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Do Firms Benefit From Agglomeration? A Productivity Analysis for Turkish Manufacturing Industry

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Abstract

The link between productivity and agglomeration is important to answer the question 'Do firms benefit from agglomeration?' This study aims to investigate such link using proper proxies and econometric methods. This study employs the Ellison and Glaeser index and Total Factor Productivity to represent agglomeration economies and productivity levels in Turkish manufacturing industries, using 1980-2001 panel data. TFP is measured using SFA and then regressed along agglomeration and other control variables using a dynamic system GMM estimation method. This estimation method allows to account for the dynamic nature of TFP and also the possible endogeneitiy between productivity and agglomeration. The results indicate that Turkish manufacturing industries stand as an example to negative externalities.

Keywords: Regional Economics, Agglomeration, Productivity, Turkish manufacturing industry, GMM.
JEL Classification: *R12, D24, C23.*

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Özet

Firmalar Kümelenmeden Yararlanıyor Mu? Türk İmalat Sanayisi İçin Bir Verimlilik Analizi

Verimlilik ve kümelenme arasındaki ilişki 'Firmalar Kümelenmeden Yararlanıyor mu?' sorusunu cevaplayabilmek için önemlidir. Bu çalışma söz konusu ilişkiyi uygun vekil değişkenler ve ekonometrik yöntemler aracılığıyla incelemektedir. Bu çalışmada kümelenmeyi temsiletmesi açısından Ellison ve Glaeser endeksi ve verimliliği temsil etmesi açısından Toplam Faktör Verimliliği kullanılmıştır. Çalışmada Türk imalat sanayisi için 1980-2001 yıllarına ilişkin panel very setinden yararlanılmıştır. Toplam Faktör Verimliliğinin ölçülmesinde tercihedilen yöntem Stokastik Üretim Sınırı yöntemidir. Daha sonar Toplam Faktör Verimliliği bağımlı değişken olarak kullanılmış ve kümelenme ve diğer control değişkenleri sisteme dahil edilerek dinamik sistem GMM yöntemi ile tahmin edilmiştir. Bu yolla Toplam Faktör Verimliliğinin dinamik yapısı ve Toplam Faktör Verimliliği ve Kümelenme arasındaki potansiyel endojen ilişki dikkate alınmaktadır. Sonuçlar, Türk imalat sanayisinin negative dışsallık literatürüne bir örnek teşkil ettiğini göstermektedir.

Anahtar Kelimeler: BölgeselİktisatKümelenme, Verimlilik, TürkİmalatSanayisi, GMM.
JEL Sınıflaması: *R12, D24, C23.*

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I. Introduction

Specialization is one of the most frequently discussed topics in the existing literature. All trade theories developed so far have been examining specialization and trying to reveal the reasons behind specialization. However, traditional trade theories were concerned with specialization in terms of industrial concentration only. According to the traditional theory, the spatial characteristics affect and determine the patterns of trade, but they do not have any effect on firms' location choice (Brülhart, 2001). In this context, industrial concentration is generally measured with either the Herfindahl index or with the Gini coefficient. The main concept measured with these indices is whether or not an industry is concentrated in terms of thenumber of firms and market shares. As a result, it is possible to state that industrial concentration provides information regarding the level of competition in an industry and the market structure that the industry is operating within. Although information on the market structure is crucial for any firm'spricing, research and development (R&D) and/or advertising strategies, the degree of clustering is also important for firms' performance.

In this regard, afternew trade theories (NTT) and new economic geography (NEG) models, location has begun to attract more attention by the studies focusing on firms' performance. New trade theories embrace the imperfect structure of the markets assuming monopolistic competition and increasing returns to scale (Wolfmayr-Schnitzer, 2000). For example, according to Krugman (1980), firms would choose to locate their activities closer to the larger market because of scale economies and transportation costs, which is called by Krugman (1980) as the "home market effect". Therefore, a common feature of new trade theories is that they assume that large countries will play a central role for the location of economic activity due to the home market effect. To be specific, new trade theories argue that larger countries/regions −because of larger demand−will be the first choice of firm location.

On the other hand, with the introduction of NEG models characterised by monopolistic competition, externalities, and endogenous labour, location becomes more important since these models introduce the concept of agglomeration. Agglomeration, by definition, means "the act or process of gathering into a mass." In the existing literature, agglomeration means specialization in terms of both spatial and industrial characteristics. In this regard, agglomeration can be regarded as an extended definition for specialization. In other words, agglomeration leads to a comprehensive definition of specialization by adding the concept of geographical concentration to industrial concentration.Geographical concentration means that an industry is becoming increasingly concentrated in a specific geographical location, which can be as large as a country or as small as a region (Amiti, 1998).

Even though agglomeration can be treated as a relatively new concept, the roots of agglomeration rest upon theMarshallian externalities(Marshall, 1920). Marshallian externalities[3] include labour market pooling, backward and forward linkages, and informational spillovers. Informational spillovers can be considered as a positive externality that arises from close proximity. Put differently, theory suggests that firms that are operating in the same industry would like to locate close to each other in order to take advantage from the possibility of informational spillovers. It can be argued that this kind of externality is especially important in high tech industries[4] since these industries substantially depend on know-how and innovation. Backward and forward linkages also serve as a positive externalitymotivatingfirms to cluster their economic activity in one particular region or area. These linkages can be defined as concentration of upstream and downstream firms in the same area which will lead to lower transportation costs of intermediate goods and support the production of non-tradable goods (i.e.; vertical linkages). Finally, labour market pooling can be defined as an externality that arises from concentration of firms in a specific area. Such concentration offers workers with industry specific skills a higher probability of employment and, at the same time, offers firms a lower probability of worker shortage. In this respect, it is possible to argue that labour market pooling creates a positive externality. However, concentration of firms and workers creates overly crowded centres with well-known disadvantages such as pollution, traffic, and higher crime rates. From the workers' point of view, although they will have a higher probability of finding work, they will have to face lower wages than they would get in not concentrated areas, since they would face a serious competition from being concentrated. Hence, it can be argued that labour market pooling can also act as a negative externality.

In the context of externalities mentioned above, it can be argued that, with the existence of positive externalities, it is expected that production will tend to locate in a specific area with high levels of competition. Concentration of economic activity in

[3] In economics, externalities usually define advantages or disadvantages that do not arise from prices.
[4] An important and significant example of this fact is the well-known Silicon Valley where most of the high-tech firms are located in the U.S.

more competitive areas will create further industrial and spatial concentration and, hence, will lead to a self-reinforcing process (Wolfmayr-Schnitzer, 2000). Because of this interesting agglomeration process, special attention in the existing literature is devoted to investigating two basic questions:where do firms locate;centre or periphery, and what factors affect firms' location decision (Amiti, 1998;Krugman, 1991b). Many empirical studies indicate that agglomeration is a stylized fact observed in various industries across the world. (see for example; Aiginger and Davis, 2004; Aiginger and Pffafermayr, 2004; Brülhart, 1998a, 1998b).However, the degree and the main structure of agglomeration differ for each country. Moreover, there are some puzzling results from the empirical literature. For example, being affected by informational spillovers, the degree of agglomeration is expected to be higher in high-tech industries. However, a significant numberof studies show that traditional sectors rather than high-tech sectors tend to be more agglomerated (see, for example;Alonso-Villar, Chamorro-Rivas, Gonzales-Cerdeira, 2004; Devereux, Griffith and Simpson 1999;Krugman 1991a). This result makes agglomeration equally interesting for economies that rely on traditional sectors rather than high-tech industries.

This study also aims to find answers to the two questions mentioned above, although; it uses a non-conventional way in search of answers. To be specific, this study aims to find out whether firms benefit from high levels of agglomeration; (i.e., do firms' want to locate in close proximity to each other) in terms of productivity. While investigating whether firms benefit from agglomeration, one important question to cope with is that through what channels productivity affects agglomeration. In other words, the choice of proxy for productivity becomes crucial when examining the relationship between agglomeration and productivity.

Productivity can be defined as the efficient use of the resources and measured in terms of labour, capital and total factor productivity (TFP). TFP is usually defined as the excess part of the output which cannot be explained by inputs, mainly labour and capital, in the production (Comin, 2006). Since TFP is the excess or unobservable part of the production technology, it is assumed that TFP is closely linked to externalities. Since the aim of this study is to investigate agglomeration and productivity via externalities, TFP is the chosen proxy for productivity which is one of the most important contributions of this study to the existing literature.

Furthermore, it is important to consider the two-way relationship between agglomeration and productivity. Ciccone (2002) suggests that the relationship between agglomeration and productivity can run both ways: While productivity can be high as a result of agglomeration effects, firms might as well choose to locate in close proximity as a result of high and appealing productivity levels in a specific area and a specific industry. In this regard, another important contribution of this study to the existing literature is that it takes into account the two-way relationship between agglomeration and productivity by employing a dynamic system GMM model as an estimation method. Additionally, no known study has addressed the relationship between agglomeration and productivity for Turkey. Thus, it can be argued that this study is the first attempt to investigate such a relationship for Turkey.

The remainder of the paper is as follows. Section 2 gives a brief discussion about previous empirical literature. Section 3 describes the data used and the methodology employed. Section 4 discusses the main findingsand policy implications, and, finally, Section 5 concludes the paper.

II. Empirical Background

There are many empirical studies aimingto investigate the relationship between productivity and agglomeration, especially for developed countries due to data availability. Most commonly used agglomeration variable in these studies seems to be the employment and/or population density (see, for example, Brülhart and Mathys, 2008; Ciccone and Hall, 1996; Ciccone, 2002; Combes, Duranton, Gobillon and Roux, 2008; Rosenthal and Strange, 2008). However, such proxies cannot be regarded as powerful ones since agglomeration is a complex phenomenon, which should be proxied by taking into account both industrial and geographical concentration. Therefore, it can be argued that choosing a proper proxy reflecting agglomeration plays an important role in avoiding unbiased and misleading results.

In the existing literature, productivity has also been analysed in many different ways. First of all, the distinction among various studies in the literature is based on the definition and use of productivity. Some studies choose to use labour productivity (see, for example, Bradley and Gans, 1998; Ciccone, 2002) as a dependent variable while some choose firm productivity (see, for example, Graham, 2006; Lall, Shalizi and Deichman, 2004). The definition of firm productivity also varies: some researchers employ TFP (see, for example, Cingano and Schivardi, 2004; Önder, Deliktaş and Lenger, 2003), while some use more direct approaches and employ output or value added (see, for example, Combes, 2000; Glaeser, Kallal, Scheinkman and Shleifer, 1992).

Glaeser *et al*. (1992), for example, use employment growth as a dependent variable to proxy production because of data limitations. They use the US data for 1956-1987 period to determine the underlying reasons behind local productivity growth. They use a specialization index (LQ)[5] to see the effect of regional specialization on local growth. Their findings indicate that specialization has a negative effect on local growth suggesting negative externalities to be evident. They also highlight the fact that industry growth would be a better proxy for productivity, but they use employment growth due to data limitations. Similarly, Combes (2000) uses employment growth to proxy productivity and the location quotient (LQ) for specialization for France. The results indicate negative effects from specialization for both industry and services sector for the 1984-1993 period. However, the methodology used by Combes (2000) does not take into account potential

[5]The LQ measures the degree of specialization in a region via measuring an industry's employment share in a specific region over the same industry's employment share in the country. Usually LQ>1 is seen as a sign of geographical clusters. The problem with LQ is that, this index only captures geographical specialization not agglomeration.

endogeneity problem between dependent and independent variables[6]. Furthermore, Cingano and Schivardi (2004) argue that Glaeser *et al*. (1992) and studies following them use a poor proxy for productivity and, hence, suffer from an identification problem. Their recommendation is to use TFP as a dependent variable which is argued to be a better proxy for firm productivity. Employing weighted least squares method to examine the relationship between agglomeration and productivity in Italy, they find agglomeration has a positive effect on productivity. However, it can be argued that their study also suffers a serious identification problem since they use LQ index as a proxy for agglomeration economies, which reveals information on regional specialization, not agglomeration.

On the other hand, most of the previous studies do not employ GMM method to deal with endogeneity problem although they point out possible path dependence while agglomeration economies are considered (see, for example, Bradley and Gans, 1998). Therefore, it can be said that there are two important points that should be accounted for in the analysis. The first one is about the choice of proxies for both agglomeration and productivity. Since there is no consensus on the proxies, it is not possible to compare any of the studies in the existing literature and to infer some general results or stylized facts. Therefore, it is also not possible to have an expectation of the underlying nature of the relationship between agglomeration and productivity, especially for a developing country where the evidence is scarce. The second point is related to the potential endogeneity problem between productivity and agglomeration, which requires instrumental variables to be used in estimation. In this context, this study extends the existing literature by using a proper index of agglomeration and using TFP as a dependent variable measured by the stochastic frontier analysis (SFA) rather than using employment or output variables.

[6]Firms tend to locate in a specific area in order to take advantage of positive externalities. These externalities might result from firms experiencing high productivity levels. On the other hand, firms might want to locate close to each other since firms in a specific region are experiencing high levels of productivity.

Furthermore, this study has an important contribution to the existing literature by focusing on a developing economy. Only a few studies have investigated the relationship between agglomeration and productivity for developing countries. For example, Lall *et al*. (2004) use output per worker as a dependent variable and LQ and urban density as two proxies for agglomeration for India in order to investigate the relationship between agglomeration and productivity for 1994-1995. Their findings indicate that specialization effects differ between the sectors and are negative for some sectors. In particular, they find that market access has a significant and positive effect on productivity and firms do not benefit from locating in dense urban areas.

When it comes to Turkey, there are a limited number of productivity studies for Turkish manufacturing industry, and they generally focus on productivity and export, FDI, trade, or technological efficiency relationships (see, for example; Aslanoğlu, 2000; Taymaz and Saatçi, 1997; Taymaz and Yılmaz, 2007). In the case of productivity and agglomeration, Coulibaly *et al*. (2007) attempt to capture this relationship using two-digit Turkish manufacturing data for 1980-2000 period. However, they try to capture agglomeration effects using several proxies such as accessibility, localization and urbanization that arise from the new economic geography (NEG) literature. It should be stated that there are some limitations for this study. First, their proxies for agglomeration and productivity do not reflect the true nature of such concepts. Second, two-digit data cannot reveal detailed information on such relationships. Another study for Turkey, Önder *et al*. (2003), is among the rare attempts to acknowledge the spatial characteristics of TFP in Turkish manufacturing industries. They investigate technical efficiency, technical change and TFP changes by estimating a trans-log Cobb-Douglas type production function employingSFA methodology. Their findings suggest that average firm size and regional characteristics are the main determinants of technical efficiency. Their findings indicate that firms operating with a larger scale are more efficient than small scale ones, and that industries located in metropolitan areas are more technically efficient than their peers in the peripheries. They use regions' share in production and population density and also a specialization index based on the value added to represent regional characteristics. Since they only attempt to account for the spatial characteristics, rather than agglomeration, their choices of proxies and the methodology used are appropriate. If the question in mind is agglomeration, however, a slightly different attempt is necessary. In this context, this study employs an agglomeration index reflecting both industrial and spatial characteristics, for which the details will be given in the next section.

III. Data and Methodology

The link between productivity and agglomeration is important to answer the question "Do firms benefit from agglomeration?" This study aims to investigate such a link using proper proxies and econometric methods. With this aim, the effect of agglomeration on productivity is examined using 1980-2001 panel data for Turkish manufacturing industries. The data set, obtained from Turkish Statistical Institute (TurkStat), provides information on the number of firms, number of workers, number of workers on payroll, payments to workers on payroll, total hours worked, changes in stocks, changes in fixed capital, value of inputs, value of outputs, value added, total income, total labour cost and Herfindahl index. Data are available on 2- and 4-digit and provided at the industry level. Data end at year 2001, because data for post-2001 period is not compatible with pre-2001 data due to the major changes in data collection procedures. Furthermore, there is no regional data available after 2001. 1980-2001 data are provided at the province level and aggregated to form regional level data. Regions used are purely geographical.

In this study, TFP is used as a proxy for productivity whereas Ellison and Glaeser index (EG index), which captures both geographical and industrial concentration, is used as a proxy for agglomeration. Ellison and Glaeser (1997) suggest the following index of agglomeration.

$$EG_{it}=\frac{G-\left(1-\sum_j s_i^2\right)H}{\left(1-\sum_j s_i^2\right)(1-H)} \qquad (1)$$

$$EG_{it}=\frac{\sum_{j=1}(s_{ij}{}^{s}-s_i)^2-(1-\sum_j s_i{}^2)H}{(1-\sum_j s_i{}^2)(1-H)} \quad (2)$$

where, j=1,…,m indicates regions and i=1,…,n indicates industries, s represents market shares, G is the measure of geographical concentration, and H is the Herfindahl index.

EG index uses a measure of geographic concentration (G) and also the Herfindahl index as a measure of industrial concentration. The expected value of the index satisfies E(EG)=0 if the data are generated by the simple dartboard model of random location choices with no natural advantages or industry specific spillovers. In other words, if the index takes the value of zero, it means a firm's location choice is completely random; as "throwing darts on a map". According to Ellison and Glaeser (1997), a value of zero shows a "complete lack of agglomerative forces". These forces are defined as natural advantages and technological or informational spillovers (i.e., externalities).Hence, EG=0 indicates a random location choice, EG>0.05 indicates high levels of agglomeration, 0.02<EG<0.05 indicates medium levels of agglomeration, EG<0.02 indicates low levels of agglomeration and finally EG<0 indicates dispersion of economic activity.

When EG index is compared with Gini index, which is widely used in the existing literature, it can be said that using Gini index will provide biased results when it is used to investigate agglomeration rather than geographical concentrationif employment is concentrated in small number of plants in a specific area (Maruel and Seddilot, 1999). However, this does not always mean that the firms' location decisions are not random.EG index, on the other hand, shows whether a firm's decision of locating in a specific area is random or not, by conditioning the geographical concentration index −which is quite similar to Gini index− on Herfindahl index. Furthermore EG index is also robust to region size. Descriptive statistics of the EG index is provided in Table 1. Even though the main concern of this study is not the EG index, it is possible to infer a general result regarding agglomeration in Turkish manufacturing industry. The mean value of the index indicates that Turkish manufacturing industry is highly agglomerated, which is presented in Table 1 as aggregated[7].

Table 1 Descriptive Statistics of EG index

	Mean	Std. Deviation	Min.	Max.
EG index	0.193697	0.06311	0.00010	0.56191

With regard to TPF, which is used as a proxy for productivity in this study, there is no consensus in the existing literature on how it should be measured.One of the commonly used methodologies to estimate TFP is calculating Solow's residual using a Cobb-Douglas type production function

$$Q_{it}=A_{it}\,F_t(K_{it}, L_{it}) \qquad (3)$$

In equation (3);*i* denotes industries, *t* denotes time, *K* denotes capital, *L* denotes labour, and *A* denotes TFP. TFP is then extracted from the equation using logarithmic transformation:

$$\ln Q_{it}= \ln A_{it}+ \beta \ln K_{it}+ \alpha \ln L_{it} \qquad (4)$$

$$\ln A_{it}= \ln Q_{it}- \beta \ln K_{it}- \alpha \ln L_{it} \qquad (5)$$

Although the Solow's residual is commonly used because of its computational simplicity, *A*(which gives the TPF) in the equations has been criticised for including also unwanted components such as the measurement error, omitted variable bias, aggregation bias, and model misspecification (Hulten, 2000). Therefore, in this study, TFP is estimated using the SFA in panel data as suggested by Batesse and Coelli (1995). The stochastic frontier production function allows for estimating technical inefficiencies in the process of producing a particular input. A production frontier can be described or characterised in two ways. The first one is the minimum input

[7]The results from the EG Index for specific years and industries are available upon request.

bundles, which is required to produce a certain output, and the second is the maximum output that can be produced by various amounts of inputs with a given technology. The econometric implication of these two definitions is the inclusion of "composed" error terms since the standard residuals which are symmetrically distributed with zero means are not suitable for such analysis. The "composed" error terms are not symmetric, and they do not have zero means. In other words, the error terms for the SFA are skewed with non-zero means (Kumbakhar and Lovell, 2000).

The production function, in this case, takes the form:

$$Q_{it} = \beta_0 + \sum_{j=1}^{k} \beta_j X_{jit} + v_{it} - u_{it} \quad (6)$$

Where, *Q* denotes the output and *X* denotes the explanatory variables, *i* denotes industries and *t* denotes time. The disturbance term in the stochastic frontier model is assumed to have two components (v_{it} and u_{it}). U_{it} is assumed to have a nonnegative distribution and v_{it} is assumed to have a symmetric distribution as the idiosyncratic error term. Such modelling allows for two different parameterisations of the error term, namely time invariant and time varying. In this study, the time varying decay model is used to account for the year specific effects. Technical efficiency (TE) and technical change (TC) are then estimated as follows:

$$TE_{ijt} = \exp(-u_{ijt}) \quad (7)$$

$$\text{Efficiency change} = TE_{ijt}/TE_{ijs} \quad (8)$$

$$TC = [1 + \partial \ln E(Q)/\partial t] + [1 + \partial \ln E(Q)/\partial s]/2 \quad (9)$$

Here, E(Q)denotes the expected value of production, and *t* and *s* denote subsequent years. Finally, the multiplication of TE and TC yields the TFP change.

After TFP is estimated via SFA, it is used as a dependent variable, and the EG index of agglomeration is used as an independent variable in addition to other standard independent variables such as capital labour ratio, labour productivity, and average firm size. The definitions and sign expectations of these variables are provided in Table 2. Since the capital stock data for Turkish manufacturing industries are not available, it is calculated using the perpetual inventory method following Yılmaz (2007):

The starting capital is calculated using

$$K_0 = \overline{I_n} * \frac{1-(1-\delta)^n}{\delta} \quad (10)$$

In equation (10) K_0denotes the initial capital, *n* denotes the number of years and *δ* denotes the depreciation rate for machinery which is used as 10%. After calculating the initial capital, investments to fixed capital is added for each year to obtain the capital stock variable.

Table 2 Definitions and Sign Expectations of the Variables

	Definition	Sign Expectation
TFP_{t-1}	Lagged value of the TFP	Ambiguous
KLR	Capital labour ratio	Positive
PROD	Labour productivity	Positive
AFS	Average firm size	Positive
AGGLOMERATION	E-G index	Ambiguous

The control variables used in the analysis are TFP_{t-1}, KLR, PROD, AFS, and AGGLOMERATION. TFP_{t-1}represents the lagged value of the measured change in TFP.Capital labour ratio is simply measured as the ratio of capital to labour (K/L). Labour productivity is measured as the ratio of labour to value added[8].Average firm size is measured by dividing number of employee to the number of firms.Finally, agglomeration is measured via EG index as explained above.

One of the most important challenges in the existing literature is to deal with the potential endogeneity problem between agglomeration and productivity. In such cases, instrumental variable (IV) approach is used. Instrumental variables are included

[8] A simple correlation test indicates that PROD and TFP are not correlated.

in a model either with two stage least squares estimation (2SLS) or with the GMM estimator.2SLS method is a kind of an extension of OLS method which allows for the use of instrumental variable. In both OLS and 2SLS, moments of regressors are set to zero. The main difference with 2SLS is that it distinguishes between regressors and instruments. However, in 2SLS methodology, it is critical to have at least as many instruments as there are regressors in order to avoid identification problem. In other words, when moment conditions outnumber parameters, it can be said that the specification is over identified. The GMM estimator is designed specifically for such situations and minimises the magnitude of the moment vector rather than trying to set them all to zero. Furthermore, the GMM estimator is linear in dependent variable and is consistent.

According to Roodman (2006), the difference and system GMM estimators are specifically designed to deal with several problems such as a dynamic estimation process, (i.e., if the dependent variable is influenced by its own past values),the existence of endogenous or pre-determined regressors, idiosyncratic disturbances that have individual-specific patterns of heteroskedasticity and/or serial correlation, autocorrelation which might arise from using the lagged dependent variable in the model,the panel data set that have a short time dimension and a large individual dimension and, finally, in the case where the only available instruments might be "internal" (i.e. depends on lags of the variables itself). However, it also allows the use of exogenous instruments. In this context, the GMM methodology is employed in this study in order to cope with the dynamic nature of the estimation process, potential endogeneity problem between productivity and agglomeration and potential heteroskedasticity problem that might arise as a result of time-invariant individual characteristics such as geography and demographics being correlated with the explanatory variables. Finally, because of data limitations the only available instruments in this study are lagged values of the used variables.

With regard to the choice between the difference and system GMM, the Arellano and Bond (1991) estimator uses first difference transformation which is referred to as difference GMM estimation. With first difference transformation, deeper lags of regressors remain orthogonal to the error term and, hence, can be used as instruments. However, if the data in hand is an unbalanced panel data, first difference transformation magnifies the gaps in the data set. This problem can be overcome with the use of forward orthogonal transformation as suggested in Arellano and Bover (1995), referred to as system GMM estimation. Forward orthogonal deviation subtracts the average of all future observations of a variable. Hence, it is computable for all observations except the last one, and therefore, minimises data loss. Furthermore, the lagged observations are valid instruments in such a case because they are not used in transformation, unlike first differencing. Finally, the main and most important difference between these two estimators is that Arrelano and Bond estimator differences with levels and implies that past changes are predictive of current realisations of the dependent variable. However, Arellano and Bover estimator levels with differences and implies past levels themselves are predictive of current realisations of the dependent variable rather than past changes. Therefore, system GMM estimation methodology rather than difference GMM estimation is employed in this study.

IV. Results

Tables 3a through 3d present the descriptive statistics of the EG index[9] for high-tech, medium-high tech, medium-low tech and low-tech industries, according to the OECD classification of technology (OECD, 2006).

[9]Detailed information regarding theresults of EG index is available upon request.

Table 3a Descriptive statistics for high-tech industries

	Mean	Std. deviation	Min.	Max.
1980	0.2308	0.4137	0.1942	0.2845
2000	0.1473	0.2156	-0.108	0.4
change[10]	-0.8348	0.1792	-0.3108	0.1164

Table 3b Descriptive statistics for medium-high tech industries

	Mean	Std. deviation	Min.	Max.
1980	0.2263	0.1101	-0.101	0.3772
2000	0.2403	0.2192	-0.1826	0.453
change	0.0048	0.2622	-0.5599	0.3489

Table 3c Descriptive statistics for medium-low tech industries

	Mean	Std. deviation	Min.	Max.
1980	0.2033	0.3011	-0.6022	0.4348
2000	0.2232	0.2101	-0.2030	0.4944
change	-0.1277	0.2276	-0.5545	0.4021

Table 3d Descriptive statistics for low-tech industries

	Mean	Std. deviation	Min.	Max.
1980	0.3073	0.0976	-0.0565	0.5092
2000	0.1815	0.5178	-2.1919	0.7015
change	-0.132	0.4717	-2.2484	0.373

Tables 3a through 3d indicate that the most agglomerated sectors in Turkish manufacturing industry belong in the low-tech group in 1980. However, throughout the investigated period, low-tech industries faced a serious de-agglomeration process. It is also clear from the tables that low-tech and high-tech industries faced decreasing degrees of agglomeration when the means from 1980 and 2000 are compared. This observation may indicate a similarity between low- and high-tech industries. Although there is a decrease in the mean value of the EG index, the highest agglomeration levels are still observed in the low-tech group, consistent with Krugman (1991a). Apart from comparing the means, comparing the standard deviations of the EG index presented in tables 3a through 3d may also reveal some

[10]Here, change refers to the descriptive statistics for the annual change of the EG index, not the difference between the years 1980 and 2000.

information. The standard deviation of EG index is quite low in high-tech industries and relatively high in medium-high and medium-low tech industries and the highest for low-tech ones, which means that the highest deviation from the mean occurs in the low-tech group.

The results of the EG index further indicate that the least agglomerated industries have become more dispersed from 1980 to 2000, and the most agglomerated industries have become more concentrated, which indicates a polarisation of industries. As a result, Turkish manufacturing industry is considered as a labour abundant industry showing high levels of agglomeration.

On the other hand, as stated above, TFP is used as a measure of productivity. Table 4 presents the results from the TFP estimation. The results are in line with the fact that Turkish manufacturing sector is dominated by low-tech firms and the sector is mainly labour abundant.

Table 4 SFA results

Dependent variable: ln(output): Time-varying decay	
ln(capital)	0.225***
	(0.057)
ln(labour)	1.997***
	(0.223)
ln(labour*capital)	-0.0007
	(0.006)
[ln(capital)]^2	0.0021
	(0.002)
[ln(labour)]^2	-0.039***
	(0.008)
Year	0.434***
	(0.006)
σ_u^2	0.3203
	(0.05)
Γ	0.716
	(0.033)
Prob>chi^2	0.0000

*Note: (1) Numbers in parentheses are standard errors (2) ***0.01>p, **0.05>p, *0.1>p*

With regard to the dependent variable, it should be mentioned that past values of the dependent variable might have an important effect on the current realisations. Hence, a dynamic panel data estimation method should be employed in order to account for the effects from past values of the dependent variable (TFP) on productivity and, also, in order to deal with the possible endogeneity problem that might occur between agglomeration and productivity. As mentioned by Ciccone (2002), the high levels of agglomeration can be both result and cause of high levels of productivity (i.e., the relationship between agglomeration and productivity can run in both ways). Hence, the following model is estimated using a two-step system GMM method of dynamic panel data estimation:

$$TFP_{it}= \beta_0 + \beta_1 TFP_{it-1} + \beta_2 KLR_{it}+\beta_3 PROD_{it}+\beta_4 AFS_{it}+\beta_5 AGGLOMERATION_{it}+\varepsilon_{it} \quad (11)$$

Here ε_{it} is again the composite error term including both time invariant industry specific effects and the remainder error term.

The results of the two step GMM estimation of equation (11) are provided in Table 5. The results from Table 5 are consistent with the sign expectations presented in Table 2. The coefficients of capital labour ratio (KLR), labour productivity (PROD) and average firmsize (AFS) are all positive. An increase in the capital labour ratio and labour productivity will increase total productivity level of a firm. Moreover, a positive effect from average firm size is expected because firm growth makes it possible to take advantage from scale economies which will increase firms' productivity levels, implying that large scale firms will be more efficient.The results further suggest that TFP is affected from its past values which means that past levels of TFP has a negative and statistically significant impact on current realisations. Table 6 represents the results from the same estimation excluding the high-tech sectors from the sample. Results from Table 5 and Table 6 are consistent with the exception of average firm size (AFS). When high tech sectors are excluded from the estimation, the sign of AFS turns from positive to negative, suggesting that small scale firms to be more efficient than large scale ones. Such results can be regarded as particularly interesting. When all sectors are considered, it is possible to say that the relationship between productivity and firm size in Turkish manufacturing industries can be considered in line with the traditional point of view.These results highlight the importance of high-tech sectors in terms of scale economies. When Table 5 and Table 6 are compared, it can be argued that scale economies are more pronounced in the high-tech sectors of Turkish manufacturing industry.All other coefficients have the same signs with slight changes to their magnitudes.

On the other hand, the coefficient of agglomeration, the main variable of interest, has a negative sign. Therefore, it can be argued that Turkish manufacturing industries stand as an example to negative externalities. As stated above, the sign of agglomeration can be either positive or negative. Agglomeration can have a positive impact on productivity via positive externalities such as vertical linkages, labour market pooling, and knowledge spillovers. On the other hand, there is avast amount of evidence on negative externalities of agglomeration economies, especially in the urban economics literature (see, for example, Cohen and Paul, 2005; Desmet and Fafchamps, 2005; Glaeser, 1998). Following Glaeser (1998), such negative externalities include costs of living and commuting, pollution costs and crime rates. Therefore, it is possible to argue that if the negative externalities outweigh the impact from agglomeration economies (i.e., positive externalities that arise as a result of agglomeration); a negative relationship can be expected between agglomeration and productivity. Such relationship can arise from the effect of one or more of the independent variables. For example, if labour costs are high in agglomerated regions, then firms would choose to employ less people or, even with a chance to do so, not to expand their scale in order to avoid the increases in labour costs.

In addition, Marshallian externalities suggest that labour market pooling is one of the important sources of positive externalities that arise from agglomeration economies (Marshall, 1920). Labour market pooling argues that skilled labour will be concentrated where agglomeration is high. However, skilled labour would be relatively costly to the firms. Furthermore, it can also be argued that unions work more effectively in agglomerated areas, which are generally assumed to be urban areas rather than rural. Apart from labour costs, rental costs are expected to be higher in agglomerated areas. Furthermore, pollution costs also increase as a result of agglomeration and regulations regarding pollution can be stricter in agglomerated areas. Finally, people might not be willing to choose in areas with high rates of crime. Hence, firms' pool of employment might be scarce in such areas. Therefore,it can be said that the effect of agglomeration on productivity of firms is not straightforward. However, there is no available data to test the effects of the negative externalities directly.

Table 5 Dynamic panel data estimation results on productivity

Dependent variable: TFP	
TFP_{t-1}	-0.0947*** (0.027)
KLR	0.1379** (0.243)
PROD	0.1530** (0.210)
AFS	0.7023** (0.502)
AGGLOMERATION	-0.2851*** (0.007)
CONSTANT	1.7328** (0.631)
Year dummies	Yes
Prob.(>chi^2)	0.000
Sargan test stat.	0.000
Diff. in Hansen test stat.	0.956
Number of obs.	1406
Number of groups	82
Number of instruments	107
Arellano-Bond test for AR(2)	0.964

*Note: (1) Numbers in parentheses are standard errors (2) ***0.01>p, **0.05>p, *0.1>p*

Table 6 Dynamic panel data estimation results on productivity (excluding high-tech sectors)

Dependent variable: TFP	
TFP_{t-1}	-0.1004*** (0.029)
KLR	0.1644*** (0.254)
PROD	0.0752** (0.215)
AFS	-0.7438** (0.524)
AGGLOMERATION	-0.0028*** (0.007)
CONSTANT	1.822** (0.655)
Year dummies	Yes
Prob.(>chi^2)	0.000
Sargan test stat.	0.000
Diff. in Hansen test stat.	0.961
Number of obs.	1351
Number of groups	79
Number of instruments	107
Arellano-Bond test for AR(2)	0.731

*Note: (1) Numbers in parentheses are standard errors (2) ***0.01>p, **0.05>p, *0.1>p*

V. Conclusion

This paper has mainly explored the relationship between productivity and agglomeration in order to provide some explanations for a specific question: “Do firms benefit from agglomeration?” This study is the first attempt to investigate such relationship for Turkish manufacturing industry by accounting for the two way relationship between agglomeration and productivity employing a dynamic system GMM model and by using proper proxies for both agglomeration and productivity. However, it should be acknowledged that there are two important data limitations for this study. First, this study could reveal more detailed information if data were plant or firm level data instead of industry level. Second, there are also other factors that might affect productivity, such as human capital and R&D expenditures, which cannot be included in the analysis as control variables. Notwithstanding these limitations, the findings of this paper are informative in terms of the agglomeration structure of Turkish manufacturing industry and the relationship between agglomeration and productivity.

The results suggest a negative relationship between productivity and agglomeration, which supports the negative externalities hypothesis. The question remains why some firms would still choose to locate or remain in the agglomerated regions even though there is persistent evidence on negative externalities, or in other words, even though agglomeration will negatively affect their productivity. As an answer to this question, it can be argued that in order to take advantage of the agglomeration economies, such as vertical linkages, access to markets or other several benefits of locating in dense areas might not offset the associated costs. Firms in specific industries may still choose to agglomerate even though this will cause a decrease in their productivity. Such fact can explain the finding of Krugman (1991) arguing that low-tech firms are the ones usually choose to agglomerate since low-tech firms are usually highly depending on natural resources as opposed to high-tech firms. Furthermore, baring the transport costs can be harder for low-tech firms and also vertical linkages are important in a similar sense. Therefore, it is possible to argue that low-tech firms choose to locate or stay in agglomerated areas, bearing the costs arise from negative externalities in order to have easy access to natural resources, the market and the upstream and downstream firms. In addition, it can be argued that some high tech firms would also choose to locate in agglomerated regions to take advantage of knowledge spillovers.

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