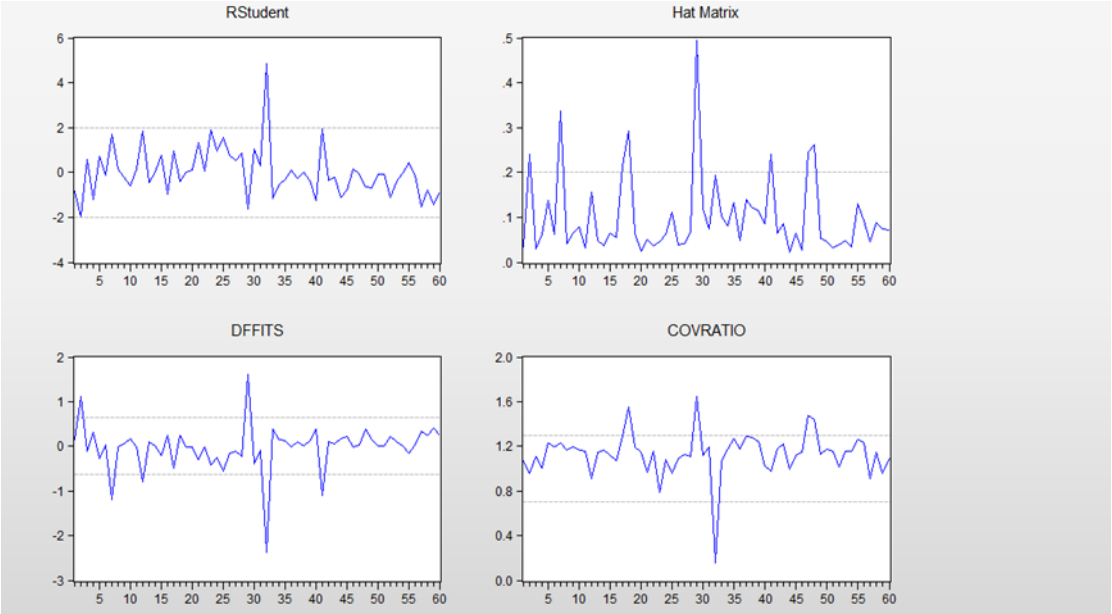

Figure 6: Influence Statistics

Given the sensitivity of Ordinary Least Squares estimators to the presence of observations that lie outside the norm for the regression model, we estimated Equation 5 using Robust Least Squarest. In fact, the sensitivity of conventional regression methods to outlier observations can result in coefficient estimates that do not truthfully reflect the fundamental statistical relationship. In this context, Robust Least Squares is a preferable method, designed to be less sensitive to those observations. Table 8 presents the estimation results.

Table 8: Regression results (Dependent variable: value added average annual growth rate)

	(1)	(2)	(3)
Constant	2.745	3.149	4.505
Unrelated Variety Growth	2.842	2.595	1.648
Related Variety Growth	3.889**	4.612**	3.862**
Population Density (log)		0.001**	0.001*
Labor Productivity	-0.124***	-0.151***	-0.127***
Human Capital (log)			-0.015***
R-Squared	0.249	0.301	0.390
Nr. of observations	60	60	60
Estimation method	Robust (pooled) OLS	Robust (pooled) OLS	Robust (pooled) OLS

* p<0.10,** p<0.05,*** p<0.01*

The estimated coefficients reveal some stability throughout the three econometric specifications. Most coefficients are significant at the conventional significance levels and show the expected signs.

With regard to our main explanatory variables, related variety growth has a positive influence on regional value added growth, as expected. The coefficients on unrelated variety show the expected sign (positive), but are not statistically significant. Regarding the control variables, population density has a positive and statistically impact on economic regional growth, as expected. More urbanized regions usually have access to better infrastructures and investment, which enhances growth. In turn, the negative and statistically significant effect of human capital and productivity labour on regional growth was not expected. These results do not confirm the economic growth theories predictions, and do not meet the *catching-up effect*, according to which the less developed regions have the potencial to grow faster than the most developed regions, leading to a convergence in the economic growth. Therefore, notwithstand, and although continues to lack futher explanation, the negative and statistically significant effect of human capital on regional economic growth is not something new in the economic literature (Teixeira and Silva, 2011) .

In general, our findings corroborate the empirical evidence from previous studies. In line with Boschma and Iammarino (2009) and Boschma *et al* (2011), we find a positive and statiscally significant relationship between related variety and economic growth and a positive but not statiscally significant relationship between unrelated variety and

regional economic growth. The finding of a non-significant impact of unrelated variety growth on value added growth may reflect, however, the relatively short time span under consideration. As explained in greater detail in Section 2, the impact of unrelated variety on productivity or value added growth requires generally a long time span to be fully materialized, since it requires the connection of previously separated pieces of information, giving rise to radical innovation. Unfortunately, export data at the regional level are only available for the Portuguese case in the period under consideration.

5. Conclusion

In this study an investigation of the impact of export variety on Portuguese regional economic growth has been made, taking into account the period between 2005 and 2013. Our analysis builds on recent work crossing international and regional economics fields of research, being, to our knowledge, the first work using regional data on Portuguese exports.

Underlying the empirical work is the concept of agglomeration economies, which, as indicated in the literature survey, has had several interpretations, from Marshall's (1920) early writings to the more recent studies inspired on the neo-Schumpeterian tradition. Follow this latter stream of research, we analyzed the role played by diversification (Jacobs' externalities and unrelated variety) on regional value added growth

Computations of the three variety indices have shown an overall rise of total, related and unrelated variety, as it would be expected. In fact, economic complexification usually accompanies the unfolding of economic development. Although notorious differences were found across regions, a broad trend of increasing variety has been found.

In line with other empirical studies focusing on other countries' experiences, our findings show a positive and significant impact of related variety on economic growth. This finding seems to corroborate the thesis according to which greater diversification in complementary industries generates important spillover effects, which materialize into regional growth (whether measured in terms of value added or productivity growth). Unrelated variety has a positive, but not significant influence on regional growth, but as indicated before, such result may be related to the relatively short time span considered. Increases in unrelated variety are harder to achieve and thus require long time spans to be fully materialized.

Although this study has accomplished its goals, using until now unexplored data and finding a significant relationship between related variety and growth, as it would be theoretically expected, there is a number of ways in which it can be improved. One possible avenue of research will be to consider other dependent variables, analyzing the impact of variety also on productivity (labor and multifactor productivity) and

employment and unemployment variables. Moreover, we focused solely on the impact of diversification externalities. Future work can explore also the role played by specialization as potential sources of MAR externalities. More generally, the inclusion of additional independent variables can be used to get a better grasp on the determinants that affect regional economic growth.

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7. Appendix