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► **To cite this version:**

Mounir Amdaoud, Nadine Levratto. Sectoral Diversity and Local Employment Growth in France. 2024. hal-04797143

HAL Id: hal-04797143

<https://hal.science/hal-04797143v1>

Preprint submitted on 22 Nov 2024

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Sectoral Diversity and Local Employment Growth in France

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Abstract

This paper investigates how variety affects regional employment growth in France over the period 2004-2015. Starting from the seminal contribution of Frenken et al. (2007), we argue that intra-industry externalities foster employment growth. However, we don't distinguish yet between the own effect of related variety of the region and that of its neighbourhood. Hence, we suggest that conceptual progress can be made when analysis considers the direct and indirect (neighbourhood) dimension of variety. Our empirical investigations confirm that related variety has a positive effect on employment growth. Moreover, this impact seems to be driven by the endogenous dimension of related variety in growth phase and by exogenous dimension in crisis period. We also find that the negative relationship between unrelated variety and employment growth goes only through the endogenous canal.

Keywords: Related variety, unrelated variety, employment growth, neighbourhood effects, France

Résumé

Cet article examine comment la variété affecte la croissance de l'emploi régional en France sur la période 2004-2015. Partant de la contribution séminale de Frenken et al. (2007), nous soutenons que les externalités intra-industrielles favorisent la croissance de l'emploi. Cependant, nous ne faisons pas encore de distinction entre l'effet propre de la variété reliée de la région et celui de son voisinage. Par conséquent, nous suggérons qu'une avancée conceptuelle peut être réalisée si l'analyse considère les dimensions directe et indirecte (du voisinage) de la variété. Nos recherches empiriques confirment que la variété reliée a un effet positif et significatif sur la croissance de l'emploi. De plus, cet impact semble tiré par la dimension endogène de la variété reliée en phase de croissance et par la dimension exogène en période de crise. Nous constatons également que la relation négative entre la variété non reliée et la croissance de l'emploi ne passe que par le canal endogène.

Mots clés: Variété reliée, variété non reliée, croissance de l'emploi, effets de voisinage, France.

Classification JEL / JEL Codes : R11; O18; D62.

1. Introduction

In a context of market globalisation, increasing competition, and recurrent crises, which type of economic composition matters in regional development remains strategically important information for policymakers and scholars.

The literature on innovation has long highlighted the importance of the geographical dimension in knowledge exchange among companies. A large bunch of papers shows that specialized or diversified clusters of firms can create conducive environments for the development of innovations, as knowledge flows between firms. In research on economic geography, urban economics, and regional science this discussion refers to the long-running debate between Marshall-Arrow-Romer's (MAR) conceptualised by Marshall (1920) and later by Arrow (1962) and Romer (1986) on the one hand and Jacobs' (1969) approach on the second hand.

However, these externalities do not capture all the dimensions involved in proximity. Recent theoretical advances have highlighted the importance of considering relational proximities - cognitive, organisational, institutional, political, cultural, etc. - in modulating the benefits linked to proximity (Boschma, 2005). The benefits attached to industrial diversity (Jacobs externalities) have since been broken down into related varieties (between closely related industries) and unrelated varieties (Frenken et al., 2007). The first concept measures variety at a high level of sector aggregation, i.e. between sub-class industries belonging to the same upper class, and the latter the variety at a low level of sector aggregation, i.e. between industries (broadly classified) different from one another (Mameli et al., 2012). While the impact of related and unrelated variety on regional growth has been widely empirically examined¹, some open questions about the empirical application of this concept can still be identified.

This paper tackles this question considering to what extent intra-industry externalities foster employment growth. However, most empirical analysis aiming to assess the contribution of related and unrelated variety to territorial dynamism rest upon modelling and economic techniques considering the phenomenon within each spatial unit considered. Some other, mainly case studies, interested in disentangling related and unrelated varieties either focus either upon one or on a small number of territories (Brenet et al., 2019; Elouaer-Mrizak & Picard, 2016) or on some specific activities (Tanner, 2014 among many others). To our knowledge, a spatial dimension of the field of possible application of this family of externalities has not yet been explored. Indeed, the relevance of extra-regional knowledge to regional growth is largely neglected by the Glaeser-Henderson related literature, which mostly focuses on the structure of the regional industry mix (Boschma, 2005). This paper seeks thus to determine if, and to what extent, variety affects regional employment growth, focussing on the local industrial structure of employment areas in France and, mostly, considering spillover effects to take into account the possible interactions and complementarity between the economic activities operating in a

¹ Frenken et al. (2007) for Netherlands; Boschma & Iammarino (2009) and Mameli et al. (2012) for Italy; Bishop & Gripiaios (2010) for the UK; Hartog et al. (2012) for Finland; Boschma et al. (2012) for Spain.

given spatial unit and between different spatial units. This research tackles this question and distinguishes the effects of related variety and unrelated variety of the region itself from those of its neighbourhood.

It proposes to empirically identify the direct and indirect dimensions of variety². A further refinement is presented, on one side, by relating our two concepts to the technological intensity of sectors and, on the other side, the territorial typology (rural and urban). In that respect, some investigations have stressed the relevance of sectoral specificities in the examination of the impact of variety on employment growth (Bishop & Gripaïos, 2010; Boschma & Iammarino, 2009). Hartog et al. (2012), for example, introduce differences in innovation processes in high-tech sectors and low-medium-tech sectors to explain the variation influence of related variety on employment. Other arguments supporting the idea that employment changes are related to how diversity mechanisms act in different geographical contexts are produced, such as the ones between cities or between rural and urban areas (Frenken et al., 2007; Duranton & Puga, 2005). According to Grabner & Modica (2022), related variety was an important driver of industrial resilience in US counties during the 2008 economic shock, and this effect was driven by intermediate and rural counties. It is based on a unique dataset representative of 304 French employment areas over the period 2004-2015. The econometric model is inspired by those introduced in the studies of Glaeser et al. (1992), Henderson et al. (1995) and Combes (2000) but innovates by dealing with the spatial dependence serious issue that can arise in the data. The model framework used in this study includes related and unrelated variety as key variables and also controls for density, skills and the nature of the area (rural or urban area).

Our empirical investigations confirm that related variety has a positive effect on employment growth. Moreover, this impact seems to be driven by the local or direct dimension of related variety in the growth phase and by its indirect dimension in times of crisis. We also find that the negative relationship between unrelated variety and employment growth goes only through the direct canal. Our empirical evidence shows too, that the impact of related variety on local employment is conditioned by rural-urban differences and, in some way, by the technological intensity of the local sectors.

This paper's central contribution is the investigation of which type of variety influences employment growth and of the origin of this influence (inside or outside the spatial unit). To the best of our knowledge, no prior studies have directly examined the link between the dynamic of a spatial unit and the structure of the productive fabric. Moreover, we introduce a distinction between the role played by the features of a spatial unit and the ones of the neighbouring areas. We also test the possibility of a change of regime corresponding to the financial and global crisis in 2008-2009, running estimations before, during and after the shock. Moreover, we produce new insights when considering our two forms of variety with respect to the R&D intensity of sectors and territory type.

² The direct dimension of variety designates the specific or local level of variety in a given territory, while the indirect or neighbourhood dimension refers to the level of variety at the neighbourhood level.

The paper progresses as follows. Section 2 discusses the literature and presents the theoretical considerations for the key variables of interest. The dataset and the variables are presented in Section 3. Section 4 focuses on results, a discussion of results, and robustness checks, while section 5 concludes the paper.

2. Literature review and theoretical background

In the last three decades, there has been a continuous discussion on the contribution of different types of agglomeration economies to local economic development. This growing literature is not unconnected to the development of the modern economic growth theory (Romer, 1986; Lucas, 1988) that stresses the important role of knowledge externalities in economic growth. The starting point of the research trend dedicated to the impact of the types of agglomeration economies on local economic growth is the paper of Glaeser et al. (1992).

In short, the controversy centred on whether the regional specialisation of economic activities (Marshall-Arrow-Romer externalities) or regional diversity (Jacobs's externalities) is more conducive to strong regional economic performance. Yet, to date, the empirical evidence around this debate has failed to reach a consensus. Studies find as much evidence in favour of the "MAR" approach as in favour of Jacobs' hypothesis (for a recent review, see De Groot et al., 2016). This ambiguity in empirical testing may be due to the theoretical concepts of specialization and diversity³ which are still unclear (Content & Frenken, 2016), to the level of spatial aggregation (metropolitan, local, or regional), to the type of sectors analysed (manufacturing and services) and the sector classification level (2-digit or more), to the nature of economic performance measure (employment, total factor productivity or either labour productivity, wages, and regional gross domestic product), and finally to sectoral lifecycles and institutional context (O'Huallachain & Lee, 2011). Recently, a new trend of studies stemming from a conceptual renewal in institutional and evolutionary economic geography has started advocating for a more differentiated perspective on how diversification and specialization affect regional economic growth (Van Oort et al., 2015; Boschma, 2005). Relying heavily on the studies that have focused on the degree of relatedness between technologies used in industries and the diffusion of knowledge and innovation (Rosenberg & Frischtak, 1983; Cohen & Levinthal, 1990; Nooteboom, 2000), scholars have integrated these concepts in the literature on agglomeration externalities and regional growth. Frenken et al. (2007) have stated that Jacobs' externalities cover two different forms of variety – related and unrelated variety effects – that must be disentangled because they generate different economic impacts. These authors argue in line with Nooteboom (2000) that some parts of knowledge are easier to

³ A largest number of studies published before Frenken et al. (2007) modelled regional diversity in terms of the inverse Hirschman-Herfindahl index (Combes et al., 2004; Henderson et al., 1995; Combes, 2000) without admitting diversity in related industries into the analysis. Beaudry & Schifffauerova (2009) emphasize that this can cause an underestimation of Jacobs's externalities and an overstatement of MAR externalities owing to diversity which would be measured as simply unrelated variety. Moreover, the entropy (or the Shannon index) approach in measuring related and unrelated variety seems preferable to the Simpson/Herfindahl–Hirschman index (For a technical discussion, see Nagendra, 2002).

recombine and spill over across sectors when their cognitive proximity and distance are neither too small nor too big. This complementarity between sectors is captured by what Frenken et al. (2007) call “related variety” defined as industries that share some complementarities in terms of knowledge bases, technologies, inputs/outputs or competences, i.e., within-industry diversity.

Regarding unrelated variety, this concept means that there are no apparent or only limited linkages or complementarities between industries (i.e., between-industry diversity). Frenken et al. (2007) claim that unrelated variety captures a portfolio-effect. Thus, the higher the presence of unrelated sectors in a region, the higher the ability to limit sector-specific shocks (Essletzbichler, 2007) through better risk spreading. That is, the local vulnerability stabilizer function increases regional resilience and mitigates unemployment growth (Content et al., 2019; Boschma & Iammarino, 2009)..

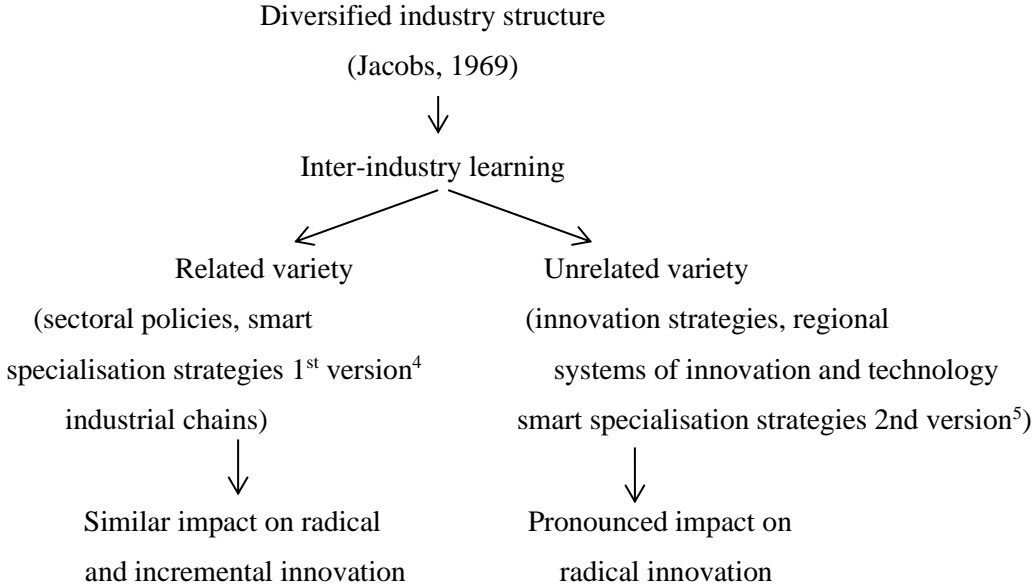
Several empirical studies have been conducted over the past fifteen years to investigate how the related and unrelated variety hypotheses explain regional economic development in terms of employment growth, unemployment and productivity growth, value-added growth and innovation performance or capacity (for a review and synthesis, see Content & Frenken, 2016). These investigations have found strong support for the importance of related variety for regional economic growth in the Netherlands (Frenken et al., 2007), Spain (Boschma et al., 2012), Great Britain (Bishop & Gripiaios, 2010), Italy (Mameli et al., 2012; Boschma & Iammarino, 2009), the United States (Casatldi et al., 2015)..

However, this is less true of the influence of unrelated variety. While Frenken et al. (2007) found that Dutch Nuts3 regions with a high level of unrelated variety between 1996-2002 dampen unemployment growth (portfolio effect), other studies show no robust correlation (Fitjar and Timmermans, 2016; Van Oort et al., 2015 ; Boschma & Iammarino, 2009).

Figure 1 presents the conceptual origin, the sources and ways of knowledge transfers corresponding to related and unrelated variety and how they impact local growth. Each type of variety can be linked to a particular type of territorialised public policy. Related variety, for example, inspires measures designed to boost a region's performance through greater specialisation in one or more sectors likely to share common resources, particularly technical and technological. A region could first be specialised in the automotive industry and abandon it to develop the aircraft industry and then develop train engineering. A related diversification strategy, utilizing both quantitative and qualitative methods, targets new activities in regions closely linked to existing local activities. The integration of relatedness metrics and qualitative analyses, inspired by entrepreneurial self-discovery, aids in identifying diversification opportunities. Advocates contend that aligning new activities with local capabilities enhances their survival rates, supported by evidence. While empirical evaluations are lacking, studies such as Balland et al. (2019) suggest that related diversification can effectively enhance the complexity of activities in a region, particularly in complex technologies. Rigby et al. (2021) further highlight the economic benefits, revealing that European regions diversifying into related and complex activities experienced higher growth from 1981 to 2015.

Unrelated variety provides more inspiration for public policy, which stands for a process of structural change in which a new activity builds on capabilities unrelated to existing capabilities. This would be the case when a textile region would diversify into aircraft making or pharmaceuticals (Boshma, 2021). Some scholars advocate for public policies promoting unrelated diversification, departing from local capabilities but aiming to create new growth paths. This approach, proposed by Grillitsch et al. (2018) and Janssen & Frenken (2019), combines unrelated local capabilities to foster innovation. The focus on unrelated diversification is driven by the need to prevent regional lock-in, with proponents arguing that overcoming economic development challenges requires radical change and the development of entirely new trajectories. Additionally, the rarity and difficulty of unrelated diversification justify government support, as it involves building new capabilities and bridging cognitive distances, requiring collective action and policy intervention.

Figure 1: **Related and unrelated variety: filiation and mechanisms**



Source: Boschma, 2017; Quatraro & Usai (2017)

Finally, using European data from the Global Entrepreneurship Monitor on NUTS-2 and NUTS-1 regions, Content et al. (2019) find an empirical support for positive relationships between related and unrelated variety and regional employment growth. An important caveat resulting from this research points out that new business formation moderates the relationship between unrelated variety (but not related variety) and employment growth. This finding suggests that technological aspects are not the only elements guiding the relationship between variety and regional dynamics.

⁴ Regions should not start from scratch when developing new domains; instead, they should promote the cross-fertilization of knowledge and ideas across domains (Frenken et al., 2007).
⁵ According to this version, regional policies should rest upon unrelated rather than related diversification to avoid regional lock-in and to promote radical change in regions (Frenken 2017; Grillitsch et al. 2018; Janssen & Frenken 2019).

Therefore, exploring direct and neighbourhood aspects of the relatedness perspective in this paper presents opportunities for new insights into the nature of externalities of the two types of variety. Scholars' recent discussions on the function of knowledge production have suggested the importance of geographical proximity for knowledge creation and diffusion (Boschma, 2005; Buzard et al., 2020; Ascani et al., 2020; Balland & Boschma, 2021). For example, in a study on five US manufacturing sectors and 853 metropolitan counties, Kekzi et al. (2022) point out the role of interregional knowledge spillovers and highlight that both intra- and inter-sectoral spillovers within a county are important determinants of knowledge production. The underlying assumption is that access to extra-regional knowledge is a way of avoiding regional lock-in. Thus, complementarity or cognitive proximity between the local knowledge base and external sources of knowledge also contributes to regional innovation and economic growth.⁶

3. Data set, construction of variables, and descriptive analysis

3.1. Data and definition of variables

To test how different forms of variety affect local employment growth, we use an original dataset depicting French employment areas. Data were provided by the French National Institute of Statistics and Economic Studies (INSEE): Knowledge of the Local Productive System (CLAP) for the period 2004-2015. The CLAP database is an information system designed from the merger of various administrative files (SIRENE, DADS, URSSAF and SIASP). Since its creation in 2003, it has provided localized data on salaried employment and remuneration at fine geographic levels (municipality). It covers the whole country and covers activities in both the market and non-market sectors. Data were spatially harmonised (using the 2010 division into employment areas or zones, see Insee Méthodes N°129 for additional details) and aggregated into 304 employment areas and different sectoral levels. These local economic areas cover mainland France (labour market areas located in overseas departments are not included⁷), and thus include both urban and rural spaces. A labour market area is a geographical unit within which most of the workers live and work. This entry point is used because they represent functional units (see for example, Broekel & Binder, 2007), are much more homogeneous than political or administrative units and make spatial analysis possible insofar as it covers the entire territory.

Dependent variable

The dependent variable used in our investigation is employment growth (Growth). It's defined as the change in the total number of employees in area i (with $i=1, \dots, I$) over the period covered, is then calculated as:

$$\text{Growth}_i = \text{Log}(E_{i,t}) - \text{Log}(E_{i,t+1})$$

⁷ These areas are not considered because of their geographical distance from metropolitan France (too far from the mainland and, in a few instances, geographically isolated)

Where E is employment and t is the time period.

Independent variables

Following the contribution of Frenken et al. (2007) and related works later, we use two indicators of regional diversity: related variety and unrelated variety. To this end, employment data are identified at five-digit sector of the French classification of activities (NAF rev.2, 2008). Barring a few exceptions, this classification corresponds to the NACE rev.2 (statistical classification of economic activities in the European Community), which is in turn derived from the International Standard Industrial Classification (ISIC) of economic activities. These two indicators will constitute our main independent variables. Entropy measure based on Shannon's function has been used to construct these two indices. Entropy captures economic variety of an area by measuring the uncertainty or disorder against a uniform distribution of employment when there is an equal distribution of employees over all sectors. The entropy of related variety estimates variety within economic sectors while entropy of unrelated variety estimates variety between sectors. They are defined and calculated as follows:

Related variety (RelVar) captures diversity of related sectors. This indicator considers that employment in detailed five-digit classification is functionally related to their two-digit aggregates. It is measured as the weighted sum of five-digit entropy within each two-digit class of French classification of activities such as:

$$RelVar_i = \sum_{g=1}^G P_{g,i} H_{g,i}$$

With H_g as the degree of entropy (or variety) within each two-digit sector. It is calculated as:

$$H_{g,i} = \sum_{j \in S_g} \frac{P_{j,i}}{P_{g,i}} \log_2 \left(\frac{1}{P_{j,i}/P_{g,i}} \right)$$

Where $P_{g,i}$ is the share of employees in two-digit sector g (NAF A88) in the total employment in area I , and $P_{j,i}$ being the share of employment in a five-digit sector j (with $j=1, \dots, J$) belonging to the same two-digit sector S_g , over the total employment of area i . Thus by summing all the five-digit shares industries $p_{j,i}$ belonging to a two-digit sector, we obtain $P_{g,i}$, as follows :

$$P_{g,i} = \sum_{j \in S_g} p_{j,i}$$

With j stands for the five-digit sector classification (NAF A732) and S_g as the two-digit sector classes where $g=1, \dots, G$.

Related variety index varies between a lower bound of 0 (when employment in each two-digit industry is concentrated in only one of its five-digit industries) to $\log_2(J) - \log_2(G)$ (if all five-digit industries within a two-digit industry have the same employment share). Since our empirical study is conducted on 732 five-digit sectors (J) within 88 two-digit sectors (G), our indicator takes as the theoretical upper bound a value of 3.06

Unrelated variety (UnrelVar) refers to diversity across two-digit sectors or inter-sector diversification. This index assumes that two-digit sectors are not complementary or are not related. It's calculated as the entropy of the two-digit level (NAF A88)

$$UnrelVar_i = \sum_{g=1}^G P_{g,i} \log_2\left(\frac{1}{P_{g,i}}\right)$$

The index of unrelated variety ranges from values between 0 (concentration of employment in just one two-digit sector) and $\log_2(G)$ (all sectors employ an equal number of employees). As our analysis is conducted on data under the NAF A88 classification with information on 88 two-digit industries, the upper bound of the index shows a value of 6.46.

Subsequently, we decompose our two indicators following the R&D intensity of the sectors (see Figure A1 in Appendix 1). We use for that, the OECD taxonomy of economic activities based on R&D Intensity (Galindo-Rueda and Verger, 2016) for both manufacturing and nonmanufacturing sectors⁸. By doing so, we disentangle, on the one hand, between related variety in high-tech sectors (RelVarHT) and related variety in low-and-medium-tech sectors (RelVarMLT), and on the other hand, related variety in high-tech sectors (UnrelVarHT) and related variety in low-and-medium-tech sectors (UnrelVarMLT). The logic behind, is to explore if the relationship between these concepts and employment growth varies when we consider the technological intensity of local industries (Hartog et al., 2012).

Machinery and equipment (NAF: 28) is the industry that contributes the most to related variety and unrelated variety in high-tech sectors. It's followed by industries like motor vehicles, trailers and semi-trailers (NAF: 29), chemicals and chemical products (NAF: 20), and information technology (NAF: 62) but not in the same order and same proportion. For related variety in low-and-medium-tech sectors, it's industries like wholesale and retail trade (NAF: 46- 47), specialized construction activities (NAF: 43) that topped the podium. For unrelated variety in low-and-medium-tech sectors, it's nonmanufacturing industries like public administration and defence; compulsory social security; education; human health; residential care and social work activities (NAF: 84-88) that contribute largely.

3.2. Main descriptive features

The descriptive statistics of the variables used in this analysis are reported in Table 1 and detailed below. The dependent variable employed in our econometric specification is the employment growth rate between 2004 and 2015, a period marked by the 2008 global financial crisis. The relation between variety and employment growth may differ depending on whether one is in a period of growth

⁸ Based on the NAF 2 or 3-digit level, high-tech sectors comprise the following industries in the manufacturing sectors: air and spacecraft and related machinery (30.3), pharmaceuticals (21), computer, electronic and optical products (26), weapons and ammunition (25.4), motor vehicles, trailers and semi-trailers (29), chemicals and chemical products (20), electrical equipment (27), machinery and equipment (28), railroad, military vehicles and transport (30.2, 30.4 & 30.9), medical and dental instruments (32.5); and in the nonmanufacturing sectors those ones: scientific research and development (72), software publishing (58.2), IT and other information services (62 & 63). All of the remaining industries are included in the low-and-medium-tech sectors (without the exclusion of sectors like public administration, education and human health).

or in one of recession. For Bishop & Gripaos (2010), the industrial structure is more conducive to rapid change during economic slumps that may disrupt the relationship between variety and employment growth. We thus split the overall time period into three sub-periods to control for this major macroeconomic shock. This allows us to examine whether the dominant effects in the ‘normal’ period of 2004-08 were stable or were reversed during the crisis. The first time period (2004-2008) precedes the 2008 global crisis, the second period (2008-2012) covers the crisis phase and the third period (2011-2015) concerns the post-crisis time.

Table 1 – Summary statistics

Variable	Mean	Std. Dev.	Min	Max
<i>Observations</i>	304	304	304	304
LnVarEmpSal_0408	0,01	0,05	-0,13	0,48
LnVarEmpSal_0812	-0,02	0,04	-0,13	0,16
LnVarEmpSal_1115	-0,01	0,03	-0,13	0,11
RelVar_04	1,87	0,27	1,09	2,37
RelVarHT_04	0,06	0,05	0,00	0,26
RelVarMLT_04	1,80	0,25	1,07	2,28
UnrelVar_04	4,84	0,23	3,63	5,31
UnrelVarHT_04	0,36	0,20	0,00	1,06
UnrelVarMLT_04	4,46	0,21	3,44	4,84
LnDens_04	3,31	1,01	0,88	8,55
Qualif_04	0,13	0,03	0,09	0,32
RelVar_08	1,95	0,24	1,18	2,40
RelVarHT_08	0,06	0,05	0,00	0,27
RelVarMLT_08	1,88	0,22	1,15	2,34
UnrelVar_08	4,87	0,21	3,98	5,34
UnrelVarHT_08	0,36	0,20	0,02	0,99
UnrelVarMLT_08	4,51	0,19	3,63	4,89
LnDens_08	3,32	1,01	1,03	8,58
Qualif_08	0,13	0,03	0,08	0,32
RelVar_11	1,96	0,24	1,13	2,42
RelVarHT_11	0,05	0,05	0,00	0,25
RelVarMLT_11	1,91	0,22	1,11	2,38
UnrelVar_11	4,85	0,20	4,04	5,31
UnrelVarHT_11	0,34	0,19	0,01	0,97
UnrelVarMLT_11	4,51	0,18	3,73	4,90
LnDens_11	3,31	1,01	0,96	8,59
Qualif_11	0,11	0,03	0,06	0,31

The top part of Figure 1 shows the distribution of local employment in each employment zone over the three periods. Globally, for the three sub-periods, the "winning" territories are located more in the west and in the south, while the territories in decline are rather in the north-east, south-west axis. The first period is characterized by a greater distribution of growth rates (from -0,13 to +0,48) than the second (from -0,13 to +0,16) and the third (from -0,13 to +0,11). This shrinking of the interval corresponds to the general economic slowdown in the country.

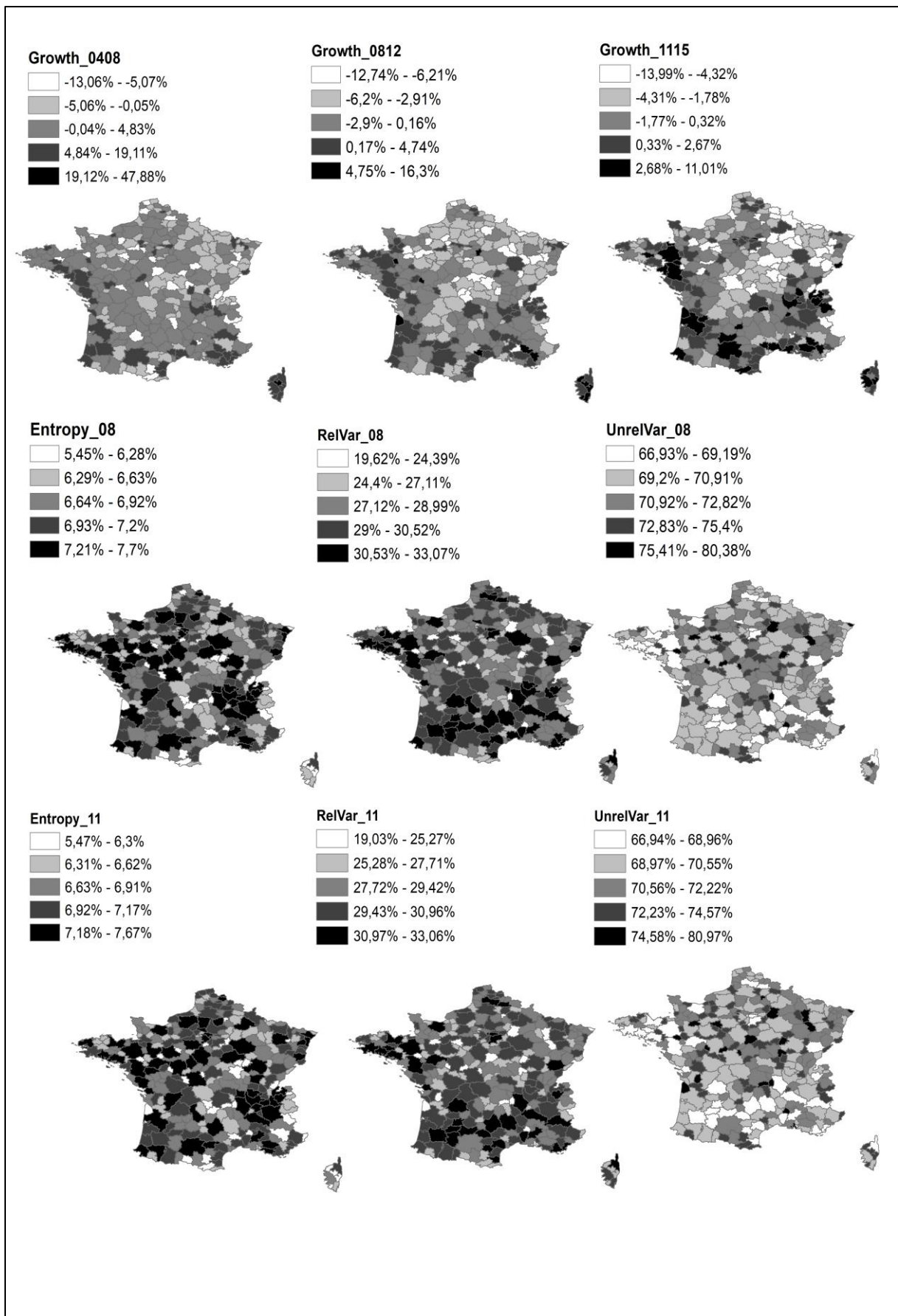
The middle and the bottom part of Figure 2 illustrate the distribution of related and unrelated variety for 2008 and 2011 across employment zones. As the maps show, the two measures of variety presented as

a share of total entropy⁹ have different regional patterns. Related variety is higher in urban areas, whereas unrelated variety seems more equally distributed in both 2008 and 2011¹⁰. Many areas with a high levels of total entropy show a strong resemblance with those on the map of related variety, which also have high levels, that is the case, for instance for Lyon, Nantes, Tours and Bordeaux. When we look at the maps of unrelated variety and entropy, some differences emerge: territories with strong performances in terms of unrelated variety show an average contribution to total entropy. A portion of areas that have relatively low levels are rural (La Lozère, Pontivy and Villeneuve-sur-Lot), but we find too high-density zones such as Avignon, Créteil, Quimper, Lorient and Orly. An interesting fact to note is the high enough correlation (0.58) between the two types of variety. This value remains close to levels found by Aarstad et al. (2016) on Norwegian data and Content et al. (2019) on 204 European regions. Table A1 in Appendix 2 reports the correlation matrix of control variables used in our three-period analysis. Overall, the results of the correlation matrix revealed no serious evidence of multi-collinearity.

⁹ The decomposability of entropy measure involves that five-digit entropy is equal to the addition of related variety (weighted sum of five-digit entropy within each two-digit sector) and unrelated variety (two-digit entropy).

¹⁰ If we read in conjunction related variety and recent employment growth maps, it is possible to observe certain similarities for high values especially in southeast-central France (Lyon, Issoire, Annecy and Bourg-en-Bresse) west (Nantes and Les Herbiers) and south-western regions too (Bordeaux, Bayonne, and La Teste-de-Buch).

Figure 2 – Employment growth, related variety, and unrelated variety



4. ESTIMATION STRATEGY AND MAIN FINDINGS

4.1. Estimation procedure

To estimate the impact of variety on regional employment growth, it is essential to consider various types of spatial interaction. Generally, three different types of interaction may explain why an observation associated with a specific location may be dependent on observations at other locations:

- An endogenous interaction, when the value of the dependent variable for one geographical area is jointly determined with that of its neighbours.
- An exogenous interaction, where the dependent variable of a particular unit depends on the observable characteristics of its neighbours.
- An interaction effect among the error terms due to omitted variables from the model that are spatially autocorrelated.

These latter are derived from a General nesting spatial model called the Manski model (1993). The Manski model is less used in empirical works because, on the one hand, its weak identifiability leads to higher uncertainty in parameter estimates (Elhorst, 2014), and on the other hand, this model is often overparameterized (Burrige et al., 2016). The preferred solution in empirical literature is to remove one of the three forms of spatial correlation. Here, we will focus on only two. We apply a spatial Durbin error model (SDEM), where the dependent variable is influenced by the spatially lagged dependent variables and the spatial correlation in the error term.

$$\begin{aligned} Growth_i &= a_0 + \alpha_1 RelVar_i + \alpha_2 UnrelVar_i + \alpha_3 Control_i + \theta_1 RelVar_{w_i} + \\ &\quad \theta_2 UnrelVar_{w_i} + \theta_3 Control_{w_i} + u_i \\ u_i &= \lambda u_{w_i} + \varepsilon_i \end{aligned} \quad (1)$$

Where $Growth_i$ refers to employment change over either pre-crisis period, crisis period or the post-crisis period. The primary explanatory variables, which depend on our dependent variable, are related and unrelated variety, respectively, $RelVar_i$, $UnrelVar_i$. w_i denotes the index of the neighbourhood of the employment area i , α_1 , α_2 and α_3 are unknown parameters to be estimated, θ_1 , θ_2 and θ_3 the neighbourhood interaction effects, λ the interaction effect among the errors, a_0 the intercept, and finally ε a vector of disturbance terms. In addition to our variables of interest, we have *Control* as a set of control variables (density and skilled labour) selected because of their importance in the dynamics of employment. The first determinant captures urbanization economies; it is measured by the employment density of the local economy¹¹. The hypothesis is that urbanized areas promote local knowledge spillovers, linkages and imply a wide offer of local public goods (Combes, 2000; Mamelì et al., 2008; Paci & Usai, 2008). Here, we expect that employment density will increase employment growth.

¹¹ Density is calculated as the logarithm of number of employees working in establishments located in an employment area per square kilometre (km²).

The second determinant considers the level of human capital, measured by the share of white-collar workers in the labour force in each employment area¹². The availability of a highly educated labour force in a region is often found to be crucial for local employment growth, as populations with higher education attainment are expected to help innovation activities and growth (Paci & Usai, 2008; Van Oort et al., 2015). More recently, in a study on 204 European regions, Content et al. (2019) stressed that educational level captures the ability and the skills to detect and exploit potential business opportunities.

The spatial weight matrix W used in the econometric estimation is the row standardized inverse spatial distance matrix (with a cut-off point).¹³

4.2. Econometric results

This section presents the findings for our estimations over three periods (pre-crisis, crisis and post-crisis). The diagnostics for spatial dependence obtained for the OLS version of the model are reported in the bottom portion of the result tables. Whatever the period, the Moran' I index from the regression residuals is highly significant.

The spatial models were estimated using a maximum likelihood estimator with White robust standard errors. Calculating the Variance Inflation Factor (VIF) for our regressions returns a score below 2.77, which infers that multicollinearity is not a serious issue in our findings, as suggested, for instance by O'Brien (2007). Our estimations are consistently significant, and the R-squared for spatial models ranges from 9% to 31%.

To assess the impact of our explanatory variables on employment growth as a dependent variable, we report direct and indirect (neighbourhood) effects. The outcomes are produced for three periods: the pre-crisis period (2004-2008), the crisis period (2008-2012) and finally the post-crisis period (2011-2015).

We further carry out in-depth-analyses of the main results by considering the presence of heterogeneous patterns when looking at rural areas vs. urban areas¹⁴ and when employment areas of Ile-de-France (IDF) region are excluded. The IDF region is very specific because of its considerable weight in employment in France (almost 23% in 2015).

The rural-urban divide makes sense as rural and urban areas can differ in many dimensions, such as economic productive structure, human capital, institutions, history, territory geography, etc. Some papers in the literature have dealt with this issue. For instance, Duranton & Puga (2005) stress that large

¹² This variable is measured as the percentage of skilled (or white-collar) employees working in establishments located in a given employment area. It corresponds to the third group in the most aggregated (level 1) classification of professions and socio-professional categories (PCS); for more detail, see online the composition of this group: <https://www.insee.fr/fr/metadonnees/pcs2020/groupeSocioprofessionnel/1?champRecherche=true>

¹³ We define employment areas as neighbours when the distance between them is smaller than 67.5 km, using the inverse distance between areas as weight. This latter is inversely related to the distances between the units. If the distance between units is larger than 67.5 Km, this weight is set to zero. As in most applied studies, the inverse distance matrix is row-standardized (each element in row i is divided by the sum of row i 's elements) so that the impact of neighbouring areas is equalized.

¹⁴ Local units are classified as urban or rural according to their total population. Areas that have a number of inhabitants equal to or greater than the national average (212 628.7 inhabitants) are urban, and the rest are rural.

cities are specialised in business services while industry takes more place in rural areas. Recently, Van Oort et al. (2015) investigated 205 small, medium and large regions and only observed a positive association between related variety and employment growth in small and medium places.

Results for the pre-crisis period

Table 2 reports the estimated direct and neighbourhood effects of related and unrelated variety on local employment growth. The total effect of related variety is found to be a crucial determinant of local employment growth during the period 2004-2008. This is in accordance with previous studies which, show a positive relation between related variety and employment dynamics (Frenken et al., 2007; Wixe & Andersson, 2017; Van Oort et al., 2015). Firms can mediate this relation, as pointed out by Cainelli et al. (2016) in their micro-level analysis, higher related variety increases firm innovativeness and, consequently, productivity, resulting in higher employment growth rates. Our finding is robust to the use of another spatial weight matrix (see columns 2 to 3 in Table A2 in Appendix 3). However, no significant impact of unrelated variety is found. This last finding is also observed by Cortinovis & van Oort (2015) in their study of 260 NUTS-2 regions in Europe.

When we compute the direct effect for the other control variables, we found that the density of economic activity, as a proxy for urbanization economies, and the level of qualification play a negative and a positive influence, respectively. These results are in line with most of those found in the literature on regional growth (Fenken et al., 2007; Hartog et al., 2012; Deidda et al., 2006). Combes (2000) considers that this negative coefficient of the size of the local system reflects congestion effects (high land rent, congestion of infrastructures and transportation, etc.) that produce negative externalities on local employment growth. As for skilled labour, in a complete analysis of 784 local labour systems in Italy, Paci & Usai (2008) stress that a higher number of educated labour forces in a region fosters innovation and knowledge spillovers and, therefore, local growth.

The indirect dimension of unrelated variety exerts a negative influence on local employment dynamics. Job qualification in neighbouring areas produces negative effects on employment.

When we decompose related and unrelated variety following the R&D intensity of sectors, we found that both high-tech and low-and-medium-tech related varieties have a direct positive impact. This finding is in some way in contrast with the result of Hartog et al. (2012), which show only a positive effect of related variety among high-tech sectors in Finland. The SDEM model also shows that high-tech unrelated variety sector has a negative direct impact on employment growth.

The low-and-medium-tech unrelated variety in the surrounding areas reinforces the negative effect on employment.

In columns 5 to 7, we observe a positive direct influence of related variety on employment in model 4 urban and rural areas and in model 6, which excludes the 19 employment areas of IDF region (10 areas are rural and 9 are urban). There is a positive association between related variety in urban agglomeration and employment. A same relation is observed in rural areas. Concerning neighbourhood effects, we observe a positive effect of related variety in model 5 and a negative impact of unrelated

variety in models 4 and 5. The findings reveal also a negative indirect impact of unrelated variety in models 5 and 6, and a positive indirect impact of related variety in model 5 considering urban areas.

Table 2 – Employment growth in 2004-2008

Local employment growth 2004-08	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2004	0.047*** (0.013)	0.039*** (0.014)		0.078*** (0.030)	0.029** (0.014)	0.051*** (0.014)
Unrelated variety in 2004	-0.014 (0.017)	-0.017 (0.017)		-0.140*** (0.038)	0.030* (0.017)	-0.024 (0.017)
Density in 2004		-0.013** (0.005)				
Job qualification in 2004		0.714*** (0.121)				
High-tech related variety in 2004			0.213** (0.095)			
Low-and-Medium-tech related variety in 2004			0.044*** (0.015)			
High-tech unrelated variety in 2004			-0.065** (0.027)			
Low-and-Medium-tech unrelated variety in 2004			-0.0172 (0.019)			
W*Related variety in 2004	0.015 (0.025)	0.010 (0.025)		-0.048 (0.060)	0.045* (0.027)	0.046 (0.029)
W*Unrelated variety in 2004	-0.064** (0.026)	-0.055** (0.026)		-0.031 (0.064)	-0.076*** (0.026)	-0.080*** (0.029)
W*Density in 2004		0.011 (0.007)				
W*Job qualification in 2004		-0.490** (0.202)				
W*High-tech related variety in 2004			0.118 (0.227)			
W*Low-and-Medium-tech related variety in 2004			0.046 (0.032)			
W*High-tech unrelated variety in 2004			-0.093 (0.058)			
W* Low-and-Medium-tech unrelated variety in 2004			-0.084** (0.038)			
Constant	0.269*** (0.095)	0.242** (0.107)	0.339** (0.168)	0.771*** (0.260)	0.0953 (0.121)	0.331** (0.130)
lambda	0.346*** (0.078)	0.377*** (0.075)	0.338*** (0.079)	0.645*** (0.181)	0.281** (0.110)	0.357*** (0.0797)
Observations	304	304	304	76	228	285
Moran's I	6.725***	7.043***	6.706***			
R2	0.133	0.206	0.135	0.309	0.115	0.123
LIK	490.660	507.180	491.993	106.285	415.011	460.255
Prob > chi2	0.000	0.000	0.0001	0.000	0.000	0.000

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10%, respectively

The crisis period results

Table 3 provides results that assess the impact of the two forms of variety during the global crisis. The analysis of related variety shows a significant positive impact driven by the neighbourhood, leading us to consider that the crisis increased interdependence between employment areas (Cousquer, 2022). This evidence confirms that when cognitive proximity between related sectors in an area with that of its neighbourhood is not too small, it raises opportunities and interactive learning between sectors that ultimately promote employment growth. This empirical relevance is in accordance with that of Boschma & Iammarino (2009), which illustrate the importance of extra-regional knowledge on employment when it comes from industries that are related but not similar to those that are present in the region.

Moreover, the level of unrelated variety in the neighbourhood seems to negatively affect employment growth opportunities.

The column 4 of the table suggests that this impact is driven by low-and-medium-tech related variety in neighbouring areas.

Concerning other neighbourhood interactions, the level of high-tech related variety has a negative effect on employment performance.

Table 3 also reports the results of three OLS estimations of employment growth after splitting the sample on one side, the rural and urban areas, and excluding the labour areas of the IDF region on the other side. When we distinguish between rural areas (model 4) and urban areas (model 5), we find that only unrelated variety exercise a positive direct influence in model 5. Regarding indirect effects, we find a positive impact of related variety and a negative impact of unrelated variety on local employment only in urban areas. This last result is verified in model 6 too, which exclude the IDF region from the analysis.

Table 3 – Employment growth in 2008-2012

Local employment growth 2008-12	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2008	0.012 (0.010)	0.007 (0.011)		0.000 (0.020)	0.014 (0.012)	0.013 (0.010)
Unrelated variety in 2008	0.0017 (0.012)	-0.006 (0.012)		-0.061** (0.027)	0.0151 (0.013)	-0.002 (0.012)
Density in 2008		0.002 (0.003)				
Job qualification in 2008		0.134* (0.081)				
High-tech related variety in 2008			0.017 (0.067)			
Low-and-Medium-tech related variety in 2008			0.0084 (0.012)			
High-tech unrelated variety in 2008			-0.003 (0.019)			
Low-and-Medium-tech unrelated variety in 2008			0.010 (0.015)			
W*Related variety in 2008	0.070*** (0.024)	0.074*** (0.026)		0.025 (0.042)	0.064** (0.025)	0.064*** (0.024)
W*Unrelated variety in 2008	-0.073*** (0.024)	-0.060** (0.025)		-0.0492 (0.044)	-0.078*** (0.024)	-0.067*** (0.024)
W*Density in 2008		-0.008 (0.006)				
W*Job qualification in 2008		0.024 (0.192)				
W*High-tech related variety in 2008			0.126 (0.168)			
W*Low-and-Medium-tech related variety in 2008			0.050* (0.0273)			
W*High-tech unrelated variety in 2008			-0.092** (0.043)			
W*Low-and-Medium-tech unrelated variety in 2008			-0.036 (0.033)			
Constant	0.168 (0.115)	0.146 (0.126)	0.018 (0.158)	0.461** (0.190)	0.134 (0.117)	0.166 (0.116)
lambda	0.515*** (0.065)	0.516*** (0.0651)	0.510*** (0.0656)	0.676*** (0.165)	0.470*** (0.094)	0.531*** (0.066)
Observations	304	304	304	76	228	285
Moran's I	9.500***	9.803***	9.424***			
R2	0.099	0.118	0.106	0.253	0.086	0.096
LIK	620.110	623.381	620.938	144.560	478.332	586.857
Prob > chi2	0.016	0.015	0.081	0.026	0.001	0.036

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10%, respectively

The post-crisis period results

The estimation of our models presented in Table 4 are close to those of the pre-crisis period shown above. When we examine the direct effects, we find three similarities between the two periods in the case of related variety, low-and-medium-tech related variety and job qualification. In the case of indirect effects, we found just a common negative impact of unrelated variety.

In addition, during the post-crisis period, we found in neighbouring areas a negative effect of unrelated variety and a positive influence of low-and-medium-tech related variety on the dynamics of local employment. This last result is also observed in the crisis period.

Concerning the rest of econometric regressions, we find exactly the same results as in the pre-crisis period for the direct positive effects of related variety in the urban areas model. For the indirect effects, the two kinds of variety play a role respectively positive for related variety and negative for unrelated variety in models 5 and 6, as in the crisis period.

To sum up, when we look at the direct effects in the three periods, we can see that related variety plays an important role in accelerating employment before the crisis. This role was insignificant during the crisis period (2008-2012) but becomes significant again in the post-crisis period. It seems that during the crisis, specialization in related sectors implies less flexibility to areas to adapt their products and reconvert their economic activities. In that vein, Steijn et al. (2023) state in a complete study on great historical depressions that crises significantly reduce the pace of diversification. The unrelated variety does not appear to play a role in our study.

When we extend the analysis by distinguishing in the calculation of the two forms of variety among high-tech sectors and low-and-medium-tech sectors, we find a double effect of related variety in the high-tech and low-and-medium-tech sectors¹⁵. Only the unrelated variety in the high-tech sector plays a role in slowing down employment during the period 2004-2008. This result is in contrast with that of Cortinovis & van Oort (2015), which found a negative impact of unrelated variety in low-tech regions when controlling for regional level of technological progress. During the crisis, there are no effects of the two decomposed varieties, as in the case of the global models.

However, a change occurs in the post-crisis period where we find a positive effect of related variety in low-and-medium-tech sectors and also a positive effect of unrelated variety in high-tech sectors.

Analysis by territory type (rural vs. urban) shows that the effect of related variety is driven by urban territories and rural areas during the period 2004 to 2008. Surprisingly, there is only a negative effect of unrelated variety in rural areas during the crisis. This result seems not persistent in the post-crisis period. Related variety in urbanized territories seems to have an effect on employment growth in also that period¹⁶. This result is confirmed by Cortinovis & van Oort (2015). Relatedly, Firgo & Mayerhofer

¹⁵ For Hartog et al. (2012), the positive and significant effect of related variety among high-tech sectors in Finnish regions can be explained by the ability of high-tech sectors to produce radical innovation and thus introduce new products on the market.

¹⁶ The bounce ability of urban cities is also verified in the study of Talandier & Calixte (2021) on the effects of the 2008 economic shock on French territories. However, in a similar study on the US case, Grabner & Modica (2022) observe effects for both rural and urban areas, with a particularly large effect for urban ones.

(2016) find in their study on Austria that employment benefits more from diversity in related fields in urban regions. However, this work conducted over a large period (2000–2013) does not include the crisis context in the analysis.

Table 4 – Employment growth in 2011-2015

Local employment growth 2011-15	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2011	0.018** (0.009)	0.015* (0.009)		-0.002 (0.018)	0.027*** (0.010)	0.014 (0.009)
Unrelated variety in 2011	0.009 (0.011)	-0.002 (0.011)		-0.009 (0.026)	0.008 (0.012)	0.011 (0.011)
Density in 2011		-0.000 (0.003)				
Job qualification in 2011		0.196*** (0.0703)				
High-tech related variety in 2011			-0.057 (0.064)			
Low-and-Medium-tech related variety in 2011			0.027*** (0.010)			
High-tech unrelated variety in 2011			0.029* (0.017)			
Low-and-Medium-tech unrelated variety in 2011			0.002 (0.013)			
W*Related variety in 2011	0.046** (0.019)	0.037* (0.0203)		0.050 (0.037)	0.047** (0.021)	0.047** (0.020)
W*Unrelated variety in 2011	-0.040* (0.021)	-0.039* (0.021)		-0.0616 (0.040)	-0.0499** (0.023)	-0.0456** (0.021)
W*Density in 2011		-0.002 (0.005)				
W*Job qualification in 2011		0.178 (0.155)				
W* High-tech related variety in 2011			-0.009 (0.155)			
W*Low-and-Medium-tech related variety in 2011			0.045** (0.023)			
W*High-tech unrelated variety in 2011			-0.029 (0.036)			
W*Low-and-Medium-tech unrelated variety in 2011			-0.034 (0.029)			
Constant	0.015 (0.093)	0.057 (0.099)	0.004 (0.133)	0.233 (0.153)	0.0482 (0.107)	0.0348 (0.0935)
lambda	0.406*** (0.0734)	0.398*** (0.0740)	0.407*** (0.0733)	0.332 (0.208)	0.465*** (0.095)	0.402*** (0.075)
Observations	304	304	304	76	228	285
Moran's I	7.172***	6.851***	7.238***			
R2	0.089	0.1272	0.095	0.112	0.101	0.093
LIK	660.047	666.543	661.229	151.829	512.374	620.069
Prob > chi2 /Prob > F	0.004	0.000	0.022	0.307	0.000	0.009

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10%, respectively

The investigation of the indirect effects obtained in the three tables of results tells us that except for rural areas, related variety has a positive impact on employment during the crisis, but this effect seems less marked during the post-crisis period. The unrelated variety exerts a negative effect for the three periods studied (intense effect during the crisis) in urban areas and those without IDF regions. When we consider the R&D intensity of economic activities, we show a positive effect of the related variety in the low-and-medium-tech sector during the crisis and post-crisis periods (lesser effect during the post-crisis period). A (negative) effect of unrelated variety is found in the low- and medium-tech sector during the period 2004 to 2008 and in the high-tech sector during the period 2008-2012. Regressions that consider the type of territory clearly show positive indirect effects of related variety and negative effects of unrelated variety during the crisis and the post-crisis periods. These effects are more strong from 2008 to 2012. This confirms an important role for related variety in the neighbourhood in mitigating the effects of the crisis. Between 2004 and 2008, the effects of related variety and unrelated variety were only presents in the urban territories and those without IDF regions. This means that, in the presence of low levels of variety in a given territory, it is the neighbouring territories that seem to compensate for the lack in order to attenuate the shock on employment. Less densely populated territories do not benefit from these externalities.

As a robustness check for our findings, we have estimated the same models for the three periods using a different specification of the spatial weight matrix, namely the square inverse distance neighbourhood matrix. The latter is supposed to be more robust in differentiating between neighbouring and distant areas since the use of square values increases the relative weights of the nearest ones.

5. Conclusions

This paper aimed to investigate the effect of related and unrelated variety on employment growth in France's mainland employment areas between 2004 and 2015. Its main contribution is to increase our understanding of how different forms of variety relate to regional employment; this is achieved on one hand, by developing a new perspective that considers the local and neighbourhood nature of industry relatedness, and on the other hand by exploring crisis times and ordinary times.

While empirical results show that diversity influences regional dynamics, two questions arise, particularly for public decision-makers. The first is whether and how diversity can be increased. It seems more straightforward and less costly to support the entry of a sector related to existing activities than creating an unrelated industry. The second question concerns how public policy should deal with the interactions between territories, which, in addition to their specific characteristics, determine the trajectory of each spatial unit. From this perspective, various institutional frameworks could be explored. For instance, the 'policy network' concept, which focuses on relations between interest groups in the broad sense and evokes a form of coordination between national and sub-national levels, could find a wider field of application. Another promising development is rooted in multi-level governance as an

alternative to hierarchical government, which implies a mode of negotiated relations between institutions at different institutional levels or as the interweaving of political networks within formal government institutions.

While empirical evidence suggests that an increase in diversity facilitates regional growth, a pivotal question for policymakers is whether diversity can be deliberately enhanced and, if so, through what means. A common assumption might be that supporting the entry and emergence of related sectors would be more straightforward and cost-effective than introducing unrelated sectors. However, empirical findings challenge this assumption, indicating that the benefits of an unrelated sectoral structure might be more economically advantageous. In addition, policymakers should also pay attention to the policies adopted in the neighbourhood to bring consistency to public action at the regional level.

To provide some answers to these questions, future research should focus on analysing how knowledge flows between related and unrelated sectors on the one hand and on the public policies that would make it possible to improve these flows on the other hand. The diversity of situations should also be addressed insofar as, since economies of variety are based on innovation, a certain level of absorptive capacity is necessary to favour their effect on growth. It would, therefore, be possible to develop different policies and target measures not only to support regional diversification but also to increase absorption capacity in order to increase the benefits of knowledge flows between sectors.

Our outcomes indicate several avenues for future research. For instance, the use of the NAF hierarchical industry classification system or its equivalent at the European level NACE to calculate related and unrelated variety measures is disputable. This classification is primarily based on product relatedness which assumes that industries belonging to a given sub-category are closer to those belonging to other categories (Hartog et al., 2012). However, this is not always the case since it fails to consider knowledge externalities and technological proximity between industries (Boschma et al., 2012).

In this respect, future works may rely on other sectoral taxonomies, such as that of Pavitt or Nefkke et al. (2008). A second research suggestion can be found in the study of Wixe & Andersson (2017), who stress the importance of two other dimensions of variety: the respective relatedness of education and occupation of employees. The argument is that information and knowledge transfers primarily involve individuals. Finally, a third promising research field is the investigation of the channels through which related variety leads to employment growth. In a recent study based on a novel pan-European regional survey, Content et al. (2019) show that entrepreneurship may be a possible transmission mechanism via which spillovers between related sectors lead to the creation of new jobs and thus to employment growth.

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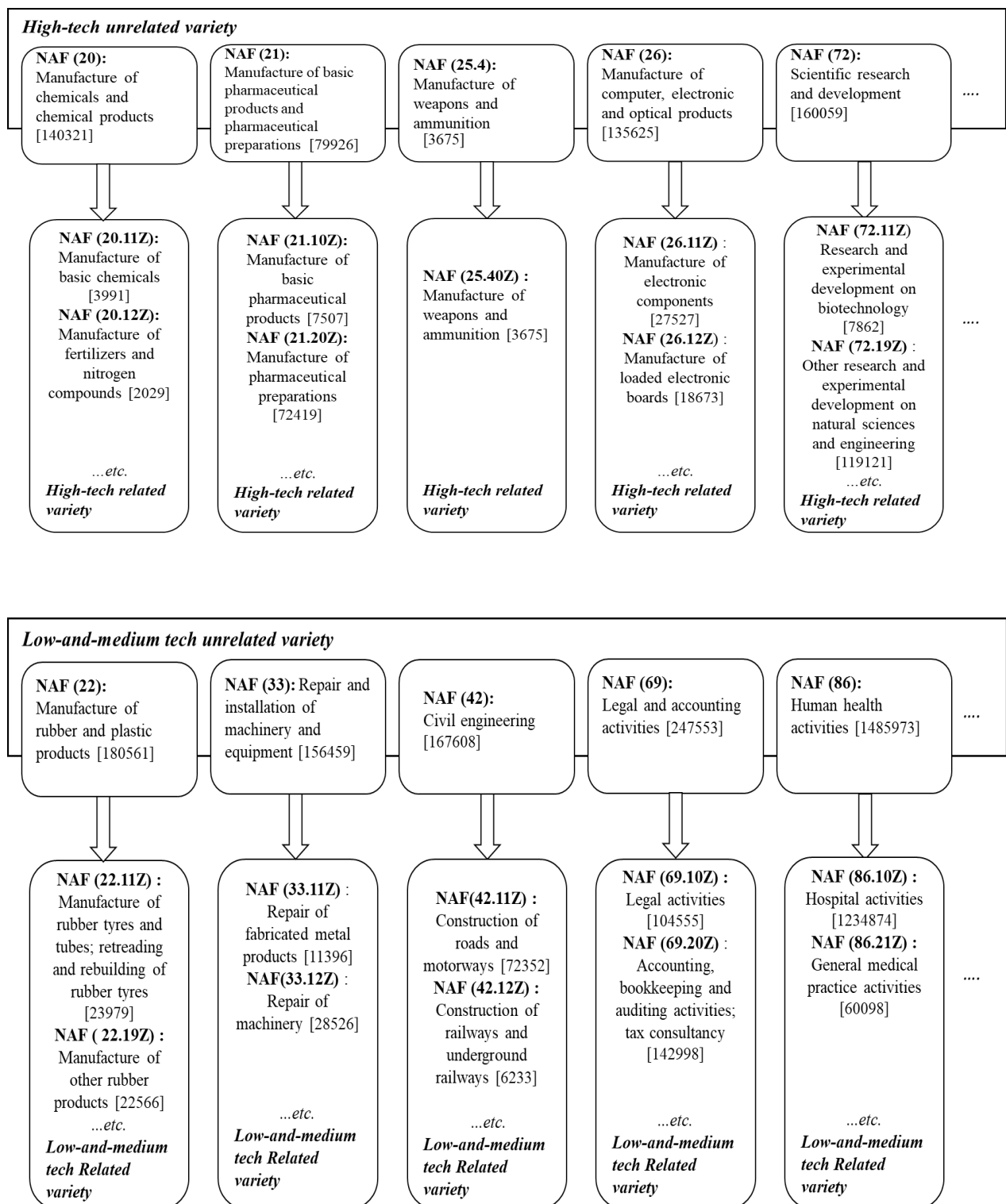
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APPENDIX 1

Figure A1 – High-tech related and unrelated variety vs. Low-and-Medium-tech related and unrelated variety



Note: the values between brackets are employment at national level in 2011, they are obtained from CLAP's information system. They are used to illustrate, on one hand, how related variety is decomposed in high-tech related variety and low-and-medium-tech related variety and, on the other hand, how unrelated is decomposed high-tech related variety and low and-medium-tech unrelated variety. The figure is just an excerpt; all sectors are not represented.

APPENDIX 2

Table A1 – Correlation matrix

2004	RelVar_04	UnrelVar_04	RelVarHT_04	RelVarMLT_04	UnrelVar HT_04	UnrelVarMLT_04	LnDens_04	Qualif_04
RelVar_04	1.000							
UnrelVar_04	0.598***	1.000						
RelVarHT_04	0.367***	0.560***	1.000					
RelVarMLT_04	0.977***	0.509***	0.167***	1.000				
UnrelVarHT_04	0.163***	0.548***	0.823***	-0.015	1.000			
UnrelVarMLT_04	0.539***	0.602***	-0.151***	0.605***	-0.334***	1.000		
LnDens_04	0.503***	0.485***	0.475***	0.422***	0.398***	0.183***	1.000	
Qualif_04	0.374***	0.293***	0.423***	0.296***	0.370***	-0.006	0.631***	1.000
2008	RelVar_08	UnrelVar_08	RelVarHT_08	RelVarMLT_08	UnrelVarHT_08	UnrelVarMLT_08	LnDens_08	Qualif_08
RelVar_08	1.000							
UnrelVar_08	0.572***	1.000						
RelVarHT_08	0.365***	0.612***	1.000					
RelVarMLT_08	0.974***	0.461***	0.150***	1.000				
UnrelVarHT_08	0.096*	0.571***	0.805***	-0.094	1.000			
UnrelVarMLT_08	0.538***	0.509***	-0.167***	0.611***	-0.415***	1.000		
LnDens_08	0.472***	0.478***	0.468***	0.386***	0.388***	0.127**	1.000	
Qualif_08	0.323***	0.364***	0.486***	0.223***	0.425***	-0.037	0.662***	1.000
2011	RelVar_11	UnrelVar_11	RelVarHT_11	RelVarMLT_11	UnrelVarHT_11	UnrelVarMLT_11	LnDens_11	Qualif_11
RelVar_11	1.000							
UnrelVar_11	0.577***	1.000						
RelVarHT_11	0.384***	0.634***	1.000					
RelVarMLT_11	0.979***	0.475***	0.194***	1.000				
UnrelVarHT_11	0.087	0.570***	0.797***	-0.082	1.000			
UnrelVarMLT_11	0.552***	0.512***	-0.132**	0.614***	-0.413***	1.000		
LnDens_11	0.463***	0.480***	0.463***	0.390***	0.382***	0.136**	1.000	
Qualif_11	0.340***	0.416***	0.497***	0.250***	0.438***	0.009	0.697***	1.000

Note: ***, **, * = significance at 1%, 5% and 10% , respectively.

APPENDIX 3

Table A2 – Employment growth in 2004-2008 using square distance neighbourhood matrix

Local employment growth 2004-08	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2004	0.048*** (0.013)	0.041*** (0.014)		0.080*** (0.030)	0.031** (0.013)	0.052*** (0.014)
Unrelated variety in 2004	-0.015 (0.017)	-0.018 (0.017)		-0.142*** (0.038)	0.030* (0.017)	-0.025 (0.017)
Density in 2004		-0.014*** (0.005)				
Job qualification in 2004		0.727*** (0.120)				
High-tech related variety in 2004			0.209** (0.095)			
Low-and-Medium-tech related variety in 2004			0.045*** (0.015)			
High-tech unrelated variety in 2004			-0.065** (0.028)			
Low-and-Medium-tech unrelated variety in 2004			-0.018 (0.019)			
W*Related variety in 2004	0.017 (0.023)	0.010 (0.023)		-0.055 (0.057)	0.046* (0.024)	0.041 (0.026)
W*Unrelated variety in 2004	-0.063*** (0.024)	-0.058** (0.024)		-0.020 (0.060)	-0.072*** (0.024)	-0.074*** (0.027)
W*Density in 2004		0.012* (0.007)				
W*Job qualification in 2004		-0.519*** (0.189)				
W*High-tech related variety in 2004			0.100 (0.199)			
W*Low-and-Medium-tech related variety in 2004			0.043 (0.028)			
W*High-tech unrelated variety in 2004			-0.086* (0.052)			
W* Low-and-Medium-tech unrelated variety in 2004			-0.080** (0.032)			
Constant	0.266*** (0.091)	0.254** (0.102)	0.331** (0.148)	0.733*** (0.249)	0.0727 (0.112)	0.316*** (0.120)
lambda	0.298*** (0.076)	0.339*** (0.0729)	0.292*** (0.0765)	0.585*** (0.179)	0.223** (0.104)	0.314*** (0.078)
Observations	304	304	304	76	228	285
Moran's I	6.423***	6.725***	6.395***			
R2	0.130	0.204	0.136	0.312	0.114	0.121
LIK	489.161	506.454	490.736	106.177	414.152	458.862
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10% , respectively

Table A3 – Employment growth in 2008-2012 using square distance neighbourhood matrix

Local employment growth 2008-12	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2008	0.012 (0.010)	0.008 (0.010)		0.000 (0.020)	0.015 (0.012)	0.013 (0.010)
Unrelated variety in 2008	0.001 (0.0118)	-0.007 (0.012)		-0.0581** (0.027)	0.0150 (0.013)	-0.003 (0.012)
Density in 2008		0.002 (0.003)				
Job qualification in 2008		0.132 (0.081)				
High-tech related variety in 2008			0.014 (0.067)			
Low-and-Medium-tech related variety in 2008			0.009 (0.012)			
High-tech unrelated variety in 2008			-0.002 (0.019)			
Low-and-Medium-tech unrelated variety in 2008			0.007 (0.015)			
W*Related variety in 2008	0.075*** (0.021)	0.078*** (0.023)		0.031 (0.040)	0.073*** (0.022)	0.068*** (0.022)
W*Unrelated variety in 2008	-0.081*** (0.022)	-0.074*** (0.0223)		-0.060 (0.042)	-0.080*** (0.022)	-0.075*** (0.022)
W*Density in 2008		-0.006 (0.006)				
W*Job qualification in 2008		0.002 (0.172)				
W*High-tech related variety in 2008			0.150 (0.148)			
W*Low-and-Medium-tech related variety in 2008			0.060** (0.024)			
W*High-tech unrelated variety in 2008			-0.104*** (0.039)			
W*Low-and-Medium-tech unrelated variety in 2008			-0.056** (0.028)			
Constant	0.203* (0.106)	0.203* (0.116)	0.099 (0.141)	0.487*** (0.183)	0.127 (0.108)	0.202* (0.107)
lambda	0.480*** (0.064)	0.479*** (0.064)	0.475*** (0.064)	0.614*** (0.163)	0.409*** (0.091)	0.495*** (0.065)
Observations	304	304	304	76	228	285
Moran's I	8.817***	9.093***	8.781***			
R2	0.109	0.126	0.115	0.262	0.100	0.102
LIK	620.466	623.317	621.005	144.581	478.601	586.317
Prob > chi2 / Prob > F	0.001	0.002	0.013	0.020	0.000	0.005

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10% , respectively

Table A4 – Employment growth in 2011-2015 using square distance neighbourhood matrix

Local employment growth 2011-15	Model 1	Model 2	Model 3	Model 4 (rural areas)	Model 5 (urban areas)	Model 6 (without IDF region)
Related variety in 2011	0.019** (0.009)	0.016* (0.009)		-0.001 (0.018)	0.028*** (0.010)	0.015* (0.009)
Unrelated variety in 2011	0.008 (0.011)	-0.002 (0.011)		-0.010 (0.026)	0.006 (0.012)	0.009 (0.011)
Density in 2011		-0.001 (0.003)				
Job qualification in 2011		0.194*** (0.07)				
High-tech related variety in 2011			-0.057 (0.064)			
Low-and-Medium-tech related variety in 2011			0.027*** (0.010)			
High-tech unrelated variety in 2011			0.027 (0.017)			
Low-and-Medium-tech unrelated variety in 2011			0.000 (0.013)			
W*Related variety in 2011	0.050*** (0.017)	0.042** (0.018)		0.044 (0.036)	0.056*** (0.019)	0.054*** (0.018)
W*Unrelated variety in 2011	-0.043** (0.019)	-0.043** (0.019)		-0.063* (0.038)	-0.047** (0.020)	-0.047** (0.019)
W*Density in 2011		-0.002 (0.005)				
W*Job qualification in 2011		0.190 (0.138)				
W*High-tech related variety in 2011			0.017 (0.139)			
W*Low-and-Medium-tech related variety in 2011			0.052*** (0.020)			
W* High-tech unrelated variety in 2011			-0.035 (0.033)			
W*Low-and-Medium-tech unrelated variety in 2011			-0.044* (0.025)			
Constant	0.027 (0.087)	0.066 (0.092)	0.041 (0.119)	0.255* (0.151)	0.026 (0.098)	0.039 (0.087)
lambda	0.371*** (0.071)	0.361*** (0.072)	0.374*** (0.0710)	0.324* (0.197)	0.405*** (0.092)	0.368*** (0.073)
Observations	304	304	304	76	228	285
Moran's I	6.525***	6.087***	6.558***			
R2	0.096	0.134	0.101	0.111	0.110	0.100
LIK	659.662	665.9991	660.785	151.868	512.037	619.564
Prob > chi2 /Prob > F	0.002	0.000	0.012	0.280	0.000	0.003

Notes: Standard errors are shown in parentheses. ***, **, * = significance at 1%, 5% and 10% , respectively.