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Abstract
This paper makes an attempt to estimate the impact of regional variety and trade linkages on regional economic growth by means of export and import data by Italian province (NUTS 3) and sector (3-digit) for the period 1995-2003. Our results show strong evidence of related variety contributing to regional economic growth, no matter how growth is defined. Thus, Italian regions well endowed with sectors that are complementary in terms of competences (i.e. having related variety) perform better. The paper also assesses the effects of the breadth and relatedness of international trade linkages on regional growth, as it may bring new and related variety in the region. Our analysis demonstrates that regional growth is not affected by being well connected to the outside world *per se*, or having a high variety of knowledge flowing into the region. When the extra-regional knowledge originated from sectors the region is already specialised in, it did not positively impact on regional economic growth either. We found, however, some evidence of related extra-regional knowledge sparking off inter-sectoral learning across regions. With respect to employment growth, we could demonstrate that a region benefits from extra-regional knowledge when it originates from sectors that are related, but not similar to the sectors present in the region. Apparently, when the cognitive proximity between the extra-regional knowledge and the knowledge base of the region is neither too small nor too large, real learning opportunities are present, and the external knowledge contributes to regional employment growth.

Keywords: related variety, agglomeration economies, trade linkages, regional growth, Italy
JEL Classification: R11, R12, O18

1. Introduction

Since the seminal contribution of Glaeser et al. (1992), a debate has been taken place on the impact of different types of agglomeration economies on innovation and economic growth. Some scholars stress the positive role of localisation economies, arguing that the sectoral specialisation of a region is a positive factor because firms are expected to learn mainly from other local firms in the same industry. Others claim that the more diversified a regional economy is (i.e. Jacob's externalities), the more knowledge spillovers will occur, because firms get new and better ideas through other local firms that are active in different industries. In this paper, our aim is to extend this literature into two directions.

Following Frenken et al. (2007), we first argue that it is not accurate to assume that Jacob's externalities necessarily result in knowledge spillovers. Knowledge will spill over effectively only when complementarities exist among sectors in terms of shared competences. Such complementarities are captured by the notion of related variety (Frenken et al., 2007). Knowledge spillovers are not expected to occur in regions where unrelated variety prevails. In these latter contexts, instead, portfolio effects are more likely to occur, as sector-specific shocks can be absorbed more easily when industries are unrelated.

Moreover, the agglomeration literature generally does not account for inter-sectoral linkages between regions, overlooking the fact that new variety may be brought into the region through the establishment of extra-local linkages. The economic geography literature is paying increasing attention to the importance of extra-regional linkages as a way to prevent regional lock-in (e.g. Bathelt et al., 2004). However, this body of literature has hardly specified what kind of extra-regional linkages may be crucial: what might be important is to have relationships that bring new knowledge into the region through a wide range of sectors located elsewhere. As such, sectoral lock-in at the regional level may be counterbalanced by the inflow of a high variety of knowledge through inter-regional connections.

Even more importantly, we argue that these knowledge flows should be related to, but not the same as, the sectoral specialisation of the region. When the external knowledge is the same (i.e. it originates from sectors the region is already specialised in), the sectors in the region can absorb it, but the new knowledge will not add anything new to the existing knowledge base of the region, and therefore will not contribute to regional growth. When the external knowledge is unrelated (i.e. it originates from sectors that are very different from the sectors the region is specialised in), the sectors in the region cannot easily absorb it, and are unlikely to learn and benefit from it. Therefore, we claim that the inflow of external knowledge should be related to the sectors in the region to have an economic impact.

The paper has two objectives. The first objective is to estimate the impact of related and unrelated variety on the economic growth of Italian provinces in the period 1995-2003. The second objective is to assess whether the breadth and the relatedness of international trade linkages of each Italian province also affect regional economic growth, as it may bring new and related variety in the region. We test these theoretical statements by means of a database on exports and imports by Italian province, by sector and by country of destination/origin for the period 1995-2003.

The structure of the paper is as follows. In Section 2 we set out the main theoretical arguments. Section 3 describes the indicators built specifically for our analysis, whilst Section 4 presents the variables and discusses the results of the estimation model. Section 5 concludes by indicating future research lines.

2. Agglomeration economies, related variety and regional growth

There is a large literature on the impact of different types of agglomeration economies on innovation and economic growth, starting with the seminal contributions of Glaeser et al. (1992) and Henderson et al. (1995). In a nutshell, the debate focuses on the question of whether regional specialisation (localisation or MAR externalities)[1] or regional diversification (Jacobs' externalities) induce knowledge spillovers and, therefore, regional growth (Van Oort, 2004).

However, this literature tends to overlook two issues. The first issue is that the meaning of Jacobs' externalities is not well specified. Following Frenken et al. (2007), we argue that it is not a matter of having a diversified economy, but an economy that encompasses related activities in terms of competences that induce knowledge spillovers. It is therefore essential to distinguish, within the generic diversification argument, between related and unrelated variety. The second issue is that non-local linkages may be crucial in bringing new knowledge into the region (Asheim and Isaksen, 2002; Bathelt et al., 2004). The importance of extra-local linkages has been overlooked by the Glaeser-related literature, which is predominantly preoccupied by the composition of the industrial structure at the local level (Wetering, 2005).

In what follows we will discuss more in detail these two connected issues, developing the theoretical framework of our analysis.

2.1 Jacobs' externalities: related and unrelated variety

Much of the literature on agglomeration economies is dealing with the question whether a specific composition of sectors in a region further enhances knowledge diffusion and innovation. It basically concerns the question whether firms learn more from local firms in the same industry, or from local firms in other industries. Or, to put it differently, are specialised regions more conducive to innovation and growth, or are regions with diversified sectoral structures the most innovative and fast-growing?

Agglomeration externalities based on regional specialisation may arise from a thick and specialised labour market, local access to specialised suppliers and large markets, and the presence of local knowledge spillovers. The idea of localisation economies was strongly embedded in Keynesian thinking during the 1970s, but dates back to Marshall's ideas on industrial districts developed in the early twentieth century (Marshall, 1920). Recent studies suggest that inter-industry spillovers may be more important than intra-industry spillovers in explaining economic growth (Martin and Ottaviano, 1999), although intra-industry effects may dominate in some

[1] The hypothesis that knowledge is sector specific and that local specialisation enhances economic growth was firstly advanced by Marshall (1920) and lately formalised by Arrow (1962) and Romer (1986). Localisation economies are thus often referred to as MAR externalities.

manufacturing activities (Henderson et al., 1995). There is a large literature that appraises the virtues of diversified economies or Jacobs' externalities (e.g. Glaeser et al., 1992). They argue that the more diversified the regional structure, the higher the local growth, because diversity triggers new ideas, induces knowledge spillovers, and provides valuable resources required for innovation to take place.[2]

However, the literature on Jacobs' externalities suffers from two shortcomings. First of all, one can question whether knowledge spillovers are expected to take place between sectors that are unrelated. For example, it is unclear what a pig farmer can learn from a microchip company despite the fact that they are neighbours. Knowledge will only spill over between two sectors when the cognitive distance is not too large (Nooteboom, 2000; Morone, 2006). Indeed, most approaches to agglomeration economies, in line with the orthodox economic tradition, tend to be largely unconcerned with the interplay between industries, technology and geographical locations: they are mainly engaged in identifying localised knowledge spillovers, irrespective of the characteristics of any functional dimension of knowledge processes, which depend on the type of industry structure and spatial configuration (Iammarino and McCann, 2006).[3] Secondly, a diversified economy may also act as an absorber of sector-specific or asymmetric shocks, as stressed in the economic integration literature (Artis and Lee, 1997). Accordingly, and quite confusingly, the notion of Jacobs' externalities covers two different effects at the same time (i.e. a knowledge spillover effect and a portfolio effect) which have not been separated analytically until recently (Frenken et al., 2007).

As a consequence, it is essential to distinguish between different forms of regional variety, because they involve different economic effects. Knowledge will only spill over from one sector to another when they are complementary in terms of shared competences. Hence, related variety is needed in order to enable effective connections. We define related variety as sectors that are related in terms of shared or complementary competences.[4] In other words, there is some degree of cognitive proximity required to ensure that effective communication and interactive learning take place, though not too extreme, in order to avoid cognitive lock-in (Nooteboom, 2000). Thus, it is neither regional diversity (which may involve too large cognitive distance) nor regional specialisation *per se* (resulting in excessive cognitive proximity) that stimulate innovation. Rather, local specialisation in related variety is more likely to induce effective interactive learning and innovation. As such, the concept of related variety goes beyond the traditional dichotomy of localisation economies and Jacobs' externalities.

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[2] More in particular, Glaeser et al. (1992) find that city-industries tend to grow faster if the local industrial structure is relatively diversified (i.e. Jacobs externalities) and if the degree of competition is relatively strong (i.e. Porter externalities). For a thorough review of the literature see Mameli (2007).

[3] Some contributions have also shown that the inter-firm spillover arguments implicit in typical models of industrial clustering are not always applicable to oligopolistic or multinational-dominated types of spatial agglomerations (Arita and McCann, 2002a,b), where the dominant innovative behaviours act against the diffusion of knowledge in the local environment.

[4] Related variety is thus not defined in terms of sectors having input-output linkages. It is relevant to make this distinction between the cognitive and the economic dimension, because business networks are not necessarily the same as knowledge networks (see, for example, Giuliani, 2005).

The idea of innovation founded on related variety comes close to the definition of innovation proposed by Schumpeter, in which real innovations stem from the recombination of existing pieces of knowledge in entirely new ways. Such a view leaves behind a traditional, narrow sectoral perspective. Instead, it is argued that innovation is driven by interaction and feedback mechanisms that cross industry boundaries (Kline and Rosenberg, 1986; Robertson and Langlois, 1995). Thus, major innovations are more likely to occur when knowledge spills over across sectors, rather than within the same sector, but only as far as the sectors are related in terms of shared competences. In a dynamic perspective, diversity in complementary sets of competences and knowledge has been argued to be advantageous when interdependent pieces of knowledge have to be integrated and recombined to sustain innovation rates (e.g. Arora and Gambardella, 1994; Feldman, 1999). Building on related variety might then be an effective way to start up new growth paths (Saviotti, 1996; Martin and Sunley, 2006).

As is argued above, the knowledge spillover effect based on related variety must be distinguished from another form of variety, that is, unrelated variety, which covers sectors that do not share complementary competences. When defined in economic terms (which is different from the cognitive-based definition of related variety), unrelated variety concerns sectors that have no substantial economic input-output linkages. In this case, a broad range of unrelated sectors in a region may be beneficial for regional growth because unrelated variety spreads risks. In other words, when a sector-specific shock occurs, it is unlikely to disturb the regional economy as a whole as no substantial input-output linkages exist. Thus, unrelated variety dampens down industry-specific shocks and stabilises regional economies in the longer term (Essletzbichler, 2005).

Frenken et al. (2007) have demonstrated the empirical relevance of related and unrelated variety at the regional level in the Netherlands. The main outcome of the study was that regions with related variety showed the highest employment growth rates in the Netherlands in the period 1996-2002. These results tend to suggest the importance of knowledge spillovers across related sectors at the regional level. Regions with unrelated variety, instead, showed the most favourable unemployment rates, suggesting a portfolio-effect.

The notion of related variety has much in common with the concept of technological system developed in the 1980s and 1990s (e.g. Rosenberg and Frischtak, 1983; Carlsson and Stankiewicz, 1991). Such technological systems account for strong inter-industry technological linkages and interdependencies, resulting in interactive learning and innovation processes in related industries. The mechanisms through which industries may be related technically give insights on how related variety enhances knowledge spillovers and radical innovations, how new sectors come into existence, and how regional economies diversify in new directions now and then. This also implies that the effects of related variety will be particularly strong in key-sectors that lead economic changes brought about by a new technological paradigm, and that provide the main sources of knowledge of new technological trajectories. Such key-sectors (currently, for example, microelectronics and ICT) are characterised by high pervasiveness, horizontal effects and inter-industry cross-fertilisation among emerging technologies (Dosi, 1982; Bussolati et al., 1995).

Economic history gives evidence of many new sectors that grow out of existing ones, such as the television industry branched out of the radio sector (Klepper and Simons, 2000). This is an example of how the economic relevance of related variety shows up over time: new sectors emerge out of related industries, on which they build and expand. The economic significance of related variety goes far beyond these empirical observations: it is not only shown in old sectors giving birth to new sectors, but also, and even more so, it increases the probability of survival of the new industry. By conducting an industrial dynamics analysis, Klepper (2002) could demonstrate empirically that prior experience in related industries (like coach and cycle making) increased the life chances of new entrants in the new US automobile sector. Boschma and Wenting (2007) showed empirically that new automobile firms in the UK had a higher survival rate during the first stage of the life cycle of the new industry when the entrepreneur had a background in these related sectors, and when the firm had been established in a region that was well endowed with these related sectors. When diversifying into the new automobile industry, such new entrants could exploit and benefit from related competences and skills in their location, which improved their life chances to a considerable degree, as compared to start-ups lacking those related competences and skills.

In sum, the basic line of argument is that neither regional diversity nor regional specialisation induce knowledge spillovers. Instead, related variety in a regional economy is required to foster effective interactive learning and innovation. This beneficial effect of related variety in a regional economy is different from the portfolio effect, which is associated with unrelated variety rather than variety *per se*.

2.2 Extra-regional linkages and related variety

Section 2.1 was concerned with what occurs at the regional level, and to what extent a particular industry structure in a region is more beneficial for economic growth. While emphasising intra- and inter-sectoral spillover effects at the geographical scale, the agglomeration economies literature has largely overlooked the importance of intra- or inter-sectoral linkages between regions. In doing so, this literature neglected the fact that new variety and new knowledge can be brought into the region through the establishment of extra-regional linkages. Recent studies have pointed out that regions may become locked in or inward looking, and, therefore, it is crucial to bring in new external knowledge (e.g. Asheim and Isaksen, 2002; Cantwell and Piscitello, 2002).

However, little attention has been devoted to specifying what kind of extra-regional linkages are crucial for knowledge flows across regions. Following a logic similar to Jacobs' externalities, one could argue that it is crucial for regions to establish external connections that bring new knowledge into the region from a wide range of sectors located elsewhere. In this way, sectoral lock-in at the regional level may be counterbalanced by the inflow of a high degree of variety of knowledge through inter-regional relationships (Camagni, 1991). Hence, the more the region is connected to other regions, and the more diversified the knowledge that flows into the region, the higher the benefit in terms of local economic growth.

Yet, the inflow of extra-regional knowledge is not *per se* a sufficient condition for ensuring economic growth: regional absorptive capacity is needed in order to

understand and transform it into regional growth. In the economics of technical change, it has long been recognized that the ability of a firm to understand and absorb external knowledge is dependent on its own knowledge base (Cohen and Levinthal, 1990). Being able to build new competences quickly involves the ability to establish links at all levels, from the 'global' to the 'local': the extent to which a region attracts innovative resources from outside – i.e. spurring its external integration – depends first and foremost upon its extant knowledge base (e.g. Simmie, 2003). In the cluster literature, this is increasingly understood: leading firms in clusters may function as gatekeepers that import knowledge that may, or may not, diffuse to other cluster firms, depending on their absorptive capacity (e.g. Owen-Smith and Powell, 2004; Giuliani, 2005).

However, regional absorptive capacity may not be sufficient to transform extra-regional knowledge into regional growth. We suggest that related variety is again crucial: extra-regional knowledge that is complementary, but not similar, to existing competences in the region will particularly enhance interactive learning.[5] In other words, we suggest that related variety in extra-regional connections is required to ensure that the knowledge flows will spark off learning and innovation *in situ*. If the external knowledge is unrelated, the sectors in the region cannot absorb it, and are unlikely to benefit from it. When the external knowledge is the same (i.e. it originates from sectors the region is already specialised in), it can be absorbed locally, but the new knowledge will not add much to the existing local knowledge base, and will not lead to breakthrough innovations and economic renewal. Thus, we expect that a region will especially benefit from extra-regional knowledge when it originates from sectors that are related, but not similar to the sectors present in the region. In these circumstances, cognitive proximity between the extra-regional knowledge and the knowledge base of the region would neither be too small – avoiding lock-in in learning processes – nor too large – enabling the absorption of the extra-regional knowledge.

In what follows, we make an attempt to estimate this effect of relatedness in inter-regional linkages through the trade profiles of Italian provinces.

3. The analytical framework

The aim of the paper is to estimate the impact of different types of variety and different types of extra-regional linkages on economic growth at the level of Italian provinces. We use their trade profiles to measure these effects. The literature on innovation and technical change has long emphasised the crucial importance of trade for intra-firm learning as a process of technological accumulation (e.g. Dosi et al., 1990; Fagerberg, 1988). As pointed out by Pasinetti (1980, 1993), trade has a positive impact on technological change and growth when comparative advantages lie in sectors in which the region has its greatest potential for learning, or when imports in

[5] Also from a historical perspective, absorptive capacity depends significantly on diversity and complementarity: innovation occurs where there is a diverse (technological, social, economic) culture, and the most dynamic capabilities lie in the combination of both exploration and exploitation of new and existing assets (e.g. Rantisi, 2002).

its comparatively disadvantaged sectors provide a competitive stimulus towards more rapid learning. These 'handmaiden' effects of trade – to assist the process of learning – have led to acknowledge that the technology-trade causal relationship goes in both directions: technological competence has a positive impact on exports and regional competitiveness, while international trade boosts the generation and transfer of innovations, giving rise to cumulative causation mechanisms (Cantwell, 1994). In a world of increasingly interdependent economies, trade profiles offer not only a good measure of different forms of specialisation – i.e. qualitative differences in the sectoral composition of regions; they also allow us to go beyond the focus of the Glaeser-related literature, taking into account extra-regional linkages.

3.1 Indicators of agglomeration economies

We use export data by sector by Italian province to measure the effect of various types of agglomeration economies[6]. Obviously, not all industries are export sectors, so the export profile of a province might not exactly reflect the sectoral composition of the local economy. Having said that, we expect export sectors to be the strongest amongst all sectors in the province. Therefore, we expect related variety (localised knowledge spillovers effect) and unrelated variety (portfolio-effect) to matter most among export sectors. In addition, we assume the export profile of a province to be rather stable over time. If this was not the case, the export profile could not accurately reflect the sectoral composition of a province. This assumption is supported by the literature (e.g. Krugman, 1987; Dosi et al., 1990): trade profiles tend to be cumulative in nature, because regions continue to do what they did in the past, due to increasing returns to scale at the industry level, and due to non-transferable tacit knowledge accumulated in production and technology.[7]

In order to assess the impact of different types of agglomeration economies, we have constructed three variables.

Following conventional analysis, we first assess the impact of diversified economies, or Jacobs' externalities, on regional growth. In other words, we test the extent to which diversified regions provide evidence of higher growth, as suggested by the Glaeser-related literature. As a proxy for diversified economies, we employ the variable VARIETY that measures the degree of export diversification by means of an entropy measure at the three-digit level.[8] The value of the entropy indicator increases the more diversified the export profile of a region is. The entropy at the three-digit level in each province is given by (where p_i stands for the share of three-digit sector i):

[6] It is more common to use production and employment data by sector by region to assess the effects of agglomeration economies, but these more direct indicators are either not available or difficult to obtain at the provincial level in Italy. On the other hand, trade indicators have been traditionally very important in assessing knowledge flows in open economic systems, particularly when there is an emphasis on extra-regional linkages.

[7] Recent contributions confirm the persistence of the Italian national and regional export patterns over time (e.g. Amendola et al., 1998; De Benedictis, 2007; Guerrieri and Iammarino, 2007).

[8] The decomposable nature of the entropy measure implies that variety at different digit levels can be included in a regression analysis without necessarily generating collinearity. On the entropy measure see Frenken (2007).

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

We built two other variables to measure the effect of related variety and unrelated variety respectively. Following Frenken et al. (2007), we make use of the entropy measure to indicate both types of variety at different levels of sectoral aggregation, based on the existing classification of sectors. Again, we use the export profile of each region, that is, the set of export industries in each province. We measure the degree of related variety in each province through the weighted sum of the entropy indicator at the three-digit level within each two-digit class. As such, the variable related variety measures the degree of variety within each of the two-digit classes in each province: the higher the variety of sectors, the more knowledge spillovers we expect at the level of the region, and the higher its economic growth.

The variable related variety is measured as follows. All three-digit sectors *i* fall under a two-digit sector S_g, where $g=1,\ldots,G$. We can derive the two digit shares P_g by summing the three-digit shares p_i:

$$P_g = \sum_{i \in S_g} p_i \quad (2)$$

Related variety (RELVAR) is then defined as the weighted sum of entropy within each two-digit sector, which is given by:

$$RELVAR = \sum_{g=1}^{G} P_g H_g \quad (3)$$

where:

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} \log_2 \left(\frac{1}{p_i / P_g} \right) \quad (4)$$

The degree of unrelated variety in each province is measured through the entropy of the one-digit distribution. Consequently, this indicator measures the extent to which a province is characterised by very different types of sectors. In doing so, it measures the portfolio-effect of variety, as explained in section 2.1. The entropy at the one-digit level, or unrelated variety (UNRELVAR), is given by:

$$UNRELVAR = \sum_{j=1}^{N} P_j \log_2 \left(\frac{1}{P_j} \right) \quad (5)$$

where p_j stands for the share of one-digit sector *j*.

3.2 Variety indicators in trade linkages

Besides the effect of agglomeration economies, we aim to assess the impact of the breadth and nature of international linkages on regional economic growth, because these may bring new variety into the region. In section 2.2, we explained the need to differentiate between types of extra-regional relationships, because these may have diverse effects on regional growth. We have constructed three variables to measure their impacts.

First, we test the effects of extra-local linkages that bring a high degree of knowledge variety into the region through a diversified set of import sectors. As a proxy for import variety, we employ the variable IMPVAR that measures the degree of import diversification by means of an entropy measure at the three-digit level. The value of the entropy indicator increases the more diversified the import profile of a province is. We assume that the wider the spectrum of import sectors, the more diversified should be the knowledge flows that enter the province through its trade linkages. The entropy at the three-digit level in each province is given by (where p_i stands for the share of three-digit sector i):

$$IMPVAR = \sum_{i=1}^{N} p_i \log_2 \left(\frac{1}{p_i} \right) \qquad (6)$$

As set out in section 2.2, we expect a region to benefit particularly from extra-regional knowledge when it originates from sectors that are related, but not too similar, to the sectors that are present in the region. We developed an indicator that relates the import profile (at the three-digit level) of the region to the existing sectoral structure of the region, as proxied by its export profile (at the three-digit level). Accordingly, we take the import profile (i.e. the sectoral distribution of imports in a province) as a starting point, and then determine the extent to which the import profile is related to the export profile of the province. When identifying the degree of relatedness between imports and exports, it is important for two reasons to exclude pure intra-sectoral trade at the three-digit level, meaning import and export in the same three-digit sector. Firstly, this might concern mere transit flows from country A to country C through the region in country B. Secondly, as explained in section 2.2, when a region imports from the same sectors the region is already specialised in, we assume there is too much cognitive proximity between import and export, which implies no substantial interactive learning is expected to take place. In that case, the external knowledge that is brought into the region through import is unlikely to add anything new to the regional knowledge base.

Thus, we expect the more related and complementary (but not similar) the knowledge base of the region and its import profile are, the more it will contribute to growth in the region. To determine the degree of relatedness between imports and exports at the regional level, we constructed the related trade variety indicator RELTRADVAR. It proxies the possible benefits regional export sectors (and thus the regional economy) can derive from learning opportunities in related import sectors. It is calculated as follows. For each three-digit export industry in a province (e.g. sector 311), we measure the entropy of the imports from the other three-digit industries (e.g. sectors 312, 313 and 314) within the same two-digit class (sector 31), excluding the

same three-digit import sector (i.e. sector 311). This entropy measure is then multiplied by the relative size of that three-digit export sector (i.e. sector 311) in the province, measured as its share in total provincial exports. This is done for all three-digit export industries in the province. Related trade variety in that province is then determined by the sums of the products for all its three-digit export industries. Accordingly, this indicator depends on the relative size of the export sector in the local economy and on how that export sector can learn from related (but not similar) imports. Thus, the higher the variety in the related imports, the greater the learning opportunities, and the bigger the export sector concerned, the more these learning opportunities may contribute to regional growth.

Let *1* be a three-digit industry within the two-digit class *I(i)*, with $i = 1,\ldots n$. Let $OE_3^M(i)$ (where $i \neq 1$) be the import entropy in three-digit industries other than *1*, but within the same two-digit industry *I(i)*. Let $X_3(i)$ be the relative size of the three-digit export industry *1* (with $i = 1,\ldots n$) in the entire provincial export, then the RELTRADVAR can be defined as:

$$RELTRADVAR \quad = \sum_i OE_3^M(i) * X_3(i) \qquad (7)$$

Finally, we calculated an indicator that accounts for the inflow of extra-regional knowledge that originates from an import sector in which the region is already specialised. As explained in section 2.2, when the external knowledge is from the same sector the region is specialised in, the region (or better, the export sector) can absorb it, but the new knowledge will not add substantially to the existing knowledge base of the region. As a result, we do not expect it will lead to additional regional growth. To test for that, we constructed a so-called trade similarity variable (TRADESIM), which is simply calculated as the sum of the products of the absolute sizes of three-digit industry's exports and imports in each province. This indicator gets its maximum value when a region is specialised in just one and the same sector in both import and export (i.e. the region is mono-specialised). The value gets lower the more diversified a region is (in both imports and exports), and the less similar the import and export profiles of the region are. Because we take absolute values, we also account for the size of the regions.

Let $X_3(i)$ be the absolute size of the three-digit export industry *i* in the province, and let $M_3(i)$ be the absolute size of the three digit import industry *i* in the province. TRADESIM is then calculated as:

$$TRADESIM = \log \sum_i X_3(i) * M_3(i) \qquad (8)$$

In the following section we describe the data and the main variables and present the results of our analysis.

4. The empirical analysis: the case of the Italian provinces 1995-2003

4.1 Data and variables description

As previously stated, this paper will test the theoretical statements discussed in Section 2 by means of a large database on exports and imports by Italian regions for the period 1995-2003. This dataset consists of trade data that are specified for 103 Italian provinces (NUTS 3 level) and for 121 three-digit sectors (ATECO-3 level). In addition, the database provides detailed information on the country of destination as far as exports are concerned, and on the country of origin in the case of imports.[9] The source of all data employed here is the Italian National Institute of Statistics (ISTAT).

We use three dependent variables, all calculated in terms of annual average growth rates: (1) employment growth by province 1995-2003; (2) value added growth by province 1995-2003; and (3) labour productivity growth by province 1995-2003, as measured by valued added divided by labour units.

All our independent variables are measured at the beginning of the observed period, i.e. 1995. As explained in Section 3.1, we distinguish between three types of agglomeration economies, proxied by three indicators of export variety in the Italian provinces. In addition, we tested whether urbanisation economies mattered, that is, to what extent more densely populated provinces show a higher growth. As is common, we took as a proxy for urbanisation economies the population density of each province, that is the number of inhabitants per squared kilometre, measured on a logarithmic scale.

As explained in Section 3.2, we developed three indicators to assess the effects of extra-regional linkages on regional growth. It should be noted that we define extra-regional linkages as the trade linkages Italian provinces have with other countries. There are some drawbacks in using this information. Firstly, trade flows do not measure directly knowledge flows. In our study, as explained in Section 3, we have followed the trade literature claiming that trade flows are accompanied by knowledge flows. Alternative conventional indicators to measure knowledge flows between regions, are, for instance, co-patenting activity or co-publications (e.g. Leten et al., 2007). The problem is, however, that these do not account for knowledge flows between non-high tech activities, which are especially relevant for the relatively low technology-intensity of a country like Italy. Secondly, extra-regional linkages have been defined as linkages between Italian provinces and other countries. In other words, our analysis does not include linkages with other Italian provinces.[10] For this reason, dummies for macro-regions have been included in our estimations, to account for externalities effects that spill over between adjacent provinces. We have distinguished the typical four major geographical areas in Italy: North West, North East, Centre and South.

We have summarised some basic descriptive statistics in Table 1. The list of dependent and independent variables used in the analyses is reported in Appendix A.1.

Table 1. Descriptive statistics of the variables

[9] The trade database covers the period 1991-2003. However, our statistical analyses consider only the shorter period 1995-2003 because of a break in the time series at the provincial level. For further information see www.coeweb.istat.it

[10] Input-output tables at the NUTS 3 level are not available, so we could not calculate technical input-output links by Italian province.

Variables	Mean	Std. Dev.	Minimum	Maximum	N
Employment growth	9.61	5.00	-5.44	19.12	103
Value added growth	40.51	6.79	23.01	56.29	103
Labour productivity growth	31.49	6.29	15.64	57.82	103
Variety	2.70	0.65	1.26	3.87	103
Related variety	0.67	0.29	0.08	1.19	103
Unrelated variety	0.88	0.17	0.28	1.16	103
Import variety	2.90	0.73	0.43	4.00	103
Related trade variety	1.05	0.40	0.04	1.72	103
Trade similarity	37.13	3.34	24.48	44.98	103

4.2 Results

In this paper we do not estimate a conventional regional growth model. To do so would require data on capital investments and capital/labour ratios, which are not available at the NUTS 3 level in Italy. As explained before, our aim is simply to estimate the impact of related and unrelated variety on the economic growth of Italian provinces in the period 1995-2003 on the one hand, and the effects of the breadth and the relatedness of trade linkages on the other hand.[11] The estimation results, adopting the ordinary least-squares (OLS) baseline model, are shown in Tables 2, 3 and 4 for the dependent variables employment growth, value added growth and labour productivity growth respectively.

Table 2 presents the main results concerning the dependent variable regional employment growth. In column 1, we observe that Jacobs' externalities (Variety) *per se* do not have a significant impact on provincial employment growth in Italy during the period 1995-2003. So, having a diversified economy does not increase local employment. However, when distinguishing between the effects of related and unrelated variety[12], the table shows that related variety has a positive and significant effect on regional employment growth in one specification. In that case, as expected, having complementarities between sectors in a province impacts positively on employment growth. When we look at the results concerning the effects of extra-

[11] Among other contributions investigating the role of agglomeration economies on economic growth in Italy see Cainelli and Leoncini (1999), Usai and Paci (2003), Cingano and Schivardi (2004), Paci and Usai (2005).

[12] In all models, we included the variable VARIETY in a separate estimation for two reasons. First of all, we wanted to see whether the effect of Jacobs' externalities (measured as VARIETY) displayed different results, as compared to the effects of related and unrelated variety. Secondly, we did not bring together these variables in the same estimations because it would have caused multicollinearity problems, due to the (too) high correlations between the variable VARIETY and both variables RELVAR (.855) and UNRELVAR (.665).

regional linkages, all our expectations tend to be confirmed. It is not variety in imports that matters, but related trade variety that is of utmost importance: while import variety has even a negative coefficient, related trade variety has a positive and significant effect on employment growth in Italian provinces during the period 1995-2003. Thus, our data suggest that being connected with the outside world (and having a high variety of knowledge inflows) does not matter for regional employment growth. By contrast, the more related the import profile and the knowledge base of the province are, the more learning opportunities the province has, and the more the external knowledge contributes to local employment growth. In addition, trade similarity has no significant effect on employment growth at the level of the Italian provinces. This is in line with expectations: when a province imports goods from sectors in which it already exports, there is not much to be learnt from, and no additional employment growth in the province is expected.

Urbanisation economies do not have any significant effect. This is true for all our estimations and for all dependent variables.[13] The macro-region dummies give rather poor results. Only being located in the Centre of Italy seems to have some positive impact on employment growth.

[13] Such a result might be interpreted in the light of the 'scarcely urban' and relatively 'low technology-intensive' nature of the development of the Italian production and export model (Viesti, 2006). The two aspects are rather interdependent: Italy has recently failed to build strong comparative advantages in industries with cutting-edge and general-purpose technological content, whose locations in many industrialised economies are prevalently urban.

Table 2. OLS regression results

Dependent variable: employment growth 1995-2003

Constant	6.061 (3.840)	4.943 (4.018)	6.224 (4.070)	2.822 (6.921)
Population density (ln)	-0.073 (0.652)	-0.085 (0.649)	-0.103 (0.645)	-0.173 (0.644)
Variety	0.984 (1.013)			
Related variety		3.116 (2.430)	4.276* (2.522)	0.603 (2.737)
Unrelated variety		2.459 (3.265)	4.545 (3.503)	1.653 (3.265)
Import variety			-1.366 (0.871)	
Related trade variety				3.106* (1.579)
Trade similarity				0.049 (0.168)
Northwest	1.255 (1.639)	0.456 (1.732)	0.603 (1.721)	0.445 (1.747)
Northeast	1.603 (1.635)	0.790 (1.692)	1.158 (1.696)	0.442 (1.716)
Centre	3.087 (1.409)	2.802 (1.406)	2.962* (1.400)	2.595* (1.441)
R-square	0.084	0.102	0.124	0.138
F	1.774 Sign. 0.125	1.808 Sign. 0.106	1.924 Sign. 0.074	1.884 Sign. 0.072

Excluded variable: South
n=103
Standard errors in parentheses; *p < 0.10, **p <0.05, ***p<0.01

In Table 3, with value added growth as dependent variable, the variety indicators at the regional level show significant results. Related variety has a strong and significant effect on provincial value added growth. This result implies that having related sectors in a province impacts positively on value added growth in the period 1995-2003. Even unrelated variety has now a positive and significant effect in one specification: the more diversified a provincial economy with unrelated sectors, the higher its performance, suggesting a portfolio-effect. When we look at the effects of trade linkages, we observe that import variety *per se*, once again, has no significant effect: the inflow of a high variety of knowledge does not positively impact on the local economic performance. However, contrary to expectations, related trade variety has no significant impact on regional value added growth either, although its coefficient is still positive. Trade similarity has now turned into a significant and negative effect: apparently, the more similar the import and export profiles of a

province are, and the more specialised the province is in the same import and export sectors, the lower the growth of valued added in the province. This is in line with expectations. As argued before, this result might reflect pure transit flows, in which no valued added is created in the region, or the external knowledge brought into the region did not add anything new to the local knowledge base. The significant impacts of the macro-region dummies seem to indicate that location matters: provinces in the South of Italy perform significantly better as far as value added growth in the period 1995-2003 is concerned.

Table 3. OLS regression results

Dependent variable: value added growth 1995-2003

Constant	40.145 (4.965)	37.625*** (5.085)	38.778*** (5.185)	2.822 (6.921)
Population density (ln)	-0.450 (0.843)	-0.476 (0.822)	-0.492 (0.821)	-0.418 (0.794)
Variety	2.596* (1.309)			
Related variety		7.188** (3.075)	8.234** (2.522)	8.986*** (3.373)
Unrelated variety		6.463 (4.132)	8.343* (4.462)	5.733 (4.024)
Import variety			-1.230 (1.109)	
Related trade variety				0.476 (1.946)
Trade similarity				-0.632*** (0.207)
Northwest	-8.838*** (2.120)	-10.442*** (2.192)	-10.309*** (2.193)	-9.181*** (2.153)
Northeast	-6.604*** (2.114)	-8.308*** (2.142)	-7.977*** (2.160)	-7.003*** (2.115)
Centre	-4.299** (1.822)	-4.870*** (1.780)	-4.726*** (1.783)	-3.483** (1.777)
R-square	0.170	0.219	0.229	0.290
F	3.960 Sign. 0.003	4.498 Sign. 0.000	4.040 Sign. 0.001	4.800 Sign. 0.000

Excluded variable: South
n=103
Standard errors in parentheses; *p < 0.10, **p <0.05, ***p<0.01

The outcomes in Table 4, where the dependent variable is labour productivity growth, demonstrate that related variety has a positive and significant effect on regional labour productivity growth in one specification, while Jacobs' externalities and unrelated variety do not matter. However, contrary to expectations, and differently

from the previous results, related trade variety has now turned into a significant and negative effect. What is again in line with expectations is that the coefficient of import variety remains insignificant. For trade similarity, a negative (and highly significant) effect is again confirmed. Thus, the more similar (and narrowly specialised) the import and export profiles of the province are, the lower the labour productivity growth in the Italian provinces. Being located in the South of Italy is again very relevant: it significantly increases the labour productivity growth of the provinces in that area, as compared to the other Italian macro-regions.[14]

Table 4. OLS regression results

Dependent variable: labour productivity growth 1995-2003

Constant	35.948*** (4.420)	34.510*** (4.636)	34.285*** (4.755)	57.399*** (7.486)
Population density (ln)	-0.542 (0.750)	-0.567 (0.749)	-0.564 (0.753)	-0.406 (0.697)
Variety	1.000 (1.165)			
Related variety		2.625 (2.803)	2.422 (2.947)	7.383** (2.960)
Unrelated variety		3.239 (3.767)	2.873 (4.092)	3.521 (3.532)
Import variety			0.240 (1.017)	
Related trade variety				-3.309* (1.708)
Trade similarity				-0.662*** (0.182)
Northwest	-7.967*** (1.887)	-8.591*** (1.998)	-8.617*** (2.011)	-7.377*** (1.889)
Northeast	-6.178*** (1.881)	-6.896*** (1.952)	-6.960*** (1.981)	-5.230*** (1.856)
Centre	-5.909*** (1.622)	-6.147*** (1.623)	-6.175*** (1.635)	-4.574*** (1.559)
R-square	0.233	0.244	0.244	0.362
F	5.883 Sign. 0.000	5.154 Sign. 0.000	4.382 Sign. 0.000	6.676 Sign. 0.000

Excluded variable: South
n=103; Standard errors in parentheses; *p < 0.10, **p <0.05, ***p<0.01

[14] Our findings also confirm the sensitivity of the estimation with respect to different dependent variables. In the debate on the impact of agglomeration economies on economic growth, the empirical evidence is based on a variety of research approaches that have produced mixed and hardly comparable results. For a study on the drawbacks of this empirical literature, specifically addressing the problems created by the lack of comparability of results, see Mameli (2007).

5. Conclusions

This paper has explored the linkages between regional growth and different forms of variety, measured within the region and by considering extra-regional linkages.

Variety *per se* does not affect regional growth, no matter how growth is defined. This outcome supports the scepticism about the relevance of unspecified Jacobs' externalities, showing the need to differentiate between various types of economic variety (see Frenken et al., 2007, for similar arguments). In fact, when doing so, we found strong evidence of related variety contributing to regional economic growth, no matter how growth was defined. As expected, having complementarities between sectors in a region impacts positively on regional growth. By contrast, we found little evidence of the economic significance of unrelated variety.

Interestingly, our analysis suggests that regional growth is not affected by being well connected to the outside world, or having a high variety of knowledge flowing into the region. Our study shows there is a need to specify the nature of extra-regional linkages in order to grasp their effects on regional growth. A very consistent outcome is that trade similarity does not contribute to regional growth, no matter how growth is defined. This is in line with expectations: when the extra-regional knowledge originates from sectors in which the region is specialised, it can be absorbed locally, but the new knowledge will not add much to the regional knowledge base, and no additional regional economic growth is expected. We found some evidence of related extra-regional knowledge sparking off inter-sectoral learning across regions. With respect to employment growth, our results show that a region benefits from extra-regional knowledge when it originates from sectors that are related, but not similar to the sectors present in the region. Apparently, when the cognitive proximity between the extra-regional knowledge and the knowledge base of the region is neither too small nor too large, real learning opportunities are present, and the external knowledge contributes to regional employment growth.

There is more than one challenge open to further research. Some of them are mentioned below.

A first step is to check whether the impact of related variety differs within some specific industrial groups based on more advanced technological systems and 'general purpose technologies' (GPTs). This might lead to a differentiation of our results both at the industry and geographical levels. For example, Paci and Usai (1999, 2000), investigating the relationship between agglomeration economies and patent intensity in 292 Italian local systems, seem to confirm that related variety might be crucial: knowledge spillovers were identified at the level of clusters of science-based sectors, supporting the view that knowledge spillovers are dependent on the type of technological system underlying industrial production. Other empirical analyses have shown that inter-industry knowledge spillovers are likely to arise in regional centres of technological excellence, where spillovers seem to operate mainly through exchanges in and around core technological systems (i.e. rooted in 'general purpose technologies' as, for instance, background engineering, mechanical methods and, particularly nowadays, electronics and ICTs), creating linkages between quite separate fields of specialisation. These centres of excellence experience a faster process of convergence between old and new technologies and a potentially greater

competitiveness, eventually leading to a process of rise and decline of technological regions or clusters.

These quantitative analyses at the spatial level should be complemented by more descriptive case studies of regions, in order to get detailed insights on how related variety may be relevant for regional development. Dynamic and historical perspectives on sectoral and technological combinations within firms and regions – and particularly on the crucial importance of complementary competences for the alignment of old and new technologies (von Tunzelmann, 2003) – could be extremely useful in order to provide a sound normative basis for drawing policy implications.

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Appendix A.1 – The variables

Dependent variables:
Employment growth 1995-2003 (EMPLGR)
Value added growth 1995-2003 (VALADGR)
Labour productivity growth 1995-2003 (PRODGR)

Independent variables:
Variety 1995 (VARIETY)
Related variety 1995 (RELVAR)
Unrelated variety 1995 (UNRELVAR)
Import variety 1995 (IMPVAR)
Related trade variety 1995 (RELTRADVAR)
Trade similarity 1995 (TRADESIM)
Population density 1995 (URBAN)
Dummy macro-region Northwest (NORTHWES)
Dummy macro-region Northeast (NORTHEAS)
Dummy macro-region Centre (CENTRE)
Dummy macro-region South (SOUTH)