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Knowledge Externalities in Turkish High-Technology Manufacturing Industries: Spatial Panel Data Analyses

Türkiye'nin Yüksek Teknolojili İmalat Sanayi Endüstrilerinde Bilgi Dışsallıkları: Mekansal Panel Veri Analizleri

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Abstract: Knowledge externalities are defined as positive spillover outcomes of new and innovative knowledge among firms. They create positive impacts on firms' productions, which did not participate in the production process and the costs of new knowledge creation. Knowledge externalities have critical importance especially for regional economies due to the fact that firms locating in the same region create networks in which knowledge disseminates quickly. This paper presents empirical evidences about the existence, types and impacts of knowledge externalities in Turkish regions for 1989 – 2008 time period. The main focus of this study is medium-high and high-technology industries due to the fact that these industries produce innovative outcomes and hence affect regional economies by creating knowledge externalities. In this context empirical evidences indicate that dynamic knowledge externalities occur more frequently than static ones and in general they affect regional economies positively in Turkey. Also, Marshall-Arrow-Romer knowledge externalities most frequently occurred before 2001 while after this year, Porter knowledge externalities have most frequently occurred in medium-high and high technology industries in Turkish regions.

Keywords: Knowledge Externalities, High Technology Industries, Spatial Econometrics

Öz: Bilgi dışsallıkları, firmalar arasındaki yeni ve yenilikçi bilginin pozitif yayılma çıktıları olarak tanımlanmaktadır. Bilgi dışsallıkları, yenilikçi bilginin üretim sürecine ve dolayısıyla da yeni bilgi yaratımının maliyetine ortak olmayan firmalar üzerinde pozitif etkiler yaratmaktadır. Belli bir mekansal alanda odaklanmış firmalar arasındaki ağ ekonomilerinin bilgi akışını hızlandırması nedeniyle ise bilgi dışsallıkları, özellikle bölgesel ekonomiler için kritik öneme sahip olmaktadır. Bu çalışma, Türkiye'de bölgeler itibariyle 1989 – 2008 zaman periyodunda bilgi dışsallıklarının varlığını, ortaya çıkan bilgi dışsallıklarının türlerini ve ekonomik etkilerini ampirik bulgular ile ortaya koymaktadır. Bu çalışmanın temel odak noktası, yenilikçi çıktılar üretmeleri ve dolayısıyla bilgi dışsallıkları üreterek bölgesel ekonomileri etkilemeleri açısından orta-yüksek ve yüksek teknolojili endüstrilerdir. Bu bağlamda ampirik bulgular, Türkiye'de dinamik bilgi dışsallıklarının static bilgi dışsallıklarından daha sık ortaya çıktığını ve bölgesel ekonomileri de genellikle pozitif etkilediklerini göstermektedir. Ayrıca, Marshall – Arrow – Romer bilgi dışsallıklarının 2001 yılı öncesinde bölgelerde en sık ortaya çıkan bilgi dışsallığı türü olduğu gözlenirken, 2001 sonrasında Porter bilgi dışsallıklarının en sık görülen bilgi dışsallıkları haline geldiği tespit edilmiştir.

Anahtar Kelimeler: Bilgi Dışsallıkları, Yüksek Teknolojili Endüstriler, Mekansal Ekonometri

1. Introduction

Scitovsky(1954) classified external scale economies into two branches: pure (technological) and pecuniary external scale economies, both of which are tools to decrease average costs. In pure external economies assuming perfectly competitive markets, industry-wide output improvements affect technological relationships between inputs and outputs in each firm. Moreover, an output increase in industry improves each firm's knowledge stock by the courtesy of positive externalities. This improvement provides output growth at the firm level. In pecuniary external economies assuming imperfect competition in the market, however, externalities are reflected to the firms by the price mechanism (Brakman et al. 2003: 26-28). In this context, knowledge is an economic fact contributing to economic growth and development by creating external scale economies. Moreover, knowledge externalities are the externalities that cause the new production knowledge to spill between production units without control of the inventor. These spillovers provide technological and pecuniary economic benefits to other producers who did not participate in invention costs.

In this sense, the main focus of this article is high-technology (high-tech) industries due to the fact that these industries mainly create knowledge externalities. High-tech industries use high technology production techniques in production processes and produce high technology outputs. They help to improve the performances of other industries by providing positive spillovers (Hatzichranoglou, 1997: 4). From this view, the context of this research is the Turkish medium-high and high-tech manufacturing industries located in NUTS2 regions between 1989 and 2008. The main hypotheses of this study are; (i) high-technology industries create knowledge externalities by producing innovative outcomes and (ii) knowledge externalities contribute to the regional economic growth by the courtesy of total factor productivity (TFP) enhancements. In the context of these hypotheses the main purposes of this study are to show spatial clustering behaviour of medium-high and high-tech Turkish manufacturing industries in NUTS2 regions; to determine the types of knowledge externalities occurring in these industries and to analyse the impacts of knowledge externalities on regional TFPs.

Following these aims, this study tries to make a contribution to the literature by making one of the most comprehensive and detailed knowledge externalities analysis for Turkish NUTS2 regions. In this context, the main contributions of this study are twofold. Firstly, this paper consists of the most comprehensive knowledge externalities analysis for Turkey. Kiymalioglu and Ayoglu(2006) have made an analysis about knowledge externalities occurred in manufacturing industries in Turkish NUTS3 regions between 1985 and 2000. However this paper has extended the time period of analysis to 1989 – 2008. Moreover, spatial econometric methods have been applied for the first time in the literature in order to detect knowledge externalities in Turkish high-tech manufacturing industries. As the second main contribution of this study, this paper is also important for the literature due to the fact that 4-digit manufacturing industry data have been used and hence analyses of this paper is one of the most comprehensive spatial knowledge externalities analyses in the literature.

This article is organized as follows. Following the introduction in Section 1, knowledge externalities are defined as an economic concept and their contributions to the regional economy are explained in Section 2. Then a brief literature review is provided. In Section 3 spatial econometric methods and spatial panel data analysis are shortly explained. In this context, data set, variables and estimated models of this study are introduced. In Section 4, the main empirical results are presented. Lastly, in Section 5 conclusions and discussions for further research are made.

2. Knowledge Externalities and Their Impacts on the Regional Economy

2.1. Definitions of Knowledge Externalities

The knowledge externalities are defined as new production knowledge spilled over without the control of the innovator. Knowledge externalities create positive impacts on other agents’ productions by both pure and pecuniary externalities.

According to their sources, knowledge externalities are classified as: Marshall-Arrow-Romer (MAR) knowledge externalities, Jacobs knowledge externalities and Porter knowledge externalities. Basically, MAR externalities are based on specialisation; Jacobs externalities are based on diversity in economic activities and Porter externalities are based on local competition.

Marshall (1890) stated that the concentration of an industry in a region increases spillovers of knowledge between firms and hence contributes to the growth of both region and industry. Arrow (1962) made the first formulisation of this idea and Romer’s (1986) study made one of the most remarkable contributions to this view (Glaeser et al., 1992: 1127). Romer developed a model which characterised knowledge as a production input which increases marginal productivity. Hence Romer formed a competitive equilibrium model with endogenous technological change.

Porter also mentioned the importance of knowledge externalities in geographically concentrated industries in terms of their contributions to the economic growth. However, he emphasized that local competition improves innovativeness and thus knowledge externalities are maximized in the regions having geographically concentrated competitive industries (Glaeser et al., 1992: 1128). The impact of local competition is the primary difference between MAR and Porter approaches to knowledge externalities (Glaeser et al., 1992: 1131).

Moreover, Jacobs (1969) pointed out the importance of industrial diversity. According to the Jacobs’ view, because the regions with more industrial diversity will bring more interchange of different opinions, industrial diversity contributes to the economic growth more than specialisation (Glaeser et al., 1992: 1132). Jacobs believes that the most important knowledge transfer comes out of the core industry. Jacobs also stated that local competition is important for local economic growth and innovativeness (Glaeser et al., 1992: 1128).

After defining knowledge externalities as to their sources, it should be mentioned that it is also possible to define them as to the period in which they are influential. In this sense, static knowledge externalities are the externalities that influence output levels, TFPs, behaviours and decisions of firms and industries in the time period in which they occurred. Dynamic knowledge externalities are the externalities those occur in previous periods and influence output levels, TFPs, behaviours and decisions of firms and industries in future periods. Thus, a cumulative process is valid about dynamic knowledge externalities (Henderson, 2003: 3-4).

Lastly knowledge externalities can be distinguished as: pure (technological) and pecuniary knowledge externalities according to their impacts in the economy by following Scitovsky (1954). In this context the output increase in an industry may increase each firm’s output level by affecting production technologies. This is called pure (technological) knowledge externalities. However, if the pecuniary knowledge externalities are relevant, then externalities are reflected to the firms by price mechanisms in the market (Brakman et al., 2003: 26-28). Pecuniary knowledge externalities occur because of the supply and demand linkages. Especially under the imperfect competition and increasing returns conditions, pecuniary externalities are critical for the market welfare. Pecuniary externalities arise from market imperfections of both demand and supply. Market-size effects are important form of pecuniary externalities and it means that as the market becomes larger, then the more firms can increase their output without cutting their prices. Also, if one firm's actions affect the demand for the product of another firm, of which price exceeds the marginal cost, then pecuniary externalities are in case (Krugman, 1990: 4).

2.2. The Impacts of Knowledge Externalities on Regional Economy

Spatial proximity of economic agents in the form of industrial agglomeration helps new knowledge creation in three ways. First of all, it helps to decrease knowledge transfer costs. Secondly, it provides the specialisation of scientific and technological labour force and hence increases the efficiency in new knowledge creation. Lastly, it increases the speed of knowledge transfers and making it easier to get benefits from knowledge externalities (Antonelli, 2003: 10). In short, agglomeration of industrial units supports spillover of knowledge externalities in numerous ways. Consequently, agglomeration directly affects firms' performances, increases the industrial competitiveness and hence reinforces regional competitive advantages (Asheim, 2002: 112). Hence, regional TFP and economic growth would increase, as the spillover of knowledge externalities increase.

The agglomeration of innovative agents like high-tech firms, research units etc…, increase mostly the pecuniary knowledge externalities by decreasing prices (costs) of goods (inputs) under the equilibrium point and thus economic agents can get real benefits (Antonelli et al., 2011: 26). In addition, the spillover of knowledge externalities in a region, directly and positively affect technological relationships between input and output in production processes. Hence pure knowledge externalities are also relevant in the regional economy.

3. Literature Review

Adam Smith was the first economist who highlighted the importance of knowledge as an economic concept providing technological development and hence economic growth. After Smith, many famous economists like Karl Marx, Alfred Marshall, Joseph A. Schumpeter, Tibor de Scitovsky and François Perroux studied the role and importance of knowledge and knowledge externalities in economic processes. Later, many studies have been published about spatial agglomeration and knowledge externalities relationships in 1990s. The main research question of these studies has been why consumers and producers tend to agglomerate in locations where others have already agglomerated (OECD, 2009: 70). This economic stream is called the New Economic Geography Paradigm and Paul Krugman took the lead of this approach. Furthermore, the New Industrial Geography Stream has described knowledge externalities and knowledge spillovers as agglomerative forces for industrial activities. In this view, spatial proximity especially increases pecuniary knowledge externalities. Because in this case, prices (costs) of goods (inputs) are less than the equilibrium price and hence economic agents get real benefit while purchasing knowledge (Antonelli et al., 2011: 26).

Since the 1990s there have existed many empirical studies conducted to analyse the existence, types and impacts of knowledge externalities in different countries. Most of these studies on knowledge externalities present empirical results for European countries. Lesage and Fischer(2012), Autant-Bernard and LeSage(2011), Antonelli et al.(2011), Zheng(2010), Fischer et al.(2009), Frenken et al.(2007), Suedekum and Blien(2005), Van Stel and Nieuwenhuijsen(2004), De Lucio et al.(2002) and Paci and Usai(1999) are the studies that have found mainly positive impacts of knowledge externalities in the European economies. However Neffke et al.(2011) applied an empirical analysis for Sweden during 1974 – 2004 and they found that as the maturity of an industry increases the impacts of Jacobs externalities may turn to negative. Moreover Van der Panne(2004) found negative impacts of competition on innovation in Netherlands between 2000 and 2002. Lastly, Combes(2000) stated negative impacts of all 3 kinds of knowledge externalities on French economy for the 1984 – 1993 time period.

There are also many studies about knowledge externalities in USA. The studies that have found positive impacts of knowledge externalities in US are; Lim(2007), Ketelhohn(2006), Henderson(2003), King III et al.(2003), Henderson(1997) and Glaeser et al.(1992). Feldman and Audretsch(1999) however applied an empirical analysis for the year of 1982 and they found negative impacts of MAR externalities on innovativeness in USA.

Zheng(2010) and Batisse(2002) conducted empirical researches on Japan economy. Zheng(2010) applied an empirical analysis for 1985 – 1993 and found that MAR and Jacobs knowledge externalities didn't have any impact on regional industrial growth in Japan. Batisse(2002) also presented estimation results of 30 industries in 29 cities between 1988 and 1994. According to the results MAR knowledge externalities have negative impacts on local economic growth.

Moreover, Gao(2004) applied empirical estimations on the Chinese economy and reached positive results about knowledge externalities. Bun and Makhlouf(2007) found negative impacts of Porter externalities on Moroccan industries and cities during 1985 – 1995.

Kıymalioglu and Ayoglu(2006) applied a dynamic panel data analysis on 67 Turkish cities and 9 main manufacturing industries for 1985 – 2000. They found that MAR externalities are dominant in Turkish manufacturing industries.

In the empirical literature, the evidence is generally suggest that all kinds of knowledge externalities contribute to the innovation, regional economic growth and productivity. Also there is nearly a consensus about the positive effects of agglomeration on regional economies in the empirical literature.

This study tries to make some contribution to this literature by conducting one of the most comprehensive and detailed knowledge externalities for Turkish NUTS2 regions. In this context, the main contributions of this study are twofold. First of all, this paper includes the most comprehensive knowledge externalities analysis for Turkey. Although Kiymalioglu and Ayoglu(2006) have conducted a knowledge externalities analysis for Turkey, this analysis was for 1985 – 2000 period. Also they used standard econometric techniques which were not taking into account spatial effects. However, this paper has extended the time period to 1989 – 2008 and also applied spatial econometric methods. As the second main contribution, this paper used 4-digit manufacturing data, which have not been used by other studies in the literature due to some difficulties about reaching the trustable and continuous data.

4. Method, Data Set and Econometric Model

4.1. Spatial Econometric Methods and Spatial Panel Data Analysis

Spatial econometrics is a sub-branch of econometrics trying to explore spatial impacts in econometric methods. The main idea behind spatial econometric analyses is that data about regions or any other type of geographic areas are not independent from each other. In other words, a geographic unit's data show similarity to other spatially close geographical units (LeSage & Pace, 2010: 355). Hence if the neighbourhood relationships are taken into account while applying econometric analyses, then empirical outcomes will become more meaningful.

There are two main types of spatial econometric models. They are: Spatial Lag Model and Spatial Error Model. Firstly, the Spatial Lag Model is defined as follows:

$$\mathrm{Y_{it}} = \rho \sum_{j=1}^{n=1} \mathrm{W_{itj} Y_{jt}} + \sum_{r=1}^{k} \mathrm{X_{irt}} \beta_{\mathrm{rt}} + \epsilon_{\mathrm{it}} \quad (1)$$

Here Y is the dependent variable, X is the independent variable, Є is the error term, W is the spatial weight matrix and ρ is the spatial autoregressive coefficient. If ρ coefficient equals to zero, spatial lag model is not valid (LeSage & Pace, 2010: 357). In this case, the model becomes a normal regression.

Moreover, the Spatial Error Model is as follows:

$$Y_{it} = X_{it} + \epsilon_{it} \qquad \epsilon_{\mathrm{it}} = \lambda \sum_{j=1}^{n} \mathrm{W_{ij}} \epsilon_{\mathrm{it}} + \mathrm{u_{it}}, \qquad \mathrm{E}(\epsilon\epsilon') = \Sigma = \sigma^2\, \mathrm{I} \quad (2)$$

The main feature of this model is the existence of spatial autocorrelation between error terms.

In the equations above, spatial weight matrix is a matrix which shows the neighbourhood relationships of analysed geographical units in the spatial analysis. A weight matrix is a symmetrical positive valued matrix which is constructed by lines and columns and the number of these lines and columns is equal to the number of analysed spatial units. In this matrix, cells having the value of 1 express the neighbourhood relationship and cells having the value of 0 express the absence of neighbourhood relationship between analysed spatial units (Anselin, 1988: 19). A simple expression of a weight matrix is as follows:

$$W_{nxn} = \begin{pmatrix} w_{11}\ w_{12} \ldots\ldots w_{1n} \\ w_{21}\ w_{22} \ldots\ldots w_{2n} \\ . \\ . \\ w_{n1} \ldots\ldots\ldots\ldots w_{nn} \end{pmatrix} \quad (3)$$

Weight matrices can be constructed as to contiguity or distance. A contiguity weight matrix can be constructed in 3 different ways according to the definition of neighbourhood. In the case of border neighbourhood, queen, bishop and rook contiguity can be chosen to determine weight matrix. In the spatial econometrics literature, these neighbourhood relationships have been constructed with inspiration from the rules of chess. Rook weights matrices include only shared borders and bishop weight matrices show the neighbourhood relationships as to only vertex. However queen weights matrices define a location's neighbours as to both shared borders and vertex. On the other hand, distance-based weight matrices are formed as to k-nearest neighbour weights (as to k closest spatial units), radial distance weights (as to the threshold distance), power distance weights (as to negative power function of threshold distance), exponential distance weights (as to negative exponential functions of threshold distance) and double-power distance weights (as to double power form of threshold distance). In this study, a queen weights matrix has been constructed in order to see the clustering behaviour of NUTS2 regions as to their TFP values.

In spatial econometric estimations, model selection is a very important issue. Since, if Spatial Error Model is valid and it's ignored, then β coefficients become statistically less meaningful. On the other hand, if Spatial Lag Model is valid but it's ignored, then β coefficients become biased. In spatial econometric estimations, Lagrange Multiplier and Robust Lagrange Multiplier tests' results should be taken into account while determining which model to be chosen. Also, in order to determine whether the model is a fixed effects or a random effects model, Hausman Test statistic should be analysed (Elhorst, 2003: 10-13).

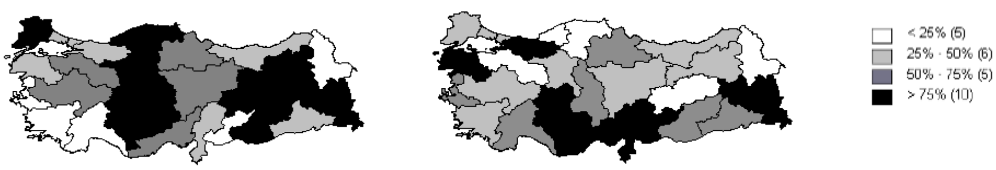
The type of data set is also very important in as much as the model selection in econometric studies. There has been increasing attention on panel data sets in recent years. The main reason of this attention is the fact that panel data provides more modelling possibilities compared to cross-section and time series data sets. Also panel data makes it possible to have higher degrees of freedom and hence more efficient estimation results (Elhorst, 2003: 244).

In the related literature LeSage and Fischer(2012), Autant-Bernard and LeSage(2011), Antonelli at al.(2011), Fischer et al.(2009), Lim(2007), Frenken et al.(2007), Van der Panne(2004), Van Stel and Nieuwenhuijsen(2004) and Paci and Usai(1999) applied spatial econometric methods to analyse knowledge externalities. In this study, spatial econometric methods are also used due to the spatial clustering inclination of regional industrial activities in Turkey. Moreover spatial panel data analyses are applied in order to benefit from the advantages of panel data. Spatial panel data analysis is a relatively new application issue in spatial econometrics. It ensures that analyses take into account both time and cross section dimensions in spatial analyses.

In the spatial analysis context, there are two maps showing Turkish NUTS2 regions' clustering inclinations as to their TFPs below. Two maps are provided for the years of 1989 and 2008 in order to show the change in spatial concentration of industrial activities in Turkey. Figure 1(a) is for 1989 and Figure 1(b) is for 2008. The dark coloured regions are the regions having high TFP values and light coloured regions are the regions having low TFP values. These maps show clearly the agglomeration behaviours of Turkish NUTS2 regions as to manufacturing activities and this is the main reason why spatial methods are applied in this article.

Figure 1: Spatial Clustering of Turkish NUTS2 Regions in 1989 and 2008

Figure 1(a) **Figure 1(b)**



TFP measurement shows the positive shifts in production function. Although it's not the measurement of technical progress in production one by one, it's assumed that it reflects the changes in technical progress as a good proxy (Hulten, 2001: 40). From this view, above maps should be read in spite of successful regions attained high technical progress in

Turkey during this time period. Consequently, some regions in South-Eastern Anatolia produce probably lower levels of output than the western regions of the country, but since their technical progresses are higher, they show better TFP performances.

4.2. Data Set

In this study, medium-high and high-tech industries as to OECD and European Union's industrial codifications have been used. In this context ISIC Rev2 and NACE Rev1.1 industrial classifications have been used for analyses.

In Turkey regional manufacturing data has been published according to ISIC Rev2 industrial classification from 1980 to 2001. After 2001, NACE Rev1.1 industrial classification has been used by Turkish Statistical Institute (TSI) while publishing regional manufacturing industry data.

In Turkey, there are 26 NUTS2 regions and for these regions, manufacturing industry data has been published at 4 digit-level as to ISIC Rev2 for the time period of 1980-2001. After 2001, regional manufacturing data has been published at 2 digit level as to NACE Rev1.1. Because there is no exact transformation method between ISIC Rev2 and NACE Rev1.1, different estimations have been applied for two different time periods. So in this study, 1989-2001 is one of the time periods and 2004-2008 is another time period for empirical analyses. For 1989-2001, 26 medium-high and high-tech manufacturing industries at 4 digit level are used for analyses. However for the 2004-2008 period, 8 medium-high and high-tech industries at 2 digit level are used due to the lack of data for some regions in other medium-high and high-tech industries. The industries analysed in this study are given as to their industrial codes and detailed names in the Table 1A and Table 2A in the appendix. Moreover, regional patent applications data has been gathered from the Turkish Patent Institute for 1989-2008 and are also used in estimations.

4.3. Variables and Econometric Model

In this study, the dependent variable of models is the regional total factor productivity. TFP covers possible output level by using given input level. In other words, TFP measures shifts in the production function. Many factors may cause these shifts such as technical innovations, organizational and institutional changes, changes in social attributes, movements in demand, changes in factor shares, unobserved variables and measurement failures. TFP does not equal to one by one technical changes but it's assumed to be so in order to provide ease in analyses (Hulten, 2001: 40).

One of the main hypotheses of Neoclassical Growth Models is that technological progress brings about economic growth. Especially in recent years, numerous studies in knowledge externalities literature such as LeSage and Fischer(2012), Antonelli et al.(2011), Zheng(2010) and Fischer et al.(2009) used TFP as a dependent variable. In this study, regional TFP is also used as the dependent variable which reflects economic progress and growth of a region. Regional TFP values have been calculated by using the Growth Accounting Approach (Solow, 1957; OECD, 2001).

In this context, assume that the regional economy is expressed by a standard Cobb-Douglas Production Function with constant returns to scale as follows:

$$Q_{rt} = A_{rt}K_{rt}^{(1-\alpha-\beta)}L_{rt}^{\alpha}M_{rt}^{\beta} \qquad (4)$$

Here Q_{rt} is the output level, K_{rt} is the capital level, L_{rt} is the labour level and M_{rt} is the material input level in region *r* at time *t*. A_{it} is a technical coefficient showing production technology. Under the constant returns to scale, it's assumed that the sum of α, β and (1-α-β) equals to 1.

If the natural logarithms of both sides are taken, then the following equation is handled:

$$lnQ(t) = lnA(t) + \alpha lnL(t) + \beta lnM(t) + (1-\alpha-\beta)lnK(t) \qquad (5)$$

If a Neoclassical approach is adopted, then the coefficients of K,L and M can be calculated by taking the ratios of each production inputs to the outputs. Thus α is the ratio of labour to the output; β is the ratio of material inputs to the output and (1-α-β) is the ratio of capital to the output (Onder & Lenger, 2003: 20).

For the 1989-2001 time period, regional production, employment, fixed capital stock and material input data are used to calculate regional TFPs. Since regional production and material input data has not been published after 2001, regional turnover data is used as a proxy for regional output and purchases of goods and services are used as a proxy for regional material input. All the data used for TFP calculation are deflated by GDP deflator and GDP deflator data have been gathered from World Development Indicators Online Database. It should also be mentioned that although 2003 data on wages, turnover and material input data which have been used for TFP calculations after 2001, are published by TURKSTAT, they are not published for 2002. In order to sustain the continuity of data, these data have been calculated from 2003-2008 growth rates of each parameter. Moreover independent variables of analyses are the knowledge externalities indexes and the innovation density.

If it's assumed that sectors are shown by s=1,….,s and regions are shown by r=1,…..,R. So X_{srt} means the production level of s industry in r region on t time. Also X_{st}, X_{rt} and X_t are production of sector s on time t; production of region r on time t and all regions' total production on time t, respectively.

By using these notations the MAR knowledge externalities index is shown as below:

$$Spec_{rt} = (X_{srt} / X_{rt}) / (X_{st}/X_t) \tag{6}$$

This ratio measures the ratio of sector *s*'s production in region *r* to the production of sector *s* in all regions. The high values of $spec_{rt}$ mean the high concentration of sector *s*'s production in region *r* relative to other regions. In other words, high values of this index indicate high specialisation of an industry.

Also diversity index showing Jacobs knowledge externalities is as follows:

$$div_{rt} = -\sum_{k=1,\, k\neq s}^{s} [\, X_{krt} / (X_{rt} - X_{krt})]^2 \tag{7}$$

Here X_{krt} shows the production of the related industry in region *r* on time *t.* This index measures the ratio of sector *k*'s production in region *r* to the sum of other industries' productions. If the value of this index is high, this means diversity is also high.

Moreover Porter externalities index showing competition between local industrial units is shown as follows:

$$Comp_{rt} = (E_{srt}/X_{srt}) / (E_{st}/X_{st}) \tag{8}$$

In this equation, E_{srt} means the number of firms in sector *s* in region *r* on time *t*. However E_{st} means the number of firms in sector *s* in all regions on time *t*.

All three knowledge externalities indexes can be calculated by using employment data instead of production data. In this study, for 1989 – 2001, these indexes have been calculated by using production values. But since regional production data have not been published after 2001, employment data have been used for calculations by following the related literature.

Moreover, as another independent variable, innovative density is used in models. Innovative density is a measurement of the ratio of regional patent applications to the regional employment level.

$$Dens = (No.\ of\ Regional\ Patent\ Applications/Regional\ Employment)*100 \tag{9}$$

This variable has the feature of being a high-tech industries' agglomeration pattern indicator. It has been chosen to include in the econometric model by following Antonelli et al.(2011).

To sum up, the estimated variables are given in the table below.

Table 1: The Estimation Variables

TFP	Total Factor Productivity
Spec	MAR Knowledge Externalities
Comp	Porter Knowledge Externalities
Div	Jacobs Knowledge Externalities
Dens	Innovative Density
W*TFP	Spatial Clustering

Note: The lagged values of the independent variables are shown by -1 and -2 in the estimated models.

In the context of our hypotheses, 4 different models are estimated in this article. The first model is called the static model. This model tries to analyse the effects of static knowledge externalities on the regional TFP. Hence all the variables have their current values in the model. The second and the third models are called dynamic models and they aim to test the effects of dynamic knowledge externalities on current regional TFPs. In this context, in the second model one-year lagged values of independent variables are used for estimations. The third model includes two-year lagged values of independent variables in order to detect if some dynamic impacts occur after one year. Lastly, the fourth model is called as the intertemporal model. In this model, a composition of 3 types of knowledge externalities and innovative density, which are statistically significant according to estimated static and dynamic models, are used. The aim of this model is to show that some effects can dominate or disappear when the effects of static and dynamic knowledge externalities are taken together.

The general structure of the models estimated in this article is as follows:

$$TFP_{rt} = \beta_1 spec_{rt} + \beta_2 comp_{rt} + \beta_3 div_{rt} + \beta_4 dens_{rt} + \beta_5 W{*}TFP_{rt} + e_{rt} \qquad (10)$$

The weight matrix used in spatial estimations has been constructed according to the queen contiguity approach and it is a 26x26 dimensional symmetrical matrix.

Since the spatial lagged dependent variable model has been found as the most significant model in all estimations and also the regional effects are taken into consideration, spatial lagged dependent variable fixed effects model results are used for all estimations. In short, spatial lag model is more significant than the spatial error model in this case.

The main expectation about the signs of knowledge externalities indexes is to be positive. Following the related literature, however, it's known that the effect of MAR externalities may turn to negative in the case of too much specialisation. Also, it's widely accepted in the literature that if there exists price-based severe competition, then this situation may lead to negative impacts of Porter externalities on regional TFP. Lastly, if the diversity in an industry is not in the type of related variety, Jacobs externalities may negatively affect the regional economy. Consequently, the signs of the variables are important to determine the specialisation levels, types of competition and types of diversity in Turkish NUTS2 regions.

For 1989 – 2001, spatial panel data analyses are applied to each of 26 4-digit medium-high and high-tech industries in 26 NUTS2 regions. First 3 models show static and dynamic externalities. Moreoever, the fourth model is estimated for the industries in which externalities are found significant. Hence the fourth model is estimated for only 19 industries in 26 regions. In other words 97 spatial panel estimations' results are presented. Moreover, spatial panel data analyses are applied for each of 2-digit 8 industries in 26 NUTS2 regions and hence 29 spatial panel estimations are presented for the time period of 2004 – 2008 (24 estimations for first three models and 5 estimations for the fourth model). 2004 – 2008 period has been taken since 2002 and 2003 values are used as lagged values for dynamic model estimations.

4.4. Estimation Results

The estimation results of static models in Table 2 show that there are 20 static knowledge externalities in 26 medium-high and high-tech industries. 12 of these knowledge externalities are MAR externalities, 7 of them are Jacobs externalities and 1 of them is a Porter externality. In other words, the SPEC variable which indicates MAR externalities is significant in 12 of the 26 industries; the DIV variable indicating Jacobs externalities is significant in 7 of the 26 industries and lastly the COMP variable which shows Porter externalities is significant only in 1 industry. The impacts of both MAR and Jacobs externalities are negative on the regional TFP in Manufacture of aircraft and Other high technology manufactures classified elsewhere. In four industries (Manufacture of paints, varnishes and lacquers; Manufacture of drugs and medicines including veterinary medicine; Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations and Manufacture of electrical appliances and housewares), however, there exist two types of static knowledge externalities occurring at the same time.

When the one-year lagged dynamic model results are taken into consideration, it may be seen that there exist 27 dynamic knowledge externalities. 16 of these externalities are MAR and 11 of them are Porter externalities. In the dynamic model results, impacts of all knowledge externalities seem positive on regional TFP. Lastly, results of two-year lagged dynamic model estimations show that there are 23 dynamic knowledge externalities occurring in 26 analysed industries.

9 of them are MAR externalities and 14 of them are Porter externalities. Only the impact of the MAR dynamic knowledge externality occurred in Manufacture of motor vehicles is seen as negative on the regional economy.

Moreover, there exist 4 dynamic knowledge externalities occurring in two-year lagged dynamic estimations but not in one-year lagged dynamic estimations. Also there exist 7 dynamic knowledge externalities occurring in one-year lagged dynamic estimations but disappearing in two-year lagged dynamic estimations.

Also, there are neither static nor dynamic knowledge externalities in 4 industries (Manufacture of engines and turbines; Manufacture of office, computing and accounting machinery; Manufacture of railroad equipment and Manufacture of professional and scientific, and measuring and controlling equipment not elsewhere classified) for this time period.

In addition, when the innovative density variable is taken into consideration, current and lagged values of density are statistically significant and have positive impacts on regional TFP in all industries. Lastly, there exist positive and highly significant spatial clustering inclinations in all industries.

Table 2: Estimation Results of Static and Dynamic Models for 1989 - 2001

	3511	**3512**	**3513**	**3521**	**3522**	**3523**	**3529**	**3821**	**3822**	**3823**	**3824**	**3825**	**3829**
STATIC KNOWLEDGE EXTERNALITIES MODEL													
Spec	-0.0005 (0.144)	0.0004 (0.563)	0.002** (0.036)	0.010*** (0.0003)	0.011*** (0.0001)	0.002* (0.085)	-0.00003 (0.973)	-0.0003 (0.142)	0.0001 (0.643)	-0.0005 (0.593)	-0.001 (0.275)	0.0002 (0.675)	0.001* (0.068)
Comp	-0.00001 (0.783)	0.00001 (0.166)	0.00001 (0.148)	0.00003 (0.471)	0.00002 (0.560)	0.000005 (0.825)	0.00002 (0.656)	0.0002 (0.441)	-0.000 (0.999)	0.0003 (0.235)	0.00002 (0.767)	0.000002 (0.913)	-0.00003 (0.404)
Div	-0.015 (0.634)	-0.029** (0.042)	-0.003 (0.116)	-0.006** (0.041)	-0.001*** (0.010)	-0.002*** (0.005)	-0.0007 (0.274)	0.019 (0.683)	-0.004** (0.026)	-0.005*** (0.002)	-0.013*** (0.00001)	-0.013 (0.356)	-0.003 (0.908)
Dens	0.055*** (0.0002)	0.078*** (0.0004)	0.075*** (0.0006)	0.073*** (0.0007)	0.084*** (0.0001)	0.084*** (0.0001)	0.076*** (0.0006)	0.076*** (0.0007)	0.078*** (0.0004)	0.080*** (0.0003)	0.079*** (0.0002)	0.074*** (0.0009)	0.058*** (0.0001)
W*TFP	0.997*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.997*** (0.000)
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (ONE-YEAR LAGGED)													
Spec-1	0.001** (0.032)	0.003*** (0.00008)	0.005*** (0.00004)	0.013*** (0.000003)	0.013*** (0.000007)	0.005*** (0.0006)	0.002** (0.042)	-0.0002 (0.301)	0.001 (0.369)	0.0005 (0.615)	-0.0001 (0.882)	0.0005 (0.409)	0.002*** (0.009)
Comp-1	0.0001* (0.072)	0.00002 (0.114)	0.00001*** (0.010)	0.00007 (0.121)	0.00008** (0.036)	0.00002 (0.310)	0.00007 (0.162)	0.0003 (0.302)	0.0001** (0.010)	0.001*** (0.001)	0.0001 (0.135)	0.00002 (0.209)	0.00001 (0.730)
Div-1	-0.058 (0.261)	-0.023 (0.636)	-0.021 (0.662)	-0.025 (0.605)	-0.045 (0.360)	-0.040 (0.420)	-0.039 (0.443)	-0.041 (0.419)	-0.038 (0.452)	-0.037 (0.465)	-0.039 (0.444)	-0.031 (0.548)	-0.010 (0.840)
Dens-1	0.139*** (0.0007)	0.138*** (0.0007)	0.146*** (0.0003)	0.114*** (0.005)	0.132*** (0.001)	0.140*** (0.0006)	0.134*** (0.001)	0.142*** (0.0006)	0.139*** (0.0008)	0.141*** (0.0006)	0.145*** (0.0004)	0.146*** (0.0004)	0.143*** (0.0005)
W*TFP	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (TWO-YEAR LAGGED)													
Spec-2	0.0008* (0.058)	0.002*** (0.005)	0.004*** (0.0003)	0.001 (0.353)	0.003 (0.101)	0.005*** (0.0009)	0.0002 (0.742)	-0.0002 (0.169)	-0.0002 (0.832)	-0.0005 (0.427)	-0.0005 (0.570)	0.0008 (0.249)	0.001** (0.057)
Comp-2	0.00009 (0.112)	-0.000001 (0.812)	0.00001** (0.013)	0.0001*** (0.0002)	0.00009** (0.033)	0.00001 (0.677)	0.0001 (0.396)	-0.0001 (0.516)	0.0003*** (0.00001)	0.001*** (0.000007)	0.0002** (0.020)	0.00002 (0.103)	0.00007 (0.174)
Div-2	-0.022 (0.691)	0.007 (0.889)	0.005 (0.911)	-0.014 (0.793)	-0.006 (0.907)	-0.010 (0.844)	-0.010 (0.843)	0.0004 (0.128)	-0.009 (0.851)	-0.0005 (0.991)	-0.006 (0.898)	0.0007 (0.988)	0.008 (0.878)
Dens-2	0.167*** (0.0001)	0.171*** (0.00009)	0.171*** (0.00007)	0.168*** (0.0001)	0.166*** (0.0001)	0.171*** (0.0001)	0.169*** (0.0001)	0.165*** (0.0001)	0.168*** (0.0001)	0.163*** (0.0001)	0.171*** (0.0001)	0.172*** (0.0001)	0.170*** (0.0001)
W*TFP	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)

Table 2-continued: Estimation Results of Static and Dynamic Models for 1989 - 2001

STATIC KNOWLEDGE EXTERNALITIES MODEL													
	3831	**3832**	**3833**	**3839**	**3842**	**3843**	**3844**	**3845**	**3849**	**3851**	**3852**	**3853**	**3854**
Spec	0.001** (0.042)	0.001 (0.112)	0.004*** (0.00008)	0.004*** (0.001)	0.0001 (0.715)	0.003 (0.165)	0.002* (0.081)	-0.0007** (0.022)	-0.0002 (0.251)	-0.0003 (0.496)	0.0001 (0.836)	0.004* (0.059)	-0.001* (0.056)
Comp	-0.000006 (0.909)	0.00003 (0.114)	0.0001** (0.025)	-0.00002 (0.581)	0.0009 (0.356)	-0.00003 (0.165)	0.00005 (0.195)	0.00004 (0.286)	0.002 (0.260)	-0.00005 (0.342)	0.00004 (0.687)	-0.0004 (0.709)	0.00003 (0.679)
Div	-0.009 (0.773)	-0.002 (0.955)	-0.006 (0.889)	-0.002 (0.957)	-0.014 (0.652)	0.024 (0.653)	-0.011 (0.707)	0.001 (0.966)	-0.013 (0.776)	-0.014 (0.657)	-0.014 (0.640)	-0.010 (0.852)	-0.015 (0.740)
Dens	0.052*** (0.0004)	0.078*** (0.0004)	0.081*** (0.0002)	0.076*** (0.0005)	0.055*** (0.0002)	0.074*** (0.0009)	0.053*** (0.0003)	0.058*** (0.00009)	0.076*** (0.0006)	0.055*** (0.0001)	0.054*** (0.0002)	0.074*** (0.0008)	0.076*** (0.0005)
W*TFP	0.997*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.997*** (0.000)	0.995*** (0.000)	0.997*** (0.000)	0.997*** (0.000)	0.995*** (0.000)	0.997*** (0.000)	0.998*** (0.000)	0.995*** (0.000)	0.995*** (0.000)
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (ONE-YEAR LAGGED)													
Spec-1	0.002*** (0.003)	0.002*** (0.013)	0.005*** (0.00005)	0.004*** (0.0007)	-0.0002 (0.713)	0.010*** (0.001)	0.004*** (0.011)	-0.0008 (0.368)	-0.0001 (0.338)	0.001 (0.102)	0.003** (0.025)	0.004** (0.046)	0.0004 (0.543)
Comp-1	0.00008 (0.243)	0.00006*** (0.001)	0.0001*** (0.001)	0.000007 (0.859)	0.001 (0.399)	0.000008 (0.730)	0.0002*** (0.0004)	0.0001* (0.081)	0.002 (0.152)	-0.00001 (0.821)	0.0002* (0.079)	-0.0001 (0.927)	0.0001** (0.054)
Div-1	-0.030 (0.541)	-0.027 (0.590)	-0.046 (0.350)	-0.030 (0.542)	-0.040 (0.436)	0.018 (0.738)	-0.047 (0.341)	-0.036 (0.475)	-0.040 (0.427)	-0.044 (0.390)	-0.042 (0.403)	-0.036 (0.516)	-0.044 (0.386)
Dens-1	0.120*** (0.004)	0.141*** (0.0005)	0.147*** (0.0002)	0.128*** (0.001)	0.145*** (0.0005)	0.132*** (0.001)	0.140*** (0.0006)	0.141*** (0.0007)	0.143*** (0.0006)	0.144*** (0.0005)	0.137*** (0.0009)	0.141*** (0.0007)	0.142*** (0.0006)
W*TFP	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (TWO-YEAR LAGGED)													
Spec-2	0.002*** (0.0004)	0.00006 (0.899)	0.006*** (0.00001)	-0.0003 (0.100)	-0.00005 (0.920)	-0.00007** (0.038)	0.005*** (0.001)	0.0002 (0.588)	-0.0002 (0.288)	0.0001 (0.875)	0.0008 (0.433)	0.0008 (0.643)	0.001 (0.195)
Comp-2	0.0001* (0.093)	0.00006*** (0.001)	0.0001*** (0.004)	0.00003 (0.385)	-0.0006 (0.138)	0.00003 (0.158)	0.0001*** (0.00)04)	0.0001** (0.055)	0.003* (0.065)	0.00003 (0.695)	0.0003* (0.035)	0.001 (0.418)	0.0001*** (0.010)
Div-2	0.003 (0.950)	0.005 (0.920)	-0.020 (0.690)	-0.014 (0.793)	-0.009 (0.863)	-0.021 (0.698)	-0.015 (0.766)	-0.056 (0.253)	-0.009 (0.856)	-0.010 (0.851)	-0.010 (0.841)	0.010 (0.860)	-0.012 (0.814)
Dens-2	0.131*** (0.003)	0.174*** (0.00007)	0.167*** (0.0001)	0.166*** (0.0001)	0.161*** (0.0003)	0.164*** (0.0002)	0.161*** (0.0002)	0.158*** (0.0004)	0.167*** (0.0001)	0.172*** (0.0001)	0.165*** (0.0001)	0.172*** (0.0001)	0.161*** (0.0002)
W*TFP	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)

Note : Coefficients are statistically significant at * p<0.10; ** p<0.05 and *** p<0.01. The coloured cells show statistically significant coefficients.

Table 3 shows the estimation results of the intertemporal model for 1989 – 2001. Since there exist no or just one knowledge externality, these estimations are not applied for the industries having ISIC Rev2 codes of 3529, 3821, 3825, 3842, 3849, 3851 and 3853.

According to the estimation results, impacts of some knowledge externalities disappear when intertemporal relationships are taken into consideration. In other words, the impacts of some knowledge externalities dominate some others in this case. This fact can be seen in all industries except Manufacture of synthetic resins, plastic materials and man-made fibres except glass.

Moreover there are 8 static and 28 dynamic knowledge externalities as a result of intertemporal estimations. 5 of static knowledge externalities are MAR-type and 3 of them are Jacobs-type.

Although Jacobs static knowledge externalities have positive impacts on the regional economy, impacts of MAR static knowledge externalities in Manufacture of aircraft and Other high-tech manufactures classified elsewhere, are negative.

17 of the dynamic knowledge externalities are also MAR knowledge externalities. However 11 dynamic knowledge externalities are Porter knowledge externalities. The impacts of Porter dynamic knowledge externalities are always positive according to the estimation results.

When the innovative density variable is taken into account, current values of this variable are statistically significant and have positive signs in all industries except Manufacture of paints, varnishes and lacquers. One-year lagged values of this variable are also statistically significant and have positive impacts on regional TFP in all industries except Manufacture of fertilizers and pesticides and Manufacture of metal and wood working machinery. Lastly, two-year lagged values of this variable are statistically significant and have positive impacts on regional economies in all industries.

Also, according to spatial estimations results there are strong spatial clustering inclinations in all industries.

Table 3: Intertemporal Estimation Results for 1989 - 2001

	3511	3512	3513	3521	3522	3523	3822	3823	3824	3829	3831	3832	3833	3839	3843	3844	3845	3852	3854
Spec	-	-	0.002* (0.091)	0.004 (0.173)	0.004 (0.202)	-0.001 (0.466)	-	-	-	0.0005 (0.582)	-0.001 (0.193)	-	0.003*** (0.002)	0.003** (0.026)	-	0.0009 (0.624)	- 0.0009** (0.053)	-	-0.001* (0.076)
Comp	-	-	-	-	-	-	-	-	-	-	-	-	0.00005 (0.264)	-	-	-	-	-	-
Div	-	- 0.0005*** (0.0004)	-	-0.004 (0.126)	-0.001 (0.520)	-0.001 (0.635)	-	-0.0005*** (0.0003)	-0.001*** (0.00004)	-	-	-	-	-	-	-	-	-	-
Spec-1	0.001* (0.095)	0.001** (0.023)	0.003** (0.020)	0.008** (0.021)	0.009*** (0.007)	0.004* (0.057)	-	-	-	0.002* (0.065)	0.001 (0.331)	0.001* (0.098)	0.002** (0.052)	0.002* (0.099)	0.009*** (0.001)	0.002 (0.264)	-	0.002** (0.033)	-
Comp-1	0.00009* (0.093)	-	0.00001** (0.020)	-	0.00004 (0.342)	-	0.0001 (0.124)	0.0003 (0.164)	-	-	-	0.00002* (0.068)	0.00007 (0.221)	-	-	0.0001* (0.078)	0.00005 (0.436)	0.0001 (0.471)	0.0001 (0.102)
Div-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spec-2	0.0006 (0.104)	0.0005 (0.270)	0.002* (0.077)	-	-	0.003* (0.071)	-	-	-	0.001 (0.154)	0.002** (0.033)	-	0.003*** (0.005)	-	- 0.00006* (0.058)	0.002 (0.218)	-	-	-
Comp-2	-	-	0.00001* (0.059)	0.0001** (0.050)	0.00005 (0.344)	-	0.0002*** (0.00005)	0.0006*** (0.002)	0.0006** (0.030)	-	0.0001 (0.115)	0.00001 (0.248)	0.00009 (0.106)	-	-	0.0001** (0.027)	0.00003 (0.587)	0.0002 (0.117)	0.0001** (0.031)
Div-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dens	0.060*** (0.005)	0.045** (0.001)	0.062*** (0.003)	0.038 (0.107)	0.060*** (0.005)	0.063*** (0.003)	0.064*** (0.002)	0.041*** (0.003)	0.0009*** (0.003)	0.065*** (0.002)	0.062*** (0.004)	0.050*** (0.0007)	0.065*** (0.001)	0.062*** (0.003)	0.064*** (0.002)	0.062*** (0.003)	0.065*** (0.002)	0.063*** (0.003)	0.062*** (0.004)
Dens-1	0.125*** (0.002)	0.027 (0.307)	0.119*** (0.002)	0.090** (0.025)	0.109*** (0.006)	0.123*** (0.002)	0.122*** (0.002)	0.022 (0.394)	0.049*** (0.015)	0.128*** (0.001)	0.097** (0.018)	0.051* (0.063)	0.128*** (0.001)	0.118*** (0.003)	0.109*** (0.006)	0.122*** (0.002)	0.114*** (0.005)	0.119*** (0.003)	0.119*** (0.003)
Dens-2	0.170*** (0.00007)	0.065** (0.019)	0.169*** (0.00004)	0.135*** (0.001)	0.146*** (0.0005)	0.172*** (0.00006)	0.165*** (0.00008)	0.059** (0.032)	0.068* (0.076)	0.168*** (0.00008)	0.137*** (0.001)	0.084*** (0.003)	0.168*** (0.00004)	0.164*** (0.0001)	0.156*** (0.0002)	0.163*** (0.0001)	0.164*** (0.0001)	0.158*** (0.0002)	0.162*** (0.0001)
W*TFP	0.995*** (0.000)	0.997*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.997*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.997*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)	0.995*** (0.000)

Notes : Coefficients are statistically significant at * p<0.10; ** p<0.05 and *** p<0.01

The coloured cells show statistically significant coefficients.

As stated before, there is another time period, as 2004-2008, for which spatial panel estimations are provided. In this time period 8, 2-digit industries are analysed. 5 medium-high and high-tech industries (Manufacture of coke, refined petroleum products and nuclear fuel; Manufacture of office machinery and computers; Manufacture of radio, television and communication equipment and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks and Manufacture of other transport equipment) are out of analyses due to the lack of data. The table below shows the spatial estimation results of static and dynamic models for 2004 – 2008.

Table 4: Estimation Results of Static and Dynamic Models for 2004 - 2008

STATIC KNOWLEDGE EXTERNALITIES MODEL								
	22	**24**	**25**	**28**	**29**	**31**	**34**	**36**
Spec	0.095 (0.126)	0.042 (0.391)	0.059 (0.182)	0.071 (0.141)	0.070 (0.109)	0.011 (0.808)	0.043 (0.119)	0.078** (0.043)
Comp	-0.007 (0.879)	-0.046*** (0.010)	0.134** (0.016)	0.118* (0.057)	0.057*** (0.007)	0.015* (0.077)	0.0005 (0.921)	0.042 (0.220)
Div	0.038 (0.660)	0.031 (0.717)	0.027 (0.747)	0.019 (0.821)	0.024 (0.769)	0.043 (0.622)	0.030 (0.734)	0.042 (0.621)
Dens	5.068 (0.171)	5.869 (0.107)	7.000* (0.058)	6.140* (0.093)	6.568* (0.071)	6.278* (0.084)	5.469 (0.149)	4.877 (0.186)
W*TFP	0.138 (0.223)	0.118 (0.298)	0.148 (0.184)	0.153 (0.174)	0.109 (0.334)	0.149 (0.185)	0.175 (0.115)	0.171 (0.124)
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (ONE-YEAR LAGGED)								
Spec(-1)	-0.065 (0.271)	-0.010 (0.842)	0.011 (0.796)	0.023 (0.601)	-0.009 (0.822)	-0.039 (0.390)	0.007 (0.812)	-0.024 (0.519)
Comp(-1)	-0.026 (0.538)	-0.011 (0.445)	0.021 (0.686)	0.217*** (0.00009)	0.093*** (0.0001)	0.013* (0.098)	-0.009 (0.176)	0.062** (0.053)
Div(-1)	2.219 (0.545)	1.989 (0.600)	1.867 (0.610)	2.627 (0.454)	2.289 (0.523)	2.860 (0.437)	1.330 (0.729)	-1.038 (0.799)
Dens(-1)	13.209 (0.125)	15.205* (0.069)	15.561* (0.064)	16.109** (0.041)	15.996** (0.044)	14.851* (0.072)	14.818* (0.071)	14.250*** (0.0005)
W*TFP	0.230** (0.035)	0.222** (0.043)	0.233** (0.033)	0.179* (0.094)	0.171 (0.113)	0.255** (0.017)	0.220** (0.044)	0.094 (0.401)
DYNAMIC KNOWLEDGE EXTERNALITIES MODEL (TWO-YEAR LAGGED)								
Spec(-2)	0.010 (0.633)	-0.035 (0.505)	0.077* (0.070)	0.041 (0.239)	-0.012 (0.736)	-0.006 (0.773)	0.010 (0.665)	-0.031 (0.304)
Comp(-2)	0.0003 (0.731)	0.004 (0.310)	0.0003 (0.821)	0.016 (0.140)	0.005 (0.398)	0.006*** (0.001)	0.011** (0.053)	0.116*** (0.000)
Div(-2)	1.077 (0.253)	1.476 (0.141)	0.586 (0.601)	1.239 (0.171)	1.277 (0.180)	1.013 (0.256)	0.739 (0.442)	-2.685 (0.115)
Dens(-2)	0.558 (0.308)	0.559 (0.305)	0.519 (0.340)	0.586 (0.281)	0.611 (0.264)	0.633 (0.232)	0.598 (0.276)	8.818 (0.252)
W*TFP	0.275** (0.010)	0.272*** (0.011)	0.229** (0.035)	0.246** (0.023)	0.279*** (0.009)	0.278*** (0.007)	0.222** (0.042)	-0.028 (0.804)

Notes : Coefficients are statistically significant at * p<0.10; ** p<0.05 and *** p<0.01

The coloured cells show statistically significant coefficients.

According to the results; there exist 6 static, 4 one-year lagged dynamic and 4 two-years lagged dynamic knowledge externalities. 5 static knowledge externalities are Porter externalities and 1 static knowledge externality is a MAR externality. All the static knowledge externalities except Manufacture of chemicals and chemical products affect regional TFP positively.

All the one-year lagged dynamic knowledge externalities are Porter externalities and they have positive impacts on regional TFP. Moreover, all two-year lagged dynamic knowledge externalities affect regional economy in positive ways too. 3 of two-year lagged dynamic knowledge externalities are Porter externalities and 1 of them is a MAR externality.

Also, current values of innovative density are statistically significant and positively influential on regional TFP in 4 industries. One-year lagged values of this variable are statistically significant and have positive values in all industries except Publishing, printing and reproduction of recorded media. Two-year lagged values of density are statistically insignificant in all analysed industries.

There are 2 dynamic knowledge externalities which do not occur in the one-year lagged dynamic model but are detected in the two-year lagged dynamic model (Manufacture of rubber and plastic products and Manufacture of motor vehicles, trailers and semi-trailers).

Lastly, there are no spatial clustering inclinations in static model for any industries (as to the W*TFP values) . In the one-year lagged dynamic model only two industries do not exhibit spatial clustering. Finally, in the two-year lagged dynamic model only one industry does not exhibit spatial clustering.

As a result of spatial estimations conducted for the 2004 – 2008 time period, there are both static and dynamic knowledge externalities in industries of 25, 28, 29, 31 and 36. Hence, spatial estimation results of the 2004 – 2008 intertemporal model are given in Table 5.

Table 5: Intertemporal Estimation Results for 2004 - 2008

	25	28	29	31	36
Spec	-	-	-	-	0.083*** (0.007)
Comp	0.138*** (0.013)	0.041 (0.239)	0.095*** (0.000002)	0.026*** (0.002)	-
Div	-	-	-	-	-
Dens	5.490 (0.132)	1.239 (0.171)	9.286*** (0.004)	6.712** (0.046)	-
Spec(-1)	-	-	-	-	-
Comp(-1)	-	0.016 (0.140)	0.132*** (0.000)	0.027*** (0.0007)	0.047* (0.084)
Div(-1)	-	-	-	-	-
Dens(-1)	12.408 (0.160)	0.586 (0.281)	9.922 (0.213)	13.115 (0.117)	8.704 (0.247)
Spec(-2)	0.067* (0.091)	-	-	-	-
Comp(-2)	-	-	-	0.007*** (0.0005)	0.106*** (0.000)
Div(-2)	-	-	-	-	-
Dens(-2)	-	-	-	-	-
W*TFP	0.139 (0.208)	0.246** (0.023)	-0.017 (0.863)	0.115 (0.283)	-0.086 (0.454)

Notes : Coefficients are statistically significant at * $p<0.10$; ** $p<0.05$ and *** $p<0.01$

The coloured cells show statistically significant coefficients.

There are seen 4 static and 6 dynamic knowledge externalities as a result of intertemporal model estimations for the time period of 2004-2008. All of those knowledge externalities affect regional TFP positively. Current values of innovative density are also statistically significant and have positive values in Manufacture of machinery and equipment n.e.c. and Manufacture of electrical machinery and apparatus n.e.c. However one-year lagged values of this variable are statistically insignificant in all industries. Lastly, spatial clustering occurs in just one industry named Manufacture of fabricated metal products, except machinery and equipment.

5. Conclusions and Discussions

In this article, the existence of different types of knowledge externalities in Turkish medium-high and high-tech industries and their effects on regional TFP in Turkey are analysed by using spatial econometric methods. In this context, several estimations about 26 NUTS2 regions of Turkey for the 1989 – 2008 time period have been conducted. There exist 70 knowledge externalities and only 9 of them are negatively influential on regional economies as a result of static and dynamic model estimations for 1989 - 2001. In other words 87.1% of knowledge externalities affect regional TFP positively in Turkey during this time period. In the intertemporal model belonging to this time period, however, there exist 36 knowledge externalities and only 6 of them negatively affect the regional economy. So 83.3% of those knowledge externalities have positive impacts on regional TFP. Moreover, according to the 2004 – 2008 estimation results of static and dynamic models, just one of 14 knowledge externalities has a negative impact on regional TFP. Hence 92.8% of knowledge externalities have positive effects on regional economy. Furthermore, in the intertemporal model for this time period, all of the statistically significant knowledge externalities affect regional TFP positively.

Moreover, the estimation results show that most of the knowledge externalities having negative impacts on regional TFP are Jacobs and MAR externalities. These results indicate the distinction of related variety and unrelated variety and also the importance of overspecialization. This article's findings about negative impacts of Jacobs and MAR externalities are in line with the studies in the literature such as; Neffke et al.(2011), Batisse(2002), Combes(2000) and Feldman and Audretsch(1999).

One of the main arguments against local diversity is how spillovers of knowledge externalities can happen between two irrelevant sectors. For example; it's uncertain how a chicken farm will get a knowledge externality benefit from a textile company operating in the same region. In this context, it's increasingly accepted that the benefits from knowledge externalities can be gathered by complementary sectors. Consequently, only spillover of knowledge externalities between technologically related local sectors will provide regional economic progress (Asheim et al., 2011: 895). Hence, it is important to support related variety in Turkish NUTS2 regions in which Jacobs externalities affecting regional economy negatively.

It should be noted that overspecialization is also crucial for industries due to the fact that in such cases regions cannot use their resources efficiently to produce goods in those they have comparative advantages. This issue negatively affects regional economic growth and development. Hence, in industries in which MAR knowledge externalities have negative impacts on regional TFP, overspecialization should be avoided in Turkey too.

Lastly, although it’s rare, there exist a few Porter knowledge externalities with negative impacts on the regional economy. These empirical findings are in the same line with the findings of Bun and Makhlouf(2007), Van der Panne(2004) and Combes(2000). One can say that competition has positive impacts on an economy when it’s product variety-based competition. When it becomes a price-based competition, then it becomes a detriment to the economy. Since price-based competition causes prices to fall too much and decrease profit levels, the amount of money devoted to innovative activities like R&D, tends to fall. Thus, product-variety based competition should be supported in industries where negative Porter externalities occur among Turkish NUTS2 regions.

To sum up, knowledge externalities occurring in Turkish medium-high and high-tech industries, have generally positive impacts on regional economies. Moreover, MAR knowledge externalities occurred most frequently between 1989 – 2001 -as in the same line with Kiymalioglu and Ayoglu(2006)- and Porter knowledge externalities have occurred most frequently after 2001. These results may indicate both a change in the production behaviours of high-tech firms and a change in the market structure. Although the reasons behind this change may be investigated by another study, one can say that Turkish high-tech manufacturing firms became more competitive in the market after 2001. Also, estimation results show that Turkish NUTS2 regions exhibit a spatial clustering inclination as to their TFPs, especially for 1989 – 2001. Finally, innovative density is one of the main factors contributing to regional economies in Turkey. Hence estimation results of this study suggest that patenting activities should be supported in Turkish NUTS2 regions.

In this study, it has been tried to show the existence and impacts of knowledge externalities that have occurred in high-tech industries on regional TFP. Further research however can be conducted for the impacts of knowledge externalities occurred in high-tech industries on industrial TFPs in Turkish NUTS2 regions.

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Appendix

Table 1A: Medium-High and High-Technology Industries According to ISIC Rev2 Industrial Classification (1989 – 2001)

CODE	INDUSTRY NAME
3511	Manufacture of basic industrial chemicals except fertilizer
3512	Manufacture of fertilizers and pesticides
3513	Manufacture of synthetic resins, plastic materials and man-made fibres except glass
3521	Manufacture of paints, varnishes and lacquers
3522	Manufacture of drugs and medicines (Including veterinary medicine)
3523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations
3529	Manufacture of chemical products not elsewhere classified
3821	Manufacture of engines and turbines
3822	Manufacture of agricultural machinery and equipment
3823	Manufacture of metal and wood working machinery
3824	Manufacture of special industrial machinery and equipment except metal and wood working machinery
3825	Manufacture of office, computing and accounting machinery
3829	Manufacture of machinery and equipment except electrical not elsewhere classified
3831	Manufacture of electrical industrial machinery and apparatus
3832	Manufacture of radio, television and communication equipment and apparatus
3833	Manufacture of electrical appliances and housewares
3839	Manufacture of electrical apparatus and supplies not elsewhere classified
3842	Manufacture of railroad equipment
3843	Manufacture of motor vehicles
3844	Manufacture of motorcycles and bicycles
3845	Manufacture of aircraft
3849	Manufacture of transport equipment not elsewhere classified
3851	Manufacture of professional and scientific, and measuring and controlling equipment not elsewhere classified
3852	Manufacture of photographic and optical goods
3853	Manufacture of watches and clocks
3854	Other

Source: TSI (2001) International standard classification of all economic activities, second revision (ISIC rev.2) manufacturing classification. http://www.tuik.gov.tr

Table 2A: Analysed Medium-High and High-Technology Industries According to NACE Rev.1.1 Industrial Classification (2004 – 2008)

CODE	INDUSTRY NAME
22	Publishing, printing and reproduction of recorded media
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
31	Manufacture of electrical machinery and apparatus n.e.c.
34	Manufacture of motor vehicles, trailers and semi-trailers
36	Manufacture of furniture; manufacturing n.e.c.

Source: Eurostat (1996) NACE rev1.1 statistical classification of economic activities in the European community. Luxembourg.