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ORIGINAL PAPER

The determinants of agglomeration for the manufacturing sector in the Istanbul metropolitan area

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Abstract This paper examines the determinants of agglomeration by seeking the patterns of urbanization economies and localization economies in the Istanbul metropolitan area (IMA). The research is developed in two steps. The first step is the measurement of concentration levels for the IMA; the Ellison–Glaeser localization index (EGI) is applied to the 22 manufacturing sector (2-digit level) at three different geographical levels. The second step is to determine the structural pattern of agglomeration. By regressing the Ellison–Glaeser localization index values on proxies for urbanization and localization economies, the determinants of agglomeration are demonstrated. The determinants of agglomeration are estimated by 12 different two-stage OLS regressions. While three of these regressions represent the agglomeration factors at each geographical level, the other nine equations represent the agglomeration factors at the industry-specific level. The results suggest that urbanization economies have a strong effect on agglomeration both at the geographical level and industry-specific level. It is noticed that density, market area potential, and labor market potential are the most effective proxies for urbanization economies on agglomeration. The effects of localization economies are consistent with Marshall for labor pooling and manufactured input. However, the results do not provide any evidence that knowledge spillovers have an influence on agglomeration in this case.

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1 Introduction

The spatial configuration of economic activities is the outcome of a process involving two opposing types of forces named as centripetal and centrifugal forces (Fujita et al. 1999a). What are the main forces that generate and sustain centripetal forces? The answer to this question goes back to Marshall (1997). He not only developed the concept of external economies but also tied them to the idea of spatial concentration and, hence, started the discussion about the concept of spatial externalities. Marshall (1997) discussion identified three reasons why a producer might find it advantageous to locate near other producers in the same industry. First, a geographically concentrated industry could support specialized local providers of inputs. Second, a concentration of firms employing workers of the same type would offer labor market pooling. Third, geographic proximity would facilitate the spread of information (Fujita et al. 1999a).

In his conceptual paper, Parr (2002) examined the concept of agglomeration economies which he defined as "cost savings to the firm which results from the concentration of production at a given location, either on the part of the individual firm or by firms in general." Also, internal economies and external economies are identified as two types of agglomeration economies. According to him, various external economies form the basis for three types of agglomeration economies, namely external economies of scale (localization economies), external economies of scope (urbanization economies) and external economies of complexity (activity-complex economies).

It is important to notice that all these agglomerations at different levels are embedded in a larger economy, altogether forming a complex system. Understanding all such phenomena is critical for the design of effective urban and regional development policies. The analysis of agglomeration economies have come to the fore in the last two decades, particularly in the manufacturing sector. The role of agglomeration economies in the spatial distribution of manufacturing sector has been in a central position in any discussion of either the location of manufacturing firms or the economic growth generated by the manufacturing sector.

Theoretical studies generally argue that external scale economies such as manufactured inputs, labor market pooling, and technological externalities are the major source of concentration of manufacturing activities across space. While agglomeration economies continue to figure prominently in urban economic theory and empirical research, the concept has not often been subject to precise statistical analysis in the context of industrial location research. However, information on characteristics common to agglomerating industries may help us understand which agglomerative forces are strongly associated with the spatial concentration of industries.

The main aim of this paper is to examine the causes of agglomeration by seeking the patterns of urbanization economies and localization economies for the manufacturing sector in the Istanbul metropolitan area. More specifically, the following issues will

be addressed: Is economic activity in the Istanbul metropolitan area (IMA) geographically concentrated? Does this concentration differ at geographical levels? What are the most striking factors that play the dominant role in this concentration? How can the main forces generating agglomeration be determined?

The paper is organized as follows. Section 2 reviews the literature; Sect. 3 describes the research methodology. In Sect. 4, the concentration level of manufacturing sector in the IMA is measured. Section 5 analyses of the determinants of the manufacturing sector agglomeration while Sect. 6 offers some conclusions.

2 Literature review

In the literature, studies related to agglomeration economies can be classified into two basic groups. The first group is mainly about the development of measures to demonstrate concentration level in a specific area whereas the second group of studies attempts to examine the determinants of this concentration.

The location quotient, Gini coefficient, and Ellison–Glaeser index are examples of well known concentration measurements. The location quotient is a ratio of a location's share of industry employment to its share of aggregate employment. The Gini coefficient is generally used to determine whether geographic specialization is a characteristic of a particular industry. Ellison and Glaeser (1997) propose a model-based index of geographic concentration by asking how industry concentration over and above the general concentration of manufacturing can be measured.

Fujita (1988) demonstrated the basic forces of spatial agglomeration of economic activities in a metropolitan area. He revealed that spatial agglomeration can be explained as outcomes of pure price interactions among activities. Additionally, the price level, and urbanization economies, related land use pattern, variety of goods and populations of firms and households are all important determinants of a spatial agglomeration. Guimaraes et al. (2000) investigated the location decisions of foreign-owned manufacturing plants in the urban areas. They tested the influence of different types of external economies and compared them with other determinants of location. Their analysis suggests that urbanization economies are more important than industry-specific localization economies.

Wheaton and Lewis (2002) tested the impact of labor market scale on worker wages and show that observationally equivalent workers in the manufacturing sector earn higher wages when they are in urban labor markets. They interpret this solution as the willingness of firms to pay more for equivalent workers in dense markets as evidence of agglomeration economies in urban labor. Glazer et al. (2003) explored how preference heterogeneity affects urban agglomeration. They concluded that if different types of people prefer different types of goods, then industries will agglomerate because of the consumption preferences of consumers.

Several studies have examined the role of linkages; for example, Sohn (2004) classified the advantages derived from agglomeration economies as intra-industrial advantage (localization economies) and inter-industrial benefit (urbanization economies) to examine the spatial distribution pattern of manufacturing activities. He demonstrated that urbanization economies condition the spatial distribution, while

localization economies have not reflected enough proof for a concentrated pattern. Smith and Florida (1994) examine the co-location of backward and forward linked manufacturing enterprises in automotive-related industries in the process of industrial location. They test whether location in close proximity is a key determinant of the location of manufacturing establishments. Additionally, larger populations, a higher manufacturing density, a more educated work force and better transportation are urbanization and localization related factors that affect the establishments' location decision.

Fujita and Thisse (1996) explained why economic activities tend to agglomerate in a small number of places and the resulting geographical organization of the economy. They found that localization economies such as increasing returns, low transport costs, product differentiation, local labor market and also historical identity of the area are strong forces generating agglomeration tendencies. Rosenthal and Strange (2001) provided a comprehensive analysis of multiple determinates of agglomeration for US manufacturing industries. Their results indicated that those localization economies consistent with Marshall (1997) have various positive effects on agglomeration at different geographic levels.

By presenting evidence on the long run trends in US regional specialization and localization, Kim (1995) examined the forces that produced them. He demonstrates that localization patterns at the industry level exhibit considerable variation. Also, he argues that long-run trends in regional specialization and localization are based not on production scale economies but external economies. The main characteristics of localization consistent with Marshall (1997) , such as manufactured inputs, labor pooling, and knowledge spillovers are the most widely explored determinants of agglomeration. For example, Ellison and Glaeser (1997) explored how industry concentration can be measured and then explained. They identified two types of agglomerative forces as localized industry-specific spillovers and natural advantage. They concluded that for most manufacturing industries, spatial concentration is attributable to spillovers or natural advantages rather than randomness. In their later study, Ellison and Glaeser (1999) explained how much of the geographic concentration of industries that are reported in their former study (Ellison and Glaeser 1997) can be attributed to natural advantages. They found that industries' locations are affected by a wide range of natural advantages with about 20% of geographic concentration explained by these advantages.

Knowledge spillovers have occupied researches especially for the past decade. Audretsch and Feldman (1996) examined the extent to which industrial activity clusters spatially and to link this geographic concentration to the existence of knowledge externalities. Their empirical results suggest that innovative activity tends to cluster more in industries where knowledge spillovers play a decisive role. Glaeser et al. (1992) stressed the role of knowledge spillovers in generating growth in cities. Their empirical results suggest that important knowledge spillovers might occur between rather than within industries which foster local competition and urban variety that has encouraged employment growth in industries. Strange et al. (2006) presented a model of uncertainty and agglomeration; their model shows that firms are attracted to agglomeration if they are innovative. They find that innovativeness is positively associated with agglomeration. Sohn et al. (2003) examined the impact of information technology on the distribution of urban economic activities, and, hence, urban spatial

structure. Their findings reflect that information technology has a very influential and positive effect on the agglomeration of firms in both of the metropolitan regions they examined, Seoul and Chicago.

Devereux et al. (2004) not only examined the extent of geographic concentration in the UK but also the role of technology in explaining the geographic distribution of production. In contrast to former research, they find that the most geographically concentrated industries appear to be relatively low-tech. While many other researchers have examined the knowledge spillovers on agglomeration, van Oort and Atzema (2004); Sedgley and Elmslie (2004) examine the role of agglomeration economies and congestion in innovation and technological change. They found that high technology firms tend to locate in spatially dense economic areas because the scale effect based on population level has a substantially significant effect on the rates of innovation. They emphasize that urbanization economies may offer many advantages to information and communication technology sector so that knowledge spillovers are geographically concentrated caused by agglomeration economies.

In summary, the research seems to highlight localization economies rather than urbanization economies as the major determinants of agglomeration. Consistent with Marshall (1997), studies focus on three critical determinants of localization economies: labor pooling, manufactured inputs and knowledge spillovers. These results will inform the research methodology that will be presented in the next section.

3 Research methodology

3.1 The case area

Istanbul is located in the northwest part of Turkey. It is divided by the Bosphorus Straits into two geographical areas, one in Asia and one in Europe. As such, it represents a metropolitan region that has been influenced by both European and non-European forces; how have these forces affected the resulting spatial distribution of activities? The Istanbul metropolitan area (IMA) is the most populated metropolitan area in the country. IMA not only accommodates the largest population in Turkey but it is also the highest value added city in the Turkish economy. Its significant contribution to Turkey's economy is based on the manufacturing sector. There are 12,236 manufacturing establishments in the IMA (ISO 2004). The manufacturing sector employment accounts for 32% of the IMA total and about 17% of the total for Turkey (TUIK 2000). Official statistics show that Istanbul's manufacturing sector contribution to country export rate is 35% (ISO 2004). The GDP that is produced by the manufacturing sector is 23% of the country's total (TUIK 2002). All these figures are important indicators of the IMA's prominence in the Turkish economy; reflecting the high concentration level of the manufacturing sector.

What is the manufacturing sector concentration level in Istanbul? What are the main factors affecting this high concentration level? What urbanization and/or localization economies have impacts on agglomeration? In particular, are there significant differences in agglomeration between the European and Asia areas, especially given the higher labor force participation rates and land rents on the European side?

3.2 The method

The first step is the measurement of concentration levels at IMA; thereafter, the focus will shift to the determinants of agglomeration. Here, the Ellison–Glaeser localization index (EGI) is applied (Ellison and Glaeser 1999) to determine the concentration level in the IMA as a whole. Then, the analysis will explore whether the concentration levels change at different geographical levels and for specific manufacturing sectors. The EGI is measured at the 22 manufacturing sector (2-digit level) at three different geographical levels, respectively, at two main geographical levels—(European and Asian sides), and at the IMA level.

In the second step, the determinants of agglomeration in the IMA are explored by regressing the Ellison–Glaeser localization index values on proxies for urbanization and localization economies (following Rosenthal and Strange 2001; Ge 2006).

4 Manufacturing sector concentration levels at Istanbul

The EGI methodology has three main steps. The first step determines the Herfindahl index (H) value that shows the industrial concentration in a defined area. Given the shares $s_1, \ldots, s_M$ of an industry's employment in each of M geographic areas, and the shares $x_1, \ldots, x_M$ of total employment in each of those areas, the Herfindahl index, $H = \sum_{j=1}^{N} z_J^2$, can be estimated for the industry plant size distribution where z_j is the each plant's employment share in a given industry in a given area. The second step generates the raw geographic concentration level (G) in a defined area. In the third step, they proposed the index (EGI) which shows whether an industry is geographically concentrated:

$$\lambda \equiv \frac{G - H}{1 - H} \equiv \frac{\sum_{i=1}^{M} (s_i - xi)^2 - \left(1 - \sum_{i=1}^{M} X_i^2\right) \sum_{j=1}^{N} z_j^2}{\left(1 - \sum_{i=1}^{M} X_i^2\right) \left(1 - \sum_{j=1}^{N} z_j^2\right)} \tag{1}$$

EGI (λ) is an equality defined by H and G. According to Ellison and Glaeser, it has the property that it emphasizes large deviations from the distribution of aggregate employment and it allows meaningful comparisons of the degrees of concentration in different industries. The localization agglomeration value (λ) takes on a value close to zero when the distribution of plant locations is completely random. A value of zero can be interpreted as a complete lack of agglomeration. Therefore, a non zero value implies localization or agglomeration. If it takes on a value close to one, it can be said that industry is completely concentrated in one location.

4.1 Localization levels at the geographical level and at the industry level

The source for all of these data is the Turkish Statistical Institute (TUIK) 2001 Census of Manufacturing Sector in each county of Istanbul at the 2-digit industry level of detail. The data provide total employment (300,840 person) and plant numbers

Table 1 Localization levels of sectors in different geographical areas

ISIC		IMA	European side	Asian side
15	Food products and beverages	0.001308	0.001995	0.001080
16	Tobacco products	0.006786		0.002465
17	Textile industry	0.004042	0.007514	0.000155
18	Wearing apparel	0.034212	0.047360	0.005228
19	Dressing of leather	0.003147	0.003944	0.002009
20	Wood products (except furniture)	0.007289	0.008773	0.005127
21	Manufacture of paper and paper product	0.004284	0.005364	0.003908
22	Publishing and printing	0.004051	0.004449	0.005058
23	Manufacture of coke, refined petroleum	0.007254	0.008442	0.005108
24	Manufacture of chemical industry	0.000135	0.000277	0.000772
25	Rubber and plastics product	0.002202	0.003745	0.000165
26	Manufacture of non-metallic	0.003362	0.005295	0.000985
27	Basic metal industry	0.004096	0.005952	0.001181
28	Metal product (except machinery)	0.000840	0.001990	−0.000038
29	N.E.C. machinery and equipment	0.000760	0.001993	0.000101
30	Office accounting, computing machinery	0.007272	0.008748	0.005108
31	N.E.C. electrical machinery apparatus	0.001548	0.004741	0.001603
32	Radio, TV and Communication equipment	0.003538	0.006907	0.001590
33	Medical, precise, optical instruments	0.006323	0.007952	0.005058
34	Manufacture of motor vehicles and trailers	0.002726	0.007343	0.002866
35	Other transportation equipment	0.006081	0.008748	0.002914
36	N.E.C. manufacture of furniture	0.002324	0.002779	0.001981

(3,707) for 22 2-digit sectors that are classified by International Standard Industrial Classification of All Economic Activities (ISIC).

At the 22 2-digit level, the calculation of the mean value of G (EGI) is 0.162 (0.162) and the median is 0.131 (0.131) in the IMA. It appears that the mean value of Istanbul's manufacturing has a relatively high level of localization in comparison to other studies (Ellison and Gleaser 1994, 1997; Rosenthal and Strange 2001; Devereux et al. 2004; Barrios et al. 2005; Bertinelli and Decrop 2005). Industries are distinctly geographically concentrated. However, the concentration levels vary across different geographical parts (EGI values for European and Asian sides are respectively, 0.187 and 0.062).

Localization levels vary greatly from industry to industry (see Table 1). Wearing apparel (ISIC-18) has the highest localization level of any sector in the IMA. Wood products (except furniture) (ISIC-20), office accounting, computing machinery (ISIC-30), manufacture of coke, refined petroleum (ISIC-23), medical, precise, optical instruments (ISIC-33) are the next most localized common industries across the IMA, European and Asian sides, respectively.

5 Determining the causes of agglomeration in Istanbul

5.1 The data

There are two main data sources in the second step. The proxies for urbanization economies are mainly based on TUIK data sets supplemented by information from the Istanbul Municipality and the Istanbul Chamber of Trade (ITO) to generate proxies for urbanization economies. However, the survey that was conducted by the Istanbul Municipality in 2005 is the only source of proxies for localization economies. According to the Istanbul Chamber of Industry (ISO) (ISO 2004) there are 12,836 officially registered manufacturing sector establishments in the IMA. The survey covered 3,099 manufacturing sector establishments, about 24% of the total establishments. The distribution of the survey is segmented with attention paid to the spatial (district) distribution as well as sectoral composition. However, the establishments for survey in these segments are chosen randomly.

5.2 Variable definition

In this study, variables are designed to be connected with urbanization economies and localization economies. Population, density, industrial area ratio, industrial employment, and service sector employment are some of variables that are designed as proxies for urbanization economies. Localization economies variables are designed to be consistent with Marshall (1997); therefore, they are proxies for labor pooling, manufactured inputs and knowledge spillovers (see Table 2).

Both population and density have priority in the general economic structure of a city. For instance, Fujita et al. (1999b) show that a gradual increase in population size effects the formation of spatial organization of an economy in cities. Ellison and Glaeser (1999) use both population and density as proxy variables which indicate that firms will reduce transportation cost or improve their marketing by locating closer to high population areas. Guimaraes et al. (2000) emphasize that the population size of the city potentially bolsters productivity and attracts more firms to a locality. Similarly, Smith and Florida (1994) use population as a proxy measure for the size of the labor pool and Barrios et al. (2005) employ density as a proxy to capture market-size effects. By taking into consideration all these studies, *population* (POP) and *density* (DNSTY) are designated as proxies for urbanization economies. In this study, *density* (DNSTY) is defined as a degree of concentration of population in a defined area.

Gross domestic product (GDP) is defined as another proxy for urbanization economies. Combes and Overman (2003) emphasize that high GDP per capita regions have good access to markets. The other proxy for urbanization economies is the *industrial area ratio* (IAREA). It is accepted that the higher the ratio, the greater the importance of industry in the economic life of IMA. *The industrial employment ratio* (IEMP) is included as a proxy for urbanization economies as well. IEMP mainly reflects the general economic activity of the city, and as Guimaraes et al. (2000) emphasize, the manufacturing employment level may be attractive to firms that have specific demands for specialized labor.

Table 2 Urbanization and localization economies' proxies

Codes	Definitions	Sources
Urbanization economies		
POP	Population	TUIK, Cencus 2000
DNSTY	Population density (person/hektar)	TUIK, Cencus 2000
GDP	GDP value (1996)	Sayilarla Istanbul, 2001
IAREA	Industrial area ratio	Istanbul Municipality, 2005
NMF	Number of non-manufacturing firms	Istanbul Municipality, 2005
UNV	Number of university	ITO, Yurtici Kuruluslar Rehberi, 2004
IEMP	Industrial employment rate	TUIK, Cencus 2000
SEMP	Service sector employment rate	TUIK, Cencus 2000
MRKP	Market potential based on population (it is measured according to Harris)	TUIK, Cencus 2000
LABMP	Labor market potential based on manufacturing sector employment (it is measured according to Harris)	TUIK, Cencus 2000
Localization economies		
TMI_1	Total manufacturing input (rent, heating, energy, water) cost (ytl)	Manufacturing sector Survey, Istanbul Municipality, 2005
TMI_2	Total manufacturing input (raw material) cost (ytl)	Manufacturing sector Survey, Istanbul Municipality, 2005
RWM	Potential raw material market area (it is measured according to Harris)	Manufacturing sector Survey, Istanbul Municipality, 2005
HSL	High skill labor-percentage of employees in professional and technical and related supporter occupations	Manufacturing sector Survey, Istanbul Municipality, 2005
MSL	Medium skill labor-percentage of employees in craft and repair occupations	Manufacturing sector Survey, Istanbul Municipality, 2005
LSL	Low skill labor-percentage of employees classified as laborers	Manufacturing sector Survey, Istanbul Municipality, 2005
R&D	Existence of R&D department (if yes = 1 otherwise = 0)	Manufacturing sector Survey, Istanbul Municipality, 2005
SIZE	Total area of an establishment (m^2)	Manufacturing sector Survey, Istanbul Municipality, 2005
PMG	Production of intermediate good (if yes = 1 otherwise = 0)	Manufacturing sector Survey, Istanbul Municipality, 2005
PRODUCT	Product types of an establishment Coded according to (3-digit) industry codes	Manufacturing sector Survey, Istanbul Municipality, 2005
SECTOR	Manufacturing sector of an establishment (2-digit, 22 sector)	Manufacturing sector Survey, Istanbul Municipality, 2005
SIDE	Location side of an establishment (if European = 1, Asian = 0)	Manufacturing sector Survey, Istanbul Municipality, 2005

Number of non-manufacturing firms (NMF) and *service sector employment ratio* (SEMP) are the other two proxies for urbanization economies. As Guimaraes et al. (2000) and Krugman (1993) emphasize, they reflect how the ready availability of particularly specialized workers in accounting, law, advertising and other technical fields can reduce the costs for businesses. Further, they may potentially bolster productivity and attract more firms to a locality especially for manufacturing firms who do produce for the international market.

Number of universities (UNV) is designed as a proxy for urbanization economies as well. The existence of a high number of universities shows an important opportunity to develop collaboration between the manufacturing sector and a university to produce innovations that may benefit the manufacturing sector. Also, it helps generate technological spillovers.

Market area potential (MRKP) and *labor market potential* (LABMP) are other two proxies that are designed for urbanization economies. The measurement of both of these variables is based on Harris (1954). According to Harris, a region's market potential could be measured as a distance weighted sum of economic activity in all other locations.[1] Some researchers in the literature have used this measurement. For instance, Fujita and Mori (2005) made two specifications of market potential where one is based on Harris. Also, the definition adopted by Ioannides and Overman (2004) market potential is closer to that of the traditional definitions by Harris. In this study, the population/manufacturing sector employment of 32 districts and the distances to the focused district are used for *market are potential/labor market potential* measurements. It is important to note that the distance of a district to another is the straight-line distance not in travel time.

Localization economies variables are designed to be consistent with Marshall (1997); therefore, they are proxies for labor pooling, manufactured input and knowledge spillovers. Three proxies are designed to reflect manufactured inputs or raw materials. The first one is *total manufacturing input cost* (TMI_1) which represents the total manufacturing input cost (YTL) for rent, heating, energy and water in a year. The second one is *total manufacturing input cost for raw material* (TMI_2) which represents the total manufacturing input cost (YTL) for raw materials in a year. It is expected that increasing manufacturing costs will affect the agglomeration process negatively. The third variable is *potential raw material market area* (RWM). Like the *market potential area* (MRKP) and *labor market potential* (LABMP), its measurement is based on Harris (1954) as well. *Potential raw material market area* (RWM) is measured as a distance weighted sum of cost of purchased raw materials in all other locations within the IMA.

According to Marshall (1997), labor pooling is the main reason for manufacturing sector concentration in an area because industry establishments locate near one another to take advantage of labor market pooling effects. Researchers have created various variables such as labor market skill, labor market cost, labor market availability to explain labor market pooling effect on agglomeration precisely

[1] i: $MP_i = \Sigma_j \frac{x_j}{d_{ij}}$ *for our calculations* x_j *is district j population / manufacturing sector employment,* d_{ij} *is the distance between geographical centers of district i and district j.*

(Smith and Florida 1994; Ellison and Glaeser 1999; Rosenthal and Strange 2001; Wheeler 2006; Kim et al. 2000). In this study, three different proxies are designed to reflect the labor pooling. The following three proxies are related with labor skill. While *high skill labor* (HSL) defines the percentage of employees in professional and technical and related occupations, *medium skill labors* (MSL) define the percentage of employees in craft and repair occupations in production process. Additionally, *low skill labor* (LSL) defines the percentage of employees classified as laborers.

As Marshall (1997) argued, firms tend to locate where they are likely to learn from other firms. This learning can take the form of workers learning skills from one another or industrial innovators copying each other. However, some researchers emphasize that it is difficult to both observe and measure patterns of information spillovers and to assess them empirically (Dumanis et al. 2002; Ellison and Glaeser 1999). In the survey, establishments were asked whether they have an R&D department or not. In this study, this question is introduced as a dichotomous variable (R&D) as a proxy of knowledge spillovers.

In addition to all these proxies, variables important for internal economies are designed following Enright (1993, 1994). He suggested that product diversification, prevalence of multiplant firms, and average plant size may influence the generation of and benefits from external economies and the propensity to agglomerate establishments. *Size* (SIZE) reflects the total area (m^2) of an establishment. *Product* (PRODUCT) is the product types of establishment; they are coded consistent with ISIC 3-digit industry codes. *Production of intermediate goods* (PMG) yields information as to whether an establishment produces intermediate goods or not. *Sector* (SECTOR) is the manufacturing sector for the establishment. They are 22 2-digit sectors that are classified by ISIC. Finally, *side* (SIDE) is designed as a dichotomous variable to reflect the location side of an establishment. It is designed to show the geographical discrimination effects on agglomeration.

A bivariate correlation test is applied to the urbanization variables and localization variables to examine the relations between the proxies for localization and urbanization economies. The results reflect that some of the urbanization economies variables are correlated with some of the localization economies variables. The direction of correlation changes in both directions.

5.3 The regression equation estimation

In this study, all the equations are estimated by two stages least squares (2SLS) regression (2SLS). The estimated equations structures are the same for the all models

$$y_i = \beta X_i + \gamma y_{i-1} + \varepsilon_i \tag{3}$$

In this equation, y_i is the localization index value for the counties. X_i is the vector of urbanization economies and localization economies proxies, $y_{i-1}$is a lagged endogenous variable, and ε_i is assumed to be an independently and identically distributed error term.

As Henderson et al. (1995) emphasized that the correlation levels might be high among huge panel data set variables, they suggested the 2SLS estimation in their studies. The dependent variable of the equations is EGI. Since EGI requires the distribution

of employment across a set of geographic areas for a set of industries, it is thought that some of the variables such as *population* (POP), *density* (DNSTY), *industrial employment rate* (IEMP), *percentage of employees in professional and technical related supporter occupations* (HSL), *percentage of employees in craft and repair occupations* (MSL), and, *percentage of employees classified as laborers* (LSL) can be endogenous variables. Therefore, a test of simultaneity is essentially a test of whether (an endogenous) regressor is correlated with the error term. To find out which is the case in a concrete situation, the Hausman's specification error test is applied. Test results show that *density* (DNSTY), *industrial employment rate* (IEMP), and *percentage of employees in craft and repair occupations* (MSL) are endogenous variables. Likewise, to avoid the endogeneity and conditional correlation problems in the equations this method is preferred in this study as well.

Twelve different 2SLS equations (models) are estimated; nine of these models are the specifications of subsamples of the data set. Hence, also, the robustness is tested by these models. The first three of them analyze the determinants of agglomeration at each geographical level. The first one reflects the agglomeration determinants across the IMA. The second and third ones cover the *European* and *Asian* areas of the IMA. These two areas have different characteristics; 89% of manufacturing sector firms are located on the European side and only 11% on the Asian side. Furthermore, 77% of manufacturing sector employment is clustered on the European side and 23% on the Asian side. Additionally, the distribution of manufacturing sectors across these geographical sides is different. Because of their distinct characteristics, it is expected that the determinants of agglomeration could differ at these geographical levels.

The other models analyze the determinants of agglomeration due to industry-specific characteristics. The fourth model reflects the agglomeration determinants for the *textile industry and wearing apparel*. Textile industry and wearing apparel is the largest manufacturing sector in the IMA, accounting for 39% of manufacturing sector firms in Istanbul. More importantly, according to EGI levels, the textile industry and wearing apparel is the most localized sector in the IMA.

Equations (5) through (7) analyze the determinant of agglomeration due to three different sectors; *metal product* (*except machinery*), *rubber and plastics product* and *food products and beverages*. While *metal product* (*except machinery*) is the second largest manufacturing sector in the IMA, accounting for 12% of manufacturing sector firms in Istanbul, *rubber and plastics product* represent the third largest manufacturing sector with the 8% of the total manufacturing sector establishments. The *food products and beverages* account for 5% of the total manufacturing sector establishments. The main aim of estimating separate equations for varying sectors is to elaborate how the agglomeration effects determine the patterns across different industries.

The eighth equation focuses on the establishment size in terms of working people. It analyzes the agglomerative forces for establishments which *employ more than 50 workers* (medium and large size industries). They are large scale establishments and their high skill labor percentage is higher than establishments employing less than 50 workers.

Henderson et al. (1995) emphasized that cities with historical concentrations of an industry and related local knowledge accumulations offer a more productive environment for establishments in that industry than those without them. As long as the age

of the establishment increases, it may show that the historical concentration in the area might be attractive for new establishments. In this context, the sixth and seventh models focus on the age of the establishments. The ninth equation estimates the determinants of agglomerations for establishments which are *5 years old and younger*. In contrast, the tenth equation estimates the determinants of agglomerations for establishments which are *25 years old or older*. The former set represents 6% of the total manufacturing sector establishments while the latter accounts for 17%. While *5 years old and younger* establishments are mainly small scale establishments that employ 1-9 workers, *25 years old and older* establishments are large-scale operations employing 100-plus workers. Additionally, *5 years old and younger* establishments are mainly representatives of the textile sector whereas *25 years old and older* establishments are mainly focused in the N.E.C. Machinery and equipment, manufacture of chemical industry and other transportation equipment sectors.

Finally, the eleventh and twelfth equations examine the agglomerative forces of establishments due to their sizes in terms of total area (m^2). While the eighth one analyzes the determinants of agglomeration for *establishments smaller than* 500 m^2, the ninth one analyzes it for *establishments bigger than* 500 m^2 total areas. Each of these subsamples represents 50% of the total manufacturing sector establishments. The estimation results of all models are presented in Table 3.

5.4 Agglomeration at geographical level

Ten variables are included in the IMA model. Results provide strong evidence that urbanization economies are positively associated with agglomeration at the IMA level. The results of manufacturing survey provide that the most important factors that affect the location decisions of manufacturing firms within the IMA are respectively, to locate closer to similar types of manufacturing sectors, transportation facilities, market area potential and labor market potential (Manufacturing Sector Survey, 2005). These results reflect consistency with the result of the equation. An increasing industrial area ratio means that an increasing potential of diversity in production or the total amount of economic activity as well as an increasing benefits from proximity to other firms engaged in similar activities. Therefore, it is the capability of stimulating agglomeration that is expected in this case. Additionally, the labor market potential of the IMA is one of the determinants of the IMA likely to affect the location decision of manufacturing firms within the metropolitan area. The other important result of the manufacturing survey is that manufacturing firms sell 85% of their production within the boundary of the IMA. Therefore, the positive impact of the market area potential of the IMA on the agglomeration is an expected outcome. These results suggest that labor pooling and manufactured inputs or raw materials contribute to agglomeration at the IMA level and provide support for Marshallian agglomeration effects. The striking point is about the knowledge spillovers. Results do not provide any evidence that knowledge spillovers have influence on agglomeration at this geographical level.

It is notable that urbanization economies are generally similar in the two geographical (European and Asian) parts. *Market area potential* (MRKP) has a positive influence on agglomeration in both European and Asian sides. On the other hand, the

Table 3 The determinants of agglomeration at the 2-digit ISIC level manufacturing sector in the IMA

	Determinants at geographical level			Determinants at industry-specific level								
	IMA	European Side	Asian side	Wearing apparel and Textile industry	Metal product (except machinery)	Rubber and plastics product	Food products and beverages	Establishments employ 50+ workers	Establishments 5 years old and younger	Establishments 25 years old and older	Establishments bigger than 500 m^{2+}	Establishments smaller than 500 m^{2-}
POP												
DNSTY	−0.0019 (−36.7162)	−0.0003 (−13.3983)	−0.0006 (−4.8260)	−0.0004 (−11.4527)				−.0.0004 (−10.2771)	−.0.0004 (−13.7415)	−.0.0003 (−3.5865)	−0.0004 (−16.8030)	−0.0003 (−10.8564)
GDP				−4.89E-10 (−1.6902)	4.03E-10 (4.5537)	3.39E-10 (2.4688)	1.09E-09 (5.6240)	2.88E-10 (2.6574)	−3.76E-10 (−1.6559)	1.24E-09 (6.4095)		
IAREA	0.0003 (38.8409)			−3.26E-05 (−3.3978)		−2.98E-05 (−4.2971)	−3.40E-05 (−2.5807)			−2.59E-05 (−2.6339)		−1.85E-05 (−4.3333)
NMF			0.0001 (41.6859)	4.96E-05 (2.8822)				4.04E-06 (2.0937)	5.34E-05 (3.8568)	−7.12E-05 (−6.0809)	3.75E-05 (3.1658)	2.67E-05 (2.3401)
UNV	−0.0647 (−17.6429)											
IEMP	12.2500 (17.8570)					−1.2871 (−3.0134)	−0.2718 (−2.0396)	−1.9521 (−3.8504)	−1.3084 (−5.9023)		−1.7335 (−7.4100)	−1.1014 (−4.3333)
SEMP	16.3452 (21.1129)				0.4445 (6.8010)	−0.9877 (−2.4712)		−1.6867 (−3.5900)	−1.1555 (−5.2147)		−1.4967 (−6.7374)	−0.7728 (−2.7560)
MRKP	1.14E-06 (47.7478)	2.74E-07 (29.3974)	3.41E-07 (3.5016)	2.29E-07 (11.8672)	2.14E-07 (7.5872)	1.28E-07 (5.1274)	8.33E-08 (2.0463)	2.94E-07 (10.3664)	2.94E-07 (18.1289)	1.45-07 (3.6897)	3.06E-07 (21.0957)	−2.38E-07 (−16.6247)
LABMP	−3.89E-10 (−51.2602)	1.67E-10 (24.0668)	−1.23E-09 (−3.8743)	−2.33E-10 (−10.6553)	−1.66E-10 (−9.3237)	−1.17E-10 (−6.4710)	−1.59E-10 (−14.8707)	−1.39E-10 (−10.7370)	−2.18E-10 (−18.7846)	−9.56E-11 (−4.5486)	−1.96E-10 (−17.7824)	−2.13E-10 (−18.5031)

Table 3 continued

	Determinants at geographical level			Determinants at industry-specific level								
	IMA	European Side	Asian side	Wearing apparel and Textile industry	Metal product (except machinery)	Rubber and plastics product	Food products and beverages	Establishments employ 50+ workers	Establishments 5 years old and younger	Establishments 25 years old and older	Establishments bigger than 500 m^{2+}	Establishments smaller than 500 m^{2-}
TMI_1												
TMI_2	−2.26E-12 (−2.9087)	−4.31E-12 (−2.6116)	2.81E-11 (−1.8355)						3.77E-12 (2.3209)	1.00E-09 (4.6269)		−1.94E-11 (−1.8040)
RWM		7.97E-12 (4.6951)	−2.92E-11 (1.8936)	1.30E-11 (1.7806)				3.89E-12 (3.9595)	−3.78E-12 (1.8649)	−1.00E-09 (−4.6222)	4.30E-12 (3.5087)	2.28E-11 (2.0803)
HSL					0.0477 (1.7506)							
MSL	0.0130 (2.1227)		0.0118 (1.7082)	0.0553 (3.5090)								0.0261 (1.9777)
LSL			0.0259 (2.5397)	0.0594 (3.5799)		−0.0262 (−2.2601)						
R&D												
SIZE									−1.20E-06 (−2.0768)			−8.48E-05 (−3.6285)
PMG		−0.0188 (−3.5038)	−0.0078 (−1.9396)	−0.0395 (−4.5824)			−0.1496 (−5.4733)		−0.0147 (−2.4812)		−0.0098 (−2.3245)	−0.0225 (−2.9578)
PRODUCT		0.0002 (2.2460)	−0.0002 (−2.0893)									
SECTOR		−0.0033 (−2.3665)	0.0025 (1.9229)									
SIDE				−0.0618 (−7.5699)	-0.0788 (−7.8815)	−0.0689 (−8.7243)	−0.0981 (−5.4733)	−0.0378 (−3.4109)	−0.0524 (−11.9013)	−0.1045 (−4.3566)	−0.0430 (−9.6242)	−0.0709 (−12.4998)
R^2	,967	,298	,832	,361	,584	,475	,640	,557	,389	,793	,528	,353
ADJ. R^2	,964	,289	,825	,346	,570	,457	,614	,528	,377	,740	,519	,340
F	333,752	34,074	119,883	23,890	40,0377	27,6635	25,1308	19,773	34,041	15,028	58,614	27,970

* *t*-Ratios are below coefficients

contribution of *labor market potential* (LABMP) to agglomeration is positive on the European side while it is negative on the Asian side. The manufacturing sector survey results reflect that the distribution of manufacturing labor is prominently different between these two sides (Manufacturing Sector Survey, 2005). While the European side accounts for 77% of the total manufacturing sector labor, leaving the Asian side with the remaining 23%. Hence, the labor market potential of the Asian side is more limited than that the European side. Another supporting survey result is that 10% of the Asian side manufacturing sector labor commutes from the European side of the metropolitan area. Consistent with the varying labor distribution between these geographical parts, *labor market potential* (LABMP) impact on agglomeration is also varying between these geographical parts.

However, localization economies have a different influence on agglomeration at these two geographical levels. Labor pooling contributes to agglomeration in the Asian side but not in the European side. Although, manufacturing inputs or raw materials contribute to agglomeration at both geographical levels, its influence on agglomeration is different. While the *total manufacturing input cost* (TMI_2) has a positive affect on agglomeration on the Asian side, its affect is negative on the European side. When it is asked to arrange the five most important factors for the location choice of the firm, the importance level of the proximity to the raw material is reflected as 412 in European side and 115 in Asian side (the total score is 3,098) (Manufacturing Sector Survey, 2005). This supporting result is consistent with the equation results and reflect that to minimize the raw material cost is more important for the European side manufacturing firms than that the their counterparts in the Asian side. Also, *potential raw material market area* (RWM) is significant but has a negative affect on agglomeration on the Asian side, whereas it is significant and positive affect on the European side. 83% of the manufacturing establishments source their raw materials within metropolitan area; the counties which are the highest suppliers are located on the European side (Manufacturing Sector Survey, 2005). This concentration may determine the positive contribution of *potential raw material market area* (RWM) on agglomeration in European part of the IMA.

Additionally, *sector* (SECTOR) contributes to agglomeration only on the Asian side. This converse situation is also similar with *product* (PRODUCT) that has a positive influence on agglomeration on the European side but not on the Asian side. 17% of the manufacturing firms produce intermediate goods and the distribution of this production according to sectors from the highest through the lowest level is that *textile industry* 43%, *metal products* (*except machinery*) 14%, *manufacture of motor vehicles and trailers* 14%, and *N.E.C. machinery and equipment* 9%. Looking at the geographical distribution of these, all of them are densely located in the European side; 89% of the total of the *textile industry*, 68% of the total of the *metal products* (*except machinery*), 53% of the total of the *manufacture of motor vehicles and trailers*, and, 63% of the total of the *N.E.C. machinery and equipment* (Manufacturing Sector Survey, 2005). The dense accumulation of the sectors that support the intermediate goods production on the European side could explain how *product* (PRODUCT) influences agglomeration positively in the European side. These results suggest that their impact on agglomeration is mostly defined by the inherent characteristics of these geographical parts such as their morphologies or demographic structures.

5.5 Agglomeration at the industry-specific level

When looking at industry-specific models, some results stand out. Urbanization economies are significant but have a negative impact on agglomeration in the all of these industry-specific models. For localization economies, labor pooling and manufactured input or raw material have significant effects on agglomeration; however, the results suggest that knowledge spillovers have no impact on agglomeration in all the models. *Location side of an establishment* (SIDE) is the most prominent characteristic in these models; it is significant but always has a negative impact on agglomeration.

The age related models' result suggests that urbanization economies proxies have significant impacts on agglomeration but in different directions. It is noticeable that manufactured inputs or raw materials have a significant impact in two models with the same direction. Internal economies related proxies are significant but negative effect on agglomeration only for the establishments 5 years old and younger.

The size related models provide that urbanization economies have similar impact on agglomeration. Similar to the earlier models, labor market pooling and manufactured inputs or raw materials that represent localization economies have significant impacts on agglomeration in these two models. Internal economies related proxies are noticeable in the both models. Their impact on agglomeration is negative in these models.

The *establishments employing more than 50 workers* demonstrate that urbanization economies have stronger impact on agglomeration than localization economies. The urbanization economies influence on agglomeration is similar with other industry-specific models implying that there is no distinctive impact on agglomeration, in contrast to the other models. The only localization economies that have an impact on agglomeration are *potential raw material market area* (RWM). The urbanization economies that affected the agglomeration pattern of the establishments employing more than 50 workers are noteworthy in differentiating it from the other industry-specific models.

The agglomeration determinants for the different sectors; *textile industry and wearing apparel*, *food products and beverages*, *rubber and plastic products* and *metal products* (*except machinery*) reflect some similarities. For instance, *market potential* (MRKP) is significant in all equations and has positive impact on agglomeration. However, *labor market potential* (LABMP) and *location side of an establishment* (SIDE) have impact on agglomeration in a negative way in all equations. While the impact of GDP is positive on agglomeration for the sectors of *food products and beverages*, *rubber and plastic products* and *metal products* (*except machinery*), its impact on agglomeration is the reverse side for *textile industry and wearing apparel* sector. *Textile industry and wearing apparel* is a labor intensive sector; therefore, it provides opportunities for low skill laborers to access a job that is easier than for other sectors. An increasing GDP rate may mean decreasing job demands of low skill laborers because they may have chance to substitute their jobs with another more beneficial job opportunity. Marshallian labor pooling has significant in three of the sectors. As could be expected the medium skill labor (MSL) and the low skill labor (LSL) impact on agglomeration is positive in *textile industry and wearing apparel* sector. *Metal products* (*except machinery*) demands high skill labor (HSL) and in case of its supply

has a positive impact on agglomeration. Differing from the other two sectors, the low skill labor (LSL) impact on agglomeration is negative in the *rubber and plastic products* sector. However, labor pooling is not a determinant of agglomeration for the *food products and beverages sector*.

The agglomeration determinants for the different sectors have some similarities with the other industry-specific models. *Market potential* (MRKP) and *labor market potential* (LABMP) are significant in all models and while the former's impact is positive on agglomeration, the latter's impact is negative on it. Whereas the role of manufactured inputs or raw materials impact is more obvious in industry-specific models, the role of labor pooling impact is more obvious in the various sectors models. The importance of the *location side of an establishment* (SIDE) is prominent in all cases. As an important natural threshold, the Bosphorus divides the metropolitan area into two geographical parts. This division is not only a geographical division but also the division of population, the division of urban function areas and facilities. As a threshold, it has a huge impact on location decision of establishments and it remarkably affects on the agglomeration pattern in the IMA.

5.6 Summary of the results

Overall, these findings demonstrate that (1) the determinants of agglomeration vary according to geographical level, (2) urbanization economies have stronger influence on agglomeration at the IMA level than its two (Asian and European) parts, (3) localization economies impact on agglomeration is more obvious on the European and the Asian sides than at the IMA level, (4) some variables (DNSTY, MRKP, LABMP) do help to systematically explain the differences in agglomeration at geographical and industry-specific levels, (5) GDP, NMF, RWM, PMG, and SIDE explain the differences in agglomeration at industry-specific levels relatively than the other variables, and (6) there is at least one characteristic which is prominent for each industry-specific model and distinguishes it from the others. For instance, labor pooling for *textile industry*, *rubber and plastic products* and *metal products* (*except machinery*), urban economies for *establishments employing more than 50 workers*, internal economies for *establishments bigger/smaller than* 500 m^2, manufactured input or raw material *establishments for younger/older than 5/25 years*, (7) both geographical and industry-specific level, labor pooling and manufactured inputs or raw materials are important localization economies proxies and finally, (8) results do not provide any evidences that knowledge spillovers have an impact on agglomeration in this case.

6 Conclusion

This paper demonstrates the causes of agglomeration explicitly by seeking the patterns of urbanization economies and localization economies for the manufacturing sector in the IMA. The research proceeded in two steps. The first step measured the concentration levels at the IMA by utilizing the Ellison–Glaeser localization index (EGI), with the measurement conducted at the 22 manufacturing sector (2-digit level) for three different geographical levels. The second step determined the characteristics of

agglomeration. For this step, the approach regressed EGI values on proxies for urbanization and localization economies. Determinants of agglomeration are estimated by nine different two-stage OLS regressions. While three of these regressions explored the role of different factors on agglomeration for different geographical levels, the other six equations examined agglomeration influences at the industry-specific level.

Results suggest that urbanization economies have a strong effect on agglomeration both at the geographical and industry-specific levels. The results suggested that *density* (DNSTY), *market area potential* (MRKP), and *labor market potential* (LABMP) are the most effective proxies for estimating the impact of urbanization economies on agglomeration both at geographical and industry-specific levels. GDP, *industrial area ratio* (IAREA), *number of non-manufacturing sector firms* (NMF),*industrial employment rate* (IEMP) and *service sector employment rate* (SEMP) are urbanization economies' proxies that have stronger effect on industry-specific agglomeration. The results suggest the strong influence of two sources of localization economies. Labor market pooling and manufactured inputs or raw materials have important effects on agglomeration both at the geographical and industry-specific levels. However, the results do not provide any evidence that knowledge spillovers have influence on agglomeration in this case.

Besides the urbanization and localization economies, the geographical structure of the IMA is one of the most remarkable determinants of the manufacturing sector agglomeration. Industry-specific equations reflect that Bosphorus is an important natural threshold and affect the location decisions of establishments considerably.

The results of this study could contribute to enhancing the understanding of the manufacturing sector agglomeration forces in a larger perspective. They could help improve growth strategies for the manufacturing sector, and provide some contributions to the development of policies that might explore the possibility and feasibility of redistribution and relocation of manufacturing sectors both within and out of the IMA. However, lacking information and with incomplete data about knowledge spillovers, the study needs to be complemented by additional research prior to the enactment of any major location policy initiatives.

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