AGGLOMERATION ECONOMIES IN TURKISH MANUFACTURING INDUSTRIES*

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Abstract

This study examines the geographic distribution of Turkish manufacturing industries for the period 2003-2008 by utilizing Annual Industry and Service Statistics micro data set provided by TurkStat. The analysis is mainly based on the index developed by Ellison and Glaeser (1997) (EG). The aim of the study is to provide a descriptive analysis of geographical concentration of manufacturing activity in Turkey. Main finding of the study reveals that agglomeration in Turkish manufacturing industries is higher than the developed countries on average, but it also exhibits very high levels of agglomeration behaviour per se. Furthermore, stylized facts for agglomeration also hold for the case of Turkey such that low-tech industries tend to have higher agglomeration levels than industries with higher technologies. The study contributes to the literature in two aspects herein: (i) exploring micro level data to reveal the agglomeration patterns of the Turkish manufacturing industry by using EG index and (ii) examining the post-2000 period, which has not much been approached (due to data related issues) within this line of research for the case of Turkey.

JEL Classification: R12, R30, L60

Keywords: Agglomeration, geographic concentration, manufacturing

TÜRKİYE'DE İMALAT SANAYİNDE YIĞILMA EKONOMİLERİ

Öz

Bu çalışma, Türkiye'de imalat sanayindeki endüstrilerin coğrafi dağılımını, TÜİK tarafından sağlanan Yıllık Sanayi ve Hizmet İstatistikleri mikro veri setini kullanarak 2003-2008 dönemi için, incelemektedir. Analiz, temel olarak Ellison ve Glaeser (1997) (EG) tarafından geliştirilen endekse dayanmaktadır. Çalışmanın amacı, Türkiye'deki üretim faaliyetlerinin coğrafi konsantrasyonunun betimsel bir analizini sağlamaktır. Çalışmanın ana bulgusu, Türk imalat sanayinde yığılmaların ortalamada gelişmiş ülkelere göre daha yüksek olmasının yanında kendi içinde de oldukça yüksek düzeylerde yığılma davranışı gösterdiğini ortaya koymaktadır. Bununla birlikte, yığılmalar için geçerli genel bulgular, Türkiye için de desteklenmektedir; düşük teknolojili endüstriler, yüksek teknolojiye sahip endüstrilerden daha yüksek yığılma seviyelerine sahip olma eğilimindedir. Çalışma burada literatüre iki açıdan katkıda bulunmaktadır: (i) mikro düzeyde veri seti ile EG endeksini kullanarak Türk imalat sanayindeki yığılma örüntülerini ortaya çıkarmakta ve (ii) Türkiye örneği için bu araştırma hattında (veriyle ilgili problemlere bağlı olarak) pek ele alınmayan 2000 sonrası dönemi incelemektedir.

JEL Sınıflaması: R12, R30, L60

Anahtar kelimeler: Yığılma, coğrafi yoğunlasma, imalat

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1. Introduction

A generally observed phenomenon is that most economic activities and industries are not uniformly distributed across space but tend to cluster in certain locations in developed and developing countries. In effect, the notion of localization of economic activity "dates back to nineteenth century and is associated with names such as von Thünen, Marshall, Weber, Ohlin,Hoover, Christaller, Palander, Lösch, Isard and Beckmann" (Karlsson, 2008, p.1). Krugman (1991a) has been the pionner in building the microeconomic foundations of New Economic Geography (NEG) inspired by the remarks of Marshall (1920). In the pioneering work of Krugman (1991a), he asks "why manufacturing in general might end up concentrated in one or a few regions of a country instead of asking why a particular industry is concentrated in a particular area" (p.485). Theoretical developments on new economic geography have enhanced following Krugman's work, to cite a few prominent ones: Krugman (1995), Fujita and Thisse (1996), Fujita et al. (1999), Fujita and Thisse (2002), Redding and Venables (2004). Nevertheless, empirical research is ort deemed comparatively less well developed (Redding, 2010).

One strand of empirical research deals with the implications of new economic geography models by testing their empirical validity, such that whether theoretical predictions regarding factor prices, distribution of employment, regional divergence or convergence, etc. are proved by data or not. Another body of empirical work have predictions for the location of economic activity within industries, which may also be called as agglomeration economies (Redding, 2010). However, before analyzing further the sources/determinants and effects of agglomeration, measuring the extent of agglomeration of an economic activity in an industry arises as a first empirical challenge. Ellison and Glaeser (1997) address this issue by developing an agglomeration index of plants (EG index thereafter) "in which the observed distribution of economic activity within an industry is compared to a null hypothesis of random location" (Redding, 2010, p. 330).

This study, staying one-step behind theoretical and policy issues, attempts to exhibit empirical evidence on the measurement of agglomeration. Neither testing models of economic geography nor providing basis for the determinants or consequences of agglomeration is within the line of this research. The sole purpose is to reveal the current situation in Turkey with respect to geographical concentration of economic activity in manufacturing, which might be considered as an initial exploratory step for further analysis. In this context, this study intends to examine the geographical concentration of manufacturing activity in Turkey in the same vein as Ellison and Glaeser (1997) for the post-2000 period by exploring establishment-level micro-data called "Annual Industry and

Service Statistics" (AISS) provided by TurkStat. Exploring micro-data permits one to use plant-level based indices in order to measure geographic concentration of economic activities. For example EG index, "unlike more traditional measures, has explicit theoretical foundations and is based on (plant-level) microeconomic behaviour" (Barrios et al., 2009, p. 723). Moreover, once plant-level data is available, Ellison and Glaeser (1997, p. 890) claim, "… the index is designed to facilitate comparisons across industries, across countries, or over time".

The focus of the study is manufacturing industry as it is considered as a fundamental indicator in the development process of a country. Rodrik (2007) remarks as a stylized fact that rapidly growing countries are those with large manufacturing sectors. Doğruel and Doğruel (2008, p. 65) indicate that there has been a significant increase in the share of Turkish manufacturing industry in total employment and GDP within the period 1970-2006. They also show that manufacturing industry has continually preserved its position as being the driving force of the economy except the crisis periods. Despite the strength the manufacturing industry gained within this period, the distribution of manufacturing activity across the regions of Turkey has been far from being even. As shown in Doğruel et al. (2011), manufacturing employment demonstrates a prominent diversification between eastern and western regions. In this regard, investigating the dispersion of manufacturing activity would give hints about understanding the regional disparities.

Research regarding agglomeration economies although is not yet extensive; there are remarkable studies in this area. In a nutshell, some of these studies include Filiztekin (2002), Kıymalıoğlu and Ayoğlu (2006, 2007) examining agglomeration by investigating the effect of local scale externalities on manufacturing employment growth; Falcıoğlu and Akgüngör (2008) and Kaya (2006) investigating the regional specialization and industrial concentration of manufacturing industry; Türkcan et al. (2009) applying spatial econometric analysis to examine clustering behaviour of manufacturing firms; Karaalp and Erdal (2012) examining the effect of agglomeration economies on regional convergence of Turkish provinces. Öztürk (2013) investigates the extent of agglomeration in Turkish manufacturing industries for the period 1980-2001 by using aggregated data and exploiting the EG index. Öztürk (2013) is very at the same line with this research, however we conduct the analysis for the post-2000 period by using micro-data on enterprise level.

Previous studies examining the geographic concentration of economic activities in Turkey employ highly aggregated data at provincial or regional level and cover a certain period, namely 1980-2000, due to the inconsistency of regional data from then on. Therefore, we have very limited knowledge about geographic concentration of industries

for the post-2000 period. In this regard, this study will be contributing to the literature in two aspects such as (i) exploring micro-data to reveal the agglomeration patterns of the Turkish manufacturing industry by using EG index and (ii) examining the period of 2003-2008, which has not been examined within this line of research for the case of Turkey.

The paper is organized as follows. The next section discusses the measure of industrial agglomeration used throughout the study. In section 3 results on the agglomeration and co-agglomeration patterns of Turkish manufacturing industries are presented. It also includes an international comparison with other studies. Lastly, section 4 concludes.

2. Measuring agglomeration

Various measures have been developed to investigate the tendencies in the distribution of economic activity[2]. Among the widely used measures of concentration are the location quotient, also known as the Hoover (1936) coefficient of localization and the spatial version of the Gini proposed by Krugman (1991b). Such classical measures have been criticized for their inadequacy in distinguishing "random concentration arising from industrial concentration from concentration arising from agglomerative externalities or natural advantage" (Rosenthal and Strange, 2001, p. 194). Assume that an industry has only a few large firms and there are no agglomerative forces leading to concentration. In this case, geographic concentration will be high based on the traditional indices simply due to the industrial organization of the industry.

To address this problem, Ellison and Glaeser (1997) and later Maurel and Sédillot (1999) have proposed indices to purge geographic concentration from industrial structure. "These measures are all based on the distribution of activity over discrete geographic units" (Devereux et al., 2004, p. 535). On the contrary, Duranton and Overman (2005) propose an agglomeration metric based on a continuous measure of location that treat space as continuous instead of using discrete units which is free from arbitrary collection of geographic units[3].

[2] A comprehensive presentations of the indices may be found Holmes and Stevens (2004) and Combes and Overman (2004) which are used in a large set of empirical studies regarding North America and European countries, respectively.

[3] "Geographers term this issue as the Modifiable Area Unit Problem (MAUP), which states that the number, size and shape of the chosen spatial unit might affect the results of the analysis. This results from the fact that the number of ways in which fine-scale spatial units can be aggregated into larger units is often great, and there are usually no objective criteria for choosing one aggregation scheme over another" (Bertinelli and Decrop, 2005, p. 569). For a detailed discussion of modelling cluster of firms on a continuous space and spatial issues related with that, see Arbia (2001a,b) and Arbia et al. (2008, 2009a,b).

The analysis in this paper uses the index of geographic concentration proposed by Ellison and Glaeser (1997) due to some reasons. It has some useful properties, as has been mentioned by the authors, such as being comparable across industries in which the size distribution of firms differ and comparable across countries irrespective of divergences in the level of geographic aggregation. The nature of the data also leads us to explore EG index as providing establishment level information on the employment level and location. However, for the same reason, the data prevents us using continuous indices since it lacks fine locational information on the establishments, as it is available at NUTS-2 level.

Agglomeration index of plants presented by Ellison and Glaeser (1997) compares the observed geographic distribution of plants with a random distribution. The plants are defined to be geographically randomly distributed by considering their expected distribution in the lack of agglomerative forces. In their model, plants cluster either to benefit from natural advantages or spillover externalities from other plants. They start with a simple location model and first define a raw geographic concentration index:

$$G_i = \sum_{m=1}^{M} (s_{im} - x_m)^2 \qquad (1)$$

where s_{im} is the share of industry i's employment in area m, and x_m is the the share of aggregate manufacturing employment in area m. "As G_i measures concentration relative to total manufacturing employment; as long as an industry mimics the pattern of aggregate employment it is not considered as being concentrated" (Alecke et al., 2006, p. 21).

However, Ellison and Glaeser (1997) note that, geographic concentration is not neutral to industrial concentration. Ceteris paribus, "industrially concentrated sectors will tend to exhibit a higher G_i index because there are fewer plants and consequently employment has to be concentrated in fewer places" (Bertinelli and Decrop, 2005, p. 569). To address this issue, they take into account industrial concentration by employing Herfindahl index of the industry's plant size distribution in building EG index.

$$H_i = \sum_{j=1}^{N} (z_{ij})^2 \qquad (2)$$

where $j = 1, \ldots, N$ number of plants in industry i, and z_{ij} is the employment share of j^{th} plant in industry i. H_i is a function of the number and size distribution of plants in industry i. Higher indices imply industries with a small number of plants and with an uneven size distribution. When plants make location decisions in compliance with the location choice model built by Ellison and Glaeser (1997), they suggest that expected value of G_i is related

to the parameters qualifying the intensity of natural advantages and spillovers, plant size distribution of the industry and the size of the regions.

They show that, "if there are no agglomeration economies and if the geographic units are equally attractive, the raw geographic concentration G_i of an industry i should be proportional to its industrial concentration H_i" (Bertinelli and Decrop, 2005, p. 570). Algebraically:

$$E(G_i) = \sum_m (1 - x_m^2)\,[\gamma + (1 - \gamma)H_i] \tag{3}$$

Using the expression (3) above, an estimator of excess-concentration is derived, which is called the agglomeration index.

$$\gamma_i = \frac{\dfrac{G_i}{(1 - \sum_{m=1}^{M} x_m^2)} - H_i}{1 - H_i} \tag{4}$$

For an industry with a large number of small plants, which may be regarded as perfectly competitive, H_i approaches zero and γ_i approaches $G_i/(1 - \sum_{m=1}^{M} x_m^2)$. In a case like that, G_i measures spatial concentration without any involvement with industrial organization. γ_i takes a value of zero if plants are distributed randomly by the dartboard model of random location choices with no natural advantages or industry-specific spillovers, while a positive value of γ_i indicates excess concentration. They also provide some value range for their index according to which they classify industries as not very concentrated ($\gamma_i < 0.02$), moderately concentrated ($0.02 \leq \gamma_i \leq 0.05$) and highly concentrated ($\gamma_i > 0.05$). A negative value would indicate dispersion of economic activity.

After calculating *EG* index, taking into account the question "Do industry *groups* concentrate due merely to the fact that its *subindustries* concentrate or there is a *common* effect on the industries of a higher industrial hierarchy group (e.g. agglomeration of 4-digit industries within 2-digit groups)?", co-agglomeration within industry groups are also examined.

The first statement implies that natural advantages and spillovers are industry-specific while the second implies them to be group-specific. To measure the degree to which the industries in the group are co-agglomerated; Ellison and Glaeser (1997) propose the use of a measure γ^c defined by:

$$\gamma^c = \frac{\dfrac{G}{(1 - \sum_{m=1}^{M} x_m^2)} - H - (1 - \sum_j^r \hat{\gamma}_j w_j^2 (1 - H_j))}{(1 - \sum_j^r w_j^2)} \tag{5}$$

where the industry group consists of r industries, H_j : plant Herfindahl of the j^{th} industry, w_j : employment share of the j^{th} industry in the group, γ_j : agglomeration index of the j^{th} industry, $H = \sum_j w_j^2 H_j$: group's plant Herfindahl index and G: raw concentration of employment in the group as a whole.

An estimate of $\gamma^c = 0$ may be interpreted as any spillovers/natural advantages found within the industry group are completely industry-specific. In other words, there is no agglomeration in the industry *group*, hence agglomeration is observed simply owing to the concentration of its industries per se.

3. The concentration of Turkish manufacturing industries

The patterns of geographic concentration in Turkish production activity are examined in this section. It begins by defining and summarizing the data. Then, summary measures of geographic concentration at the four-digit industry level are presented. In the following subsections, co-agglomeration within related four-digit industries and between industry pairs is investigated, respectively. The final part of this section discusses the main findings of this study in comparison with other country cases as EG index paves the way for this.

3.1. Data

This study explores enterprise-level micro-data called "Annual Industry and Service Statistics" (AISS) provided by TurkStat. The sectoral coverage of the dataset encompasses all the manufacturing and service industries with a few exceptions[4]. NACE Rev.1.1 classification is used as a statistical classification of economic activities for the years 2003-2008. Since 2009, NACE Rev.2 is in use.

The statistical unit of surveys on AISS is enterprise. An enterprise is defined as "*an organizational unit that produces goods and services using decision autonomy concerning allocation of resources. An enterprise is real or legal personality that produces goods and services on the market by carrying out one or more activities at one or more locations*"[5]. In fact AISS provide enterprise level data in two bases. One of them provides quiet detailed information about the employment, expenditure, income, stocks and investment structure of

[4] The sector codes of non-covered sectors according to NACE Rev.1.1 are A, K, O, T, U, a division of J ("Programming and broadcasting activities") , a division of S ("Activities of membership organizations") and two classes of L, namely "Buying and selling of own real estate" and "Renting and operating of own or leased real estate".

[5] TurkStat (2019), Annual Industry and Service Statistics Metadata
http://www.turkstat.gov.tr/PreIstatistikMeta.do?istab_id=2234

enterprises based on the responses collected by the questionnaires. However, it does not provide information on the location of the enterprise because an enterprise may have more than one plant located in different locations, but it provides information on the *number of local units* of an enterprise. Thus, this dataset provide detailed information on the aggregated plants of an enterprise as a whole. So if one wants to get more information on the individual plant records of a particular enterprise, then should resort to the second dataset which conveys information about the local units. The dataset based on *local units* identifies the plants of an enterprise and additionally provides information on the location of the plants in NUTS-2 level which covers 26 statistical regions in Turkey. So this dataset based on local units is utilized throughout this study as it provides information on employment at plant, industry and region. Henceforth, the term *firm* will be used in return for plant which is the unit of observation in this dataset.

The number of firms (plants) covered in the survey ranges from 125000 to 144850 as shown in Table 1 throughout the sample period. However the focus of this study is the sub-sample of manufacturing firms as the purpose is examining the trends of industrial agglomeration. The number of manufacturing firms covered in the sample ranges from 39700 to 48000. We observe an upward trend in the dataset as the number of manufacturing firms has been growing over the sample period, but there is a decrease in the number of establishments from 2004 to 2005 due to a change in the sampling procedure.

Table 1: Sample size of the dataset based on *local units*

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Number of all firms in dataset	125003	125652	109397	137481	144057	144849
Number of manufacturing firms	39714	43958	36051	45908	47532	48024

Table 2 shows the distribution of manufacturing in terms of number of firms and employment by 2-digit sectors for years 2003 and 2008. As observed in the table, the sectors food products and beverages (15), textiles (17) and wearing apparel, dressing & dyeing of fur (18) comprise almost 40 and 38 per cent of all firms for 2003 and 2008, respectively. In terms of employment, these sectors comprise 46 and 38.5 per cent of the overall employment in manufacturing, again for the years 2003 and 2008, respectively. It is striking to note that these sectors take place within the low-technology group according to Eurostat technology classification.

3.2. How much are industries agglomerated?

By making use of AISS dataset based on local units, *EG* index is calculated for Turkish manufacturing industries for both years. In our sample, there are 228 and 229 4-digit industries in 2003 and 2008 respectively in terms of NACE Rev.1.1. Industries with less than three plants are dropped due to the fact that EG index tends to be biased upwards, as mentioned before. In the simple dartboard model of EG in which plants choose their location in a random manner, in the absence of natural advantages or spillovers, expected value of the raw geographic concentration should be proportional to the industrial concentration. To state algebraically in terms of equation (3), γ equals 0 and $E(G_i) = \sum_m (1 - x_m^2)\,[\gamma + (1-\gamma)H_i]$. So, as a first step it should be tested whether observed geographic concentration *G*, is statistically significantly different from $\sum_m (1 - x_m^2)H_i$. For the year 2003, the mean values for the above expressions across 228 manufacturing industries are calculated to be 0.17 and 0.09 respectively and the difference between these measures is significant at 5 % significance level. Regarding 2008, these values are calculated to be 0.16 and 0.08 respectively across 229 manufacturing industries and the difference is again highly significant[6].

6. Ellison and Glaeser (1997, p.97) provide a lengthy formula for the variance of G under the null hypothesis of no natural advantages and spillovers, as follows:

$$var(G) = 2\left\{H^2\left[\sum x_m^2 - 2\sum x_m^3 + \left(\sum x_m^2\right)^2\right] - \sum_j z_j^4\left[\sum x_m^2 - 4\sum x_m^3 + 3\left(\sum x_m^2\right)^2\right]\right\}$$

Under this formula, the standard deviation of the sample mean under the null is calculated as 0.004 and 0.003, as regards 2003 and 2008 respectively.

Table 2: Distribution of firms and employment by 2-digit sectors (%)

		Firms		Employment	
2-digit industry NACE Rev.1.1 code		2003	2008	2003	2008
15	Food products and beverages	14,74	12,72	12,50	11,44
16	Tobacco products	0,14	0,10	1,02	0,65
17	Textiles	11,81	10,65	18,36	13,13
18	Wearing apparel, dressing and dyeing of fur	13,87	14,72	15,75	14,00
19	Tanning and dressing of leather	2,79	2,28	1,91	1,77
20	Wood products, except furniture	3,77	2,68	2,43	2,50
21	Pulp, paper and paper products	1,36	1,53	1,39	1,51
22	Publishing, printing and reproduction of recorded media	2,97	2,94	2,03	2,48
23	Coke, refined petroleum products and nuclear fuel	0,24	0,20	0,29	0,22
24	Chemicals and chemical products	3,44	3,64	3,60	2,92
25	Rubber and plastic products	5,39	5,28	4,33	5,22
26	Other non-metallic mineral products	6,54	7,16	5,45	6,27
27	Basic metals	2,20	3,15	3,37	3,56
28	Fabricated metal products, except machinery and equipment	8,61	9,48	6,08	8,16
29	Machinery and equipment	6,91	7,71	6,52	8,17
30	Office machinery and computers	0,06	0,07	0,03	0,04
31	Electrical machinery and apparatus	2,04	2,31	2,34	2,83
32	Radio, TV and communication equipment and apparatus	0,34	0,36	0,89	0,65
33	Medical, precision and optical instruments, watches and clocks	0,77	0,80	0,55	0,87
34	Motor vehicles, trailers and semi-trailers	2,01	2,28	3,86	4,77
35	Other transport equipment	0,74	1,98	1,05	2,15
36	Furniture; manufacturing n.e.c.	9,20	7,84	6,21	6,61
37	Recycling	0,06	0,12	0,02	0,04

To be more precise, 191 out of 228 industries in 2003 and 188 out of 229 4-digit manufacturing industries in 2008, the level of raw geographic concentration is found to be exceeding the value which would be obtained in the case of a random location choice. Hence, the null hypothesis of a random location choice cannot be rejected for 37 and 41 industries regarding 2003 and 2008, respectively. [7]

Figure 1 shows the distribution of γ over 228 and 229 4-digit industries for years 2003 and 2008, respectively. Regarding year 2003, the mean value of γ is 0.1060 with a median value of 0.0675 for Turkish manufacturing industries. As for 2008, the mean and the median values are calculated as 0.1046 and 0.0602, respectively. The two distributions in the figure appear to be slightly right skewed depicting the agglomeration at higher levels. Ellison and Glaeser (1997) calculate γ across 459 US manufacturing industries and they also found the distribution of the index to be right skewed with a mean value of 0.051 and median value of 0.026.

The extent of agglomeration by the number and per cent of industries according to the ranges they lay is displayed in Table 3. In 2003, 57.9 % of the industries are highly agglomerated displaying a value $\gamma > 0.05$, 14.5 % are moderately concentrated with $0.02 < \gamma \leq 0.05$ and 11.4 % of them have a low degree of concentration, $0 < \gamma \leq 0.02$. 16.2 % of the industries take a negative index value which implies plants choosing to locate more diffusely than expected by randomness. Regarding year 2008, 56.3 % of the industries are highly agglomerated, while 16.6 % of them are moderately concentrated and 9.2 % of them have a low degree of concentration. The results of EG index calculations show that agglomeration of the 4-digit manufacturing industries is widespread in Turkey while a small number of industries fall in the category of low concentration industries.

[7] Regarding year 2003 (2008), the difference between G and $\sum_m (1 - x_m^2) H_i$ is positive and larger than twice its standard deviation in 176 (182) of the 191 (188) 4-digit industries, hence the difference statistically significant, while 15 (6) of them are not significant despite being positive. In 37 (41) of the 4-digit industries, the difference is found to be negative. It's important to mention as a striking point that these industries exhibit negative values of EG as well. This would indicate that negative agglomeration indices are far from being statistically significant, hence displaying a random distribution across space rather than a dispersion.

Figure 1: Histogram of γ (4-digit industries)

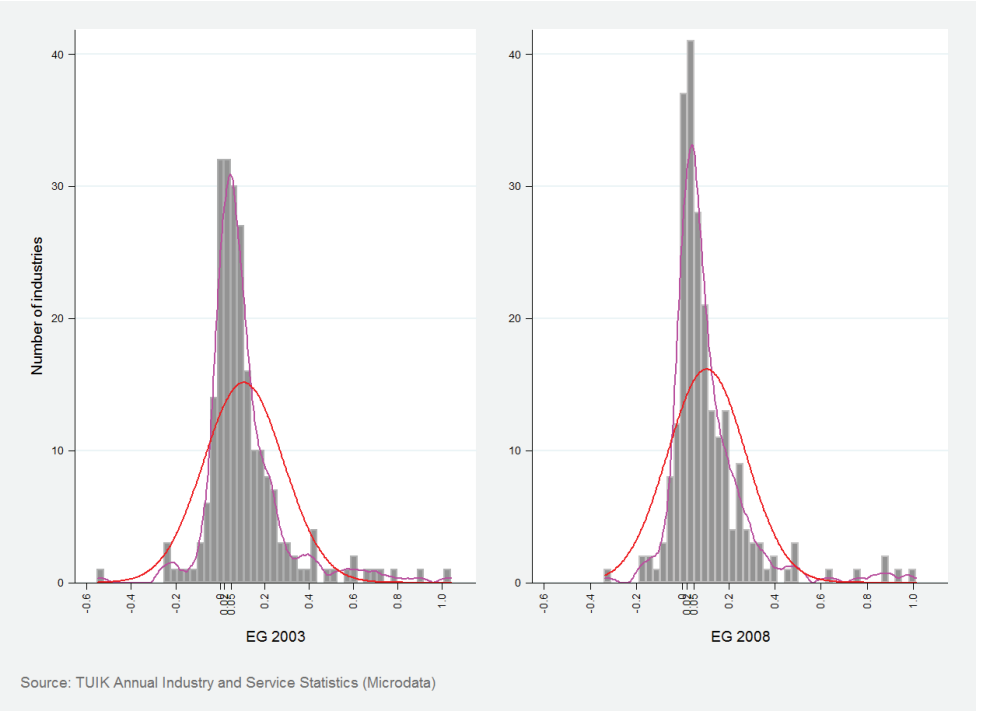

Table 3: Extent of agglomeration by years

	Number of 4-digit industries		Per cent (%) of 4-digit industries	
Degree of concentration	**2003**	**2008**	**2003**	**2008**
$\gamma > 0.05$ – *High*	132	129	57.9	56.3
$0.02 \leq \gamma \leq 0.05$ – *Intermediate*	33	38	14.5	16.6
$0 < \gamma < 0.02$ – *Low*	26	21	11.4	9.2
$\gamma \leq 0$ – *No conc./dispersion*	37	41	16.2	17.9
Total	228	229	100	100

Table 4 summarizes the pattern of agglomeration in 2003 by showing the mean of γ calculated at the four-digit industry level by two-digit industries and the percentage of four-digit industries in each concentration level. Recycling (37) and manufacture of coke, refined petroleum products and nuclear fuel (23) industries have two 4-digit sub-industries and manufacture of office machinery and computers (30) and tobacco products (16)

industries have only one 4-digit industry. They show the highest level of agglomeration on average where the index ranges in the high concentration degree in each case. These industries share a common point such that they comprise of a small number of firms with the lowest numbers across two-digit industries[8]. So, high levels of agglomeration may be due to the fact that agglomeration index tends to be upward biased when the number of firms are relatively small in an industry.

Textile (17) and other non-metallic mineral products (26) industries show significant level of agglomeration on average both comprising a large number of subindustries. Approximately, 79 % of the 4-digit industries in textiles (17) fall in the high concentration degree which indicates high levels of agglomeration in its 4-digit sub-industries. Regarding other non-metallic mineral products (26) industry, 62.5 % of sub-industries fall into the high concentration range. Food products and beverages (15) industry has 30 sub-industries and on average display a value of 0.1277 where 63.3 % of them lie within high degree range.

[8] For detailed information on size distribution of firms by 2-digit NACE Rev. 1.1 sectors, please refer to Kent (2015, p.74).

Table 4: Agglomeration in 4-digit industries, by 2-digit NACE Rev.1.1 (2003)

NACE Rev 1.1 2-digit	Mean γ	No conc.	Low	Intermediate	High	Total	No. of 4-digit industries
37	0.5599	0	0	0	100	100	2
23	0.4726	0	0	0	100	100	2
30	0.2118	0	0	0	100	100	1
16	0.2045	0	0	0	100	100	1
17	0.1715	10.53	5.26	5.26	78.95	100	19
26	0.1501	16.67	8.33	12.5	62.5	100	24
15	0.1277	16.67	16.67	3.33	63.33	100	30
24	0.1246	16.67	5.56	22.22	55.56	100	18
27	0.1197	12.5	12.5	12.5	62.5	100	16
18	0.1192	0	16.67	16.67	66.67	100	6
32	0.1150	33.33	0	0	66.67	100	3
35	0.0999	25	0	12.5	62.5	100	8
34	0.0963	0	33.33	0	66.67	100	3
29	0.0873	22.73	13.64	13.64	50	100	22
36	0.0598	16.67	8.33	16.67	58.33	100	12
28	0.0586	12.5	25	18.75	43.75	100	16
19	0.0577	0	0	33.33	66.67	100	3
21	0.0527	0	16.67	33.33	50	100	6
20	0.0398	16.67	16.67	0	66.67	100	6
22	0.0389	33.33	0	25	41.67	100	12
25	0.0245	14.29	28.57	28.57	28.57	100	7
31	0.0199	28.57	14.29	28.57	28.57	100	7
33	-0.1008	25	0	50	25	100	4
Total	**0.1059**	**16.23**	**11.4**	**14.47**	**57.89**	**100**	**228**

To have a closer look, Table 5 lists the 20 most localized industries in terms of γ index for 2003.[9] The table also shows the number of firms in each industry, the geographic

[9] In order to interpret agglomeration more reliably, Table 5 displays 20 most agglomerated four-digit industries comprising of at least 20 firms. Because, although EG index accounts for industrial concentration, it may still produce biased results for industries with small number of firms. Table 4.9 in Kent (2015, p. 81) also shows the results that are obtained if the number of firms in an industry is not restricted to at least 20. Another reason is the following; the methodology used for the enterprises having more than 20 employees is full enumeration; while for the enterprises having less than 20 employees, sampling method is used. So for the firms employing less than 20 workers, weighted employment data is provided in order to account for sampling bias. However, since data does not provide information on the number of firms, we derive that information by counting the number of firms surveyed. So, Herfindahl index tends to be upward biased for those firms. In order to set aside this bias, sectors comprising of at least 20 firms are listed.

concentration measure *G* and the industrial concentration measure *H*. The most concentrated industry arises as manufacture of processing of tea and coffee (1586) with an EG index value of 1.029 and raw geographic concentration of 0.869. This result is rather expected as very high portion of tea production takes place in Trabzon (TR90) NUTS-2 region including six provinces. Herfindahl index of this industry is 0.013 which implies that industry is quite competitive and the employment is distributed across many plants, so localization may be attributed to raw geographic concentration. This may be broadly ascribed to natural advantages.

Table 5: Top 20 concentrated industries (2003)

4-digit	*NACE Rev.1.1 definition*	*H*	*G*	*γ*	*# of firms*
1586	Processing of tea and coffee	0.013	0.869	1.029	215
1724	Silk-type weaving	0.116	0.492	0.528	22
2653	Manufacture of plaster	0.147	0.483	0.499	20
2614	Manufacture of glass fibers	0.346	0.513	0.399	21
2960^{mh}	Manufacture of weapons and ammunition	0.085	0.365	0.379	163
1830	Dressing and dyeing of fur; man. of articles of fur	0.116	0.357	0.347	26
3220^{h}	Manufacture of TV and radio transmitters and apparatus	0.395	0.507	0.341	35
2863	Manufacture of locks and hinges	0.034	0.286	0.315	129
3511	Building and repairing of ships	0.014	0.273	0.313	158
1725	Other textile weaving	0.023	0.24	0.267	236
1751	Manufacture of carpets and rugs	0.031	0.231	0.25	197
1771	Manufacture of knitted and croch. hosiery	0.108	0.274	0.243	217
2211	Publishing of books	0.034	0.223	0.238	68
1715	Throwing and preparation of silk	0.022	0.213	0.236	166
1512	Production and preserving of poultry meat	0.049	0.23	0.235	158
2442^{h}	Manufacture of pharmaceutical preparations	0.024	0.208	0.228	190
1587	Manufacture of condiments and seasonings	0.055	0.218	0.216	47
3002^{h}	Manufacture of computers, other info. processing equip.	0.103	0.247	0.212	23
2640	Manufacture of bricks, tiles and construction products	0.007	0.183	0.211	382
1772	Manufacture of knitted and croch. pullovers, cardigans, etc.	0.007	0.182	0.209	517

It is also worth mentioning the variation in industrial concentration while all of these industries display high geographic concentration (*G*). For example building and repair of ships (3511), has high geographic concentration and low industrial concentration, whereas manufacture of knitted and crocheted hosiery (1771) has rather high geographic concentration along with high industrial concentration. Textile and related industries (17) have 19 four-digit sub-industries (Table 4) of which six are ranked in the list of 20 most concentrated industries in Table 5. Also three sub-industries of food products and beverages (15) and other non-metallic mineral products (26) take place in this list.

Table 6 provides more detailed information on the location characteristics of most agglomerated 20 industries listed in Table 5. Second and third columns display the two regions with the highest proportion of industry employment. For many industries, first and second regions are contiguous to each other and hence may signal a larger agglomeration. Manufacture of weapons and ammunition (2960) in Kırıkkale and Ankara, building and repairing of ships (3511) in Istanbul and Kocaeli, other textile weaving (1725) in Bursa and Istanbul may be given as examples to agglomerations in neighboring regions. Fourth and fifth columns show the percentage of industry employment in these two regions. The ratio of industry employment in the top region ranges from 92.9 % in dressing and dying of fur (1830) industry to 22.3 % in manufacture of bricks, tiles and construction products (2640). Column 6 shows the total number of firms in the industry, and columns 7 and 8 display the proportion of firms in the two regions. This ratio ranges from 76.3 % in processing of tea and coffee (1586) to 5.5 % in manufacture of weapons and ammunition (2960) industry. Finally, last two columns display the average firm size in the first and the second region.

Table 6: Most agglomerated regions (2003)

			Employment in region (%)		Number of firms	Firms in region (%)		Av. firm size (employment)	
4-digit	**1st region**	**2nd region**	**1st**	**2nd**		**1st**	**2nd**	**1st**	**2nd**
1586	TR90 - Trabzon	TR10 - İstanbul	88.7	6.3	215	76.3	13	63	26
1724	TR41 - Bursa	TR10 - İstanbul	77.1	20.9	22	68.2	22.8	25	20
2653	TR51 - Ankara	TR41 - Bursa	62.8	12.4	20	40	5	26	41
2614	TR42 - Kocaeli	TR10 - İstanbul	70.5	9.9	21	19	14.3	223	42
2960	TR71 - Kırıkkale	TR51 - Ankara	41.9	34.8	163	5.5	10.5	355	156
1830	TR10 - İstanbul	TR21 - Tekirdağ	92.9	3	26	65.4	3.8	33	18
3220	TR51 - Ankara	TR10 - İstanbul	73.2	19.9	35	28.6	28.6	348	95
2863	TR10 - İstanbul	TR41 - Bursa	87	4.7	129	67.5	3.1	67	78
3511	TR10 - İstanbul	TR42 - Kocaeli	84.9	7.5	158	78.5	7	73	73
1725	TR41 - Bursa	TR10 - İstanbul	54.6	21.6	236	68.6	14.5	40	75
1751	TRC1 - Gaziantep	TR72 - Kayseri	38.8	20.1	197	32	9.1	65	117
1771	TR10 - İstanbul	TR21 - Tekirdağ	85.4	4.7	217	68.2	2.8	127	171
2211	TR10 - İstanbul	TR51 - Ankara	78.6	15.3	68	58.8	20.6	42	23
1715	TRC1 - Gaziantep	TR41 - Bursa	42.8	19.7	166	38	10.2	157	267
1512	TR42 - Kocaeli	TR22 - Balıkesir	31.7	21	158	19.6	7.6	124	211
2442	TR10 - İstanbul	TR42 - Kocaeli	78.7	6	190	52.6	7.9	196	100
1587	TR31 - İzmir	TR10 - İstanbul	49.4	16.3	47	29.8	12.8	44	34
3002	TR10 - İstanbul	TR31 - İzmir	83.2	5.9	23	43.5	13	44	10
2640	TR33 - Manisa	TR83 - Samsun	22.3	18.5	382	17.3	16	49	45
1772	TR10 - İstanbul	TRC1 - Gaziantep	75.5	6.5	517	68.6	7.5	60	48

Table 6 reveals some basic and significant inferences. Saliently, Istanbul appears to be the most agglomerated region as it takes place in 14 out of 20 cases and in 8 of those it is

the first most agglomerated region while in the other 6 cases it is the second one. In four-digit industries that Istanbul is listed as the most agglomerated region, it's observed that the second regions in those industries have ratios far below Istanbul, both in terms of employment and firm percentage. It hints about the dominance of Istanbul region in those industries.

If we zoom out of Istanbul region and adopt a broader look at the picture, two types of industries arise: single agglomeration type and two-agglomeration type. First type single agglomeration industries comprise large proportions of both employment and firms. Examples include processing of tea and coffee (1586) in which Trabzon region involves 88.7 % of employment and 76.3 % of firms, manufacture of locks and hinges (2863) in which Istanbul region involves 87 % of employment and 67.5 % of firms, manufacture of knitted and crocheted hosiery (1771) in which again Istanbul comprises 85.4 % of employment and 68.2 % of firms. These industries have large number of firms and average firm size of these industries is around 65.

However, there are a few industries in the single agglomeration type which are characterized by high percentage of employment with low percentage of firms. For instance manufacture of glass fibres (2614) industry has 70.5 % of its employment in Kocaeli where only 19 % of the related industry firms are located. However average employment size in this region is quite high, namely 223, which signals the existence of a few large firms in the region. Number of firms in this industry is also pretty low which amounts to 21. Another similar example is manufacture of TV and radio transmitters and apparatus (3220) industry. This industry also has small number of firms, and 73.2 % of its employment and 28.6 % of firms are located in Ankara. Average firm size in this industry is pretty high at a level of 348 which shows the dominance of only a few large firms in the industry.

It is also worth noting that even this first type is called single agglomeration industries, we observe that when the share of employment in the first and second region are summed up, total share of employment in these regions reaches to ratios between 80 to 95 %. These high shares of employment only in two regions actually mean that production is concentrated in these two regions where the first region far above the second one.

On the other hand, second type of industries comprises the ones with two agglomerations where relatively similar sized regions in terms of employment take place. Examples to this type include production and preserving of poultry meat (1512) and manufacture of bricks, tiles and construction products (2640) industries which of both have very close shares of employment. Regarding industry 1512, 31.7 % of employment is concentrated in Kocaeli and 21 % is concentrated in Balıkesir region. As for the industry

2640, 22.3 % of employment is concentrated in Manisa and 18.5 % is concentrated in Samsun region. Another example to second type industries is manufacture of weapons and ammunition (2960) industry with employment shares 41.9 % and 34.8 % concentrated in Kırıkkale and Ankara, respectively. However a striking point in this industry is that only a small portion of firms takes place in the first region, to name it 5.5 % and average firm size in the first region is 355, which is quite high. This is the highest average firm size in the list of most agglomerated regions. It also shows that there is small number of pretty large firms in the first region.

Table 7 summarizes the pattern of agglomeration in 2008 in the same vein as Table 4. Recycling (37) and manufacture of coke and refined petroleum products and nuclear fuel (23) industries again rank in the top five as in 2003, but compared to that, the mean value of γ for these industries declined definitely. Two industries ranking in top five in 2003, namely tobacco products (16) and manufacture of office machinery and computers (30), are not among the top ranked industries in terms of average γ's in 2008.

Especially tobacco products (16) industry is ranked as the last in 2008 contrary to the case in 2003 where it was the fourth. This fact is most likely related to the privatization of TEKEL. As a result of the privatization of the cigarette unit in 2008, the number of firms in cigarette manufacturing activity and hence employment in this activity significantly decreased. This structural change may, to some extent, help one to reason the de-agglomeration of the industry.

On the other hand, textile (17) industry which was ranked fifth in 2003 is ranked as the top in terms of average values of 4-digit γ's in 2008. It had an average value of 0.1715 in 2003 and increased to 0.2583 in 2008. Four-digit industries displaying low concentration in 2003 disappeared and percentage of industries in intermediate concentration group increased. It also shows that many of the 4-digit sub-industries of textiles (17) industry have absolutely experienced increases in their index values.

Radio, television & communication equipment (32) industry also displays a significant change with respect to two years. The average value of the industry has been observed as 0.1150 in 2003 and increased to 0.1431 in 2008. Note that there are three sub-industries in this sector, and one of these has switched from no concentration to high concentration group in 2008, hence pulling the average value up. Basic metals (27) industry is ranked fifth among the two-digit industries in 2008. Its average value increased from 0.1197 to 0.1431. In this sector, percentage of industries increased in the low concentration group compared to 2003, while percentage of industries in the high concentration group slightly declined.

Table 7: Agglomeration in 4-digit industries, by 2-digit NACE Rev.1.1 (2008)

NACE Rev 1.1 2-digit	Mean γ	No conc.	Low	Intermediate	High	Total	No. of 4-digit industries
17	0.2583	10.53	0	15.79	73.68	100	19
37	0.1723	0	0	0	100	100	2
23	0.1555	0	0	0	100	100	2
32	0.1476	0	0	0	100	100	3
27	0.1431	6.25	31.25	6.25	56.25	100	16
15	0.1326	13.33	6.67	10	70	100	30
18	0.1277	0	0	16.67	83.33	100	6
36	0.1242	16.67	8.33	8.33	66.67	100	12
34	0.0978	0	0	0	100	100	3
29	0.0962	18.18	18.18	18.18	45.45	100	22
24	0.0943	5.56	16.67	22.22	55.56	100	18
26	0.0908	29.17	8.33	12.5	50	100	24
30	0.0908	50	0	0	50	100	2
19	0.0856	0	0	0	100	100	3
20	0.0742	16.67	0	33.33	50	100	6
25	0.068	14.29	14.29	42.86	28.57	100	7
21	0.0475	16.67	0	50	33.33	100	6
28	0.0439	31.25	12.5	25	31.25	100	16
33	0.0422	50	0	0	50	100	4
35	0.0412	37.5	0	12.5	50	100	8
31	0.0269	14.29	14.29	28.57	42.86	100	7
22	0.0219	33.33	0	25	41.67	100	12
16	-0.1505	100	0	0	0	100	1
Total	**0.1046**	**17.90**	**9.17**	**16.59**	**56.33**	**100**	**229**

Table 8 list top 20 four-digit industries with at least 20 establishments in 2008. Textile (17) sub-industries constitute 6 out of 20 industries which is an expected outcome as Table 7 displays this two-digit sector in the top of the list with the highest percentage in the high concentration group. It is worth noting that 11 industries that are marked with an asterisk in Table 8 have also been listed within the top 20 regarding year 2003. In other words, we may say that 55 % of the industries remained in the top list during the period. Moreover, four textile (17) related industries in this group have all enhanced their rankings relative to 2003. Again this is not a surprise as Table 7 signaled that on average textile (17) industries

have increased their index values. Except the first ranked industry (1586), the rest of the industries are ranked lower relative to their 2003 values.

A striking feature of the most localized industries is that it largely encompasses low-tech industries. Within this technology group textile and traditional industries are observed to be dominant. In 2003, one medium tech and three high-tech industries appear in the list of 20 most localized industries as shown as a superscript in the first column of Table 5. Regarding 2008, there are three medium-high tech industries within the list of most localized industries, namely manufacture of weapons and ammunition (2960), manufacture of explosives (2461) and manufacture of essential oils (2463). The agglomeration in these sectors is presumably driven by spillovers rather than natural advantages. However, it should be noted that EG index solely is not capable of revealing the sources or determinants of agglomeration as it does not make differentiation between the natural advantage or spillovers. A thorough analysis is essential to detect the drivers of agglomeration by also considering agglomeration theories. Hence it's better taking the information revealed by EG index as a useful tool for detecting the extent of agglomeration.

Table 8: Top 20 concentrated industries (2008)

4-digit	*NACE Rev.1.1 definition*	*H*	*G*	*γ*	*# of firms*
1586*	Processing of tea and coffee	0.013	0.812	0.944	184
1751*	Manufacture of carpets and rugs	0.019	0.433	0.495	261
1725*	Other textile weaving	0.012	0.429	0.494	259
1724*	Silk-type weaving	0.088	0.454	0.483	26
2621	Manufacture of ceramic household	0.115	0.44	0.449	73
1715*	Throwing and preparation of silk	0.019	0.353	0.399	209
3615	Manufacture of mattresses	0.049	0.364	0.394	114
2960*,^{mh}	Manufacture of weapons and ammunition	0.038	0.298	0.321	209
2653*	Manufacture of plaster	0.076	0.317	0.317	31
2461^{mh}	Manufacture of explosives	0.189	0.371	0.299	22
1830*	Dressing and dyeing of fur; man. of articles of fur	0.019	0.263	0.293	113
3663	Other manufacturing n.e.c.	0.051	0.267	0.274	218
1772*	Man. of knitted and crocheted pullovers, cardigans, etc.	0.011	0.24	0.272	540
1712	Preparation and spinning of woolen-type fibers	0.118	0.297	0.259	69
2463^{mh}	Manufacture of essential oils	0.143	0.305	0.248	28
3710	Recycling of metal waste and scrap	0.309	0.411	0.246	23
2863*	Manufacture of locks and hinges	0.041	0.238	0.246	162
3511*	Building and repairing of ships	0.005	0.212	0.243	715
3622	Manufacture of jewellery and related articles n.e.c.	0.013	0.216	0.242	829
2123	Manufacture of paper stationery	0.074	0.255	0.24	50

Table 9 gives detailed information on the location characteristics of most agglomerated 20 industries in 2008 in the same way as in Table 4.6. As the case has been in 2003, Istanbul arises as the most agglomerated region as it appears in 12 out of 20 cases. In the cases where Istanbul is listed as the first region, we see that the shares of second regions are far below Istanbul in terms of employment and firm percentage, e.g. 3622, 2863, 3663 etc.

Also in 2008 two types of industries arise, as has been called before, single agglomeration type and two agglomeration type industries. The first type encompasses industries with large percentage shares of both employment and firm number. Examples include other manufacturing (3663) industry in which Istanbul region involves 82.2 % of employment and 77.1 % of firms, manufacture of paper stationery (2123) industry again Istanbul involves 80.5 % of employment and 84 % of firms, other textile weaving (1725) industry in which Bursa region involves 70.2 % of employment and 65.6 % of firms, processing of tea and coffee (1586) industry in which Trabzon region involves 86.3 % of employment and 59.2 % of firms, etc. What is most striking in this type is that industries taking place therein are extremely concentrated in Istanbul region and roughly constitute more than 75 % of employment and at least 70 % of firms.

On the other hand, second type of industries includes industries with two agglomerations where relatively similar sized regions in terms of employment take place. For instance, preparation and spinning of woolen-type fibers (1712) industry and manufacture of essential oils (2463) industry where in the former one employment is concentrated in Tekirdağ (%39.9) and Manisa (%31.7) and in the latter one in Antalya (%53.3) and Istanbul (%42.6). However a striking point is observed regarding industry 1712. Although almost 40 % of the employment is concentrated in Tekirdağ, the region holds only 5.8 % of the firms in the industry and average firm size in this region is 295 which is the highest value in the list of most agglomerated regions. These together indicate that there is small number of quite large firms in the region. Another example to this type may be given as industry 2960 in which Kırıkkale is the second most agglomerated region with an employment share of 30.5 % and holds only 5.7 % of firms with an average firm size of 284.

Table 9: Most agglomerated regions (2008)

			Employment in region (%)		Number of firms	Firms in region (%)		Av. firm size (employment)	
4-digit	1st region	2nd region	1st	2nd		1st	2nd	1st	2nd
1586*	TR90 - Trabzon	TR10 -İstanbul	86.3	6.6	184	59.2	16.3	113	32
1751*	TRC1 - Gaziantep	TR72 - Kayseri	61.4	8.8	261	34.5	4.2	111	130
1725*	TR41 - Bursa	TR10 - İstanbul	70.2	9.7	259	65.6	19.7	61	28
1724*	TR41 - Bursa	TR10 - İstanbul	72.4	11.4	26	50	15.4	26	13
2621	TR33 - Manisa	TR41 - Bursa	64.3	16.5	73	32.9	9.6	160	140
1715*	TRC1 - Gaziantep	TR41 - Bursa	52.2	20.5	209	29.2	18.2	194	122
3615	TR72 - Kayseri	TR10 - İstanbul	57.9	10.9	114	27.2	16.7	115	35
2960*	TR51 - Ankara	TR71 - Kırıkkale	41.3	30.5	209	15.3	5.7	144	284
2653*	TR51 - Ankara	TRC3 - Mardin	48.3	12.4	31	32.3	6.5	39	50
2461	TR42 - Kocaeli	TR51 - Ankara	48.9	31.3	22	13.6	36.4	129	31
1830*	TR10 - İstanbul	TR21 - Tekirdağ	79	17.7	113	85	8	17	40
3663	TR10 - İstanbul	TR21 - Tekirdağ	82.2	5	218	77.1	2.8	53	90
1772*	TR10 - İstanbul	TRC1 - Gaziantep	78.6	11.2	540	78.3	3	44	167
1712	TR21 - Tekirdağ	TR33 - Manisa	39.9	31.7	69	5.8	29	295	47
2463	TR61 - Antalya	TR10 - İstanbul	53.3	42.6	28	71.4	17.9	9	30
3710	TR31 - İzmir	TR42 - Kocaeli	60	13.4	23	21.8	17.4	82	23
2863*	TR10 - İstanbul	TR31 - İzmir	79.8	3.6	162	58	5.5	81	38
3511*	TR10 - İstanbul	TR42 - Kocaeli	75	10.7	715	71.3	14	62	45
3622	TR10 - İstanbul	TR31 - İzmir	77	5.5	829	74.5	4.3	27	34
2123	TR10 - İstanbul	TR21 - Tekirdağ	80.5	8.6	50	84	2	32	143

Comparing location characteristics of industries common in both years also reveals important information. Processing of tea and coffee (1586) industry has maintained the shares of employment in two regions in 2008; however the share of firms in the first region has decreased from 76.3 % to 59.2 % where average firm size increased from 63 to 113. This shows that firms in Trabzon has become fewer but larger throughout the period. Manufacture of carpets and rugs (1751) industry is again mostly agglomerated in Gaziantep and Kayseri. However the share of Gaziantep has increased significantly both in terms of employment and number of firms throughout the period while Kayseri experienced a notable decline in the respective shares reflecting the dominance of Gaziantep in the industry over the years. Other textile weaving (1725) industry has experienced increase in the employment share of Bursa as the first region while Istanbul has lost more than half of its share in terms of employment. Contrarily Bursa had a slight decline in regional firm share while Istanbul experienced 5 percentage points increase where average firm size has increased in the former and decreased in the latter. Thus we may infer that Bursa has had fewer large firms and Istanbul had more small firms according to 2003.

Both regions in silk-type weaving (1724) industry has experienced slight declines in both employment and firm shares, which indicates that Bursa and Istanbul are not as dominant as has been in 2003 in the sector but still most agglomerated regions. Manufacture of plaster (2653) industry has undergone a different process than other industries. The first most agglomerated region in both years has been observed as Ankara, however in 2008 the second most agglomerated region switched from Bursa to Mardin. Also the industry has small number of firms (31) and the index tends to be biased in such cases as mentioned before. A similar case happened in manufacture of weapons and ammunition (2960) industry where first two regions switched; each one took the other's place in 2008. Kırıkkale and Ankara have been the first and second agglomerated regions in 2003 and the case has been vice versa in 2008. Gaziantep has experienced a notable increase, 10 percentage points, in its employment share in throwing and preparation of silk (1715) industry where Bursa had a slight increase in this share. Nonetheless, firm share of Gaziantep declined almost by 8 % while in Bursa increased by the same amount. Also having the information on average firm sizes of the regions we may conclude that Gaziantep has held fewer large firms and Bursa held more small firms according to 2003.

Employment share of Istanbul in dressing and dyeing of fur (1830) industry has declined while its firm share declined in 2008. Also the number of firms has significantly increased in this industry. Manufacture of knitted and crochet pullovers, cardigans, etc. (1772) industry has experienced an increase in employment share in the second region Gaziantep while firm share declined. Also the significant increase in the average firm size in this region demonstrates that large firms have been dominant when it comes to year 2008. Manufacture of locks and hinges (2863) industry was mostly agglomerated in Istanbul and Bursa in 2003 and in 2008 the second most agglomerated region came out to be Izmir. In building and repairing of ships (3511) industry, Istanbul still being the most agglomerated region in 2008 has experienced declines in both employment and firm shares. On the other hand, Kocaeli has enhanced both its employment and firm share within the industry.

3. 3. Technology-wise agglomeration

Eurostat classifies industries in manufacturing according to technological intensity for compiling aggregates related to high-technology, medium high-technology, medium low-technology and low-technology. Based on this classification Table 10 presents the extent of agglomeration by technology groups. Each row shows the percentage of the technology-wise agglomeration within the agglomeration range defined in the first column and the last column shows the number of 4-digit industries in that range.

Table 10: Extent of agglomeration by technology groups

	Low	Med-low	Med-high	High	Total	N
			2003			
$\gamma \leq 0$ – *No conc./dispersion*	37.9	24.3	32.4	5.4	100	37
$0 < \gamma < 0.02$ – *Low*	38.5	38.5	23	0	100	26
$0.02 \leq \gamma \leq 0.05$ – *Intermediate*	33.3	33.3	27.3	6.1	100	33
$\gamma > 0.05$ – *High*	47	28	19.7	5.3	100	132
			2008			
$\gamma \leq 0$ – *No conc./dispersion*	36.6	34.1	17.1	12.2	100	41
$0 < \gamma < 0.02$ – *Low*	14.3	47.6	38.1	0	100	21
$0.02 \leq \gamma \leq 0.05$ – *Intermediate*	42	29	29	0	100	38
$\gamma > 0.05$ – *High*	48.8	24.8	21	5.4	100	129

Low and medium-low technology sectors show a higher degree of agglomeration. Specifically, above the 0.05 threshold, the share of low-technology sectors is much higher than other technology levels for both years. We also observe that from 2003 to 2008, the share of low-technology group at medium and high agglomeration levels increased. Regarding medium-level technology group, the picture is somewhat different. The share of this group at no agglomeration and low agglomeration levels have increased while for higher levels decreased over the period. It shows that agglomeration in this group has undergone a moderation process. On the contrary, throughout the period the share of medium-high sectors at each level of agglomeration has increased while a significant decline has been observed at no concentration level. This indicates an enhancement in agglomeration levels in the medium-high technology group. The share of high technology

[10] In order to have detailed information on industries according to NACE Rev.2 2-digit and 3-digit level, please follow: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_ industries

group in each range is substantially low compared to others. The decline in agglomeration in this group is pretty obvious as its share in no agglomeration level has increased, in medium agglomeration level has dropped to zero and in high agglomeration level has been stable around 5.4 %. Consistent with the existing literature on agglomeration, also in Turkey high technology sectors display agglomeration to a very limited degree.

In fact, inferences we obtained regarding technology-wise agglomeration above are supported by mean values of agglomeration index in the related technology group as shown in Table 11. As mentioned above, on average agglomeration has increased in two technology levels, namely low and medium-high group. Mean of agglomeration has increased from 0.114 to 0.130 in the former group and from 0.081 to 0.084 in the latter one. On the other hand, in the med-low and high technology sectors agglomeration on average has declined.

Table 11: Average agglomeration by technology groups

	2003	**2008**
Low	0.113	0.130
Medium-low	0.118	0.094
Medium-high	0.081	0.084
High	0.080	0.055

3.4. Industrial Scope of Agglomeration

To measure the degree to which the industries in the group are co-agglomerated; equation (5) proposed by Ellison and Glaeser (1997) is explored for the case of Turkey manufacturing at the two-digit industry level for the 22 industry groups that contain more than one sub-industry. γ^c reflects the degree of correlation between the locations of establishments that belong to the same group and the scale of it is the same as that of γ. $\gamma^c = 0$ may be interpreted as indicating that there is no correlation across sub-industries, hence there is no agglomeration in the industry group and spillovers are industry-specific rather than group-specific**.**

Ellison and Glaeser (1997) also find it useful to rescale the index γ^c with the weighted EG indices ($\hat{\gamma}_j$) of the sub-industries to measure the strength of co-agglomerative forces relative to agglomerative forces.

$$\lambda = \frac{\gamma^c}{\sum w_j \hat{\gamma}_j} \qquad (6)$$

If $\lambda = 0$, it would point that sub-industries exhibit no co-agglomeration at all, while a value of $\lambda = 1$ would show that natural advantages and/or spillovers that exist are group-specific rather than industry specific.

Table 12 reports the values of γ^c and λ obtained from four-digit sub-industries of each two-digit industry for year 2003. Regarding the index γ^c, 12 out of 22 twodigit industries exhibit co-agglomerative behaviour within the traditional ranges such that $\gamma^c \geq 0.02$. In 7 out of these 12 industries γ^c is found to be greater than 0.05, indicating that in these industries spillovers are group-specific rather than being industry-specific. The same characteristic is also valid for the year 2008 as shown in Table 13. 13 out of 22 two-digit industries exhibit co-agglomerative behaviour within the traditional ranges such that $\gamma^c \geq 0.02$. In 8 out of these 13 industries γ^c is found to be greater than 0.05.

Table 12: Co-agglomeration within 2-digit industries (2003)

NACE Rev. 1.1 2-digit code	# of subind.	*H*	*G*	γ^c	λ
37 Recycling	2	0.076	0.599	0.557	0.806
30 Office machinery and computers	2	0.095	0.268	0.372	-0.429
23 Coke, refined petroleum products and nuclear fuel	12	0.106	0.205	0.234	1.495
34 Motor vehicles, trailers and semi-trailers	3	0.012	0.101	0.108	0.922
20 Wood and of products of wood and cork, except furniture	6	0.002	0.073	0.066	0.593
18 Wearing apparel; dressing and dyeing of fur	6	0.001	0.054	0.064	0.898
15 Food products and beverages	30	0.001	0.049	0.052	0.393
19 Tanning and dressing of leather; man. of luggage, handbags,	3	0.003	0.047	0.05	0.873
31 Electrical machinery and apparatus n.e.c.	7	0.009	0.047	0.049	1.676
22 Publishing, printing and reproduction of recorded media	12	0.004	0.031	0.036	0.907
26 Other non-metallic mineral products	24	0.002	0.034	0.03	0.348
33 Medical, precision and optical instruments, watches and clocks	5	0.01	0.03	0.02	0.181
24 Chemicals and chemical products	18	0.008	0.039	0.015	0.124
27 Basic metals	16	0.028	0.064	0.01	0.081
17 Textiles	19	0.002	0.016	0.009	0.088
25 Rubber and plastic products	7	0.004	0.013	0.009	0.409
29 Machinery and equipment n.e.c.	22	0.002	0.009	0.005	0.078
36 Furniture; manufacturing n.e.c.	12	0.004	0.014	0.004	0.055
21 Pulp, paper and paper products	7	0.007	0.014	-0.001	-0.03
28 Fabricated metal products, except machinery and equipment	16	0.001	0.004	-0.003	-0.051
32 Radio, TV and communication equipment and apparatus	3	0.1	0.073	-0.004	-0.089
35 Other transport equipment	8	0.029	0.035	-0.09	-0.458

The five industries, namely, recycling (37), office machinery and computers (30), coke, refined petroleum products and nuclear fuel (23), motor vehicles, trailers and semi-trailers (34) and wearing apparel; dressing and dyeing of fur (18) appear within the most co-

agglomerated in industries in both years. The spillovers are found to be group specific in these industries and this fact has been stable through the observed period. Ellison and Glaeser (1997) find substantial co-agglomeration of the three-digit sub-industries within the two-digit tobacco, textile, and lumber industries. In line with our findings, they find co-agglomeration in apparel and other textiles industry in US. Bertinelli and Decrop (2005) examines the co-agglomeration of the four-digit sub-industries within the two-digit according to the NACE Rev.1.1 classification, likewise this study, for Belgian manufacturing industry. Hence their findings are directly comparable. The most co-agglomerated two-digit industries are found to be textile (17), clothes and fur industry (18), publishing, printing and reproduction of recorded media (22), production of medical, precision, optical and clock instruments (33) and production of office machines and computer materials (30). Excluding textile industry, their findings completely agree with our findings in terms of co-agglomeration patterns within two-digit industries.

Table 13: Co-agglomeration within 2-digit industries (2008)

NACE Rev. 1.1 2-digit code	# of subind.	*H*	*G*	γ^c	λ
23 Coke, refined petroleum products and nuclear fuel	12	0.123	0.216	0.272	1.942
37 Recycling	2	0.119	0.263	0.236	1.284
33 Medical, precision and optical instruments, watches and clocks	5	0.036	0.124	0.122	1.186
34 Motor vehicles, trailers and semi-trailers	3	0.014	0.101	0.11	1.082
18 Wearing apparel; dressing and dyeing of fur	6	0.001	0.062	0.071	0.876
30 Office machinery and computers	2	0.115	0.236	0.065	0.339
22 Publishing, printing and reproduction of recorded media	12	0.003	0.053	0.059	1.046
19 Tanning and dressing of leather; man. of luggage, handbags,	3	0.006	0.052	0.054	0.811
32 Radio, TV and communication equipment and apparatus	3	0.081	0.138	0.05	0.322
20 Wood and of products of wood and cork, except furniture	6	0.003	0.046	0.048	0.69
15 Food products and beverages	30	0.001	0.04	0.042	0.33
26 Other non-metallic mineral products	24	0.002	0.04	0.039	0.404
17 Textiles	19	0.001	0.029	0.022	0.14
21 Pulp, paper and paper products	7	0.006	0.021	0.015	0.404
24 Chemicals and chemical products	18	0.004	0.022	0.015	0.248
27 Basic metals	16	0.014	0.047	0.009	0.083
31 Electrical machinery and apparatus n.e.c.	7	0.007	0.018	0.004	0.092
28 Fabricated metal products, except machinery and equipment	16	0.001	0.007	0.002	0.042
29 Machinery and equipment n.e.c.	22	0.003	0.005	0.000	0.003
35 Other transport equipment	8	0.008	0.105	0.000	-0.001
36 Furniture; manufacturing n.e.c.	12	0.002	0.016	-0.001	-0.009
25 Rubber and plastic products	7	0.002	0.004	-0.002	-0.068

One may argue that, co-agglomerative forces operating at different technology levels might be different and NACE classification system may fail to capture this fact. For instance, it may be expected that high tech industries are more likely to agglomerate in order to benefit from knowledge spillovers while low-tech and medium tech industries are more likely to gather together to take the advantage of input sharing and labour pooling. In order to see whether a potentially inappropriate definition of industrial activities masks this, we group industries according to technology levels in accordance with Eurostat classification and compute co-agglomeration index based on this. For the year 2003, Table 14 displays that low and medium-low tech industries do not exhibit co-agglomeration behaviour, whereas medium-high tech industries show a considerable degree of co-agglomeration with a λ of 0.0769 and high tech industries show a moderate degree of co-agglomeration with a λ of 0.327.

Table 14: Co-agglomeration within technology groups (2003)

Technology level	# of ind.	*H*	*G*	γ^c	λ
Low	97	0.0004	0.0013	-0.0024	-0.0260
Medium-low	67	0.0013	0.0045	0.0010	0.0131
Medium-high	53	0.0017	0.0095	0.0058	0.0769
High	11	0.0159	0.0485	0.0046	0.0327

3.5. International Comparisons

Ellison and Glaeser (1997, p. 890) point out that "the index is designed to facilitate comparisons across industries, across countries, or over time". However, one should be cautious when dealing with comparisons. Regarding comparisons across industries, sectors entailing few observations should be considered carefully, as the index tends to be upward biased. Hence performing cross-country comparisons is even more critical. Apart from this, comparing same sectors in different countries raises several issues. Making comparisons across different industrial classifications may make the analysis inaccurate. Even this issue may easily be dealt by using or transforming to same classification scheme, the issue related to the spatial units is not an easy one to solve. When exploring concentration indices, one is limited to use existing spatial units within the country for which it's not easy to find comparable counterparts across countries. This is of great importance since the size of the index is very sensitive to locational fineness of the data, the index tends to be higher at more coarsened spatial units. A possible explanation lies behind the assumptions of the location model that treats natural advantages and spillovers as being uncorrelated across space. But if spillovers reach beyond borders or natural advantages are correlated across

spatial units, measuring index at that spatial unit becomes incompatible with the true location model and thus nonsense (Alecke et al. 2006). Briefly, in such a case, the index fails to capture the entire range of spillovers and natural advantages as they are operating at a higher spatial unit, hence it is calculated lower. This arises due to the a-spatial nature of the index.

Bearing in mind all these potential shortcomings in making cross-country comparisons, still a cross country comparison may be performed cautiously on broader terms. To have an idea about the extent of agglomeration in different countries Table 15 shows mean levels of EG indices calculated by some notable studies as all of these studies well go beyond this in terms of research topic. A striking point is that the extent of overall agglomeration is similar for developed countries ranging between 0.03 and 0.05 which falls within the ranges of medium level agglomeration according to Ellison and Glaeser's (1997) classification. Two countries, namely Portugal and China, lie outside this range with values 0.133 (and 0.095 in Barrios, Bertinelli, Strobl, and Teixeira (2005)) and 0.014 respectively. Portugal having higher mean values of EG relative to other countries is associated with quite low levels of industrial concentration, as both Barrios, Bertinelli, Strobl, and Teixeira (2005) and Barrios, Bertinelli, Strobl, and Teixeira (2009) agree on this fact. On the other hand China's industrial agglomeration is observed to be lower when compared with those in developed countries. Lu and Tao (2009) relate this to some institutional factors such as local protectionism which may preclude the process of industrial agglomeration in China.

Table 15: Comparison with other countries

Author(s)	Country (group)	Mean EG (γ)
Ellison and Glaeser (1997)	USA	0.051
Rosenthal and Strange (2001)	USA	0.048
Devereux, Griffith, and Simpson (2004)	UK	0.033
Bertinelli and Decrop (2005)	Belgium	0.040*
Barrios, Bertinelli, Strobl, and Teixeira (2005)	Ireland-Portugal	0.042*-0.095*
Alecke, Alsleben, Scharr, and Untiedt (2006)	Germany	0.036
Lafourcade and Mion (2007)	Italy	0.033
Barrios, Bertinelli, Strobl, and Teixeira (2009)	Belgium-Ireland-Portugal	0.027*-0.038*-0.133*
Lu and Tao (2009)	China	0.014
Leahy, Palangkaraya, and Yong (2010)	Austria	0.044
This study	Turkey	0.112

*Weighted means

In this picture, Turkey arises as having high levels of agglomeration compared to developed countries with an average EG index of 0.112. This fact may hinge on to the differences in terms of transportation costs, labour market conditions, and more broadly any other factors influencing the location of plants across countries considered. Notwithstanding that may well be a possible case for Turkey as a developing country, it should completely be discussed in a deeper research framework.

Again broadly speaking, there is a stylized fact arising from the research on agglomeration that traditional and low-tech industries tend to show higher degrees of agglomeration relative to others. A notable inference that can be retrieved from the studies mentioned above is the presence of textile (or textile-related industries) ranking high in many of the countries, for instance in US (Ellison and Glaeser (1997), Rosenthal and Strange (2001)), UK (Devereux, Griffith, and Simpson (2004)), Belgium (Bertinelli and Decrop (2005)), Spain (Alonso-Villar, Chamorro-Rivas, and González-Cerdeira (2004)) and Italy (Lafourcade and Mion (2007)) for the sample of small plants. In this sector high proportion of the labour is unskilled and Ellison and Glaeser (1999) find that access to unskilled labour to be the most important factor in explaining geographic concentration for the textiles and apparel industries in US. Along with textile, extraction and mining industries are found to be among the most agglomerated ones. Alecke, Alsleben, Scharr, and Untiedt (2006) state that extractive industries dominate the top group within German manufacturing industries. In Alonso-Villar, Chamorro-Rivas, and González-Cerdeira (2004) also, extractive industries are found to be highly agglomerated for the Spanish case. Here, natural advantages arise as a plausible candidate for explaining agglomeration in these type of industries. Along with these sectors, in general there is a clear evidence on the high agglomeration of low-tech industries. These stylized facts are also valid for Turkey, 80 per cent of the 15 most agglomerated industries fall within the low and medium-low technology sectors. Consistent with the previous findings textile and traditional sectors dominate the group.

Taking into account the literature highlighting knowledge externalities, high-tech industries may be anticipated to appear among the most agglomerated ones. However, as a common aspect across country studies, high-tech industries do nor rank high. Agglomeration to a certain degree in high-tech industries is supported in a few studies including Ellison and Glaeser (1997), Alonso-Villar, Chamorro-Rivas, and González-Cerdeira (2004), Alecke, Alsleben, Scharr, and Untiedt (2006) and Bertinelli and Decrop (2005). There might be some reasons for these sectors to be less agglomerated. One reason is that "they are newer and agglomeration is a dynamic process and geographic concentration in these sectors might still be at an early stage" (Devereux, Griffith, and

Simpson, 2004, p. 545). Another reason might be that even technological spillovers are important, geographic contiguity may be less important in today's world in capturing knowledge externalities due to the developments in communication technologies (Devereux, Griffith, and Simpson, 2004). Regarding Turkey, high-tech industries also exhibit lower levels of agglomeration such that almost half of the industries listed within the least agglomerated industries are high and medium-high tech industries.

4. Concluding remarks

This paper examines the geographic distribution of Turkish manufacturing industries using an enterprise level micro data set which is firstly explored in this line of research for the case of Turkey. The analysis is mainly based on the index developed by Ellison and Glaeser (1997), which has been designed to allow for comparisons across industries and countries. The intention has been to provide a rigorous descriptive analysis of the distribution of manufacturing activity in Turkey.

Main findings of the paper indicate that Turkish manufacturing industries reveal a high degree of agglomeration. Most localized industries in both years encompass low-technology industries. Within this technology group textile and traditional industries are observed to be dominant. Based on the OECD technology classification scheme, on average low and medium-low technology sectors show a higher degree of agglomeration in Turkey. Specifically, the total share of low and medium-low technology sectors displaying a high level of agglomeration above 0.05 threshold level within all technology groups is around 75% for both years. Although medium-high and high technology sectors on average display agglomeration above the 0.05 threshold, their share is rather low compared to other two lower technology groups.

The stylized fact arising from the research on agglomeration that traditional and low-tech industries tend to show higher degrees of agglomeration relative to others, also hold for the case of Turkey. 80 and 85 per cent of the 20 most agglomerated industries fall within the low and medium-low technology sectors in 2003 and 2008, respectively. This finding is consistent with the rest of the literature confirming that low technology sectors tend to agglomerate more than the others. However, there is limited evidence on the agglomeration of high-tech industries, which has been subject to policy considerations in developed countries.

Based on the agglomeration studies on developed countries, Turkey on average has a higher degree of agglomeration than the developed countries. This fact may hinge on to the differences in terms of transportation costs, labour market conditions, and more broadly any

other factors influencing the location of plants across countries considered. Still, it may well be a possible case for Turkey as a developing country whose dynamics behind agglomeration motives are likely to be different than developed countries.

One of the limitations of the study is related to the geographic units confining it. Geographic scale of the available data is quite broad and only available at NUTS-2 level which does not allow one to consider geographic scope of agglomeration at different scales. This is important in the sense that different agglomeration mechanisms work at different scales of spatial units. Secondly, the analysis is conducted without taking into consideration the firm size. However, both theoretical and empirical studies show that agglomeration patterns differ between different firm sizes. The latter also point the way for further research.

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