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Location analysis of manufacturing activity in Greece: A point pattern analysis

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Abstract

This paper implements a point pattern analysis using a novel dataset with exact coordinates of statistical data for Greek manufacturing industry. Specifically, the dataset comprises the precise location of 2.452 observations of enterprises including 146.923 employees. For the year 2018 these industries are divided into twenty-four two-digit NACE 2 sub-industries of manufacturing activity. The method of point pattern analysis permits the estimation of the pattern in manufacturing activity across space. The highest agglomeration appears to be taking place in sectors of High (H) technological intensity as well as in the Middle High (M-H) sectors. In addition, sectors belonging to the middle category and the large category according to the number of employees tend to be more agglomerated in space. Findings reveal that the level of concentration or dispersion differs substantially among different sectors underlying the specialization and dispersion of economic activity in the country.

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1. INTRODUCTION

The study of the location of economic activities constitutes a pole of attraction between scientists. Industries, in contrast to their spatial distribution, choose to concentrate on specific areas where other industries are also accumulated along with large population concentrations. Multitude of authors has integrated in their approaches the benefits for industries from their agglomeration on specific points in space. Weber (1929), Hoover (1937) followed by Isard (1967) and Pred (1977) are among the authors who attempt to explain the phenomenon of industry concentration. The benefits of agglomeration are evident in economic activity since industries appear in clusters and are not randomly distributed in space (Christaller, 1933; Lösch, 1954). As a result, regional competitiveness is strengthened through technology and innovation since it reinforces the cooperation between the private and public sector (Korres et al., 2013). In the present study the existence or not of statistically significant industry agglomeration in the Greek context will be analyzed using two distanced based measures in economic geography, the K_d and M function.

2. LOCATION THEORY AND ECONOMIC GEOGRAPHY

Location theory is closely connected to industrial organization which makes it indispensable part of economic geography (Isard, 1956; Beckman, 1968; Gorter & Nijkamp, 2015; Tsobanoglou & Photis, 2013; Papafragkaki & Photis, 2014). The relationship between geographical location and agricultural land rent aimed at maximizing land entry was studied by Thünen (1826). Launhardt (1885; Launhardt and Bewley, 1900) first studied the choice of location followed by Weber (1909) introducing the spatial triangle in order to identify the point where the total cost per unit distance and weight of material transport becomes the minimum. Agglomeration is crucial and provides benefits in the formation of cities, while the concept of externalities is achieved with better skills, specialized equipment and availability of skilled workers (Marshall, 1925). Hotelling (1929), Polander (1935) and Lösch (1954) affirmed that the location choices of companies in the same industry depend on the choices of competing companies. Concretely, Lösch (1954) argued that the point of minimum cost is not always supported by the point of maximum profit for a company considering the effect of demand on the choice of company's location. Alonso (1964) implemented various types of land use (housing, commercial and industrial) for the accessibility requirements in the city center. Smith (1966) instead of one point in space it defines a wider area by combining the perspective of economic geography for the location of companies providing the opportunity for the company to operate profitably in one area. Local demand and good transportation system in an area has also significant positive impact in geographical clustering.

According to Krugman (1991) agglomeration is one of the most appealing aspects of the geography of economic activity which is strongly related to increased yields, transportation costs and demand. The relationship between space and economy is theoretically established through the new economic geography (Fujita et al., 1999). Economists use concentration indicators such as Gini (1912), Herfindahl (1964) and Ellison and Glaeser (1997) in order to measure economic activity in a specific area. The above mentioned measures examine the existence of agglomeration at a single geographical level which causes sensitivity in the respective selected zone (regional, municipal or national level) (Arbia, 2001; Briant et al., 2010; Bartzokas-Tsiompras & Photis, 2019). In order to study the type of an existing industrial model distance based methods are the most recent statistical measures in spatial economics because they consider space as continuous.

Regarding the Greek context, there exist a variety of approaches for the study of Greek manufacturing industry. In general, these analyses do not use any kind of distance metric so from a spatial point of view they may be considered as a descriptive spatial analysis. Katochianou (1984) conducted a sectoral spatial analysis of Greek manufacturing at each sector and prefecture between 1963 - 1978 calculating Gini coefficient, inter-sectoral and interregional indices in order to examine the participation in regional and national development. Louri and Anagnostaki (1994) studied the determinants of entry in Greek manufacturing industry between the main urban center, Athens, and the rest of the country across 1984 – 87 finding significant influence in Greek periphery. Greek firms located in Athens, experience better survival expectations and tend to agglomerate and benefit from agglomeration economies (Fotopoulos and Louri, 2000).

A study in Greek NUTS-II regions also revealed that spatial clusters occur with firms of the same sector locating close to each other in order to benefit from agglomeration economies although large urban area of Attiki may deter *«congestion effects»* (Filipaios and Kottaridi, 2004; Kottaridi and Lioukas, 2011). Daskalopoulou and Liargovas (2008) identified that strong localization economies exist. More specifically, different causes of externalities among Greek manufacturing start-ups have a great impact due to agglomeration economies (Liargovas and Daskalopoulou, 2011). Vogiatzoglou and Tsekeris (2012) applied two spatial concentration indices, Krugman's and Glaeser's, in Greek manufacturing during the period 1993 – 2006 concluding that high level of agglomeration exists especially on high technology industries. Our study utilizes a novel dataset with exact coordinates of firm data on Greek manufacturing plants and applies point pattern analysis in order to estimate the pattern of manufacturing enterprises in Greek territory weighing it in terms of the number of employees of each industry.

3. Data and Methods

3.1 Data

Our analysis handling a sample of 2.452 observations of *société anonyme* manufacturing firms functioning in Greece of the year 2018 (Table 1). Manufacturing impact on Greek economy accounts for 31% of Greek GDP (55 bil. €) while 31.3% of employment in Greece (IOBE, 2017). ICAP directory provides individual firm information which is published annually and stipulates data based on published accounts of all Greek firms. More specifically, for each firm we dealt with the exact coordinates, latitude and longitude, as well as the number of its employees which is equivalent to 146.923. It is worth emphasizing that in order to make use of the distance based functions, that is K_d and M which analyzed in detail in the following section, the given coordinates will be converted to the Universal Transverse Mercator (UTM) system. In addition, any companies with zero employees were replaced by the value one, indicating that they had at least one employee, the owner. Small scale backyard firms which did not follow accounting standards were excluded. Finally, all duplicates firms were deleted.

Table 1: Greek manufacturing by sector Nace 2 and Technological Intensity, 2018

Manufacturing (Sectoral analysis Nace 2 v.2)	Number of Enterpises	Number of Employees	Tecnological Intensity
Food products	533	43.592	L-T
Beverages	88	6.271	L-T
Tobacco products	11	1.956	L-T
Textiles	93	3.605	L-T
Wearing apparel	136	5.124	L-T
Leather and related Products	*25*	629	L-T
Wood and products of wood and cork, except furniture	48	1.065	L-T
Paper and paper products	97	5.569	L-T
Printing and reproduction of recorded media	104	2.817	L-T
Furniture	80	2.238	L-T
Other manufacturing	79	3.391	L-T
Coke and refined petroleum products	19	4.209	M-L
Rubber and plastic products	157	7.642	M-L
Other non-metallic mineral products	180	7.375	M-L
Basic metals	46	5.643	M-L
Fabricated metal products, except machinery and equipment	246	10.836	M-L
Repair and installation of machinery and equipment	37	2.447	M-L
Chemicals and chemical products	130	8.027	M-H
Electrical equipment	88	5.324	M-H
Machinery and equipment n.e.c	129	3.723	M-H
Motor vehicles, trailers and semi-trailers	22	1.048	M-H
Other transport equipment	13	1.099	M-H
Basic pharmaceutical products and pharmaceutical preparations	50	9.899	H
Computer, electronic and optical products	41	3.394	H
Total	**2.452**	**146.923**	

Source: Based on data obtained from ICAP directory

3.2 Methodology

Distance based methods are the most recent statistical measures in spatial economics since they consider space as continuous. Concentration at all scales is considered simultaneously thus as a result overcoming zoning effect that is Modifiable Areal Unit Problem (MAUP) (Openshaw and Taylor 1981; Openshaw, 1984; Arbia, 1989). Point pattern attempts to estimate of the pattern or distribution, of a set of points on a study area. It can refer to the actual spatial or temporal exact location of these points (events) in the given study area. The term intensity is the mean number of points that is the expected number of points per spatial unit. The intensity can be outlined either as constant, homogeneous, or it can alter from each area that is inhomogeneous. Additionally, we highlight a rather important concept, the *stochastic dependence* which is defined as the interaction among the points of a point pattern. In the vast majority of cases when working in the two dimensional area the respecting point pattern which is defined as a vector **x** with coordinates $\mathbf{x}_i = (x_i, y_i)$ is treated as a realization of the random process **X**. The general spatial distribution process is defined by first and second-order properties.

First order properties depict the spatially varying intensity of a point pattern. The mean value of the distribution at locations across the area of interest is defined as the intensity (Diggle, 1983). Second order properties state that the marginal distributions of points have a constant frequency but the marginal densities of all points is such that marginal distributions of points are not independent (Brunsdon, 2015). If we assume that the distribution of $\mathbf{x}_i$ are independent and the marginal densities are uniform it is often called *Poisson Process* or *Complete Spatial randomness (CSR)*.

Random point process theory is used in order to investigate the empirical spatial distribution. Møller et al. (2004) theoretically substantiated the point process theory and studied square area. A plentitude of windows areas has been examined for example rectangular, circular, an administrative area or study zone (Cole et al., 1999; Szwagrzyk et al., 1993; Arbia et al., 2012 Lagache et al., 2013). If we consider a random set of events at a distance d then the expected number of events will be equal to the frequency multiplied by the distance d.

$$K_{CSR}(d) = \pi d^2,$$

The clustering of the processes can be obtained with the above reference quantity. More specifically, If $K(d) > K_{CSR}(d)$ clustering occurs at distance d while if $K(d) < K_{CSR}(d)$ spatial dispersion exists. $\widehat{K}(d)$ constitutes an estimator of K function (Ripley, 1976). Graphical representation of functions $\widehat{K}(d)$ and $K_{CSR}(d)$ can be used in order to conduct hypothesis testing where null hypothesis is the complete spatial randomness (CSR). A variety of authors suggested hypothesis testing using the principal of Monte Carlo (Ripley, 1977; Ripley, 1981; Hope, 1968; Besag et al., 1977; Besag et al., 1989).

K function initially introduced in economic literature by Arbia and Espa (1996). However, two important constraints are present on Ripley's K function. First, the null hypothesis of random distribution appears to be binding. Secondly, if we wish to include weighting of points which is necessary for studies on industrial concentration following Ellison et al (1997) then the K function cannot include weighting of points. Zoning based spatial concentration indicators were proposed by Maurel et al (1999) which constitutes an attempt to combine spatial statistics with economics.

In order to characterize the spatial concentration of economic activities a variety of economic criteria were proposed (Duranton et al., 2005; Combes et al., 2004; Bonneu et al., 2015). A crucial criterion is the insensitivity of the measure according which a change in the definition of geographical measures in order to avoid the pitfall of the MAUP. It is worth to mention that no measure has yet tackled sectoral divisions. Edge effects problem (Illian et al., 2008; Baddeley et al 2015b) constitutes the main problem where part of the circle is located outside the field of study. The importance of not taking this bias into account when estimating the concentration of industrial activities in France was highlighted by Marcon et al. (2003). Ellison et al (1997) showed that natural advantages have an effect on the location of establishments that is indistinguishable from that of positive externalities which as a result causing the agglomeration.

Distance based functions are classified according to two main criteria. The reference value and the type o function. Marcon and Puech (2017) proposed an initial grouping of distance based functions according to these two criteria. Three reference values can be used. The first are the topographical measures which according to (Brülhart et al., 2005) use physical space as a reference value. Secondly, relative measures use a distribution that is not the physical space. Thirdly, absolute measures do not require any standardization by space or by other references. Monte Carlo method is used in order to compare the number obtained to its value under the null hypothesis (Marcon and Puech, 2017). Neighborhood contribute significantly when studying the proximity of the points analyzed up to a certain distance r or at a certain distance r. Density functions are more precise around the study radius but luck of information at smaller distances in contrast to cumulative functions (Insee, 2018). Wiegand et al (2004) and Condit et al (2000) highlighted that there is not a golden rule in the choice of neighborhood and each choice has its advantages and disadvantages.

Two distance based functions are computed in order to examine the existence or not of spatial agglomeration of Greek manufacturing level. Firstly, the probability density function of Duranton and Overman's K_d (Duranton and Overman, 2005) and secondly the cumulative M function (Marcon, 2010). Industrial establishments are represented in each point weighted by its employee's number in each of the above two functions.

Both K_d and M functions can be regarded as beneficial supplements in economic geography (Marcon, 2010; Marcon, 2012). Duranton et al (2005) proposed an indicator which estimates the probability of finding a neighbor at distance r from each point. It has no reference so is categorized as absolute measure of density with no direct link to point process theory.

$$K_d(r) = \frac{1}{n(n-1)} \sum_i \sum_{j \neq i} k(\|x_i - x_j\|, r),$$

where $k(\|x_i - x_j\|, r) = \frac{1}{h\sqrt{2\pi}} \exp\left(-\frac{(\|x_i - x_j\| - r)^2}{2h^2}\right)$ is the Gaussian kernel.

Counting neighbors at a distance r it requires the use of a smoothing function, hence the use of a Gaussian kernel in the type of function. For the bandwidth K_d function uses the Silverman (1986) method. A confidence interval of the null hypothesis can be constructed in order to assess the significance of the results obtained. The marks, namely the weights, representing employees are redistributed to all existing concentration and the general location trends of all types of points. If the function K_d is above or below the confidence threshold then the null hypothesis of the random position of the S-type points is rejected. Weighting of points can be introduced in the K_d function (Duranton et al., 2005).

Like Ripley's K cumulative function, M indicator is computed around each point by varying a cylinder of radius r. (Marcon et al., 2010). It is a relative indicator since it compares the proportion of points of interest in a neighborhood with the proportion of points seen throughout the territory analyzed M function has the number 1 as a reference value. Spatial concentration exists when values of M function are greater than 1. Respectively, lower values of 1 for M function suggest spatial dispersion with 0 represents the minimum value. The values of M can also be interpreted in terms of ratio comparisons: Finally, like K_d function, M can include weighting of points (Marcon et al., 2017). For the s type points: **M** function of Marcon and Puech.

$$\mathrm{M}(\mathrm{r}) = \sum \frac{\sum_{\mathrm{j}\neq \mathrm{i},\mathrm{j}\in \mathrm{S}} 1(\|\mathrm{x_i} - \mathrm{x_j}\| \leq \mathrm{r})}{\sum_{\mathrm{j}\neq \mathrm{i}} 1(\|\mathrm{x_i} - \mathrm{x_j}\| \leq \mathrm{r})} \Big/ \frac{\mathrm{n_s} - 1}{\mathrm{n} - 1}$$

n_s and n denote the total number of S type points and the entire number of all types of points in the study window. Two frequency rations constitute M function. For each radius r around S type points, a comparison of two averages is made that of the local mean of S type points and that of the whole study area multiplying the indicator by the weight of the neighboring point in question (Marcon et al., 2010) while using Monte Carlo methods a confidence interval can be generated. For M, as for K_d, the control for industrial concentration is not present in the definition of the function but in the definition of the confidence interval as the points weights are redistributed to the existing locations. It is important to be highlighted that correction of edge effects is not essential for M function. Both Kd and M function can be used in order to characterize the spatial distribution of economic activity and to identify the determinants of agglomeration (Marcon et al., 2010). Authors proposed as a general rule when we intend to analyze a point pattern in economics first compute M function in order to have an overview of the spatial structure of the distribution and then Kd to obtain a more detailed picture (Marcon et al., 2010).

3.4 Contiguity matrix for Greece

From a spatial point of view all firms in Greece are divided into two categories, i.e those which are located on continental Greece and those are located on islands. So by construction, the specific location on the map of each firm may be viewed as the result of a random process of a spatial distribution. In order to draw any conclusions about the process which created this distribution or to conclude that the observed distribution is just random we have to study the relations among the firms location (Cliff and Ord 1981; Tiefelsdorf, 2000).

It is a common practice in spatial analysis to define spatial relations as the Cartesian product of locations of the firms under study resulting in an $n \times n$ matrix representing the structure of the space, called contiguity matrix. The elements of this matrix are either zero indicating no relationship between the corresponding spatial objects, or some positive value indicating some degree of spatial inference between the firms. So by constructing contiguity matrix is semi positive matrix (Lancaster, 1968). In the special case of Greece contiguity matrix has the form $\begin{bmatrix} W_{CG} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{bmatrix}$ where W_{CG} is a contiguity matrix of firms located on continental Greece while zeros represent spatial interactions among firms located on islands. It must be noted that it is assumed that there is no direct relationship between firms which are located on islands. As a result, the only firms that interfere each other from a spatial perspective are only those that located on continental Greece. Concluding, we may write the spatial interference as $\rho W_x = x, W_x = kx$ where following (Lancaster, 1968) we may partition matrix W and vector x into X_{CG} containing the firms located on continental Greece and X_{IG} the rest of them located on islands and correspondingly the matrix W into $\begin{bmatrix} W_{CG} & 0 \\ 0 & W_{IG} \end{bmatrix}$ where W_{CG} , W_{IG} describes the spatial structure of continental Greece and island respectively while the zeros indicate the absence of spatial relationships among any pair of firms containing at least one firm located on a island. Then,

$$\begin{bmatrix} W_{CG} & 0 \\ 0 & W_{IG} \end{bmatrix} \begin{bmatrix} X_{CG} \\ X_{IG} \end{bmatrix} = k \begin{bmatrix} X_{CG} \\ X_{IG} \end{bmatrix},$$

$$W_{CG} \cdot X_{CG} = kX_{CG}$$

$$W_{IG} \cdot X_{IG} = kX_{IG}$$

The above result signifies that from a spatial point of view we may proceed to the analysis of continental Greece without island regions as they are independent of our analysis. It must be noted that W_{IG} may have elements different to zero, if there are more than one firms located on the same island.

4. RESULTS

Out of a total of 2.452 companies (Table 1) and 146.923 employees we can highlight the following: Observing Figure 1 it is clear that the largest number of firms is concentrated in the metropolitan areas of Athens and Thessaloniki which is reasonable since there is located 52% of the Greek population. In the following two sections primarily analyze M and K_d functions. As will emerge from our analysis the specialization, concentration and dispersion of economic activity in Greece differs significantly between different sectors. In the last sections we consider the relationship between the type of the point pattern (agglomerated, dispersed or none) with technological intensity or industry size.

Figure 1. Weighted distribution by employees of all Sectors in Greece, 2018
Source: Based on data obtained from ICAP directory

4.1 M function

Analyzing M function (Appendix 6.2) we observe that when agglomeration exists, that happens at very short distances (Table 2). More specifically, examining M function at r = 10 km, namely M(10), we can observe the following: The six most statistical significant agglomerated sectors (Table 2) are: 1) Repair and Installation, 2) Wearing Apparel, 3) Basic Pharmaceuticals 4) Food products, 5) Other transport equipment and 6) Leather and related products.

By way of example, M(10) for Leather & related products equals 5 indicating that on average there is a 5 times higher frequency for Leather & related products around Leather & related products. M(10) for Basic Pharmaceuticals equals 1.7 indicating that on average there is a 1.7 times higher frequency of Basic Pharmaceutical manufacture around basic Pharmaceuticals. Finally, M(10) for Repair & Installation of Machinery equals 5 indicating that on average there is a 5 times higher frequency of Repair & Installation of Machinery around Repair & Installation of Machinery. According to M function, most dispersed manufactures are 1) Textiles, 2) Furniture and 3) Machinery.

Table 2. Intra-industry agglomeration (M function) by sector (Nace 2)

Industry	M (10)	Pattern	Spatial extent (km)
Basic Pharmaceuticals	1.7*	agglomeration*	All distances
Repair & and installation of machinery & equipment	4.8*	agglomeration*	0 -10
Food products	1.2*	agglomeration*	All distances
Wearing apparel	3*	agglomeration*	0 - 90
Other transport equipment	5*	agglomeration*	0 - 10
Leather & related products	5*	agglomeration*	0 - 50
Textiles	0.8	dispersion	0 - 10
Furniture	0.8	dispersion	0 - 50
Machinery equipment	0.7	dispersion	0 - 25

Note: *significant at 5%

4.2 K_d function

Therefore to K_d function (Appendix 6.1) we underline that when agglomeration exists, that happens between zero and fifty kilometers (Table 3). Our results indicate that most agglomerated and statistical significant sectors at distance r are the following: 1) Basic Pharmaceuticals 2) Chemicals & chemical products, 3) Electrical equipment and 4) Other manufacturing. However, strong agglomeration but not statistical significant exists in sectors i) Repair & Installation of machinery and in ii) Printing & reproduction of recorded media. It is worth highlighting that the highest probabilities of finding a neighbor are noted on Basic Pharmaceuticals and on Repair & Installation of machinery at distance 25 km and 50 km respectively. Accordingly, one sector presents statistical significant dispersion the Tobacco products. Lastly, 3 sectors exhibit dispersion: 1) Wood & Products,

2) Textiles and 3) Beverages. As quoted above, the two functions, M and K_d, are complementary so the sectors that exhibit simultaneous concentration within distance r (M function) and at the distance r (Kd) are Basic Pharmaceuticals and Repair & Installation of machinery. Respectively, only Textiles reveal dispersion in both M and K_d functions.

Table 3. Intra-industry agglomeration (K_d function) by sector (Nace 2)

Industry	**K_d**	**Spatial extent (km)**
Basic Pharmaceuticals	agglomeration*	0-25
Chemicals & chemical products	agglomeration*	0-45
Electrical equipment	agglomeration*	0-45
Other manufacturing	agglomeration*	0-40
Repair & and installation of machinery & equipment	agglomeration	25-50
Printing & reproduction of recorded media	agglomeration	0-40
Tobacco products	dispersion*	0-75
Wood & products of wood	dispersion	0-50
Textiles	dispersion	0-40
Beverages	dispersion	0-25

Note: *significant at 5%

4.3 Technological Intensity and Industry size

According to Eurostat indicators for technological intensity we consider whether there is any relationship between the different levels of technological intensity and the respective industry according to K_d function from which we can extract valuable information. Based to the low-tech industries, the industries exhibit no concentration are i) Food Products, ii) Wearing apparel, iii) Paper & Paper products and iv) Furniture. Conversely, high concentration exhibit industries of i) Printing and ii) Other manufacturing. Finally, sectors with high dispersion are i) Tobacco products, ii) Wood iii) Textiles and iv) Beverages In conclusion we note that in the 11 branches belonging to low technological intensity 36% percent shows no concentration while 36% displays dispersion. Finally, 18% of low technology intensity sectors appear statistical significant agglomeration.

Concerning the medium technology intensity sectors we identify the following interesting results. Four sectors are neither concentrated nor dispersed. The sectors are i) Rubber & Plastic Production, ii) other non – metallic mineral, iii) basic metals and iv) Fabricated metal products. High concentration exists in sectors i) Repair & In. of Machinery and ii) Coke & Refined Petroleum while no dispersion exists. In conclusion, 67% of the medium technology sectors are neither concentrated nor dispersed. The rest 33% are concentrated.

Regarding the medium high technology intensity sectors we identify the following compelling outcome. Four out of five sectors exhibit strong agglomeration namely, i) Chemicals & Chemical Products, ii) Electrical equipment, iii) Motor Vehicle (non-statistical) and iv) Other Transport (non-statistical) while one sector, Machinery & equipment does not present anything. With respect to high technology intensity sectors we identify the following interesting results. Both 2 sectors exhibit high agglomeration patterns Basic Pharmaceuticals and Computer & electronics. Especially, Pharmaceuticals presents the highest statistical significant agglomeration from all over the sectors.

Therefore, by classifying the sectors in terms of technological intensity, we conclude that the branches with the highest concentration are the branches of High Technology and medium high technology indicating that technology matters in agglomeration patterns. On the contrary, low-tech sectors exhibit the greatest dispersion. An interesting conclusion emerges from the medium technology sector where 67% of companies show neither concentration nor deviation.

Aspiring to examine the relationship between the size of sectors and the existence or non-existence of statistically significant concentration, we divide the sectors into 3 major categories depending on the number of employees. The average number of employees is equal to 6.122 therefore that value is used for the definition of middle and upper sector class. As a **i)** *small* sector we define sectors that have from 600 to 2.300 employees. A **ii)** *medium* sector ranging between 2.300 to 6.122 employees and **iii)** *large* sector above 6.122 employees respectively. Similarly, according to K_d function five sectors exhibit statistical significant agglomeration. Two out of five sectors belonging to large group present statistical significant agglomeration, Chemicals and Basic Pharmaceuticals, resulting 40% of all statistical significant sectors and 29% of the large group. The rest of the sectors do exhibit neither agglomeration nor dispersion. Medium category of sectors contains 3 statistical significant sectors which constitutes 60% of sectors with statistical significant agglomeration and 40% of medium category. According to small sector category there is no indication that sectors with a low number of employees tend to be more concentrated on space. To conclude, sectors belonging to the middle category and the large category tend to be concentrated in space.

The present study allows comparing Greek manufacturing sector with other countries. For example, the patterns coincide with those of economic theory in relation to the technology sector for the Spanish manufacturing sector confirming the literature that the high-tech industry is the most concentrated. (Albert et al, 2012). According to the wide spread of urbanization, networked structures that exist in urban areas with high technological economic development attract and are agglomerated together with rural areas (Vysluzilova, 2019). This paper confirms that also for Greek manufacturing sector, the greatest geographical concentration appears to be on high tech and middle high technological intensity industries. Conversely, many studies advocate that the greatest geographical concentration exists in low tech industries. The same conclusion reached both for the United Kingdom and France. Devereux et al (2004) underlined that *«The industries with the greatest geographical concentration seems to be on low tech»* while Maurel and Sedillot (1999) revealed that the most agglomerated sectors are textiles and leather products, two of the most conventional and low-tech sectors. More specifically, similar agglomeration patterns between countries tend to follow the manufacturing sectors of Spain, the United Kingdom (Albert et al, 2012) and Japan (Nakajima et al., 2012).

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5. CONCLUSION

Industry agglomeration creates economies of various forms such as scale, concentration, and urbanization. Our study applies in the Greek context the method of point pattern analysis and identifies five important findings. First, the highest agglomeration appears to be taking place in sectors of High technological intensity as well as in the Middle High sectors. The speed of technological diffusion in companies is enhanced by urban size while the greater the certainty provided in urban centers, the more likely it is to create new businesses. Secondly, Low-Intensity technologies exhibit the greatest dispersion which highlights the different composition of Greek industry in relation to other countries (England, Spain). Thirdly, from our analysis seventy percent of Mid Tech firms do not seem to be agglomerated or divergent. Our fourth finding deals with the identification of the relationship between the existence of concentration or divergence and the number of employees separating all industries into three categories. In this direction, agglomeration observed in middle category and in large category. Finally, it is worth noting that in almost all cases where concentration takes place, it is achieved up to 40 - 50 km suggesting strong agglomeration economies. In a nutshell, agglomeration exists in middle category and large category and at the same time on high technology and medium high technology. These results are consistent to the economic geography and the evaluation and fulfillment of regional policy. Of particular interest in a future study is the composition of industries in the metropolitan region of Attica, the capital of Greece, an area with the highest concentration of businesses and at the same time population density. This will allow us to compare Attica with other metropolitan areas with similar conditions.

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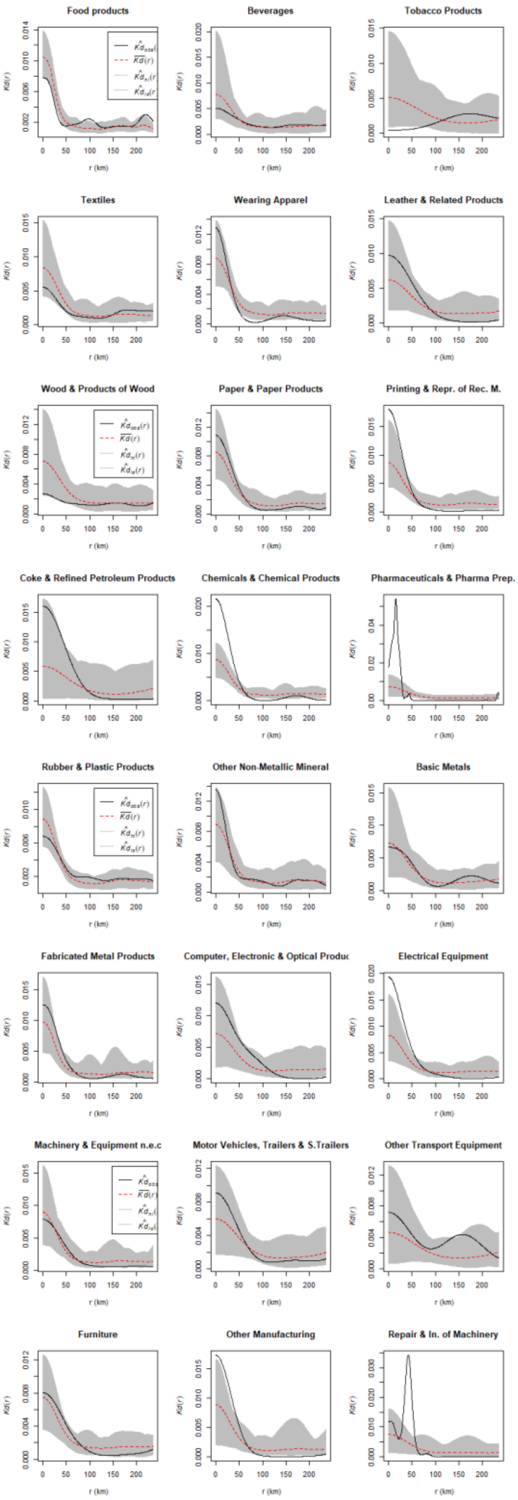
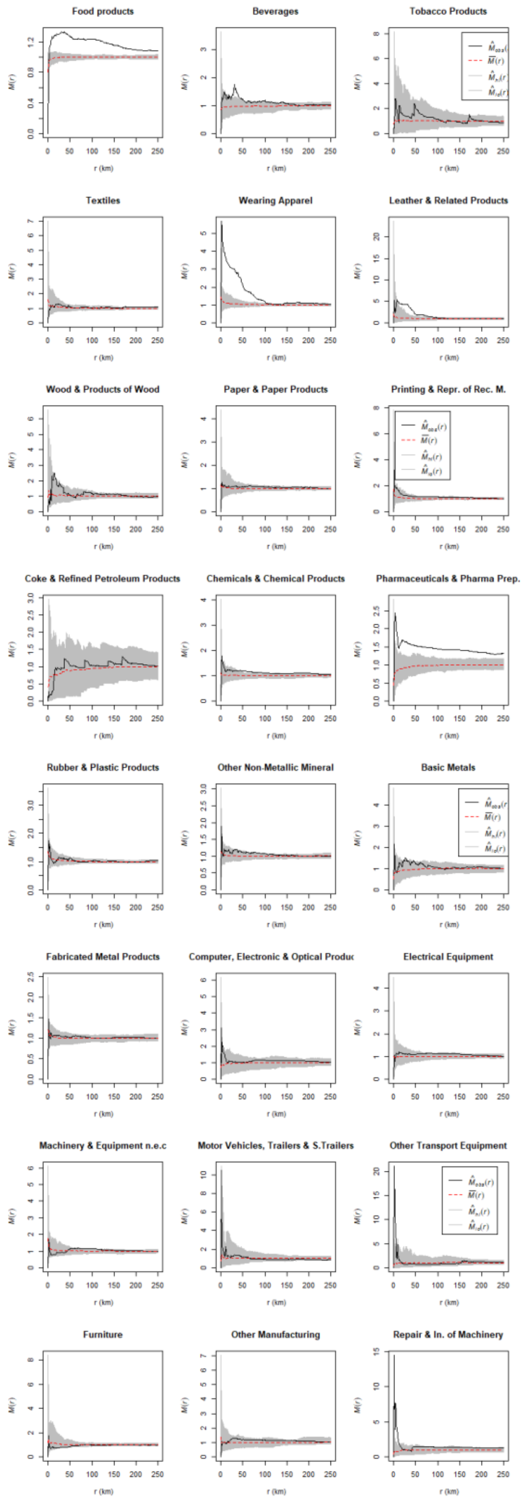
APPENDIX

6.1 Results of K_d function



6.2 Results of M function



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