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Knowledge spillovers, related variety and firm heterogeneity

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Abstract

Economic geographers and regional economists have traditionally analysed the mechanisms driving learning processes and the diffusion of knowledge among local economic actors. During the past decade, the concept of 'related variety' has been frequently used to denote an agglomeration force able to explain knowledge-related advantages for firms and geographically bounded productive systems, and which arises from the heterogeneity of local industries. Besides this concept, more recent studies have emphasised the role of firm heterogeneity as an alternative ─ but not substitute ─ mechanism for knowledge creation and diffusion. This paper discusses the factors driving the emergence of knowledge spillovers within agglomerative spaces, and conducts a critical comparison between the concepts of industrial related variety and firm heterogeneity as two potential sources of local knowledge externalities, and, thus, of local economic development.

Keywords

Knowledge spillovers; agglomeration economies; related variety; firm heterogeneity.

JEL Codes

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1. INTRODUCTION

The competitive advantage of a firm – and, particularly, of a small or medium sized enterprise (SME) – depends not only on internal factors, such as organisation, quality of management, innovative propensity and internationalisation strategies, but also on external factors. Among these, a key dimension that has received great attention in economic geography and regional economics is that identifying the local environment as an agglomerative space.

Since the early 1990s, the literature has focused on the analysis of the benefits that a firm derives from location in an agglomerated area. Studies within this research stream have generally shown that the geographic concentration of production tends to generate positive returns for firms in terms of productivity (Cainelli *et al.*, 2016; Cainelli and Ganau, 2018), innovative propensity (Cainelli and De Liso, 2005; Cainelli, 2008), as well as internationalisation choices (Cainelli *et al.*, 2014; Burlina, 2016).

This paper analyses the agglomerative space from a different perspective, which emphasises the role played by two different types of heterogeneity in promoting knowledge spillovers among firms located in a region or a local system. The first type of heterogeneity is associated with the concept of related variety, and refers to the heterogeneity existing among 'different but related' industries located within the same bounded geographic area. Instead, the second type refers to firm-level heterogeneity which can be observed within the same industry located in a region or a local system. Indeed, these two types of heterogeneity ─ i.e. related variety and firm heterogeneity ─ play a key role in promoting knowledge transfer among firms, and, therefore, in supporting the economic growth and dynamism of a region or a local system.

The rest of the paper is organised as follows. The second section presents and discusses the concepts of related variety and firm heterogeneity, as well as their interplay as sources of knowledge spillovers. The third section concludes the paper.

2. SPATIAL AGGLOMERATION AND FIRM ECONOMIC PERFORMANCE

The idea that the location within a bounded geographic area characterised by a particular productive structure can have positive effects on the economic performance of firms has been clear to economists since the work of Alfred Marshall (1890). The English economist, on studying the cutlery and knitwear district of Sheffield, and the knitwear district of Northampton, realised that firms located in these geographic areas benefitted from some advantages – also called 'externalities' – compared to firms operating in the same industries but located in non-agglomerated areas. Specifically, Marshall (1890) identified three different mechanisms underlying agglomeration-related advantages: (i) the concentration of a large number of highly specialised suppliers (input sharing); (ii) the availability of highly specialised workers (labour matching); and, finally, (iii) the existence of knowledge spillovers among the local actors.

The first mechanism – i.e. input sharing – concerns the fact that the majority of manufacturing sectors require *ad hoc* machineries and specialised services to produce final goods. The concentration of a large number of final producers in a bounded geographic area, and the consequent development of a large demand for capital goods, have the effect of attracting specialised suppliers of machineries and services. The presence of a large network of suppliers can have three effects. First, it makes capital goods cheaper because suppliers can exploit economies of scale by serving many final producers. Second, it enables suppliers to become highly specialised with respect to the demanded machineries and services. Third, it allows final firms to concentrate on their core business by outsourcing stages of the supply chain.

The second mechanism – i.e. labour matching – concerns the presence of a local labour market characterised by a high concentration of skilled workers. The development of a local labour market can generate benefits for both firms and workers. On the one hand, firms can reduce the risk of not finding workers with a sufficient level of skills when they are expanding their production activity. On the other hand, workers can increase the probability of finding a new job when they are unemployed. In other words, the geographic concentration of production increases the matching between labour demand and supply at the local level.

Finally, the third mechanism involves knowledge spillovers, i.e. non-intentional transmission and/or informal exchange of information, knowledge, technologies, and innovations among firms located within an agglomerated area. It is now widely documented that these processes are very common in agglomerated areas, where spatial proximity increases the frequency of interactions among workers and firms, thus enabling the more rapid dissemination of (tacit) information and knowledge among local actors. One of the mechanisms suggested by the literature operates through social activities – for example, sports – which allow managers and employees of different firms to meet and then freely exchange the information and knowledge in their possession.[1]

These three mechanisms, identified by Marshall (1890), make it possible to explain why firms located in an agglomerated area, and benefitting from lower production costs, tend to record higher levels of productivity with respect to their non-agglomerated counterparts. Recent empirical studies have generally confirmed this positive relationship between agglomeration and a firm's economic performance (e.g. Henderson, 2003; Martin *et al.*, 2011; Cainelli *et al.*, 2016).

The most recent empirical interest in agglomeration-related advantages can be traced back to the seminal paper by Glaeser *et al.* (1992), who investigated two different forms of agglomeration forces and their returns on urban employment in the USA: agglomeration advantages associated with the productive specialisation of a local industry; and agglomeration advantages associated with the productive diversification of an urban area. The former type of advantages – generally measured by the level of productive specialisation of an industry in a locality – captures knowledge spillovers among firms operating in the same industry. The underlying hypothesis is that physical proximity among firms in the same industry can foster the transmission of ideas, information and knowledge among those firms. The latter type of agglomeration advantages – also called 'Jacobs externalities' – comprises knowledge spillovers occurring among different industries located in the same geographical area. The cross-fertilisation of information, knowledge and innovations among localised

[1] This process is described very well in a press article about Silicon Valley: "every year there was some place, the Wagon Wheel, the Chez Yvonne, at Rickey's, the Roundhouse, where the members of this esoteric brotherhood, the young workers of the semiconductor industry, went after work to have an aperitif and chat about circuits, memories, tests, RAM, NAK, MOS, PCM, PROM...", as reported in Saxenian (1994, 33).

firms operating in different industries generates advantages for individual firms and, thus, positive effects on the aggregate economic performance of the local system. In fact, almost 70% of the innovations developed in one industry are then used in another one (Glaeser *et al.*, 1992).[2] It follows that an industry located in an area characterised by high degrees of diversification and variety of the productive structure should grow more rapidly due to the transfer of ideas, information, knowledge, and innovations among the different local industries.

Glaeser *et al.* (1992) empirically tested the role played by these two different forms of local externalities as potential determinants of urban growth in the USA. Specifically, they considered the 170 largest metropolitan areas between 1956 and 1987, and found that urban employment growth is favoured by local productive diversification, rather than by industrial specialisation. Analyses carried out in other countries, such as the Netherlands (van Soest *et al.*, 2002), Portugal (Almeida, 2001) and France (Combes, 2000), confirmed these results, albeit with significant distinctions. With reference to the Italian case, Cainelli and Leoncini (1999) and Paci and Usai (2006) also found that it is productive diversification, rather than industrial specialisation, which has a positive effect on local employment growth.

The feature shared by these early works was the analysis of the role played by agglomeration forces on urban employment growth. In fact, it is only since the early 2000s that the analysis of industrial specialisation versus local productive diversification has been extended to investigate the agglomeration returns on firm-level productivity. After Henderson's (2003) seminal work, the most important contribution can be considered that of Martin *et al.* (2011), who empirically demonstrated that industrial specialisation plays the main role in explaining productivity at the firm level. By contrast, they did not find any effects ascribable to local industrial diversification.

The impact of agglomeration economies on firm-level performance has been analysed in regard to a variety of countries, and, overall, empirical studies report results that can be considered unequivocal. A firm located in an agglomerated area benefits from some localisation advantages

[2] For example, the support used in Parma (Italy) to cut the ham rind was originally developed in the industry producing the supports for tyre dealers.

which generally materialise in better economic performance and/or a greater propensity to innovate and internationalise. The key issue concerns the type of externality which is prevalent – whether industrial specialisation or diversification – but the contribution made by location in an agglomerated area is now certain.

2.1. RELATED VARIETY

As already noted, local industrial diversification is one of the main sources of agglomeration-related advantages and, particularly, of knowledge spillovers. Its importance was first evidenced in the fundamental study by Jane Jacobs (1969) on American cities. Jacobs (1969) identified urban variety as one of the key mechanisms supporting and promoting the transfer of ideas, information and knowledge among the different industries located in a city. The idea was that the cross-fertilisation of innovations among local firms operating in different industries is the fundamental factor driving local development. Indeed, empirical studies carried out since the early 1990s have substantially confirmed the role of local industrial diversification in promoting employment growth in the USA and in some European countries.

A more recent research stream, which has developed during the past decade, has significantly improved understanding of the mechanisms driving spillover effects arising from local industrial diversification. It has done so by showing that the industrial variety of a locality is not a sufficient condition to guarantee the cross-fertilisation and the transfer of information and knowledge among the various localised industries. In fact, there must be technological similarity among the industries located in a bounded geographic area for externalities to materialise (Frenken *et al.*, 2007). The transfer of information, knowledge and innovations can only occur among industries which share the same – or at least similar – technological and knowledge bases. A traditional industry, such as the footwear industry, is unlikely to transfer knowledge or technology to a high-tech industry like the biomedical industry. Thus, transfer and transmission processes are activated only if the cognitive distance among the firms operating in the different localised industries is not too large (Nooteboom,

2000; Boschma and Iammarino, 2009). In other words, industrial heterogeneity is quite important for the dynamism of firms and local systems, but the key type of heterogeneity is that among related industries.

Since the study by Frenken *et al.* (2007) on the concepts of related and unrelated industrial variety, many empirical works have investigated which form of industrial diversification at local level matters the most for regional economic performance. In their pioneering analysis, Frenken *et al.* (2007) sought to capture local industrial variety by using the entropy measure, and they employed a standard statistical classification of industries to identify relatedness among sectors within an industry. Specifically, they operationalised related variety as the weighted sum of entropy at five-digit sector level within each two-digit level industry in a locality, while unrelated variety was operationalised as the entropy at two-digit level industry.[3] Frenken *et al.* (2007) analysed the Dutch case, and showed positive returns of related variety on employment growth, but not on productivity and unemployment growth, at the sub-national geographic level 3 of the *Nomenclature des Unités Territoriales Statistiques* (NUTS).

The positive link between related variety and regional employment growth was confirmed by several subsequent studies, which, however, provided further interesting insights. For example, Hartog *et al.* (2012) found positive returns of related variety on employment growth in Finnish NUTS-4, but only when considering industrial relatedness among high-tech sectors. On Swedish municipalities, Wixe and Andersson (2017) found that variety among related industries matters for employment growth, while it exerts an overall negative effect on productivity growth. Firgo and Mayerhafer (2018), focusing on Austrian Local Labour Markets (LLM), found that related variety drives employment growth in the manufacturing industry and in urban areas, while unrelated variety

[3] It should be pointed out that the industrial classification approach proposed by Frenken *et al.* (2007) to capture industrial relatedness has been criticised for various reasons in the literature on related variety. For example, Boschma *et al.* (2012) underline that standard statistical classifications of industries use some priors to establish industrial relatedness (e.g. similarities in product characteristics or in production technologies), and their use does not allow to account for "similarities in regulatory framework, complementarities in their use, the intensive use of a certain type of infrastructure, the use of advertisement to build trade marks, etc." (Boschma *et al.*, 2012, 242). Moving from this criticism, the most recent literature has proposed alternative approaches to capture local industrial related variety. For example, Boschma *et al.* (2012) consider the geographic correlation of employment across traded industries, and proximity indexes of industrial products, while Cainelli *et al.* (2016) consider input-output linkages among industries.

matters more than related variety for employment growth in the services industry, as well as in industrial and rural local systems.[4]

Regarding the Italian case, Boschma and Iammarino (2009) found a positive association of related variety not only with employment, but also with value added and labour productivity growth, in Italian NUTS-3 regions. By contrast, Quatraro (2010) finds that the positive association between related variety and productivity growth at the geographic NUTS-2 level becomes statistically negligible once spatial dependence across neighbouring regions is accounted for. Considering a finer geographic level of analysis, i.e. the LLM, Mameli *et al.* (2012) find that related variety matters for employment growth in the services industry, while unrelated variety seems to be a key driver of manufacturing employment growth. Moreover, these results appear robust when controlling for both substantive and nuisance spatial dependence among LLMs. Innocenti and Lazzeretti (2017) partially corroborate previous findings on local employment growth, as they find that related variety matters at the geographic NUTS-3 level, even more than unrelated variety. In their analysis of the configuration of the local knowledge base, Colombelli and Quatraro (2018) consider (related and unrelated) variety measures defined in terms of patent classes, and find that knowledge related variety tends to outperform knowledge unrelated variety, although both dimensions are positively associated with new firm formation in mid-high and high technology sectors at the geographic NUTS-3 level. Considering the same empirical framework, Colombelli *et al.* (2019) provide evidence that knowledge related variety matters more than knowledge unrelated variety for the formation of new firms in science-based and specialised supplier sectors, while the opposite occurs with respect to scale-intensive and supplier-dominated sectors.

In the spirit of Henderson (2003), another branch of studies has focused on the firm-level returns of related variety. These works have considered different measures of firm-level productivity and

[4] More recent studies have extended the analysis of related variety to the study of regional resilience to exogenous shocks. In fact, the Great Recession provided fertile ground to test the role played by the local industrial structure as a shock absorber (Cainelli *et al.*, 2019). Overall, the works which contributed to this research topic tended to identify related variety as one of the main factors enabling a region to react better to an economic shock ─ e.g. Cainelli and Ganau (2016) and Sedita *et al.* (2017) on Italy; Xiao *et al.* (2017) and Cainelli *et al.* (2019) on European regions.

innovativeness. For example, Eriksson (2011) used both municipality- and plant-specific measures of industrial related and unrelated variety, finding that, overall, related (unrelated) variety is positively (negatively) associated with plant-level labour productivity growth in Sweden. Aarstad *et al.* (2016) used region-specific variables for industrial related and unrelated variety defined at the Norwegian municipality level, and found that related variety is positively associated with enterprises' innovation only, while unrelated variety is negatively associated with enterprises' labour productivity only. For the Italian case, Cainelli *et al.* (2016) considered a measure of industrial related variety based on input-output relationships across pairs of two-digit industries, and defined at the Italian NUTS-3 geographic level. By using fixed effects and instrumental variable estimation approaches, they found a positive effect of (market-based) industrial related variety on firm-level total factor productivity (TFP). Finally, Wixe (2018) analysed the association of industrial related and unrelated variety with Swedish firms' probability of introducing product innovations, and found that industrial related variety matters the most for industrial firms located in metropolitan regions, while industrial unrelated variety matters the most for services firms located in rural regions.

2.2. FIRM HETEROGENEITY

Most of the traditional literature on agglomeration economies draws on two hypotheses. The first one is that firms are homogeneous, and, therefore, do not have effects distinguishable in terms of local knowledge spillovers. Indeed, Munari *et al.* (2012, 430) state that "both conceptually and empirically, firms operating within industrial districts have been traditionally modelled as undifferentiated and characterized by low variance in their strategies and business models". This means that the traditional literature on agglomeration economies neglects firm heterogeneity. However, some more recent studies have shown that firms with different sizes, technological levels, business models and strategies, ownership structures and nationalities, motivations and cultural backgrounds, generally co-exist in many localised industries and clusters (e.g. Wang and Lin, 2013).

These studies suggest that firm heterogeneity is an empirical regularity in agglomerated areas and clusters.

The second hypothesis usually assumed in the spatial agglomeration literature is that firms operating in localised industries and clusters are 'passive actors' which benefit from the available external knowledge (Alcacer and Chung, 2007). However, as underlined by Shaver and Flyer (2000), firms behave both as 'passive actors' benefitting from knowledge spillovers, and as 'active actors' which contribute to the generation and diffusion of these externalities. For example, the literature on geographic clusters shows that focal firms perform a gatekeeper function, as they absorb knowledge generated outside the cluster, and then spread it to the other firms within the cluster (Lazerson and Lorenzoni, 1999). These 'focal agents' are generally large companies or plants characterised by a strong propensity for innovation, and which have advantages related to both external knowledge acquisition and diffusion (Munari *et al.*, 2012). A similar role is played by multinational companies with respect to domestic firms in developing countries, and by business groups in Italian industrial districts (Brioschi *et al.*, 2002; Cainelli *et al.*, 2006). Thus, these types of firms act not only as knowledge receivers, but also as knowledge producers and disseminators.

According to these studies, heterogeneity at the firm level can be considered a source of local knowledge spillovers, and two different effects can be identified. The first effect of firm heterogeneity concerns the 'nature' of local knowledge spillovers. Under the homogeneity hypothesis, firms apply the same solution to the same – technological, organisational, commercial or managerial – problems (Bathelt *et al.*, 2004); by contrast, if firms are heterogeneous, they will apply different solutions to the same problems even if they belong to the same localised industry or cluster. Thus, the presence of heterogeneous firms leads to the emergence of different knowledge outflows compared to the case of homogenous firms. This means that the nature of local knowledge spillovers depends on both the number of firms operating in a localised industry or cluster, as well as on their characteristics, such

as size, technological level, organisation structure, innovation propensity, etc. (e.g. Cainelli and Ganau, 2018; Cainelli and Ganau, 2019).[5]

The second effect of firm heterogeneity relates to the 'intensity' of knowledge spillovers. For the sake of simplicity, let us consider only two types of firms which differ in their technological capabilities. In the presence of this type of firm heterogeneity in 'technological capabilities' (Wang, 2015), firms with 'poor' technological capabilities benefit disproportionately from knowledge spillovers with respect to firms with 'good' technological capabilities (Shaver and Flayer, 2000). In fact, the latter type of firms generate more knowledge than they can absorb, thereby increasing the flow of external knowledge within the localised industry or cluster. Instead, if the localised industry or cluster is dominated by firms with low levels of technological capabilities, then the opposite effect will emerge. Similar effects arise with respect to firm size heterogeneity. Large firms have a greater capacity than small firms to exploit 'advanced' external knowledge sources – such as universities and (private and public) research centres – thanks to their stock of accumulated knowledge. Thus, it is more likely that large firms develop both a greater absorptive capacity and a greater capacity to source knowledge in the local system, with respect to small firms. This means that large firms can generate more knowledge than they can absorb. The opposite effect will occur if small firms prevail. In both the cases considered, firm heterogeneity leads to asymmetric knowledge spillovers and knowledge spillover benefits, thus increasing the knowledge stock in the localised industry or cluster.

Along these lines, Cainelli and Ganau (2018) empirically tested the role played by different characteristics of the firms forming the agglomerative space for the Italian case. They considered firm-specific measures of industrial specialisation and industrial diversification defined for continuous and non-overlapping distance bands, and, particularly, constructed to account for agglomerated firms' size and TFP characteristics. They found that the association between both

[5] Maskell (2001, 928-929) suggests that since firms located within a cluster have "different perceptive powers, divergent insights and dissimilar attitudes … *they* develop a variety of solutions … to similar problems", which leads to a "parallel process of experimentation and testing" of a variety of solutions. Therefore, firms can engage in interactive learning and local knowledge creation by observing, discussing and comparing these different and dissimilar solutions.

industrial specialisation and diversification with firm-level TFP growth depends on the characteristics of neighbouring firms.

2.3. RELATED VARIETY, FIRM HETEROGENEITY AND KNOWLEDGE SPILLOVERS

According to this line of reasoning, firms with different attributes and characteristics which belong to the same localised industry or cluster, can be 'likened' to firms operating in different but related industries. In both cases, 'knowledge heterogeneity' is a fundamental determinant of inter-firm knowledge creation, and a key driver of firm's economic performance.[6]

It follows that knowledge spillovers can be promoted by two different types of heterogeneity. The first type is associated with the concept of related variety, and refers to the heterogeneity of related industries located within the same bounded geographic area. The second type is associated with the concept of firm heterogeneity, and refers to the heterogeneity among firms belonging to the same industry (or cluster) within a bounded geographic area.

Only a very small number of papers have compared the effects of industrial related variety and firm heterogeneity on firm- or local-level performance measures. To the best of our knowledge, Cainelli and Ganau (2019) is the only study which has attempted to compare these two types of heterogeneity empirically. Specifically, Cainelli and Ganau (2019) used a sample of about 28,000 Italian manufacturing firms observed over the period 2010-2013 to compare the effects of industrial related variety – capturing knowledge spillovers arising from the local heterogeneity of related industries – versus within-industry firm heterogeneity – capturing knowledge spillovers arising from firm-level heterogeneity within a localised industry – on short-run employment growth. They found that both types of heterogeneity have a positive effect on firm-level employment growth, even though the returns of within-industry firm heterogeneity seem to be more intense than those of industrial

[6] Moreover, firms belonging to the same localised industry or cluster, but with different attributes and characteristics, and firms operating in different but related industries can be 'likened' to the distinction between the horizontal and the vertical dimensions of a cluster proposed by Maskell (2001) and Bathelt *et al.* (2004). According to these authors, the horizontal dimension of a cluster consists of firms producing similar goods, and competing with each other; the vertical dimension, instead, consists of firms which are complementary and interlinked through a network of suppliers, services providers and customer relations.

related variety. This result is very interesting, because it suggests that agglomeration generates an effect on the behaviour and performance of firms not only in the presence of industrial variety, but also in the presence of firms with different characteristics operating in the same localised industry.

Therefore, the unintentional transfer of technological, organisational and managerial knowledge, and information about new markets and products within a bounded geographic area is favoured by both a correlated diversified production structure, and the presence of firms with different characteristics operating in the same local industries. This means that the entry into a region or a local productive system of subsidiaries of foreign multinational companies – which are, generally, larger and more productive than local firms – can increase the flow of technological knowledge available to the other local firms, with positive overall effects on the regional economy. The same can be said with respect to the entry of a firm belonging to a business group.

3. CONCLUSIONS

The diffusion of knowledge represents, probably, the most important mechanism driving agglomeration-related advantages for firms and, consequently, for the local systems where they are located and operate. This paper has discussed two types of heterogeneity promoting the creation and dissemination of knowledge among firms within a bounded geographic area – namely, industrial related variety and firm heterogeneity. The first type of heterogeneity concerns the heterogeneity existing among 'different but related' industries located within the same local system. The second type concerns firm-level heterogeneity which can be observed within the same industry located in a region or a local system. Our main thesis is that these two forms of heterogeneity are both important in promoting local knowledge spillovers, and thus the economic growth of a local system.

Although this paper has focused on knowledge externalities arising from heterogeneity among local industries and across firms within localised industries, it should be pointed out that other sources of heterogeneity at the local level deserve attention as sources of knowledge creation and diffusion. For example, Wixe and Andersson (2017) and Wixe (2018) suggested that local knowledge spillovers

should be captured also by considering heterogeneity among individuals and individual skills. The key idea is that learning processes – and, consequently, knowledge spillovers – within bounded geographic areas take place among individuals, rather than at the level of industries. For example, Wixe and Andersson (2017) and Wixe (2018) proposed measures of related – and unrelated – variety based on educational and occupational heterogeneity to capture local knowledge spillovers, and compared them with the standard industry-based measures of variety *à la* Frenken *et al.* (2007) to analyse their returns on regional employment and productivity growth, and firm-level innovativeness, respectively.

Therefore, future research analysing agglomerated-related advantages and the role of knowledge spillovers in promoting firm- and local-level dynamism and economic performance should integrate and compare these different forms of heterogeneity among individuals, workers, firms and industries. All these types of heterogeneity contribute not only to the emergence of learning processes and knowledge spillovers, but also to the economic development of a local system.

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