Ann Reg Sci (2017) 59:209–230
DOI 10.1007/s00168-017-0827-4

ORIGINAL PAPER

Regional and structural analysis of the manufacturing industry in Turkey

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Received: 14 March 2016 / Accepted: 17 April 2017 / Published online: 5 May 2017

Abstract The geography of the manufacturing industry has been changing due to technological development, flexible production and reducing transportation costs regarding the new specialization and distribution process in the world. While manufacturing production has been moving from developed countries to the relatively less developed ones, which have become the emerging economies over the last two decades, the concentration of these activities within the countries has always received the attention of researchers. On the other hand, not only the geographical shift but also structural shifts have increasingly been an important phenomenon of the twenty-first century. It is known that the level of technology and innovation makes a significant contribution to regional economic development. Determinants of manufacturing agglomerations have created a wide literature based on different empirical studies. Moreover the structural changes of industry need to be investigated regarding the spatial agglomerations. The aim of this paper is to explore how the factors of manufacturing agglomerations have differentiated due to the technological level across the country. Furthermore, we assume that the agglomeration mechanism is likely to vary across the space. Therefore, we have run both global and local regression models based on the employment data of the 81 NUTS III level regions (provinces) of Turkey in 2012. The results point out

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that the factors of agglomerations are different in the east and west provinces, while GWR has significantly improved global results.

JEL Classification L600 · R320 · O140

1 Introduction

One of the main questions in regional economics literature has long been why some economic activities are concentrated in a certain number of regions. This question is also important as the cities and regions have been faced with structural changes. Therefore agglomeration economies and structural changes need to be taken into consideration with their mutual relationships. According to Imbs et al. (2012), the evolution of sectoral specialization at a country level reflects the joint dynamics of local and global processes, while structural change is associated with systematic changes in the geographical dispersion of activities. In the development economics literature, the countries that are able to diversify away from agriculture to manufacture and services would manage structural changes as developing countries. Furthermore, when labor and other resources move from less productive to more productive activities, the economy grows. This process has both supply and demand side reasons; and the role of business R&D in medium- to high-technology sectors has become significant for technology intensity and productivity (McMillan and Rodrik 2011; Rodrik 2013; Acemoglu 2002; Lall 2000). The manufacturing industry is still the engine of development in developing countries with respect to the spillovers and impact on other sectors in the economy. Also, leading industries play a critical role for structural changes and export performance of the countries.

The study of Kilicaslan and Taymaz (2004) shows that the impact of the structural change in the productivity growth of the manufacturing sector has been negligible for most developing countries, especially since the 1980s. Countries such as South Korea, Malaysia and Singapore are the performing ones that show a radical structural change in favor of high-tech industries between the analyzed period of 1965–1999. On the other hand, Kaloudis and Smith (2005) show that there is a relationship between the share of high-tech industries in manufacturing value added and a high level of GDP per capita, whereas there is not a positive relationship between the high-tech share in manufacturing value added and the rate of GDP growth. Kilicaslan and Taymaz (2004) share similar findings; the level of development is not independent of the industrial structure. Furthermore, the countries that were not able to change in industrial structure toward high- and medium-tech industries would not be successful in sustaining industrial development.

Due to the link between structure and geography of manufacturing industries, we need to focus on the wide literature on the determinants of agglomerations of the manufacturing industry. The determinants of spatial differences on production patterns have traditionally been presented with the differences in factor endowments, technology and policy regimes (Ottaviano and Puga 1998). Two economic forces and trade-offs between them mainly organize activities in economic space: transportation costs and agglomeration economies (Krugman 1991; Capello 2007; Ottaviano and

Thisse 2003). Even though the traditional factors have been changing in time, initial advantages, low transportation costs, accessibility to market and skilled labor are still significant forces generating agglomeration tendencies (Fujita and Thisse 1996; McCann 2001; Parr 2002). On the other hand, Combes et al. (2005) point out the micro-economic foundations of agglomerations as sharing, matching and learning. Areas with high concentrations of economic activities have the benefits of easy information exchange, face-to-face encounters, advanced services and the matching of jobs and skills. After Marshall, the role of urban space has become more significant as the place where agglomeration economies are generated. According to Jacobs (1969), urban areas have been the main sites of innovative activity, knowledge spillovers to other sectors and geographical proximity is an enabling factor. Therefore, the concentration of people and economic activities in cities or core areas would be explained through the urbanization economies (Malberg and Maskell 2002), while the manufacturing sector has benefited from locating near other sectors.

Rosenthal and Strange (2004) divide agglomeration economies into three main scopes: industrial, geographical and temporal. Along with the localization and urbanization economies, they also are concerned about geographical proximity and further complexity and dynamic agglomeration economies due to the learning and innovation process, which have been increasing in importance in recent years on the performance of the local systems (Becattini 1989; Bramanti and Maggioni 1997; Simmie 2005).

Based on different studies, Puga (2009) highlights that the productive advantages of the large cities have been attributed to agglomeration economies. Moreover, Guimaraes et al. (2000) point out that urbanization economies are more important than industry-specific localization economies. Considering the location pattern of the manufacturing industry, it is well known that firms are likely to cluster within the metropolitan areas where they have larger markets and lower transport costs. On the other hand, cities provide a wide array of final goods and specialized labor markets that make them attractive to consumers and workers (Krugman 1980, 1991; Puga 2009). New firms are more likely to occur where there is already an existing concentration of industrial activity. However, agglomeration diseconomies such as congestion and increasing cost of land have caused the industries to move from the core areas to the neighboring regions.

The issue of spatial concentration of industries has found renewed interest with the emergence of NEG. Regarding the assumptions of new economic geography, agglomerations are the outcome of a cumulative process involving both the supply and demand sides, while the space economy is an outcome of interplay between centripetal and centrifugal forces (Krugman 1991; Fujita and Thisse 2002; Ottaviano and Thisse 2003). According to Fujita et al. (1999), the forces of agglomeration would be stronger while the barriers of trade have been diminishing. Furthermore, the studies, which are exploring the concentration tendencies of sub-sectors, put forward different patterns (Ellison and Glaeser 1997; Duranton and Puga 2000). Alecke et al. (2006) indicate that the most concentrated manufacturing industries appear to be more traditional ones, such as the textile and leather industries, while the majority of the most dispersed sectors are customer-related services. The studies of Rosenthal and Strange (2006) point out that some industries require being close to the natural resources such as the wine industry, while software industries, which do not have any raw material dependency, are concentrated as well because of the importance of face-to-face interactions of knowledge flows. Sectors such as information technology would have very different determinants of agglomeration from the traditional manufacturing sectors. The study of Vogiatzoglou and Tsekeris (2011) for Greece indicates that high-technology sectors exhibit a high level of agglomeration, while technological progress depends on agglomeration economies (Pede et al. 2011).

Although the significant contributions to the literature for exploring the determinants of agglomerations, Rosenthal and Strange (2001) and Puga (2009) highlight that the determinants of agglomeration still need to be explored. Pylak and Majarek (2014) analyze European regions and assume that the role of agglomeration economies may differ between more and less developed regions, while less developed ones are path dependent and are unlikely to break away from this dependency. Since we know that not only the sector-specific differentiations, but also the location-specific differentiations on relationships are important, spatial heterogeneity should be considered. Geographical weighted regression (GWR) provides seeing the spatial variation of the relationships rather than global approaches (Fotheringham 1997; Fotheringham et al. 2002). However, the studies looking at the spatial variations of relationships on agglomerations have still been limited. Huang and Leung (2002) analyze the industrialization by looking at the relationships with urbanization and economic indicators, while Yu (2006) analyzes regional dynamics. Additionally, there have been studies focused on new firms' dynamics using GWR (Breitenecker 2007; Cheng and Li 2011; Li et al. 2011).

In this paper, we intend to explore the determinants of agglomeration for the manufacturing industry in Turkey during the twenty-first century considering the localities. The following section includes the structure of the economy and the manufacturing industry in Turkey. It also displays the concentration pattern of manufacturing industry in 2012 in order to explore which sectors based at the technology level are more concentrated or dispersed throughout the country. After the methodology and data section, the fourth section displays the findings of the regression analysis on the factors which explain the agglomeration of manufacturing industry at the aggregate level and the high-tech manufacturing industries. We strongly assume that a global regression model is not sufficient to explain the relationships for all regions of the country, and the relationships between variables are likely to vary across space. Therefore we have conducted a local regression model in order to explore the localities of the relationships. The conclusion section discusses the results for further research.

2 The structure and concentration pattern of manufacturing industry in Turkey

Since Turkey has been defined as one of the emerging economies in the world in the 2000s, a structural shift of production is worth investigating as well as geographical shifts in the twenty-first century. The distribution of growing GDP has indicated a significant differentiation among the regions and people, since 35% of the total population covered 50% of the income in 2012 (Yeldan et al. 2012). The share of five

Table 1 Change of export and employment due to the technology in Turkey's manufacturing sector (2003–2012). *Source* TurkStat (2014) and Ministry of Economy (2014)

	Export			Employment		
	2003	2012	%	2003	2012	%
Low	19,915,048	45,465,364	1.09	256,611	1,876,807	1.25
Medium low	9,605,867	53,392,139	1.21	449,132	912,986	1.08
Medium high	12,739,742	43,049,256	1.14	330,801	570,620	1.06
High	2,117,773	3,287,152	1.05	49,858	57,207	1.02

important sectors in the Turkish economy (manufacturing, financial, wholesale trade, transportation and construction), increased from 59.5 to 68.2% from 2002 to 2012. However, the contribution of the manufacturing industry to GDP (24%) has not been increasing in the last decade, while the financial, construction, transportation sectors have been the fast growing sectors in the 2000s. In order to deal with the issue of the middle-income trap,[1] there should be an increase in value-added production and structural change. The low-technology sectors are still the main employment generators in the manufacturing sector, although there has been an increasing trend in medium-low- and medium-high-technology sectors especially in exports (Table 1). Primary metal, textile and wearing apparel, motor vehicles, food and beverages, coke and chemical products are the most important sectors in export from Turkey.

A rapid urbanization process goes hand in hand with the structural shifts from agriculture to manufacturing in Turkey. Until the 1980s, urban agglomerations were the main bases for manufacturing activities as their attractiveness for labor, who migrated to the big cities. However, especially the eastern regions still have the dominance of the agricultural economy, while the more productive sectors are concentrated in the western regions, and a cumulative process has occurred. Therefore, each region has different conditions based on labor, capital and technology. In the 1980s, an export-oriented policy accelerated manufacturing activities and favored the developed regions. Later on following the trends in the world, big metropolitan cities started to shift from manufacturing to service-based activities, while the neighboring provinces of metropolitan cities in the western part of the country became the most attractive regions for relocating manufacturing activities and de-concentration. Although the dynamics of the Marmara region had been dominating the economic growth, there are Anatolian regions that became manufacturing agglomerations during the 1990s. As Gönenç et al. (2012) point out, the growth of high-tech industries appears to have accelerated in the 2000s due to the skilled labor force of the western regions.

The concentration index[2] of manufacturing industries indicates that mostly resource-based sectors such as coal and petroleum and wooden goods have tended

[1] According to Kharas and Kohli (2011), countries mostly could not compete with low wage economies in manufacturing exports and could not compete with developed ones with high skill innovations and were stuck in the middle-income trap.

[2] The Hirschman–Herfindahl index of industrial spatial concentration is given by the sum over all regions of the squared deviations of each region's share of total national manufacturing. Where an industry is

to be more concentrated, while textile and wearing apparel and machinery equipment sectors are more dispersed. On the other hand, most of the high-technology sectors (other motor vehicles, production of office machines and computers) tend to be concentrated (Table 2). The concentration index indicates that three metropolitan regions (Istanbul, Ankara and Izmir) are the most important concentration areas for manufacturing employment (40% of total), since geographical advantages of being close to Europe as the main market for export, proximity to the ports and accessibility to wider (internal and external) markets have been significant for agglomeration. However, there has been increasing de-concentration in neighboring provinces of metropolitan regions and those provinces are also among the first 10 concentration areas (Table 3).

Furthermore, LQ analysis is used to see which regions are more specialized in high-tech sectors. In general, LQ values point out that the Marmara region is the main concentration area for manufacturing employment (Table 3). Kocaeli, Tekirdağ and Bursa, as neighboring provinces of Istanbul, are highly specialized in manufacturing activities, whereas 20 of the 81 provinces indicate LQ values of more than 1. Among the first ten provinces with the highest LQ values, only four (Kocaeli, Bursa, Eskişehir, Sakarya) of them are specialized in both the aggregate manufacturing and high-tech sectors (Table 3; Fig. 1). Yalova, Manisa, Ankara, Çankırı, Aksaray and Konya are the provinces that appear among the ten high-tech sector specialization areas with higher LQ values (Table 3). Therefore, other than the three metropolitan provinces, neighboring regions and some new industrial regions have become the base for medium-high and high-technology sectors such as electrical machinery and apparatus, radio, television and communication equipment, motor vehicles and other transportation equipment.

Due to the above analysis, the metropolitan regions are still the main concentration areas for manufacturing activities. However, the structural changes in these regions have been obvious, while specialization values are diminishing for the manufacturing sector, increasing for high-tech sectors. We did not take into account the rapidly growing sectors (finance, construction, transportation, etc.) other than manufacturing in this paper, but it is known that metropolitan regions are the places of concentration of those sectors as well. In the following section, the determinants of a manufacturing agglomeration will be explored using global and local regression.

Previous studies analyzing the geography of the manufacturing industry in Turkey (Doğruel 2006; Eraydın 1999, 2002; Dinçer et al. 2003; Kazancık 2007; Kıymalıoğlu and Ayoğlu 2006; Karadağ et al. 2004; Filiztekin et al. 2011; Çağlar and Kutsal 2011; Elburz and Gezici 2012) pointed out that the spatial distribution of manufacturing activities enhances the east–west differentiation. Although the developed provinces are the main concentration areas of the manufacturing industry, some trends display more dispersed patterns, especially after the 1990s (Eraydın 2006; Çağlar and Kutsal 2011). However, the previous studies did not take into account the spatial heterogeneity on manufacturing agglomerations.

Footnote 2 continued
evenly distributed across an urban system, such that its spatial distribution exactly mirrors that of the urban hierarchy, the value will be 0.

Table 2 Share and concentration of sectors based on their technology level in 2012

Code*	Name of industry	Employment	%	H–H index
Low-technology and medium-low-technology industries				
15	Manufacture of food products and beverages	421.224	11.95	0.0423
16	Manufacture of tobacco products	5.236	0.15	0.0525
17	Manufacture of textiles	430.213	12.21	0.042
18	Manufacture of wearing apparel; dressing and dyeing of fur	454.754	12.91	0.0275
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	60.591	1.72	0.0491
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	64.067	1.82	0.0512
21	Manufacture of pulp, paper and paper products	41.251	1.17	0.0507
22	Publishing, printing and reproduction of recorded media	68.778	1.95	0.0484
23	Manufacture of coke, refined petroleum products and nuclear fuel	9.187	0.26	0.0525
25	Manufacture of rubber and plastic products	170.217	4.83	0.0451
26	Manufacture of other non-metallic mineral products	202.306	5.74	0.0485
27	Manufacture of primary metals	164.795	4.68	0.0478
28	Manufacture of fabricated metal products, except machinery and equipment	357.841	10.16	0.0387
36	Manufacture of furniture; manufacturing n.e.c	139.836	3.97	0.0478
37	Recycling	50.852	1.44	0.0518
High-technology and medium-high-technology industries				
24	Manufacture of chemicals and chemical products	75.509	2.14	0.0497
29	Manufacture of machinery and equipment n.e.c	312.539	8.87	0.0389
30	Manufacture of office machinery and computers	33.407	0.95	0.051
31	Manufacture of electrical machinery and apparatus n.e.c.	98.940	2.81	0.0486
32	Manufacture of radio, television and communication equipment and apparatus	155.246	4.41	0.0456

Table 2 continued

Code*	Name of industry	Employment	%	H–H index
33	Manufacture of medical, precision and optical instruments, watches and clocks	41.836	1.19	0.0498
34	Manufacture of motor vehicles, trailers and semi-trailers	124.728	3.54	0.0497
35	Manufacture of other transport equipment	40.418	1.15	0.0513

* Eurostat′s NACE Rev 1.1 sector coding

Table 3 Ten provinces that have the highest value of specialization in the manufacturing industry and high-tech manufacturing industries

	LQ		LQ
All manufacturing		*High-tech manufacturing*	
Kocaeli	2.33	Yalova	2.54
Tekirdağ	2.12	Manisa	1.68
Bursa	2.11	Kocaeli	1.65
Bilecik	1.97	Eskişehir	1.50
Düzce	1.73	Sakarya	1.47
Eskişehir	1.63	Bursa	1.45
Gaziantep	1.55	Ankara	1.45
İstanbul	1.53	Çankırı	1.44
Sakarya	1.46	Aksaray	1.34
Denizli	1.44	Konya	1.19

Fig. 1 LQ values of high-technology sectors (2012)

Recent studies on the manufacturing industry in Turkey which used the Exploratory Spatial Data Analysis pointed out that east–west dualism in Turkey still exists. The results of Kaygalak and Reid (2016) underline presence of spatial heterogeneity in the period of 1992–2009, whereas structural change of manufacturing in the last two decades has resulted in more geographical concentration. The study of Karahasan (2015) concludes that the manufacturing industry indicates regional duality leaving the eastern regions well behind the western ones between 2003 and 2008. Furthermore, the findings of Karahasan (2014) on new firm formation enhance the spatial duality: "peripheral provinces are suffering from low levels of new firm formation unlike the provinces with higher market potential and are closer to economic centers". Findings of these recent studies support the motivation and hypotheses of this paper that an agglomeration mechanism is likely to vary across space.

3 Methodology and data

3.1 Data

The availability of most of the data has changed from provincial to NUTS 2 level regions in Turkey since 2002. Furthermore, the changes in sectorial aggregation create another limitation to run a time series analysis. Beyond these limitations, the main motivation of this paper is to explore the determinants of manufacturing agglomerations in the twenty-first century. The dependent variable is manufacturing employment in 2012, and the analysis units are the 81 NUTS III level regions (provinces) of Turkey. Spatial units are a reflection of administrative convenience rather than economic boundaries. Furthermore, taking the provinces as the main unit of analysis is an approach to investigate macro-territorial foundation of agglomeration economies (Capello 2007). The manufacturing employment data were obtained from the Social Security Institution (SGK) in 2012. For the definition of high- and medium-high-technology manufacturing sectors, we used the OECD classification of NACE two digit sectors (see in Table 2). The explanatory variables were defined based on the agglomeration literature, and data were gathered by using a variety of methods and resources, while they were grouped under 5 datasets: market potential, labor pool/human capital, accessibility, advanced services and public policy. With respect to the definition of independent variables, the main objective is to find out the impacts of liberalization on manufacturing agglomerations in Turkey; export-oriented policy in the 1980s and the reform of financial sector in the 2000s. Therefore, we choose the independent variables as the sum of export and import, and total bank credits in addition to other well-known variables for explaining agglomerations.

Sixteen potential independent variables are identified in Table 4. The density and urbanization rate are used as the proxy of market potential as Henderson (1986), Ottaviano and Puga (1998), Brülhart and Torstensson (1996) did. Additionally, the sum of the import and export volume is identified based on the assumptions of new economic geography and new trade theory which provide the background of the research formulation as trade induces agglomeration (Krugman 1991). The opportunity to export at low cost to immobile sources of demand allows all the mobile consumers and producers to congregate in the so-called manufacturing core. The reason to take the sum of export and import is that the export of manufacturing industry has increased, but it also depends on import for intermediate or high-technology goods. Trade-off between the increasing returns and transportation cost needs to pay attention to the

Table 4 Definition of variables

Variables	2009–2012		
	Source	Unit	Year
Market potential			
Density	TSI	pop/km^2	2012
Urbanization rate	TSI	urbanpop/pop	2012
Import + export	TSI	$	2012
Accessibility			
Airport facility	SAA	dummy	2011
Port facility	TMB	dummy	2012
Highway	TSI	km/km^2	2011
Railway facility	TRSR	dummy	2012
Labor pool/human capital			
School enrollment rate	TSI	Rate	2012
Number of academic staff	OSYM	Number	2012
Advanced services and economic dynamics			
Total bank credits (average of 3 years)	BAT	TL	2012
Invesments			
FDI	ME	TL	2012
Real estate	PMUT	TL	2012
Number of firms listed in ICI registered first 500 firms	ICI	Number	2012
Public policy			
Public investments (average of 3 years)	ME	TL	2012
Incentives	PMUT	TL	2012
Number of OIZ	MSIT	Number	2012

variables of market access. Therefore, the presence of airport, port and railway facility of the provinces is identified as dummy variables, whereas the highway is defined as the ratio of its length within the province. Rather than the quantity, the quality of the labor force induces the importance of human capital (Alecke et al. 2006; Rosenthal and Strange 2001; Moretti 2004). The number of academic staff and the school enrollment rate are identified as proxies for the labor pool and the role of human capital.

With respect to urbanization economies, we have also considered the advanced services. As Clark et al. (2015) point out, the focus on a narrow definition of manufacturing may ignore the role of finance, retailing and logistics in the production. Regarding the growing trend and reforms in the financial sector in Turkey, total bank credits are taken into account as a proxy of efficiency in financial sector in each province. Total bank credits are not only for manufacturing sector, it includes any kind of bank credits in the provinces. There has been increasing literature on developing countries, which looked at the relationship between financial markets and industrial clusters by using bank credits as the efficiency of the financial market (Deichmann et al. 2003; Zhang and

Wang 2009; Narjoko 2008). In addition to the bank credits, real estate investments and foreign direct investments are defined as proxies for advanced services in the provinces. In order to avoid the misspecification of allocation in 1 year, an average of 3 years has been taken into account for the investments and the credits. Furthermore, the existence of leading firms (firms in the first 500) is another variable to find out how agglomeration is triggered by large firms as Narjoko (2008) tested it in the case of Indonesia. Finally considering the criticism of the first generation of NEG models that they contained little discussions on the role of policy (Martin 1999; Neary 2001), we have identified the variables as the proxy of public policy. The variables of public investment, incentives and the number of Organized Industrial Zones which are used to be a tool to define where the manufacturing activities should develop, are defined to see whether public policy still has a significant role in the manufacturing industry in Turkey within the neo-liberal economic system.

3.2 Methodology

The aim of the paper is twofold. First, it is to explore the determinants of agglomerations for the aggregated manufacturing sector and high- and medium-high-technology sectors. Secondly, we know that issues are very complex rather than being based on a single explanation for everywhere in the country; therefore, the aim is to test the hypothesis that determinants would be different across the country. Based on the latter research hypothesis that the relationships vary over the space in the provinces of Turkey, the stationary processes like ordinary regression models would not be the right models to select and they would lead the research to some misspecification. As a result, a Geographically Weighted Regression model is used with its power to provide a location-specific perspective. It has been used in different disciplines and varying research during the last two decades. One of the popular fields applying this method is regional studies since locational attributes matter a lot in these studies. GWR is a local spatial statistical technique used to analyze spatial non-stationarity as when the relationships among variables differ from location to location (Fotheringham 1997; Fotheringham et al. 2002). Mapping the results of GWR gives spatial information on both the magnitude and the significance of the parameter estimates (Mennis 2006).

The general concept behind the Geographically Weighted Regression model is the first law of geography stated by Tobler (1970) as "everything is related to everything else, but near things are more related than distant things". As a result of this approach, data points and regression points work based on a weight matrix. This process helps GWR act as a local model and differ from the global regression models. So, the formula of the global regression model (1) gets a new form (2) for this local regression model.

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots \beta_n x_{ni} + \varepsilon_i \tag{1}$$

$$y_i = \beta_{0(i)} + \beta_{1(i)} x_{1i} + \beta_{2(i)} x_{2i} + \cdots \beta_{n(i)} x_{ni} + \varepsilon_i \tag{2}$$

Each observation is weighted according to being nearer or farther away from the location i, and these weights will vary as the regression point changes. A relationship varying over space will be handled by calculating a weight matrix in which the weights are computed for each point i (3). So, the data points close to i will be weighted more and they will have more influence, compared to the data points that are farther away (Fotheringham et al. 2002).

$$W(i) = \begin{bmatrix} W_{i1} & 0 & \dots & 0 \\ 0 & W_{i2} & & 0 \\ . & . & & . \\ 0 & 0 & \dots & W_{in} \end{bmatrix} \tag{3}$$

Before running the analysis, different data exploration techniques including both qualitative and quantitative were applied to arrive at the final independent variables set. Based on a statistical approach, a stepwise procedure is run with the 16 potential independent variables including indicators from five different datasets, as mentioned in the previous section. A stepwise procedure is run to select the independent variables, which will direct us to the best explanatory model out of all the possible relationships. In other words, the outcome of this procedure will lead us to the most powerful equation in order to describe the relationship based on the selected variables. It is a key issue to analyze and describe a statistical relationship by including the important independent variables and excluding the less important ones (Leung et al. 2000).

The procedure is based on the principle of AIC minimization and involves both forward and backward variable selection steps. During the forward step, the model is run with each variable. The variable which causes the minimum AIC will be added to the model. After the forward step, if there are more than two variables in the model, a backward step will occur where the model is run leaving out one of the previously included variables. This forward–backward process repeats until the AIC cannot be lowered to less than 3 by the addition or elimination of any variables. At the end of this two-step process, the potential variables that should be included in the best explanatory model are obtained, which will be discussed in the following section.

GWR, as a local regression modeling technique, brings a new perspective to the spatial regression models. It is widely separated from the global ones since it can represent the local form of spatial analysis. With this approach, it has started to be an important part of regional studies in the recent years. The advantages of this over ordinary regression models in this research will be evaluated in the next section. The fact that there are not any available data smaller than a province level in Turkey is the limitation for this research. Higher numbers of data points could result in a higher level of relationships over the space.

4 Global and local analysis results and discussion

We conducted two different models; one for aggregate manufacturing and one for medium-high- and high-tech manufacturing industry. Both models have the global and the local outcomes.

4.1 Model 1

For our first relationship, the best model of aggregate manufacturing employment has an 87% explanatory power with two independent variables. These two variables are:

Table 5 Global regression parameters

Parameter	Estimate	Std. error	*T* value
Intercept	−1.6849	0.3416	−4.93
Import + export	0.1598	0.0439	3.64
Credits	0.7996	0.0830	9.64
Residual sum of squares 4.133			
Sigma 0.230			
Coefficient of determination 0.874			
Adjusted R-square 0.869			
Akaike information criterion AIC −2.612			

the sum of export and import and total bank credits. The coefficient of determination is 0.874 and the adjusted R^2 is 0.869. So, 87% of the variation of manufacture employment can be explained with this model in the global regression analysis. To be able to compare the global regression results with the local ones, rather than R^2, the AIC value will be used. As Fotheringham et al. (2002) stated, the "AIC is the measure of this closeness and not simply a measure of 'goodness of fit' such as a sum of squared errors." It also takes model complexity into account which makes it better to use in the comparison of two models rather than relying on coefficient of determination (Fotheringham et al. 2002). The rule is working in the way that the smaller the AIC value, the better the model. The AIC value for the global regression is −2.6 (Table 5).

The volume of export and import has a significant and positive impact on the concentration of manufacturing industries in Turkey. The variable is considered as a market/trade potential of the provinces, and an increase in the total trade volume would increase the concentration of the manufacturing employment. The propositions of the new trade theory and the new economic geography enhance the result of the analysis: The existence of scale economies encourages firms to choose a single location; barriers to trade encourage firms to locate near to their main markets; agglomeration economies encourage firms to cluster in particular locations (Krugman 1991; Puga 2009). Therefore, the export-oriented economic policy in Turkey since the 1980s has enhanced the relationship between the trade and manufacturing agglomerations.

The variable of credits indicates a significant positive relationship with the manufacturing agglomerations. This relationship would be the reason of both the economic dynamics of the region, but it also points out that the manufacturing sector is dependent on financial support to make investments. Recent literature paid attention to the efficiency of the financial market due to the neo-liberal policies and decreasing public support for the investments. An increasing number of studies has occurred seeking the relationship between the group of variables such as manufacturing agglomerations, new firm creations, FDI and financial markets, especially in developing countries such as China, India and Turkey (Yang and Xu 2015; Zhang and Wang 2009; Zhang 2014; Rajesh Ray et al. 2014; Deichmann et al. 2003). Yang and Xu (2015) emphasize that the financial market plays an important role in the formation process of firms. In particular, when the firms try to expand the size of the business and the demand of the capital increases in rapid growth phase, they have to use formal financial institutions for their funding needs. Moreover, financial resources promote regional economic growth

Table 6 GWR estimation diagnostics

Residual sum of squares	1.538
Sigma	0.149
Akaike information criterion AIC	−60.229

Table 7 Model 1 ANOVA test results

	SS	DF	MS	F
OLS Residuals	4.1	3		
GWR Improvement	2.6	8.84	0.2935	
GWR Residuals	1.5	69.16	0.022	13.1959

(Zhang 2014). The study of Deichmann et al. (2003) proves that foreign manufacturers are attracted by bank credits in Turkey, while Rajesh Ray et al. (2014) emphasize that greater access to external finance can help the new firms in expanding their business. Therefore, it is obvious that the financial market is a significant factor for manufacturing investment and employment concentration in Turkey as an emerging country, while the financial sector has seen the rapid growing ones in the last decade.

Although two variables explain the agglomeration of the manufacturing industry for the whole country, we believe that the relationships are likely to vary across space. Therefore, in order to overcome the misspecification of the global regression model considering the spatial heterogeneity, the local model results should be investigated. According to the Geographically Weighted Regression Analysis outcomes, we can observe that the local regression model outperforms the global one.

These values make it possible to investigate the differences in both models. As mentioned before, the adjusted R^2 is not valid/enough to make the comparison between the local and global regression model, so the AIC value will be our control value. The GWR model has an AIC value of −60.2 which is less than the global model value. Given the fact that minimum AIC is the better fit for the model, it can be easily stated that GWR as a local modeling technique performs better than the global regression modeling (Table 6). On the other hand, not only the minimum value of AIC but also the results of the ANOVA test are approving the improvement with the GWR model (Table 7).

The comparison can be supported by the ANOVA (analysis of variance) test which is also an output of the GWR analysis. Adoption of the GWR model causes a decrease in the residual sum of squares, and so this test also suggests that GWR is performing better than OLS, and *F*-test can also be used to compare the global model and GWR in which the value in this case is supporting the previous statement.

The other issue in the GWR model is the test for the spatial stationarity of each of the parameters included in the model. To compute the variability distribution of the local parameters, a Monte Carlo approach is adopted. With this approach, it is also possible to test the significance of the spatial variability of each coefficient (Fotheringham et al. 2002). As a result of this test, it displays that these relationships are varying locally (Table 8).

The other important outcome of the analysis is that the parameter estimate values are also varying based on the location (between 0.02–0.49 for export + import and 0.14–1.23 for credits) (Figs. 2, 3).

Table 8 Spatial variation of the independent variables (Monte Carlo significance test)

Parameter	*P* value
Intercept	0.00000***
Import + Export	0.04000*
Credits	0.00000***

*** Significant at .1% level
** Significant at 1% level
* Significant at 5% level

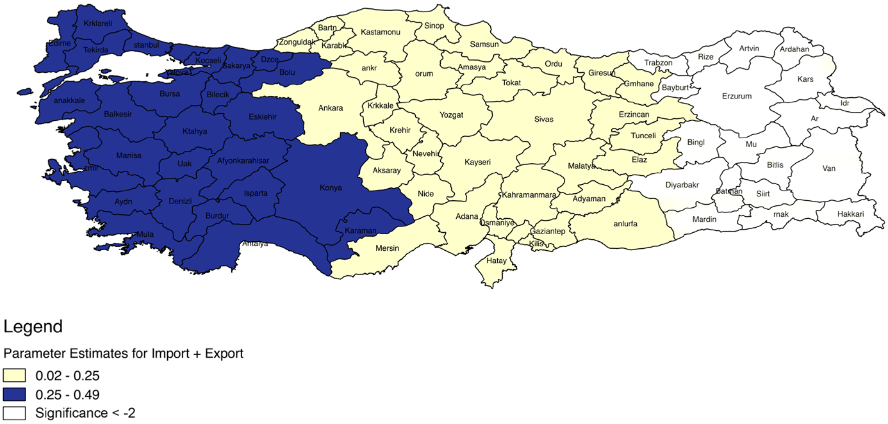

Fig. 2 Result of the GWR model—the variable of export + import

According to the spatial local regression analysis, the variable of export + import does not indicate a significant relationship for 19 provinces in the east (Fig. 2), even though the global model argues that this relationship is significant in every province of Turkey at the same level. Additionally, the level of impact is decreasing from the western to the eastern provinces, as trade potential has a significant impact on manufacturing agglomeration, especially on the west coast provinces. This result supports the findings of Karahasan et al. (2011) where market potential is highly spatially dependent in Turkey and trade induces agglomeration. The results are meaningful since the main export and import relations of Turkey are with the western countries and especially Europe, while there have been several political conflicts as the barrier for trade with the eastern and southern neighbors. However, Gaziantep needs special attention as the main manufacturing agglomeration center in the east, and the agglomeration is also related to export potential of the provinces.

The results of the GWR analysis indicate the locally varying effects of credits on agglomerations as well. Parameter estimates point out that the relationship between the agglomeration of manufacturing industries and credits is stronger in the eastern provinces (Fig. 3). As an indicator of financial support, the results are expected since the eastern provinces are the less developed regions of Turkey. However, credits do not play a significant role in the provinces of the west-south coast (Izmir, Manisa, Aydın, Muğla, Denizli, Burdur, Isparta, Antalya), and a relatively low level impact on the dependent variable in the provinces of the Marmara region. The findings of Karahasan (2009) support our results by pointing out that the distribution of credit volumes mainly

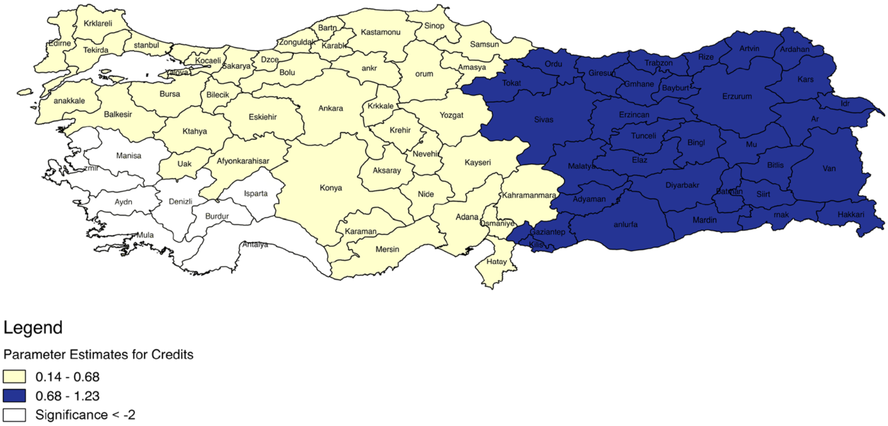

Fig. 3 Result of the GWR model—the variable of credits

worsens in developed regions and real per capita credit volume has positively affected the total firm formation between 1997 and 2006. Furthermore, Birkan and Akdoğu (2016) found that the hot spot consists of the southeastern provinces expanding since 2008 with a reduction in regional financial inequalities. The locality of two significant variables emphasizes the different dynamics of east and west (spatial regimes) that still exist in Turkey.

4.2 Model 2

Furthermore, we intend to explore the determinants of high- and medium-high-tech sectors. Thus, this paper would concern both sector-specific and location-specific determinants of manufacturing agglomerations, different from previous studies. We take the high-tech and medium-high-tech manufacturing employment as a dependent variable in the second model. The coefficient of determination is 0.807 and the adjusted R^2 is 0.796. So, only 80% of the variation of high-tech industries can be explained with this model in the global regression analysis. As mentioned in the previous part of the paper, the AIC value will be used to compare the global and local outcome as well as the ANOVA test result. The AIC value for the global regression is 1793.2 (Tables 9, 10).

The global model has good explanatory power, whereas the variable of Organized Industrial Areas (OIZ) is not significant. In this model, credits and incentives indicate a significant effect on high-tech and mid-high-tech manufacturing agglomerations. Credits are significant for the high-tech sector concentrations as we observed for the aggregated manufacturing industry. Thus we realize that high-tech companies also require financial support, in other words, the availability of financial capital is significant for firm formation. Moreover, incentives are significant for high-tech industries, since Turkey has had an industrial policy to increase the value-added production and support for high-technology sectors in the last decade.

Table 9 Global regression parameters

Parameter	Estimate	Std. error	T value
Intercept	−82,965.77	25705.15	−3.22
OIZs	−546.97	803.11	−0.68
Credits	14,019.40	4409.02	3.17
Incentives	61.84	5.35	11.54
Residual sum of squares 17,094,777,559.594			
Sigma 14,900.003			
Coefficient of determination 0.807			
Adjusted R^2 0.796			
Akaike information criterion AIC 1793.242			

Table 10 GWR estimation diagnostics

Residual sum of squares 5,784,714,027.175
Sigma 9481.573
AIC 1740.547

Table 11 Spatial variation of the independent variables (Monte Carlo significance test)

Parameter	P value
Intercept	0.00000***
OIZs	0.63000n/s
Credits	0.00000***
Incentives	0.73000n/s

*** Significant at .1% level
** Significant at 1% level
* Significant at 5% level

After the fact that GWR is a better technique for investigating our potential relationship based on the high-tech industries in Turkey, it is also important to understand which of the independent variables are actually showing a varying attribute in the country. The spatial variation test is showing us that one of the independent variables—total bank credits—is an important variable to look at it intensely (Table 11). The parameter estimate values are also varying based on the location (between 1414–62.399 for total bank credits) (Fig. 4).

We observe that there is a locally varying relationship between the credits and high-tech manufacturing agglomerations, while there is not any significant locality for the incentives. Furthermore the global relationship between the credits and high-tech manufacturing agglomerations holds true only for the west/core regions and vicinity (Fig. 4). Since the concentration of the high-tech sector is mainly in the western developed provinces, finding a spatially varying relationship in the western rather than the eastern provinces can be the probable reason. The findings of Kaygalak and Reid (2016) put forward that structural change of manufacturing in the last two decades has resulted in more geographical concentration. On the other hand, high-tech industry activities are also looking for the availability of financial capital. This relationship is very high in the Marmara region, which has long been the base for manufacturing activities. The presence of manufacturing agglomerations encourages the probability

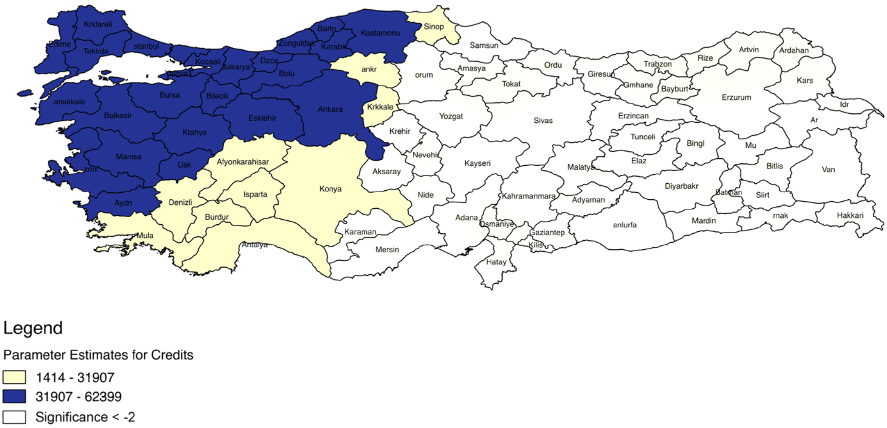

Fig. 4 Results of GWR model (2) high- and medium-high-tech employment—the variable of credits

of firm entry and regions' attractiveness. As Karahasan (2014) pointed out, peripheral provinces in Turkey are suffering from low levels of new firm formation unlike the provinces that are closer to the economic centers. Not only the new firms, but also the structural changes have more likely occurred where there is already an existing concentration of industrial activity.

The results of the two models not only emphasize that the relationships vary across the space, but also highlights that the factors of manufacturing agglomerations are dominated by neo-liberal forces (international trade and availability of financial capital). However, the share of high- and medium-high-technology sectors has been increasing and concentrating in the developed regions of Turkey through public support, as the variable of incentives did not indicate any variations across the space.

5 Conclusion

The causes of agglomeration have long been the interest of many researchers and still need to be explored by the empirical studies considering the new theoretical contributions. However, geographical concentration or dispersion of the manufacturing industry has been changed due to different forces, especially the trade-off between transportation costs and agglomeration externalities. While the technological progress and fragmentation of production would provide opportunities for relatively less developed peripheral areas, the power of agglomeration has still been there for growth and productivity. Geographical shifts should be explored along with the structural shifts, since technological progress matters for the new production system.

Turkey has put forward the priority of increasing the share of high-tech industries within the manufacturing sector strategies during the last decade. However, the share of high-tech industries is still very low, while the dominance of low- and medium-low-technology sectors is obvious. On the other hand, high- and medium-high-technology sectors are mainly concentrated in the west and prefer to locate where there is already an existing concentration of industrial activity. Thus, agglomerations are the main driving forces behind attractiveness for new activities.

The main contribution of this paper is to find out the factors of manufacturing agglomerations considering the spatial variation of the relationships, different from previous studies. Since Geographically Weighted Regression significantly outperformed the global regression analysis, noteworthy variations of regional agglomeration mechanisms are present in Turkey. Furthermore, the results essentially enhance the well-known east–west dualism of Turkey, as we observe that the factors of manufacturing agglomerations are also different in diverse locations due to the regions' development level. The first model (aggregated manufacturing) indicates that the relationships are stronger in the western part of Turkey considering the trade, and the relationships are stronger in the east considering the financial support. Export potential seems to favor provinces in the west/core regions and their immediate vicinity. Thus both centripetal and centrifugal forces have been seen in Turkey. In the second model (high- and medium-high-tech manufacturing), it is realized that high- and medium-high-tech industry agglomerations are more likely to depend on the availability of financial capital and incentives. Government supports play a significant role in agglomerations of high- and medium-high-tech sectors; however, there is not any sign of local variations. The availability of financial capital is significant for high- and medium-high-technology sectors in the western developed provinces regarding the increasing literature on the financial market in developing countries. Therefore, for further studies, attention should be more directed to the exploration of the micro-foundations of a neo-liberal economic system such as the increasing of international trade and growing financial markets. The results would provide new insights for exploring the relationships. Since the issues are complex, rather than being based on a single explanation for all areas, exploring the dynamics of different localities would be worthwhile against one size fits all policies.

Acknowledgements We would like to thank to Istanbul Technical University Research Fund for supporting the project: Modelling the Industrial Location Factors in Turkey with Global and Local Regression Models.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding This study was funded by ITU Research Fund.

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