Indicators and Growth effects of Related Variety at the national and regional level in the EU

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Content

1. Executive summary

Following the study by Frenken et al. (2007) introducing the concept of related variety in regional economics, a number of studies have been undertaken to analyze the effect of related variety on economic development. The review of related variety research made clear that – although the evidence base is still rather small with about 15 studies – most studies find support for the initial hypothesis by Frenken et al. (2007) that related variety supports regional employment growth. We also reviewed the studies looking at branching, following the study by Hidalgo et al. (2007). That is, the process in which a region or countries develops comparative advantage in new industries. Also here it was found that if a region or countries already hosts industries that are related to a specific industry, it is much more likely to become specialized in that industry. We end with a number of further research questions regarding: i. methodology, ii. the role of unrelated variety in regional development, an iii. the need to analyze how related variety may spur innovation and entrepreneurship.

2. Related Variety: A review

2.1 Related variety: the concept

In recent research in economic geography, an empirical body of literature has emerged on the role of related variety in regional development. The concept of related variety was put forward by Frenken et al. (2007) as to further specify the common hypothesis that regions benefit from producing a variety of products and services, as more variety implies more potential for inter-industry knowledge spillovers. Frenken et al. (2007) emphasized that: “one expects knowledge spillovers within the region to occur primarily among related sectors, and only to a limited extent among unrelated sectors” (p. 688). That is, they hypothesized that inter-industry spillovers occur mainly between sectors that draw on similar knowledge: knowledge originating from one sector is most relevant to, and can most effectively be absorbed by, another sector that is related in the sense that firms draw on similar knowledge (about technology, markets, etc.).

The concept of related variety was introduced in an attempt to resolve an earlier empirical question put forward by Glaeser et al. (1992) whether regions benefit most from being specialized or being diversified. This "controversy" is commonly referred to as MAR versus Jacobs referring to the theories of Marshall, Arrow and Romer suggesting spillovers to take place primarily within a single industry versus the theory of Jacobs (1969, p. 59) who argued that “the greater the sheer numbers and varieties of divisions of labor already achieved in an economy, the greater the economy’s inherent capacity for adding still more kinds of goods and services". The theories of MAR view innovation mainly as incremental where firms learn from knowledge and innovation from same-industry firms (otherwise known as "localization economies"), while Jacobs views innovation essentially as a recombinant process that necessarily builds on a pre-existing variety of knowledge and artefacts that are being combined in new ways leading to new products and services, viz. new employment.

As reviewed by De Groot et al. (2015), the many empirical studies that followed the seminal study by Glaeser et al. (1992) have provided mixed results (Figure 1).[1] There are almost as many studies that prove the MAR hypothesis, as there are studies that disprove it. And, while a large share of studies finds evidence confirming Jacobs externalities, still a substantial share finds the opposite. Moreover, it is evident from

[1] Note that most studies also take into account a competition variable, following Porter’s (1990) work on the advantages of competition (in clusters).

the many studies yielding insignificant results, that the theoretical notions of specialization and variety seem too simplistic to capture the varied effects of an economy's composition on its further development.

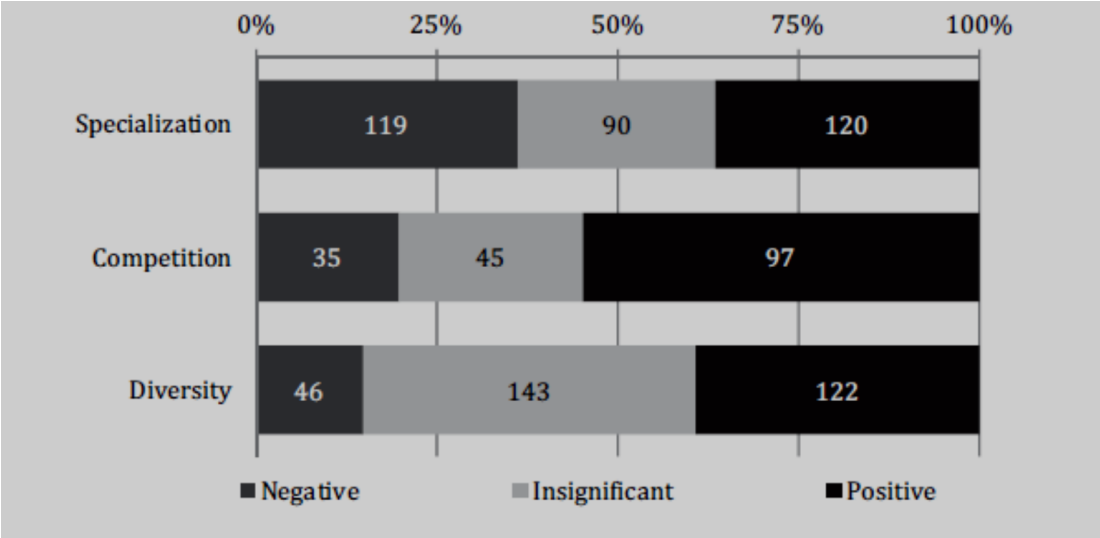

Figure 1. Overview of outcomes of empirical studies on MAR (specialization) vs. Jacobs (diversity) externalities. Taken from: De Groot et al. (2015).

Frenken et al. (2007) agreed with Jacobs that innovation is essentially a recombinant process (what Schumpeter famously called "Neue Kombinationen"), but qualified the notion of recombination arguing that some pieces of knowledge and artefacts are much easier to recombine than other pieces of knowledge and artefacts. Hence, variety is especially supportive for innovation and regional development when variety is *related*, be it in a technological sense or in a market sense. The reasoning here is similar to that of diversified firms, where is has been argued that firms with related diversification outperform firms with unrelated diversification, because only the former profit from economies of scope. Analogously, some authors prefer to speak of *geographies of scope* (Florida et al. 2012) instead of related variety.

Frenken et al. (2007) specifically hypothesized that related variety would spur employment growth, as new combinations lead to new products and, indirectly, to new jobs. Localization economies stemming from the spatial concentration of firms in the exact same industry, instead, would enhance process innovation as specialized knowledge is used to optimized production processes in existing value chains. Indeed, it is well-known from product lifecycle theory that young industries with high rates of product innovation are overrepresented in more diverse, knowledge-rich urban areas, while mature industries with high rates of process innovation are expected to be overrepresented in specialised peripheral low-wage areas (Duranton and Puga 2000; Capasso et al. 2015).

The concept of related variety is consonant with the concept of product space introduced by Hidalgo et al. (2007). They argued that countries develop by diversifying their export portfolio over time. They showed that countries typically do so by "branching out", that is, by entering export products that are closely related to the products they already export. The reasoning underlying this phenomenon holds that once a country has developed the capabilities to specialize in exporting particular products, it can easily diversify in related products that require very similar capabilities to produce them. By calculating, for each possible new product, the "density" of related products already present in a country's export portfolio, the authors could show that the higher the density of related products vis-à-vis a potential new product, the higher the chance that a country will diversify into this new product. This idea is in line with related variety, because the more products a country already exports related to a product that it does not yet export, the more likely you will start exporting that product as well in the future. The difference between the related-variety and the product density concepts is that the former is use to explain aggregate employment growth while the latter is used to explain diversification events into new products.

Finally, the related-variety hypothesis is in line with firm-level studies, which showed that firms profit most if co-located with firms in other, but related, industries rather than being co-located with firms operating in the same industry (for a review, see Frenken et al. 2015). In the latter environments, the benefits from learning from firms in the same industry may well be offset by increased competition as well as knowledge spillovers to direct competitors, especially for the more advanced firms (Boschma 2005). By contrast, firms co-locating with firms operating in related industries profit from knowledge spillovers, while they hardly suffer from their own knowledge spilling overs over to competitors and increased competition for resources (Staber 2001).

The related-variety hypothesis has motivated a large number of empirical studies on the effect of related variety in sectoral composition on regional productivity and employment growth. We provide a systematic review of empirical studies at the regional and national level in the next section. That means that we focus on the *related-variety* literature following Frenken et al. (2007) analyzing how related variety affects regional/national employment growth as well as the *branching* literature following Hidalgo et al. (2007) analyzing how related variety vis-à-vis a specific industry affects the probability that a region/nation becomes specialized in that specific industry. Given the macro-scope of the review with a focus on regional and national growth, we do not go into micro-level studies investigating the effect of regional related variety on firm performance. This is, to a large extent, already

covered by a recent review by Frenken et al. (2015) on industrial dynamics in clusters.

2.2 Empirics

2.2.1 Related variety

Below, we review 16 studies we found that analyzed the effect of related variety on employment growth, or another economic performance indicator, at either national or regional levels. We summarize the set-up and results of each study in the Appendix.

The first study to associate variety with regional economic growth is Frenken et al. 92007), who look at employment growth in a study on 40 Dutch regions. They argue that on the one hand related variety is expected to increase employment growth and on the other hand unrelated variety is expected to decrease unemployment growth. Variety in this respect can be described as a measure of risk-spreading that cushions the effects of an external demand shock in a certain sector. This is explained by the fact that a higher degree of variety in a region will cause that region overall to be affected just moderately in the case of a sector specific shock in demand. Whereas the specialization in one or few sectors will result in the opposite scenario, as the region is exposed to the probability of a severe slowdown.

Empirically, using the Standard Industrial Classification scheme, related variety is measured by the average entropy across employment in five-digit industries within each two-digit class, while unrelated variety is the entropy in employment across 2-digit classes. The results confirm the portfolio effect, as they find that unrelated variety is negatively related to unemployment growth. They also found that related variety, as hypothesized, affected employment growth.

Using OECD data on a national level Saviotti and Frenken (2008) found related export variety stimulates GDP growth per capita and labor productivity, while unrelated export variety only promotes growth with a considerable time lag. They explain this finding by the type of innovation that benefits from variety. Related variety means that knowledge is easily recombined in new products causing direct growth effects. Unrelated variety is harder to recombine, but if successful, can lead to complete new industries sustaining long-term growth.

Boschma and Iammarino (2009) used regional trade data of Italy to study the effects of variety in regional exports and found that variety *per se* was not found to explain regional growth. However, related export variety was found positive and significant when related to regional growth and employment, in contrast to unrelated export

variety. The authors also looked at the similarity between the importing- and exporting sectors and found some evidence that it will support regional employment. This finding, however, is not robust in the sense that this effect was not found for regional growth in labor productivity or value added growth.

Boschma et al. (2012) showed that Spanish regions with higher levels of related variety are likely to have higher levels of economic growth. They did so using two additional measures of related variety in order to overcome some limitations in the method proposed by Frenken et al. (2007). As this method is based on the standard industrial classification (SIC) or the harmonized system (HS), the relatedness in this measure is based on ex ante determined similarities in product characteristics or in the production process, as Boschma et al. (2012) put it. In addition, this method might fail to capture similarities in for instance the organizational structure of sectors. One of the alternative methods is based on Porter's (2003) study on clusters and is based on the spatial correlation of employment between sectors. The other is based on the proximity index of Hidalgo et al. (2007). The main advantage of these is that they are ex post measures of relatedness. Boschma et al. (2012) find that related variety is positively related with regional growth and employment and that the effect is stronger for the cluster (Porter) and proximity (Hidalgo) indicators relative to the Frenken-indicator.

Instead of looking at the industrial structure, Quatraro (2010) analyzed how knowledge may affect regional economic growth in Italy. The results suggest that, not only the regional knowledge stock affects, regional productivity growth rates but also the composition and the variety of the knowledge stock matter. Related knowledge variety seems to positively affect regional productivity, while unrelated knowledge variety was found to be insignificant.

Colombelli and Quatraro (2013) looked at whether the variety in the stock of knowledge, besides the knowledge coherence and cognitive distance, affects the creation of new firms for Italian regions. The results suggest that indeed the stock of knowledge is important together with the coherence of the local knowledge and its variety. When the total variety of knowledge is decomposed into a related and an unrelated component, no significant effect for either of the two is found by the authors. It needs to be mentioned, however, that entrepreneurship is measured using the total number new firms rather than opportunity driven firm formation. In addition, variety is measured differently with respect to Frenken et al. (2007). The authors calculated a multidimensional entropy indicator, which measures the probability that two technological classes co-occur in the same patent. By doing so, the authors want to measure the combinatorial nature of knowledge.

A more recent set of studies analyzed whether the effect of related variety differs across certain types of regions. Falcioğlu (2011) finds that related variety, rather than variety as a whole, of regional economic activity in Turkey positively impacts a region's productivity. The author has defined productivity in two ways, as output divided by labor and value added dived by labor. Van Oort et al. (2015) extend this line of related variety research to a pan-European study. In addition, they make a distinction between smaller and larger regions' urban size in order to account for differences in agglomerative forces. They find that related variety has a positive effect on employment growth, which seems to be stronger for small and medium urban regions compared to large urban regions. No significant effect was found for unrelated variety.

Cortinovis and van Oort (2015) also conduct their research using a European dataset. They hypothesize that related variety is positively related to employment growth due to knowledge spillovers across sectors, unrelated variety is negatively related to unemployment growth due to portfolio effects associated with a diversified economy and as a result dampened effects of sector-specific shocks. Specialization is positively then related to productivity due to cost-reduction and efficiency gains achieved through localization externalities. They fail to find evidence supporting these hypotheses, however, when the technological regime of a region is not taken into account. Therefore they introduce technological regimes, like Hartog et al. (2012), to control for the heterogeneity of diversification dynamics of regional economies. Consequently, related variety is found to positively affect employment growth and productivity in regions characterized by high technology.

Brachert et al. (2011) find evidence for a positive effect of related variety on regional employment growth in German labor markets. The effect, however, is not found when looking solely to related variety and employment. Motivated by the discussion that the method used by Frenken et al. (2007) might fail to capture the effects of individual knowledge and skills, the authors make a distinction in functional specialization. Consequently, they find that related variety is significantly positive when a region has a high functional specialization, i.e. a high concentration of white-collar activities relative to blue-collar activities.

Yet other studies analyzed whether the effect of related variety differs across industries. Hartog et al. (2012) investigated the impact of related variety in Finland, and like Brachert et al. (2011), they did not found evidence that related variety in itself influences employment growth. Rather when its decomposed into a low- and medium-tech, and high tech component, related variety between high-tech sectors seems to positively impact regional employment growth. The distinction is based on the R&D intensity and the share of tertiary educated persons employed, as

knowledge spillovers between industries might be relevant for high-tech sectors in particular.

Mameli et al. (2012) examined the relationship between related variety and regional employment growth in local labor systems of Italy. Without making further distinctions both related and unrelated variety in general have a positive effect on regional employment growth. However, motivated by the notion that the impact of diversity on regional employment growth is ambiguous when differentiated between manufacturing and services, Mameli et al. (2012) make such a distinction in their analysis. The result is that related variety seems to positively affect regional employment among the services industry, while unrelated variety positively affects regional employment growth among the manufacturing industry.

Bishop and Gripaios (2010) studied spatial externalities, relatedness, and regional employment growth in Great Britain. They argue that distinguishing between the manufacturing and services industry might be an oversimplification as these sectors themselves are also heterogeneous and thus the mechanisms and extent to which spillovers occur differ between sectors. Motivated by this argument the authors make use of a disaggregated approach, and look at employment growth in each 2-digit sector as dependent variables. Their assumed heterogeneity between sectors is reflected in the results, as related variety has a significant positive impact on employment growth only in 3 out of the 23 sectors (telecom, computing and other business activities), and – surprisingly – unrelated variety has a significant positive impact in 8 out of the 23 sectors.

In a more recent pan-European study on employment growth at the sectoral level, Caragliu et al. (2016) did not find evidence for the hypothesis that related variety enhanced employment growth. Instead, they found a positive and significant effect of unrelated variety on employment growth. This study is rich in that is looks at 259 NUTS2 regions in the EU and for an extensive period (1990-2007). However, given data limitations, the authors defined unrelated variety as the entropy at the one-digit industry level and related variety as the weighted sum of the entropy at the two-digit level, within each one-digit class. Hence, their results are not fully comparable with studies looking at a more fine-grained industrial level in line with Frenken et al. (2007). Furthermore, their dependent variable was employment growth within a single sector, as only Bishop and Gripaios (2010) did before, rather than overall employment growth in a region as most studies did before.

2.2.2 Branching

The concept of related variety as introduced by Frenken et al. (2007) associated related variety in a regional economy with total employment growth of that regional

economy. A complementary perspective is to analyse whether related variety vis-à-vis a specific industry enhances the growth of that industry as in Bishop and Gripaios (2010), again, because spillovers and complementarities – such as in institutions, skills and infrastructures – are also stronger. Hidalgo et al. (2007) proposed to look at this particular effect of related variety, or "relatedness", by analyzing if a country that has a comparative advantage in producing certain products is likely to gain a comparative advantage in a product that is closely related to these products.[2]

Hidalgo et al. (2007) introduce the concept of product space, where each product has a certain proximity to each other product, indicting its relatedness. Some regions or countries are intertwined in the center of this product space and have a lot of connections to related products, whereas others are located more to the periphery with less connections to related products. They measure relatedness of products using a proximity indicator based on how often two products co-occur in countries' export portfolios. The idea here holds that if many countries have a comparative advantage both in product A and in product B, apparently A and B are somehow related (sometimes referred to as revealed relatedness following Neffke and Henning 2008).

Hidalgo et al. (2007) argue that if a country has a comparative advantage in producing a certain product, chances are high it will also have a comparative advantage in products that are related to it in terms of, for instance what kind of institutions, infrastructure, physical factors, or technology is needed. Regions or countries then develop new products which are related to products it already is producing and in doing so can travel through the product space. Being located more to the periphery thus means having to travel a larger distance to the center, which in turn might help explain that poorer countries are struggling to develop competitive products and therefore might fail to converge as they are located more to periphery of the product space with less connections to related products.

Hidalgo & Hausmann (2009) also developed a method that captures an economy's complexity and show that higher levels of complexity of an economy are associated with higher levels of income. Their method is based on two dimensions, the first is the ubiquity of the products exported (by how many countries is a product exported?) and the second is the diversification of an economy (how many products does a country export?). They show there is a negative relationship between these

[2] A country has a comparative advantage in a product, if the product's share in a country export portfolio exceeds the product's share in total trade worldwide.

two dimensions, i.e. diversified countries tend to export less ubiquitous products. A country's position on the diversification-ubiquity diagram is informative about its abilities in producing certain products. Countries that have more capabilities, are also more likely to be more diversified, as they are capable of producing a broader set of products. And because these countries can produce products that require more capabilities, chances are smaller that there are many countries able to produce these products as well, reducing the ubiquity of these products in turn.

In a later study Hausmann and Hidalgo (2010) conclude that poorly diversified countries produce products that are made by many other countries, which means a high ubiquity. Highly diversified countries then produce products that are produced by few other countries, which means a low product ubiquity. They explain this by means of capabilities that countries own. Countries can differ not only in the sheer number of capabilities but more importantly also the composition of these capabilities differs between countries. Products in turn require countries to own certain sets of capabilities to be produced efficiently enough to make it profitable for countries to export them. Products differ in the number and composition of capabilities they need: more complex products require a larger number and more complex set of capabilities. logic thus implies increasing returns to scale and instead of converging, countries diverge in terms of product diversity. Building on this logic Hausmann and Hidalgo (2011) show that an increase in a country's diversification due to the adoption of a small number of new capabilities is indeed small for less developed countries and large for more developed countries.

Neffke et al. (2011) ask the same question as the original study by Hidalgo et al. (2007), but at the regional level. Indeed, as for countries, regions are most likely to branch into industries that are technologically related to the preexisting industries in the region. Using production data for 70 Swedish regions during the period 1969-2002, they show that industries that were technologically related to pre-existing industries in a region had a higher probability to enter the region, as compared to unrelated industries. Furthermore, they show that unrelated industries had a higher probability to exit the region.

Similarly, Boschma et al. (2013) analyzed the emergence of new industries in 50 Spanish regions in the period 1988–2008. A novel element in this study is the inclusion of measure indicating how related a local industry is vis-à-vis the national production profile. In line with Neffke et al. (2011), this study also provides evidence that regions tend to diversify into new industries that use similar capabilities as existing industries in these regions. They show that proximity to the regional industrial structure plays a much larger role in the emergence of new industries in regions than does proximity to the national industrial structure. This finding suggests

that capabilities at the regional level enable the development of new industries. This result was further confirmed by a more recent study on 360 U.S. metropolitan areas (Essletzbichler 2015).

A final topic that has been addressed building on the original study by Hidalgo et al. (2007) is the question of spatial spillovers. If a region or country lacks a certain local capability rendering it difficult to diversify into related products, it may still be able to do so if it can leverage the spatial proximity to such capabilities through spillovers. Bahar et al. (2014) address this question and show that a country is more likely to start exporting a product when a neighboring country is already exporting the product. In addition, they find that having a neighboring country with a strong comparative advantage in a certain product, has positive predictive power on future growth in the country's own comparative advantage of that same product. Their explanation for this finding is that a knowledge advantage, which is necessary for being productive enough to export a product, might be obtained due to tacit knowledge being transferred. While the nature of tacit knowledge has it that its transferability strongly decays over geographical distance. Their results furthermore indicate that, regardless of size, income level, cultural and institutional dimensions, and factor endowments, the variety of products exported by countries is remarkably similar to their neighbors.

Boschma, Martín, and Minondo (2014) extent this line of research by analyzing the effect of neighboring regions and the probability a region develops a new industry for US states. They show that a region has a higher probability to develop a certain industry if the neighboring region is specialized in it. This might be explained by knowledge spillovers that are more easily induced on small distances and the strong decay effect of knowledge spillover over longer distances. In addition they find that neighboring states show a high similarity in the variety of exported products, suggesting a convergence process. The authors argue that this might be explained by a higher social connectivity, measured as commuting zones that allow for more intimate professional ties.

3. Conclusion

The review of related variety research made clear that – although the evidence base is still rather small with about 16 studies – most studies find support for the initial hypothesis by Frenken et al. (2007) that related variety supports regional employment growth. Those who looked at inter-industry differences found that the effects of related variety on growth may be specific to certain industries only, especially knowledge-intensive ones. Concerning the studies looking how regions develop new industries, it was also found that if a region or countries already hosts industries that are related to a specific industry, it is much more likely to become specialized in that industry.

A number of follow-up research questions come to mind that can be taken up in future research:

1. Methodologically, what is the best method and data source to capture related variety? Frenken et al. (2007) relied entirely on the pre-given hierarchical classification as provided by the Standard Industrial Classification scheme. This has the advantage of being amenable to entropy decomposition into related and unrelated variety, yet has the disadvantage that relatedness is defined ex ante from a hierarchical classification scheme that was never intended to capture technological relatedness viz. spillovers. Hidalgo et al. (2007) derive relatedness from the co-occurrences of products in countries' portfolios. This method derives relatedness ex post from data rather than ex ante from a classification scheme, yet only measures relatedness indirectly and remains agnostic about the exact source of relatedness causing industries to co-locate in countries. As an alternative to Frenken et al. and Hidalgo et al., the work by Neffke and Henning (2013) seems promising. They measure relatedness by the number of people changing jobs between two industries, thus capturing directly "skill-relatedness". Alternatively you could explore, at least for the industries that patent large parts of their knowledge base, the relatedness of patents by looking at patent classes, citations and inventor mobility. The best results are probably obtained by a smart triangulation of these approaches.
2. Theoretically, there are many reasons to expect that regions or countries generate product innovation from related variety (Frenken et al. 2007) and diversify into related industries (Hidalgo et al. 2007). However, this leaves unexplained why, and under what conditions, regions/countries with unrelated variety can also yield product innovation (especially radical ones), and also leaves unexplained why some regions/countries manage to diversify into unrelated industries. To break with path dependence and create new

growth paths through true new recombinations, regions will have to rely more on knowledge and resources residing in other regions. Hence, multinationals, immigration of entrepreneurs and/or scientists and e.g. a very targeted industrial policy, are all elements that come into play in explaining new path creation. Some evidence on this thesis is already available but more research would be needed to come to a more comprehensive understanding (Binz et al., 2014; Dawley, 2014; Neffke et al., 2014).

3. Another question concerns the geographical sources of spillovers through related variety. Rather than solely looking at a region's internal structure, the relatedness vis-à-vis other regions with which a regions intensively interacts, may also matter. That is, as Boschma and Iammarino (2009) argued, earlier studies did not pay attention to knowledge spillovers originating from extra-regional activity. These type of spillovers can occur in numerous ways, for instance the trading of goods and services, foreign direct investment, and global value chains are relations that may cause otherwise tacit knowledge to spillover between regions. The extent to which a region can benefit from foreign knowledge inflows trough these types of relationships depends also on the region's own knowledge and knowhow, i.e. its absorptive capacity. In addition to that they suggest that the inflow of knowledge needs to exhibit complementarities to the existing knowledge. It should be related, however not similar. More research along these lines would highlight the role of trade, and global value chains in particular, in generating spillovers between related industries.
4. A natural extension of the current research – both theoretically and empirically – is to look at relatedness in other dimensions than those related to technological knowledge. For example, Tanner (2014) developed a market relatedness indicator and has showed how this indicator predicts quite well regions' technological development in fuel cell technology.
5. Finally, since most studies focus on the effect of related variety on either employment growth or the emergence of a new export specialization as dependent variable, the mechanism *how* related variety leads to growth and export specializations remains rather implicit. What can be done in future studies is to analyze directly the impact of related variety on entrepreneurship, knowledge and innovation, which in turn are expected to lead to employment and exports. Quite some studies along these lines are already undertaken on patents, taking either patents as dependent variable (Kogler et al. 2013; Rigby 2013; Tavassoli and Carbonara 2014; Castaldi et al. 2015), but much less on scientific publications (Heimeriks et al. 2014) or new firm formation (Colombelli and Quatraro 2013; Guo et al. 2015).

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Appendix: Table 1

The columns RV and UV show the significance of related- and unrelated variety on the dependent variables shown in the column dV(s). + and –indicate significant positive or negative effects, respectively, whereas 0 and M indicate no significant- or mixed results, respectively.

Author(s)	Geog. aggr.	Geog. area	Period	Data source	Main iV(s)	Digits	dV(s)	RV	UV
Frenken, van Oort, & Verburg (2007)	NUTS3	Netherlands	1996 - 2002	CBS	Related variety Unrelated variety	RV = 5 in each 2 UV = 2	Employment growth Productivity growth Unemployment growth	+ - 0	0 0 -
Saviotti & Frenken (2008)	National	OECD	1964 - 2003	OECD trade data	Unrelated export variety Semi related export variety Related export variety	UV = 1 SV = 2 in each 1 RV = 3 in each 2	GDP per cap Labor productivity	+ +	- -
Boschma & Iammarino (2009)	NUTS3	Italy	1995 - 2003	ISTAT	Export variety Related export variety Import variety Related trade variety Unrelated export variety Trade similarities	Variety = 3 RV = 3 in each 2 UV = 1	Employment growth Value-added growth Labor-productivity growth	M + M	0 + 0
Bishop & Gripaios (2010)	Sub-national	Great Britain	1995 - 2002	NOMIS	Related variety Unrelated variety	RV = 4 in each 2 UV = 2	Employment growth at industry-level	M	M
Quatraro (2010)	Sub-national	Italy	1981 - 2002	ISTAT and EPO	Total variety Unrelated variety Related variety	RV = 3 in each 1 UV = 1 TV = 3	Productivity growth	+	0
Brachert, Kubis & Titze (2011)	Local labor market	Germany	2003 - 2008	Federal employment office	RV, UV, functional specialization (ratio of WC and BC workers)	RV = 5 in each 2 UV = 2	Employment growth	+	0
Falcioğlu (2011)	NUTS2	Turkey	1980 - 2000	Turkish statistical institute	Variety Related variety	Variety = 3 RV = 3 in each 2	Productivity growth	+	
Boschma, Minondo & Navarro (2012)	NUTS3	Spain	1995 - 2007	INE, Ivie, and Agencia	Frenken, Porter and Hidalgo measures of relatedness.	RV = 6 in each 2 UV = 1	Value-added growth	+	0

				Tributaria					
Hartog, Boschma & Sotarauta (2012)	NUTS4	Finland	1993 - 2006	Statistics Finland	Related variety RV-HiTech RV-LowTech Unrelated variety	Variety = 5 RV = 5 in each 2 UV = 2	Employment growth	+	0
Mameli, Iammarino & Boschma (2012)	Local labor market	Italy	1991 - 2001	ISTAT	Variety Related variety Unrelated variety	Variety = 3 RV = 3 in each 2 UV = 1	Employment growth	+	+
Colombelli & Quatraro (2013)	NUTS3	Italy	1995 - 2011	ISTAT	Knowledge variety Related knowledge variety Unrelated knowledge variety Cognitive distance Knowledge coherence	KV = 4 UKV = 1 RKV = 2 each 4	Entrepreneurship	0	0
Tavassoli & Carbonara (2014)	Local labor market	Sweden	2002 - 2007	SCB	R&D investments Related variety Unrelated variety Trade related variety	UV = 2 RV = 5 in each 2 TRV = 5 in each 2	Patent applications as proxy for innovation	+	M
Castaldi, Frenken & Los (2015)	State	US	1977 - 1999	NBER	Related variety Semi-related variety Unrelated variety	UV = 1 SRV = 2 in each 1	Number of patents Share of super patents	+ 0	0 +
Cortinovis & van Oort (2015)	NUTS2	Europe	2004 - 2012	ORBIS, Bureau van dijk	Unrelated variety Related variety Specialization Technological regime	UV = 1 RV = in each 2	Employment growth Unemployment growth	+ M	0 M
van Oort, de Geus & Dogaru (2015)	NUTS2	Europe	2000 - 2010	Amadeus	Related variety Unrelated variety	RV = 4 in each 1 UV = 2	Employment growth Productivity growth Unemployment growth	+ 0 0	M 0 0

Caragliu, de Dominicis & De Groot (2016)	NUTS2	Europe	1990 - 2007	Cambridge Econometrics	Related variety Unrelated variety	RV = 2 in each 1 UV = 1	Employment growth at industry-level	0	+