Regional knowledge spillovers in the European Economic Area: The case of three high-tech industries

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Abstract

This paper investigates the impact of specialization, diversification, and competition externalities on the regional growth of employment in the high-tech industries of the European Economic Area (EEA). A dynamic panel dataset of two-digit NACE rev 1.1. industries in the EEA regions is used in this analysis. It is found that regional growth is positively related to specialization externalities, and negatively to local competition while diversification has no impact on growth.

Keywords: local employment growth, externalities, high-tech industries, knowledge spillovers, diversification, specialization, competition, European Economic Area.

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Introduction

The so-called new growth theory literature that emerged in the late 1980s and early 1990s stresses the importance of knowledge spillovers for economic growth. In one of the earliest theoretical studies Romer (1986) proposed a formal model in which knowledge of other firms was assumed to be an important input in the production function of an individual firm leading to increasing returns. However, the idea that increasing returns are external to the firm but internal to the industry had been suggested already by Marshall (1890) and later employed by Arrow (1962).

According to their views firms in the same industry located within a close proximity to each other should grow faster due to the faster flows of ideas among them. In the seminal empirical study Glaeser et al. (1992) called the aforementioned type of externalities Marshall-Arrow-Romer (MAR) spillovers. One of the most frequently mentioned examples of such spillovers is the Silicon Valley in Northern California, where firms operating in the high-tech industries locate in a close proximity to each other in order to benefit from the access to diffused knowledge of their rivals. Moreover, according to the MAR approach monopoly should be associated with the higher firm growth because the firm can internalize innovations more efficiently in a monopolistic market, in which there are no other firms to imitate its ideas.

In contrast, Jacobs (1969) in her highly influential book entitled "Economies of the Cities" argued that knowledge spillovers are mainly based on urbanization, in which diversity of technologies and industries should lead to the faster flows of ideas. In particular, she claimed that the close proximity of firms from various industries in a region would stimulate growth. According to her view diversity of various industries should speed up the transfer of knowledge between individuals and motivate the innovations in firms. In addition, she postulated that a competitive market structure should be associated with faster innovation and firm growth.

In the context of urbanization, she argued that even if a city is specialized in some sets of industries, the demand for raw materials and even other final goods and services could lead to the birth and growth of other industries within the same region. The practical illustration of her idea was that Detroit's shipbuilding industry in the 1830s was the main cause of the development of the automobile industry in the 1890s. This was explained by the fact that the production experience of firms in the former industry that could produce gasoline engine for ships could later be used to build engines for automobiles.

Finally, Porter (1990) presented an alternative view on the role of various externalities that combined the elements of the two previous approaches. On the one hand, he emphasized the positive role of increased specialization, while on the other tougher competition in the faster industry growth. Similar to the MAR approach, Porter (1990) claims that there is a positive impact of intra-industry externalities on growth which means that the increased specialization should stimulate growth. However, similar to Jacobs (1969) he also argued that higher local competition among the firms of the same industry could facilitate the flows of ideas between economic agents.

The main goal of this paper is to study empirically the importance of specialization, diversification and competition externalities for the growth of the high-tech industries in the European Economic Area (EEA) during the period 1995-2007 using the dynamic panel data (DPD) approach. In the previous literature, several measures of externalities were used; therefore, we employ different measures in this study and investigate the robustness of results. In particular, this paper extends the recent study by Cieślik and Ghodsi (2013) and tests empirically the MAR and Porter hypotheses using two alternative measures of specialization.Since panel data is used, there might be endogeneity, regional specifics, and time fixed effect problems in the estimation. Hence, to control for these problems DPD approach proposed by Arellano and Bond (1991) is used.

The structure of this paper is organized as follows. In Section 1 we provide the review of the existing empirical studies on regional externalities associated with knowledge spillovers. In Section 2 we describe the analytical framework and research hypotheses. Section 3 presents various measures of regional externalities associated with knowledge spillovers. In Section 4 we discuss the estimating equation and the properties of the dataset. In Section 5 we present the empirical results and sensitivity tests. The last section concludes with the summary of main findings.

1. Literature Review

In this section we summarize the main findings of the related literature. The first empirical studies on localization and urbanization economies were undertaken for the US cities and metropolitan areas in the early 1990s. In particular, in their seminal study Glaeser et al. (1992) employed the simple OLS method to test for these externalities using industry-level data on 170 largest U.S. cities during the period 1956-1987. According to their findings urban diversity and local competition, but not regional specialization encouraged employment growth in industries. This means knowledge spillovers occur between rather than within industries which was consistent with the Jacobs hypothesis and contradicted the MAR hypothesis.

In the follow-up study Henderson et al. (1995) used a very similar approach to Glaeser et al. (1992). Their dataset included eight different industries of about 224 Metropolitan Statistical Areas in the U.S. during the period 1970-1987. However, in contrast to the previous study, they divided industries into two main categories: mature industries and new high-tech industries. For the mature industries they found evidence of MAR externalities but not of Jacobs externalities. However, for the new high-tech industries they reported evidence of both Jacobs and MAR externalities.

In the later years, many studies for other countries followed. In one of the earliest studies for the European countries Bivand (1999) analyzed the effect of localization and urbanization on development of regional manufacturing employment in Poland during the period 1976-1996. Since this period covered two different economic systems: central planning and transition to the market economy, he used averages of employment for some years to obtain better estimates of the growth model. He found that a positive pre-transition impact of specialization has changed to a negative effect after transition, and diversification became strongly positively related to growth after transition. His findings showed the strong impact of transition on economic structural externalities.

Subsequently, Combes (2000) studied how the local economic structure affected the employment growth in 52 manufacturing industries and 42 service industries in 341 French local areas during the 1984-1993 period using the generalized Tobit method. He found that the impact of local economic structure differed greatly in manufacturing and service industries. In the manufacturing industries local total employment density, competition and plant size reduced local employment growth. Sectoral specialization and diversity generally had a negative impact on growth but also increased the growth of employment in a few industries. Service sectors always exhibited negative specialization effects and positive diversity effects. Competition and plant size had on average a negative impact and density a positive one.

Van Soest et al. (2002) analyzed the relationship between agglomeration economies and employment growth in Dutch city-industries and in zip code industries in the Dutch province of South-Holland. They showed that at both levels of data aggregation industrial diversification and local competition enhanced the employment growth while concentration of firm within the industry impeded growth. In addition to the application of spillovers indices that were used by Glaeser et al. (1992), they used distance-weighted measures to see whether there is an impact of knowledge spillovers between regions. They found that there is an insignificant knowledge spillover between cities that can enhance the innovation and employment in other cities than the respective city.

Further evidence for the Netherlands was provided by van der Panne (2004) for the years 2000-2002 who found some evidence for the existence of MAR spillovers, although limited to more research and development intensive and small firms. He also concluded that tougher local competition could lead to lower innovations in a specific industry. In their follow-up study van der Panne and van Beers (2006) examined MAR and Jacobs spillovers in the Netherlands at both the regional level and firm level. They demonstrated that regions with higher specialization of economic activity had a higher number of innovating firms, and once the product was launched, diversified regions seemed more successful in commercial terms than regions with high concentration of industry. Also Frenken et al. (2005) tried to find appropriate measures of Jacobs externalities in an empirical analysis over the Netherlands sub-regions during 1996-2002. They found that within sectors diversification increased the employment growth, while between sectors diversity reduced employment growth.

De Lucio et al. (2002) studied the effects of various externalities on productivity of 26 large industrial branches in 50 Spanish provinces during 1978-1992. Their model was estimated by DPD program by Arellano and Bond (1988) allowing for unbalanced panel data, fixed effects and possible endogeneity. They found that diversity and competition had no significant impact on productivity growth while regional and industry specializations had negative impacts on growth with some non-linearities. In a subsequest study for a particular region of Spain - Catalonia, Monseny (2005) showed the importance of localization and urbanization effects on the regional activities of Catalonia, a Spanish region during the period 1997-2000.

Usai and Paci (2003) initiated the study of externalities for Italy. They reported the positive role of diversity and the negative role of specialization in their empirical findings over 97 manufacturing sectors in Italy during 1991-1996. In another study for Italy, Cingano and Schivardi (2004) used firm level data on total factor productivity (TFP) instead of employment-based data. In their estimation, they found that specialization had a significant positive impact on growth of TFP, while diversification and competition externalities did not have any effect. In addition to TFP growth they also tested a model similar to previous empirical studies, in which city-industry employment growth was used as the dependent variable. In the majority of their specifications, specialization and competition had a negative effect on the growth of employment, and variety a positive impact.

Mukkala (2004) studied the effect of agglomeration economies on regional productivity of the manufacturing sector in 83 Nuts-04 regions in Finland during the period 1995-1999. He demonstrated that both specialization and diversification positively affected industry growth. However, localization played a more significant role in regions with smaller size of firms. Hence, smaller firms can profit more from the positive externalities associated with MAR spillovers.

Blien et al. (2006) investigated the impact of specialization and diversification on employment growth during the period 1980-2001 using a panel data on 326 West Germany Nuts-03 regions. They assigned different industries in two groups: fifteen manufacturing industries, and six advanced services sectors. They corrected for endogeneity and fixed effect problems in the regression using the GMM method modified by Arellano and Bond (1991). They found a positive sign for the estimated coefficient on the lagged dependent variable which served as a proxy for MAR externalities. Moreover, they found a positive impact of the diversification measure on the growth of employment of both groups of industries.

The vast majority of the aforementioned studies focuses on specific countries and there is still little more general evidence for the whole European Union, especially after its Eastern enlargement. The notable exception is the study by Greunz (2004) who investigated the impact of MAR and Jacobs spillovers on innovation in 16 manufacturing sectors in 153 European regions during the period 1997-1998. She used average number of regional patent applications of sectors to the European Patent Office as the main dependent variable in her analysis. She found that both specialization and diversification had positive impact on innovations of the firms. However, her study was limited only to the old EU member states. Therefore, in the current study we extend the previous literature on knowledge spillovers by focusing on the whole European Economic Area that includes both the old and the new EU members states as well as the EFTA countries.

In the literature, empirical studies for non-European countries can also be found. However, since our attention focuses on Europe, we do not provide a detailed review of this literature. The representative example of this strand in the literature is the study of Batisse (2002) who used value added instead of employment and the data for thirty different sectors of 29 provinces of China during the period 1988-1994. He used fixed effect and white estimator of variance to control for potential heteroskedasticity. He analyzed three measures of externalities in four different models, one consisting all of them together and other three including only one of the externalities indices. The estimated coefficient on the concentration variable was negative while the other two coefficients were positive indicating the existence of Jacobs spillovers. According to his findings specialization and MAR spillovers had negative effect on growth of industries and cities in China.

Table 1 briefly summarizes the main findings of the previous empirical studies. The literature summarized in the table reveals that there have been many empirical studies investigating the importance of externalities for growth of industries and cities. However, there are many differences across those studies due to the application of different estimation techniques, the focus on different industries, the use of various externality measures and dependent variables, which makes the comparison of the estimation results difficult. Positive, negative, and insignificant impacts of three types of knowledge spillovers have been found in all those analyses. In their extensive survey of 67 previous empirical studies, Beaudry and Schiffauerova (2009) could not definitely conclude which type of externality enhances growth. Therefore, the impact of particular externalities seems to be context-specific and must be determined empirically.

Table 1. Summary of empirical results in previous studies

		Dependent Variable	Period of study	Country of study	Specialization Effect	Diversification Effect	Competition Effect
Glaeser et al. (1992) Industrial local wages growth		Industrial local employment growth	1956-87	USA	Negative	Positive	Positive
		1956-87	USA	Insignificant	Positive	Negative	
Henderson et al. (1995) Industrial local employment (New Born Industries)		Industrial local employment (Mature Industries)	1970-87	USA	Positive	Insignificant	----
		1970-87	USA	Positive	Positive	----	
Batisse (2002)		Industrial local value added growth	1988-94	China	Negative	Positive	Positive
Combes (2000) Industrial local employment growth (initial total local employment as control variable)		Industrial local employment growth (initial industrial local employment as control variable)	1984-93	France	Positive	----	----
		1984-93	France	Negative	----	----	
De Lucio et al. (2002)		Industrial local productivity growth	1978-92	Spain	Negative	Insignificant	Insignificant
Cingano and Schivardi (2004)	Industrial local productivity growth	1991	Italy	Positive	Insignificant	Insignificant	
	Industrial local employment growth	1991	Italy	Negative	Negative	Positive	
	Industrial local wage growth	1991	Italy	Positive	Negative	Positive	
Greunz (2004)	Regional patent applications of industries	1997-98	EEA	Positive	Positive	----	
Blien et al. (2006)	Industrial local employment growth	1980-2001	West Germany	Positive	Positive	----	
Bivand (1999)	Regional manufacturing employment growth	1976-96	Poland	Positive	Positive	----	
Van Soest et al. (2002)	Industrial local employment growth	1988-97	The Netherland	Negative	Positive	Positive	
Mukkala (2004)	Regional productivity of the manufacturing sectors	1995-99	Finland	Positive	Positive	----	

		Dependent Variable	Period of study	Country of study	Specialization Effect	Diversification Effect	Competition Effect
Usai and Paci (2003)	Local industrial employment growth	1991-96	Italy	Negative	Positive	----	
Van der Panne (2004)	Announcement of products (innovation)	2000-2002	The Netherland	Positive	Insignificant	Negative	
Frenken et al. (2005)	Local industrial employment growth	1996-2002	The Netherlands	----	Positive	----	
Monseny (2005)	Birth of new establishment of firms	1997-2000	Spain	Positive	Positive	----	
Van der Panne and van Beers (2006)	Industrial local innovation	2000-2002	The Netherland	Positive	Positive	Negative	

Source: Own compilation.

2. Analytical Framework and Research Hypotheses

In this section, we introduce the analytical framework based on the simplified Cobb-Douglas production function to evaluate empirically the importance of external effects in stimulating the regional employment growth in the high-tech industries in the EEA countries. Following Glaeser et al. (1992) we define the regional production function for i-th industry which produces output *Y*, using labor *L* with a technology level *A* as follows:

$$Y_{rit} = A_{rit} L_{rit}^{1-\alpha} \quad (1)$$

where $0 < \alpha < 1$ and r denotes region, i industry, and t time. Given the level of technology, prices, and wages, the representative firm maximizes its profits given by:

$$\pi_{rit} = p_{it} A_{rit} L_{rit}^{1-\alpha} - w_{rit} L_{rit} \quad (2)$$

where "p_{it}" is the price of the product of the industry "*i*" at time "*t*" that is for simplicity normalized to unity, and "w_{rit}" is the wage rate. The resulting first order condition can be written as:

$$(1-\alpha) A_{rit} L_{rit}^{-\alpha} = w_{rit} \quad (3)$$

After taking logs of both sides of equation (3) and some rearrangements, the level of employment can be expressed as the function of the level of technology and wages:

$$\ln L_{rit} = \left(\frac{1}{\alpha}\right)\ln(1-\alpha) + \left(\frac{1}{\alpha}\right)\ln A_{rit} - \left(\frac{1}{\alpha}\right)\ln w_{rit} \tag{4}$$

Assuming that α is constant over time and substracting from equation (4) its one-period-lag, we obtain the rate of growth of technology:

$$\ln\left(\frac{L_{rit}}{L_{rit-1}}\right) = \left(\frac{1}{\alpha}\right)\ln\left(\frac{A_{rit}}{A_{rit-1}}\right) - \left(\frac{1}{\alpha}\right)\ln\left(\frac{w_{rit}}{w_{rit-1}}\right) \tag{5}$$

Hence, the rate of growth of regional employment in i-th industry is a function of regional growth of technology and wage rate growth. The level of regional technology in the industry can be decomposed into its two constituent components: global and local technology levels:

$$A_{rit} = A_{local}\,A_{global} = A_{rt}\,A_t \tag{6}$$

Consequently, the growth rate of regional technology is the sum of the rates of growth of its components:

$$\ln\left(\frac{A_{rit}}{A_{rit-1}}\right) = \ln\left(\frac{A_{rt}}{A_{rt-1}}\right) + \ln\left(\frac{A_t}{A_{t-1}}\right) \tag{7}$$

The global component of technology captures the exogenous changes in technology that affect both the industry and the whole economy. The regional component of technology is a function of externalities associated with knowledge spillovers in the region:

$$\ln\left(\frac{A_{rt}}{A_{rt-1}}\right) = g(S, D, C) \tag{8}$$

where "S, D, and C" are the measures of specialization, diversification, and competition. Substituting equations (8) and (7) into equation (5) yields:

$$\ln\left(\frac{L_{rit}}{L_{rit-1}}\right) = \left(\frac{1}{\alpha}\right)\ln\left(\frac{A_t}{A_{t-1}}\right) - \left(\frac{1}{\alpha}\right)\ln\left(\frac{w_{rit}}{w_{rit-1}}\right) + g(S, D, C) \tag{9}$$

Equation (9) shows that regional employment growth of i-th industry is a function of the wage growth, global technology changes and various regional externalities. On the one hand, the wage growth exerts a negative impact on the growth of employment, since higher salaries decrease the demand for labor. On the other hand, growth of the global level of technology positively affects the regional growth of employment. However, the theory does not offer unambiguous predictions on how various types of spillovers affect the regional employment growth and their impact must be determined empirically. Several theoretical hypotheses must be investigated.

According to the MAR hypothesis, "g" is a positive function of specialization "S," which suggests that concentration of firms should enhance regional employment growth. According to the Jacobs hypothesis, "g" is a positive function of diversification "D", which means that more diversity of industries in the region should improve the employment. Hence, the predictions of the MAR theory are completely different from the theory proposed by Jacobs. Finally, according to the Porter hypothesis, "g" is a positive function of competition "C," which means that regional competition among firms within the industry should positively affect regional employment growth. Moreover, Porter agrees with MAR on the positive effects of specialization and agrees with Jacobs on the positive impact of competition.

The aforementioned hypotheses are subject to empirical tests in the subsequent part of the paper. However, before reporting our empirical results in the next section we discuss the empirical measures of particular externalities used in our study.

3. Measures of Externalities

Henderson et al. (1995) used in their early study a very simple measure of specialization based on the geographical concentration of economic activity that is measured using the ratio of regional industrial employment to the total local area:

$$S_1 = \frac{L_{rit}}{area_{rt}} \tag{10}$$

where: L_{irt} is the total employment for industry "i" in region "r" at time "t", $area_{rt}$ is the whole area of region "r" at time "t" in square kilometers. The bigger value of this measure the higher the geographical concentration of employment.

In the present study we use two alternative measures of specialization to study two separate aspects of specialization.[1] One of them is within regional concentration that measures the level of concentration of the industry within the respective region. The higher value of this index shows that there is more employment concentrated in that industry in the given region. In particular, this measure was used by Henderson et al. (1995) and Cingano and Schivardi (2004).

$$S_2 = \frac{L_{i,r,t}}{L_{r,t}} = \frac{L_{i,r,t}}{\sum_{i=1}^{N} L_{i,r,t}} \tag{11}$$

Definitions of i, r, t, and L are as previously and N is the number of all industries in the region. De Lucio et al. (2002) used productivity instead of employment in this measure, which can provide a different interpretation.

[1] The empirical results obtained using the S_1 measure have been reported in the recent study by Cieślik and Ghodsi (2013).

The second index of specialization is within industry concentration that measures the level of concentration of the region within the respective industry in the whole sample. This measure shows how big the industry of region is relative to the total industry. The bigger value of this index determines the higher specialization of the region and bigger economic activity.

$$S_3 = \frac{L_{i,r,t}}{L_{i,t}} = \frac{L_{i,r,t}}{\sum_{r=1}^{R} L_{i,r,t}} \tag{12}$$

where i, r, t, and L are defined as previously and R is the total number of regions that have this industry. De Lucio et al. (2002) used this measure to show within industry concentration of the value added.

Various measures of diversification can be found in the literature. The most commonly used measure of diversification is the Hirschman–Herfindahl index (HHI).[2] This index is defined as the sum of squares of share of other industries employment in the region relative to the total employment of the region except the respective industry in question:

$$D_1 = HHI_{rit} = \sum_{i' \neq i}^{N} S_{ri}^{\prime 2} = \sum_{i' \neq i}^{N} \left(\frac{L'_{rit}}{\sum_{i' \neq i}^{N} L'_{rit}} \right) \tag{13}$$

where *i'* denotes all industries in the region other than the respective one under analysis, and definitions of r, i, t, N, and L are the same as before. This measure shows the within regional concentration of industries other than the respective one under investigation. The value of this index ranges between 1/N and 1, and the higher value of this index shows less diversity in the region. In fact, if all of the economic activities other than the respective industry are agglomerated in one industry this measure will receive the value of 1.

Another measure of diversification can be the normalized form of HHI. This measure controls for regional characteristics of the economic activity among all regions and is defined in the following way:

$$D_2 = \frac{\left(\frac{1}{\sum_{i' \neq i}^{N} \left(\frac{L_{r,i',t}}{\sum_{i' \neq i}^{N} L_{r,i',t}} \right)^2} \right)}{\left(\frac{1}{\sum_{i' \neq i}^{N} \left(\frac{L_{i',r,t}}{\sum_{i' \neq i}^{N} \sum_{r}^{R} L_{i',r,t}} \right)^2} \right)} \tag{14}$$

[2] This index was previously employed, inter alia, by Henderson et al. (1995), Duranton and Puga (2000), and Cingano and Schivardi (2004).

where: *i'* denotes the other industries. Since this measure is the inverse of normalized *HHI*, the higher values of this measure are associated with the higher degree of diversification of other industries. Finally, the alternative measure of diversification that ranges within the interval [0,1], can be defined as follows:

$$D_3 = \left[1 - \left(\frac{T_r}{\ln N}\right)\right] \tag{15}$$

This measure is based on the Theil index which shows the distribution of industrial activities in the region, and is defined as:

$$T_r = \frac{1}{N_r} \sum_{i=1}^{N} \frac{L_{r,i,t}}{\overline{L}_{r,t}} \ln\left[\frac{L_{r,i,t}}{\overline{L}_{r,t}}\right] \tag{16}$$

where: N_r is the total number of industries in region, $L_{r,t}$ is the average employment over N sectors in the region. The higher value of the diversification index D_3 the higher is the degree of diversification.

In this study we use two competition measures: the first measure concerns competition between industries within the same region, while the second is a proxy for local competition between firms of the same industry. The first measure is defined in the following way:

$$C_1 = \frac{HHI_{r,i,t}}{N_{r,i,t}} = \sum_{i=1}^{N} \frac{(L_{r,i,t})^2}{\left(\sum_{i=1}^{N} L_{r,i,t}\right)^2 \times N_{r,i,t}} \tag{17}$$

Since the larger number of industries (N) can increase the level of competition, and the lower value of the *HHI* means more even distribution of industrial activities in the region, the lower value of "C_1" is associated with the higher degree of competition in the region.

The second measure captures competition within the local industry relative to entire competition of the industry within all regions defined as follows:[3]

$$C_2 = \frac{\left[\dfrac{I_{r,i,t}}{L_{r,i,t}}\right]}{\left[\dfrac{\sum_{r=1}^{R} I_{r,i,t}}{\sum_{r=1}^{R} L_{r,i,t}}\right]} \tag{18}$$

where: I_{rit} is the number of firms in the industry "*i*" and in region "*r*" at time "*t*". The higher value of this index means that the industry in this region is locally more competitive than it is elsewhere.

[3] This famous measure of competition was used by many authors, among others, Glaeser et al. (1992) and Van der Panne and van Beers (2006).

4. Estimating Equation and Dataset

The theoretical framework based on the simplified Cobb-Douglas function discussed in Section 2 can be used to derive our estimating equation. We can easily transform equation (9) into the following dynamic panel setup:

$$L_{r,i,t} = \gamma + \sum_{\tau=1}^{T} \varrho_{\tau} L_{r,i,t-\tau} + \sum_{\tau=0}^{T} \theta_{\tau} X_{r,i,t-\tau} + \delta_{r,i} + D_t + \varepsilon_{r,i,t} \tag{19}$$

where "$L_{r,i,t}$" is the log of local employment of industry i (i =1,…,N) in region r (r =1,…,R) at time t (t =1,…,T); γ is the constant term, "$L_{r,i,t-\tau}$" (τ =1,…,T) are the lags of the dependent variable. "$X_{r,i,t-\tau}$" is the vector of current or lagged explanatory variables, $\delta_{r,i}$ represents the invariant region and industry fixed effects, D_t indicates time fixed effects, and $\varepsilon_{r,i,t}$ is the vector of error terms.

The appropriate estimation technique for these types of models is the Generalized Method of Moments (GMM). "Difference" and "system" GMM are elaborated by Arellano and Bond (1988) and Arellano and Bond (1991), which were modified and developed by Arellano and Bover (1995), and Blundell and Bond (1998). These two estimators are specially designed for panels with few time periods and many individuals; with also explanatory variables that are correlated with past and current error terms; with fixed effects and possible heteroskedasticity and autocorrelation within individuals. Since the characteristics of our model are very close to these attributes, we choose these two estimators for our analysis, which are compiled in xtabond2 command in Stata by Roodman (2007).

In line with this estimation technique, the first differences of equation (19) are taken to eliminate time invariant effects $\delta_{r,i}$. Since we use the logarithmically transformed variable, we obtain the growth rate of the dependent variable on the left hand side of the equation. Thus, our estimating equation becomes:

$$\Delta L_{r,i,t} = \sum_{\tau=1}^{T} \varrho_{\tau} \Delta L_{r,i,t-\tau} + \sum_{\tau=0}^{T} \theta_{\tau} \Delta X_{r,i,t-\tau} + \Delta d_t + \Delta \varepsilon_{r,i,t} \tag{20}$$

where $\Delta L_{r,i,t-\tau} = L_{r,i,t-\tau} - L_{r,i,t-\tau-1}$.

All the externality indices are expressed in levels, wages are in logarithmic forms, and assumed to be strictly exogenous, while employment is in logs and endogenous. The first difference of the lagged dependent variable is predetermined and it is instrumented using the higher order time lags of it in levels.[4]

[4] Including logarithmic forms of spillovers measures does not change much the significance of coefficients.

The effects of various types of externalities on the rate of employment growth in the high-tech industries is investigated using European regional structural business statistics at NUTS-02 regional level during the period 1995-2007. The data was obtained from the Eurostat statistic database website[5]. The choice of the period was determined by data availability.[6]

Our dataset comprises three high-tech industries classified according to the 2-digit level NACE rev1.1 classification.[7] The industries include manufacture of office machinery and computers (DL30), manufacture of radio, television and communication equipment and apparatus (DL32), manufacture of medical, precision, and optical instruments, watches and clocks (DL33). Since high-tech industries are relatively research and development intensive, and they are more involved in the process of innovation than other industries, it is expected that knowledge spillovers can be of special importance in these industries. The basic statistics for these three industries are shown in Table 2.

[5] Eurostat Statistical Database: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[6] It is not possible to include more recent years due to the change in the NACE classification.

[7] According to industrial codes of NACE Rev. 1.1, Eurostat 2009 and OECD 2011 classified manufacturing industries at 2-digit level in four subgroups of high-technology, medium high-technology, medium low-technology, and low-technology based on the technology intensity and level of R&D used in these industries. See Appendix for details.

Table 2. Externality measures statistics for three high-tech manufacturing industries in the EEA.

Index	Definition	Minimum				Maximum				Average	No. Observation
		Val.	Ind.	Reg.	Year	Val.	Ind.	Reg.	Year		
L	Employment	1	Some	Some	Some	62698	DL32	Île de France	2006	3013.42	5882
I	No. of firms	1	Some	Some	Some	6988	DL33	Lombardia	1998	200.59	5706
W	Wages	0.1	Some	Some	Some	459046	DL33	Bucuresti – Ilfov	2004	1425.94	5540
S1	Specialization	8.853E-06	DL30	Nord-Norge	2005	45.884	DL32	Wien	1995	0.4456	5312
S2	Specialization	1.003E-05	DL30	Nord-Norge	2005	0.2759	DL32	Stockholm	1996	0.00805	5882
S3	Specialization	5.645E-06	DL32	Sud-Vest Oltenia	2001	0.1671	DL30	IE02	1995	0.00663	5882
D1	Diversification	0.03793	DL30	Vest	2005	0.5312	DL33	Bremen	2001	0.072	5882
D2	Diversification	0.0884	DL30	Illes Balears	1998	1.535	DL30	Vest	2005	0.8103	5882
D3	Diversification	0.4362	Some	Illes Balears	1998	0.92505	DL33	Andalucía	1995	0.8014	5882
C1	Competition	0.00064	All	Vest	2005	0.0927	DL33	Bremen	2001	0.0018	5882
C2	Competition	0.0239	DL30	Detmold	2006	128.685	DL30	Ipeiros	2003	2.684	5706

Source: Own calculations

5. Estimation Results

In Table 3 we report the estimation results for the model specification in which we include both within regional and within industrial specialization in three high-tech manufacturing industries of EEA. These two measures of specialization can be included simultaneously in the regression because they are showing two separate characteristics of specialization. To control for potential non-linearities in the specialization-growth nexus we include also the squares of these two variables and their lags. The orders of lags are determined by the best statistics of diagnostics tests. Both Sargan and Hansen tests are suggesting that the GMM constructions using instruments are appropriate for all three models. In other words, all diagnostic tests approve the validity of used instruments.

The benchmark results are reported in column 1, while the sensitivity tests based on alternative measures of diversification are reported in columns 2 and 3. In all the estimated specifications, only the first lag of employment is statistically significant at the 1 per cent level while the wage rate and its lags are not statistically significant at all. The first lag of employment has a positive coefficient which is associated with the reversion of employment. For instance, the first model suggests that if employment increases by 1 percent, the growth of employment in the next period will be expected to increase by 0.65 percent.

Table 3. Estimation results for three high-tech manufactures in the EEA over 1995-2007 period: within regional versus within industry specialization

Dependent Variable: Regional employment of the industry		**Using lags of dependent variable**		
		1	**2**	**3**
$\log L_r$	t-1	0.654*** (0.196)	0.718*** (0.108)	0.794*** (0.226)
	t-2	0.085 (0.181)	0.015 (0.114)	0.055 (0.147)
	t-3	0.042 (0.039)	0.055 (0.034)	0.039 (0.037)
	t-4	-0.006 (0.041)		-0.001 (0.039)
$\log W_{r,i}$	t	-0.009 (0.016)	0.012 (0.016)	-0.011 (0.014)
	t-1	0.002 (0.017)	0.017 (0.021)	0.011 (0.011)
	t-2	-0.011 (0.037)	-0.001 (0.023)	-0.006 (0.030)
Within regional specialization (S_2)	t	91.700* (51.800)	71.700*** (26.100)	82.600* (45.400)

Dependent Variable: Regional employment of the industry		Using lags of dependent variable 1	2	3
	t-1	-20.100 (35.070)	9.250 (21.900)	-42.500 (26.700)
	t-2	-11.030 (20.040)	-33.800* (18.500)	-27.100 (18.600)
Within industry specialization (S_3)	t	15.050 (23.600)	-47.800** (24.300)	4.630 (15.010)
	t-1	13.030 (16.600)	-20.600 (15.400)	9.430 (14.700)
	t-2	27.800* (15.900)	49.300*** (16.100)	24.400* (13.100)
Square of within regional specialization$(S_2)^2$	t	-35407.300 (22485.500)	-204.000** (10416.900)	-31143.000 (21467.300)
	t-1	4472.500 (17251.200)	-7935.500 (8843.500)	6058.070 (11554.010)
	t-2	557.600 (7720.800)	14542.400* (7815.800)	3241.200 (8324.700)
Square of within industry specialization$(S_3)^2$	t	9529.700 (22227.500)	50799.400 (31085.800)	15671.900 (25929.800)
	t-1	493.400 (18614.500)	37564.200 (23192.200)	16399.600 (19216.200)
	t-2	-9046.100 (10315.600)	-37825.600** (16134.900)	-9042.800 (10042.300)
Diversification Indices		D_1	D_2	D_3
	t	7.330 (12.100)	0.608 (0.394)	-2.450 (2.620)
	t-1	9.917 (12.200)	0.813* (0.478)	1.117 (2.520)
	t-2	5.320 (13.300)	-0.233 (0.405)	1.850 (2.450)
Inter-industry competition (C_1)	t	-85.800 (356.200)	-17.900 (114.100)	128.200 (140.700)
	t-1	-181.100 (231.700)	167.600 (114.030)	38.400 (78.600)
	t-2	-6.450 (188.300)	-29.800 (110.600)	102.500 (93.500)
Local competition between firms (C_2)	t	-0.192** (0.078)	-0.215*** (0.057)	-0.159** (0.071)
	t-1	0.0303 (0.064)	0.157*** (0.048)	0.007 (0.031)
	t-2	0.018 (0.049)	-0.007 (0.014)	-0.031 (0.049)
Sargan test of overid. restrictions; Prob > chi2 =		1.000	1.000	0.924
Hansen test of overid. restrictions; Prob > chi2 =		0.525	0.788	0.228

Dependent Variable: Regional employment of the industry	**Using lags of dependent variable**		
	1	**2**	**3**
Iv, Difference (null H = exogenous); Prob > chi2 =	0.329	0.103	0.074
AB test for AR(1) in first differences: P>z=	0.494	0.079	0.448
AB test for AR(2) in first differences: P>z=	0.988	0.122	0.603
Number of Observations	2141	2695	2141
Number of Groups	493	536	493

Source: Own estimations obtained using Stata 11.1; ***-significant at 1% level; **-significant at 5% level; *-significant at 10% level; robust corrected standard errors are reported in parentheses.

The estimated coefficient on the within regional specialization variable S_2 reported in column (1) displays a positive sign and is statistically significant but only at the 10 per cent level of statistical significance. This results suggests that a one unit increase in the within regional specialization can potentially increase the growth of regional-industrial employment by about 91.7 percent. This effect is very large but as it is observed in Table 2, the maximum value for this spillover is about 0.28, and the average value of this index across EEA regions is about 0.008. Therefore, since the variations of this index is very small, we can argue that an increase of 0.01 unit in the specialization measured by S_2 can potentially increase the employment growth of the regional industry by 0.92 percent. Its squared value displays a negative sign but it is not statistically significant at all. Thus, there is only a weakly confirmation of the hypothesis that regional specialization is positively related to the growth rate of regional industrial employment in high-tech industries. The estimated coefficient on the other measure of specialization S_3 is positive but statistically not significant at any of the usually accepted levels of statistical significance. In addition, the estimated coefficients on the diversification measure D_1 and the measure of competition between industries C_1 are not statistically significant. Therefore, neither diversification nor inter-industry competition have a statistically significant impact on employment growth. Finally, the estimated coefficient on local competition between firms within the same industry C_2 displays a negative sign and is statistically significant at the 5 per cent level. This means that a one-unit increase in the local industrial competition between firms decreases the rate of regional employment growth in the high-tech industries by 0.19 percent. Overall, these results confirm the existence of MAR spillovers within the EEA high-tech industries.

The robustness of our benchmark results presented in column (1) is investigated in columns (2) and (3). In column (2) we report estimation results obtained using the alternative measure of diversification D_2 based on the inverse of the normalized Hirschman-Herfindahl Index. Similar to the results presented in column (1), the estimated coefficient on the diversification variable is also not statistically significant at all. The change of the measure of diversification affects, however, the statistical significance of the estimated parameters on other variables. In particular, the estimated parameter on the measure of within regional concentration S_2 becomes now statistically significant already at the 1 per cent level. This means that now there is a strong evidence that within regional concentration S_2 is positively related to the regional growth of employment. A 0.01 unit increase in the specialization will increase the growth of regional industrial employment by 0.717 percent. Moreover, the square of within regional specialization variable which displays a negative coefficient now becomes statistically significant at the 5 per cent level. Since the calculated within regional specialization is bound between zero and one, the squared of it will refer to a smaller value. Therefore, the negative sign associated to this coefficient can be interpreted as a positive impact of high level of specialization. In other words, we can argue that when concentration increases to a very high level, a 0.01 unit increase of it will induce a rise of about 2.04 percent in employment growth of within regional industry.

The estimated parameter on the within industry specialization variable S_3 now becomes negative and statistically significant at the 5 per cent level while its squared value remains statistically not significant. Therefore, it can be argued that within industry specialization is negatively related to employment growth. In other words, we can state that when employment share of a specific industry in a region relative to the total employment of that industry within EEA increases by 0.01 unit, the growth of that regional industry will decrease by 0.478 percent. In other words, market share of employment within the industry has negative impact on the growth. The estimated parameter on the inter-industry competition variable C_1 remains statistically not significant. Moreover, the statistical significance of the estimated parameter on the local competition variable C_2 increases to the 1 per cent level. In addition, the magnitude of the estimated coefficient is higher in the absolute terms, which means that the negative impact of local competition between firms of the same industry on the growth of employment has increased compared to the estimation from column (1).

Finally, in column (3) we report estimation results obtained from using the alternative measure of diversification D_3 based on the Theil index. However, the estimated coefficient on this diversification variable is not statistically significant which means that diversification in the context of equal distribution of industries in the region is not related to the rate of employment growth in the high-tech industries. The sensitivity test in the third column shows that the estimated parameter on the within regional specialization variable S_2 is still positive but now it becomes statistically significant only at the 10 per cent level. According to this result, it can argued that an increase in the within regional concentration by 0.01 unit will potentially increase the employment growth of regional industry by 0.826 percent. Its squared value is not statistically significant at all.

Moreover, neither the estimated coefficient on the measure of within industry specialization S_3 nor its squared values are statistically significant. Similarly, the estimated parameter on inter-industry competition C_1 it is not statistically significant. Finally, the estimated coefficient on the local competition variable C_2 is statistically significant at the 5 per cent level. Therefore, it seems that local competition between firms is negatively related to the growth of employment. However, the magnitude of this effect is slightly smaller compared to the benchmark specification.

Conclusions

In this paper we studied the effects of various externalities associated with knowledge spillovers on regional employment growth in the European Economic Area (EEA). In our study, we focused on 3 high-tech industries at NACE rev. 1.1 2-digit levels in 285 EEA NUTS-2 regions during the period of 1995-2007. Possible problems in the dynamic panel regression have been controlled using Difference and System GMM.In particular, we demonstrated that within regional specialization had a significant positive impact on the employment growth. Therefore, it can be concluded that MAR spillovers exist in the high-tech manufacturing industries in EEA. We also demonstrated that within industry specialization does not seem to be important for the growth of employment in these industries. Moreover, we showed that urbanization economies do not exist in the high-tech manufacturing industries since none of the diversification measures we used was statistically significant. Therefore, it can be argued that Jacobs spillovers are not important for the growth of regional employment. Similar to the earlier studies, we found that the hypotheses of Porter and Jacobs about the positive impact of fierce competition between firms on the growth of regional industry can be rejected. Instead, in line with the MAR hypothesis, monopoly can provide an opportunity for firms to internalize the externalities, in order to have higher profits from their innovations. Therefore, in reality monopoly can enhance the growth of regional employment of the high-tech manufacturing industries.

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Appendix

Table AI. List of 285 EEA regions under investigation

No.	Code	Name of the region	No.	Code	Name of the region
1	AT11	Burgenland (AT)	43	DE21	Oberbayern
2	AT12	Niederösterreich	44	DE22	Niederbayern
3	AT13	Wien	45	DE23	Oberpfalz
4	AT21	Kärnten	46	DE24	Oberfranken
5	AT22	Steiermark	47	DE25	Mittelfranken
6	AT31	Oberösterreich	48	DE26	Unterfranken
7	AT32	Salzburg	49	DE27	Schwaben
8	AT33	Tirol	50	DE30	Berlin
9	AT34	Vorarlberg	51	DE41	Brandenburg - Nordost
10	ATZZ	Extra-Regio NUTS 2	52	DE42	Brandenburg - Südwest
11	BE10	Région de Bruxelles-Capitale	53	DE50	Bremen
12	BE21	Prov. Antwerpen	54	DE60	Hamburg
13	BE22	Prov. Limburg (BE)	55	DE71	Darmstadt
14	BE23	Prov. Oost-Vlaanderen	56	DE72	Gießen
15	BE24	Prov. Vlaams-Brabant	57	DE73	Kassel
16	BE25	Prov. West-Vlaanderen	58	DE80	Mecklenburg-Vorpommern
17	BE31	Prov. Brabant Wallon	59	DE91	Braunschweig
18	BE32	Prov. Hainaut	60	DE92	Hannover
19	BE33	Prov. Liège	61	DE93	Lüneburg
20	BE34	Prov. Luxembourg (BE)	62	DE94	Weser-Ems
21	BE35	Prov. Namur	63	DEA1	Düsseldorf
22	BG31	Severozapaden	64	DEA2	Köln
23	BG32	Severen tsentralen	65	DEA3	Münster
24	BG33	Severoiztochen	66	DEA4	Detmold
25	BG34	Yugoiztochen	67	DEA5	Arnsberg
26	BG41	Yugozapaden	68	DEB1	Koblenz
27	BG42	Yuzhen tsentralen	69	DEB2	Trier
28	CY00	Kypros/Kibris	70	DEB3	Rheinhessen-Pfalz
29	CYZZ	Extra-Regio NUTS 2	71	DEC0	Saarland

No.	Code	Name of the region	No.	Code	Name of the region
30	CZ01	Praha	72	DED1	Chemnitz
31	CZ02	Strední Cechy	73	DED2	Dresden
32	CZ03	Jihozápad	74	DED3	Leipzig
33	CZ04	Severozápad	75	DEE0	Sachsen-Anhalt
34	CZ05	Severovýchod	76	DEF0	Schleswig-Holstein
35	CZ06	Jihovýchod	77	DEG0	Thüringen
36	CZ07	Strední Morava	78	DEZZ	Extra-Regio NUTS 2
37	CZ08	Moravskoslezsko	79	DKZZ	Extra-Regio NUTS 2
38	CZZZ	Extra-Regio NUTS 2	80	ES11	Galicia
39	DE11	Stuttgart	81	ES12	Principado de Asturias
40	DE12	Karlsruhe	82	ES13	Cantabria
41	DE13	Freiburg	83	ES21	País Vasco
42	DE14	Tübingen	84	ES22	Comunidad Foral de Navarra
85	ES23	La Rioja	130	FR93	Guyane (FR)
86	ES24	Aragón	131	FR94	Réunion (FR)
87	ES30	Comunidad de Madrid	132	FRZZ	Extra-Regio NUTS 2
88	ES41	Castilla y León	133	GR11	Anatoliki Makedonia, Thraki
89	ES42	Castilla-la Mancha	134	GR12	Kentriki Makedonia
90	ES43	Extremadura	135	GR13	Dytiki Makedonia
91	ES51	Cataluña	136	GR14	Thessalia
92	ES52	Comunidad Valenciana	137	GR21	Ipeiros
93	ES53	Illes Balears	138	GR22	Ionia Nisia
94	ES61	Andalucía	139	GR23	Dytiki Ellada
95	ES62	Región de Murcia	140	GR24	Sterea Ellada
96	ES63	Ciudad Autónoma de Ceuta (ES)	141	GR25	Peloponnisos
97	ES64	Ciudad Autónoma de Melilla (ES)	142	GR30	Attiki
98	ES70	Canarias (ES)	143	GR41	Voreio Aigaio
99	ESZZ	Extra-Regio NUTS 2	144	GR42	Notio Aigaio
100	FI13	Itä-Suomi	145	GR43	Kriti
101	FI18	Etelä-Suomi	146	GRZZ	Extra-Regio NUTS 2
102	FI19	Länsi-Suomi	147	HU10	Közép-Magyarország
103	FI1A	Pohjois-Suomi	148	HU21	Közép-Dunántúl
104	FI20	Åland	149	HU22	Nyugat-Dunántúl
105	FIZZ	Extra-Regio NUTS 2	150	HU23	Dél-Dunántúl
106	FR10	Île de France	151	HU31	Észak-Magyarország
107	FR21	Champagne-Ardenne	152	HU32	Észak-Alföld
108	FR22	Picardie	153	HU33	Dél-Alföld

No.	Code	Name of the region	No.	Code	Name of the region
109	FR23	Haute-Normandie	154	IE01	Border, Midland and Western
110	FR24	Centre (FR)	155	IE02	Southern and Eastern
111	FR25	Basse-Normandie	156	IEZZ	Extra-Regio NUTS 2
112	FR26	Bourgogne	157	ITC1	Piemonte
113	FR30	Nord - Pas-de-Calais	158	ITC2	Valle d'Aosta/Vallée d'Aoste
114	FR41	Lorraine	159	ITC3	Liguria
115	FR42	Alsace	160	ITC4	Lombardia
116	FR43	Franche-Comté	161	ITD1	Provincia Autonoma Bolzano/Bozen
117	FR51	Pays de la Loire	162	ITD2	Provincia Autonoma Trento
118	FR52	Bretagne	163	ITD3	Veneto
119	FR53	Poitou-Charentes	164	ITD4	Friuli-Venezia Giulia
120	FR61	Aquitaine	165	ITD5	Emilia-Romagna
121	FR62	Midi-Pyrénées	166	ITE1	Toscana
122	FR63	Limousin	167	ITE2	Umbria
123	FR71	Rhône-Alpes	168	ITE3	Marche
124	FR72	Auvergne	169	ITE4	Lazio
125	FR81	Languedoc-Roussillon	170	ITF1	Abruzzo
126	FR82	Provence-Alpes-Côte d'Azur	171	ITF2	Molise
127	FR83	Corse	172	ITF3	Campania
128	FR91	Guadeloupe (FR)	173	ITF4	Puglia
129	FR92	Martinique (FR)	174	ITF5	Basilicata
175	ITF6	Calabria	218	PT11	Norte
176	ITG1	Sicilia	219	PT15	Algarve
177	ITG2	Sardegna	220	PT16	Centro (PT)
178	ITZZ	Extra-Regio NUTS 2	221	PT17	Lisboa
179	LU00	Luxembourg	222	PT18	Alentejo
180	LV00	Latvija	223	PT20	Região Autónoma dos Açores (PT)
181	LVZZ	Extra-Regio NUTS 2	224	PT30	Região Autónoma da Madeira (PT)
182	NL11	Groningen	225	RO11	Nord-Vest
183	NL12	Friesland (NL)	226	RO12	Centru
184	NL13	Drenthe	227	RO21	Nord-Est
185	NL21	Overijssel	228	RO22	Sud-Est
186	NL22	Gelderland	229	RO31	Sud - Muntenia
187	NL23	Flevoland	230	RO32	Bucuresti - Ilfov
188	NL31	Utrecht	231	RO41	Sud-Vest Oltenia

No.	Code	Name of the region	No.	Code	Name of the region
189	NL32	Noord-Holland	232	RO42	Vest
190	NL33	Zuid-Holland	233	ROZZ	Extra-Regio NUTS 2
191	NL34	Zeeland	234	SE11	Stockholm
192	NL41	Noord-Brabant	235	SE12	Östra Mellansverige
193	NL42	Limburg (NL)	236	SE21	Småland med öarna
194	NLZZ	Extra-Regio NUTS 2	237	SE22	Sydsverige
195	NO01	Oslo og Akershus	238	SE23	Västsverige
196	NO02	Hedmark og Oppland	239	SE31	Norra Mellansverige
197	NO03	Sør-Østlandet	240	SE32	Mellersta Norrland
198	NO04	Agder og Rogaland	241	SE33	Övre Norrland
199	NO05	Vestlandet	242	SEZZ	Extra-Regio NUTS 2
200	NO06	Trøndelag	243	SI_X _021	Slovenia except Osrednjeslovenska
201	NO07	Nord-Norge	244	SK01	Bratislavský kraj
202	PL11	Lódzkie	245	SK02	Západné Slovensko
203	PL12	Mazowieckie	246	SK03	Stredné Slovensko
204	PL21	Malopolskie	247	SK04	Východné Slovensko
205	PL22	Slaskie	248	UKC1	Tees Valley and Durham
206	PL31	Lubelskie	249	UKC2	Northumberland and Tyne and Wear
207	PL32	Podkarpackie	250	UKD1	Cumbria
208	PL33	Swietokrzyskie	251	UKD2	Cheshire
209	PL34	Podlaskie	252	UKD3	Greater Manchester
210	PL41	Wielkopolskie	253	UKD4	Lancashire
211	PL42	Zachodniopomorskie	254	UKD5	Merseyside
212	PL43	Lubuskie	255	UKE1	East Yorkshire and Northern Lincolnshire
213	PL51	Dolnoslaskie	256	UKE2	North Yorkshire
214	PL52	Opolskie	257	UKE3	South Yorkshire
215	PL61	Kujawsko-Pomorskie	258	UKE4	West Yorkshire
216	PL62	Warminsko-Mazurskie	259	UKF1	Derbyshire and Nottinghamshire
217	PL63	Pomorskie			
260	UKF2	Leicestershire, Rutland and Northamptonshire	273	UKJ4	Kent
261	UKF3	Lincolnshire	274	UKK1	Gloucestershire, Wiltshire and Bristol/ Bath area
262	UKG1	Herefordshire, Worcestershire and Warwickshire	275	UKK2	Dorset and Somerset
263	UKG2	Shropshire and Staffordshire	276	UKK3	Cornwall and Isles of Scilly

No.	Code	Name of the region	No.	Code	Name of the region
264	UKG3	West Midlands	277	UKK4	Devon
265	UKH1	East Anglia	278	UKL1	West Wales and The Valleys
266	UKH2	Bedfordshire and Hertfordshire	279	UKL2	East Wales
267	UKH3	Essex	280	UKM2	Eastern Scotland
268	UKI1	Inner London	281	UKM3	South Western Scotland
269	UKI2	Outer London	282	UKM5	North Eastern Scotland
270	UKJ1	Berkshire, Buckinghamshire and Oxfordshire	283	UKM6	Highlands and Islands
271	UKJ2	Surrey, East and West Sussex	284	UKN0	Northern Ireland (UK)
272	UKJ3	Hampshire and Isle of Wight	285	UKZZ	Extra-Regio NUTS 2

Source: Eurostat

Table AII. Categories of industries

Group	Industry	Type	Denomination (Eurostat)
1	Manufacturing	High-tech	**DL30**-Manufacture of office machinery and computers, **DL32**-Manufacture of radio, television and communication equipment and apparatus, **DL33**-Manufacture of medical, precision and optical instruments, watches and clocks
2	Manufacturing	Medium-high-tech	**DG24**-Manufacture of chemicals and chemical products, **DK29**-Manufacture of machinery and equipment n.e.c., **DL31**-Manufacture of electrical machinery and apparatus n.e.c., **DM34**-Manufacture of motor vehicles, trailers and semi-trailers, **DM35**-Manufacture of other transport equipment
3	Manufacturing	Medium-low-tech	**DF23**-Manufacture of coke, refined petroleum products and nuclear fuel, **DH25**-Manufacture of rubber and plastic products, **DI26**-Manufacture of other non-metallic mineral products, **DJ27**-Manufacture of basic metals, **DJ28**-Manufacture of fabricated metal products, except machinery and equipment
4	Manufacturing	Low-tech	**DA15**-Manufacture of food products and beverages, **DA16**-Manufacture of tobacco products, **DB17**-Manufacture of textiles, **DB18**-Manufacture of wearing apparel; dressing; dyeing of fur, **DC19**-Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear, **DD20**-Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, **DE21**-Manufacture of pulp, paper and paper products, **DE22**-Publishing, printing and reproduction of recorded media, **DN36**-Manufacture of furniture; manufacturing n.e.c., **DN37**-Recycling

Group	Industry	Type	Denomination (Eurostat)
5	High-tech-knowledge-intensive Services		**K72**-Computer and related activities, **K73**-Research and development, **I64**-Post and telecommunications
6	Knowledge-intensive-financial Services		**J65**-Financial intermediation, except insurance and pension funding, **J67**-Activities auxiliary to financial intermediation
7	Mining		**CA10**-Mining of coal and lignite; extraction of peat, **CA11**-Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying, **CA12**-Mining of uranium and thorium ores, **CB13**-Mining of metal ores, **CB14**-Other mining and quarrying
8	Energy Supply		**E40-**Electricity, gas, steam and hot water supply, **E41-**Collection, purification and distribution of water
9	Construction		**F45**-Construction
10	wholesale and retail trade		**G501**-Sale of motor vehicles, **G502**-Maintenance and repair of motor vehicles, **G503**-Sale of motor vehicle parts and accessories, **G504**-Sale, maintenance and repair of motorcycles and related parts and accessories, **G505**-Retail sale of automotive fuel, **G511**-Wholesale on a fee or contract basis, **G512**-Wholesale of agricultural raw materials and live animals, **G513**-Wholesale of food, beverages and tobacco, **G514**-Wholesale of household goods, **G515**-Wholesale of non-agricultural intermediate products, waste and scrap, **G518**-Wholesale of machinery, equipment and supplies, **G519**-Other wholesale, **G521**-Retail sale in non-specialized stores, **G522**-Retail sale of food, beverages and tobacco in specialized stores, **G523**-Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles, **G524**-Other retail sale of new goods in specialized stores, **G525**-Retail sale of second-hand goods in stores, **G526**-Retail sale not in stores, **G527**-Repair of personal and household goods
11	Hotels and Restaurants		**H55**-Hotels and restaurants
12	Transport		**I60**-Land transport; transport via pipelines, **I61**-Water transport, **I62**-Air transport, **I63**-Supporting and auxiliary transport activities; activities of travel agencies
13	Other industries		**K70**-Real estate activities, **K71**-Renting of machinery and equipment without operator and of personal and household goods, **K74**-Other business activities

Source: Eurostat 2009.