The Size Distribution of Cities and Determinants of City Growth in Turkey

Ertugrul Deliktas a, A. Özlem Önder a & Metin Karadag a

a Department of Economics, Ege University, Bornova-Izmir, Izmir, 35100, Turkey


To cite this article: Ertugrul Deliktas, A. Özlem Önder & Metin Karadag (2012): The Size Distribution of Cities and Determinants of City Growth in Turkey, European Planning Studies, DOI:10.1080/09654313.2012.722922

To link to this article: http://dx.doi.org/10.1080/09654313.2012.722922

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The Size Distribution of Cities and Determinants of City Growth in Turkey†

ERTUGRUL DELIKTAS, A. ÖZLEM ÖNDER & METIN KARADAG

Department of Economics, Ege University, Bornova-Izmir, Izmir 35100, Turkey

(Received November 2010; accepted April 2011)

ABSTRACT The aim of this study is two-fold. Firstly, this study examines the size distribution of cities by using Zipf’s law. The second objective of this study is to investigate the effects of determinants of urban growth in Turkey by using the data for the 1980–2007 time period. The main findings of the study show that there is some evidence that Zipf’s law holds in Turkey. Moreover, according to the rank-minus-half rule, the results suggest stronger support for Zipf’s law in size distribution of the cities. Furthermore, the regression results indicate that fertility rate, location of the city, migration, agglomeration in services and specialization in manufacturing industry have positive impact, whereas schooling rate has a negative effect on growth of the urban population regarding Turkey.

1. Introduction

The world population increased three times between 1800 and 2000, and it is predicted that the world population, which was around 6.8 billion in 2009, will become around 8 billion in 2025 and 9.5 billion in 2050. Also, the largest part of the population growth is in the developing countries, and it is predicted that 84% of the world population will live in the developing countries in 2020 (Bongaarts, 2001).

In line with the population growth, another important issue is the rapid urbanization process. For example, in industrialized countries, 75% of the population lives in city centres, while only around 33% of the population lives in the city centres in the developing countries. However, it is predicted that 58% of the world population will live in the cities in the world before 2020 (Bongaarts, 2001). Therefore, city administrations should be aware of this development and make necessary decisions.

†The previous version of this study was also presented at IASK international conference 13–15 October 2008, Porto, Portugal.

Correspondence Address: A. Özlem Önder, Department of Economics, Ege University, Bornova-Izmir, Izmir 35100, Turkey. Email: ozlem.onder@ege.edu.tr ozlem.onder@ege.edu.tr

ISSN 0965-4313 Print/ISSN 1469-5944 Online/12/000001–13 © 2012 Taylor & Francis

http://dx.doi.org/10.1080/09654313.2012.722922
Regarding Turkey, the population growth has been relatively high since its foundation in 1923. For instance, Turkey’s total population increased from 13.6 million in 1927 to 20.9 million in 1950, to 56.4 million in 1990, to 67.8 million in 2000 and, finally, to around 71 million in 2007. On the other hand, the population of the metropolitan cities has increased more rapidly. For example, the population of Istanbul increased from 4.7 million in 1987 to 11.1 in 2007, the population of Ankara increased from 2.8 million to 4.1 million, while the population of Izmir increased from 1.9 million to around 3 million for the same time period. Besides, the total population in Turkish cities increased from 3.3 million in 1927 to 5.2 million in 1950, to 30.5 million in 1990, to 44 million in 2000 and, finally, to 49.7 million in 2007. Thus, the share of the population of the cities in total population is 24%, 25%, 54%, 65% and 70% in order.

Hence, investigating the city-size distribution using Zipf’s law and the reasons why there are large differences in the growth of the cities gains importance as far as Turkey is concerned. There are a few studies related to Zipf’s law in Turkey (see, for example, Turk & Dokmeci, 2001; Gedik, 2003; Filiztekin, 2006; Marin, 2007). However, these studies test Zipf’s law in a conventional way. Also, to the best of our knowledge, there appears to be only one study (Filiztekin, 2006) that investigates the determinants of the city growth by using a few variables in Turkey.

The main aim of this study is two-fold. Firstly, we examine the size distribution of the city by using Zipf’s law and try to find out whether the size distribution of the city has been even or uneven for the time period under consideration. Secondly, we estimate the effects of factors that may have impact on city growth in Turkey over the period 1980–2007.

The remainder of this article is organized as follows. Second section gives brief descriptive information about city population growth in Turkey. Third section presents a theoretical explanation of Zipf’s law. Fourth section includes the data set used in the study. Fourth section also provides the results of empirical analysis based on Zipf’s law and regression analysis including the estimation of effects of determinants of city population growth. Finally, fifth section concludes.

2. Brief Descriptive Information about City Population Growth in Turkey

Turkey has experienced a rapid urbanization process since 1950. The urbanization rate has increased more rapidly especially since the 1980s. For example, the rate was around 44% in 1980, while it was around 65% in 2000 (Evcil et al., 2006). It is estimated that urbanization rate will become 80% in 2030. The urbanization rate has increased more rapidly in the metropolitan cities. For example, the rate increased from 85% to 88% in Istanbul, from 75% to 85% in Izmir and from 81% to 92% in Ankara between 1980 and 2007. However, it increased from 49% to 70% on average in Turkey for the same time period (see TURK-STAT, 1980–2008). These figures show us that both population growth and urbanization rate are above Turkey’s average in the metropolitan cities. The main factor for the growth of the city population in Turkey is continuous migration of villagers to the urban areas (Evcil et al., 2006). One of the main reasons for this migration can be given by the structural change in the Turkish economy especially after the 1980s. Since the 1980s, the share of the agricultural sector has decreased rapidly, and thus, the percentage of the labour force in the agricultural sector has also decreased.2

The important differences in the size distribution of the city population might well be explained by various factors including economic, social, cultural, political and demo-
graphical variables, and migration and geographical situation. Depending on these factors, some cities may grow either faster or slower. In this process, the population of the city has increased on the one hand; the number of provinces has increased on the other. Currently, the number of provinces has reached to 81. However, there are great differences in the size distribution of the provinces. For example, being the biggest city in Turkey, the population of Istanbul as a province is 12.5 million, while the population of the city is 11.1 million according to the last population census in Turkey. However, being the last regarding the population size, the population of Bayburt is only 76,600 in the province, while it is 35,000 in the city.

Also, Table 1 shows the data related to distribution of city sizes in Turkey.

As can be seen from the table, 64% of the cities are medium-sized cities the population of which lies between 150,000 and 500,000, while 25% of them are small-sized cities (the population is less than 100,000). In 1990, the proportion of medium-sized cities is 62, and it is 17 for the small-sized cities. Two cities, namely Ankara and Izmir, have a population between 2 and 4 million. In 2000, 63% of cities are medium-sized, while 11% are small-sized. In 2000, the cities that have a population between 1 and 4 million are, namely, Ankara, Izmir, Adana, Bursa, Gaziantep and Konya. In 2007, Mersin is added to those cities. On the other hand, the cities that have a population over 4 million are Istanbul (11,174,257) and Ankara (4,140,890). In this year, the smallest population is in Ardahan. In general, one can say that over 60% of Turkish cities are medium-sized ones for all years. Also, as can be seen from Table 1, recently, there have been nine metropolitan cities which have a population over 1 million, and Istanbul is the largest of all.

### Table 1. City-size distribution in Turkey

<table>
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<tbody>
<tr>
<td>Population &gt;4 million</td>
<td>1^a</td>
<td>1^a</td>
<td>1^a</td>
<td>1^a</td>
<td>2^b</td>
</tr>
<tr>
<td>2–4 million</td>
<td>1^c</td>
<td>1^c</td>
<td>2^d</td>
<td>2^d</td>
<td>1^e</td>
</tr>
<tr>
<td>1–2 million</td>
<td>1^e</td>
<td>2^f</td>
<td>2^g</td>
<td>4^h</td>
<td>6^i</td>
</tr>
<tr>
<td>500,000–1 million</td>
<td>4^j</td>
<td>4^k</td>
<td>12^l</td>
<td>14^m</td>
<td>13^n</td>
</tr>
<tr>
<td>250,000–500,000</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>100,000–250,000</td>
<td>27</td>
<td>31</td>
<td>34</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>&lt;100,000</td>
<td>17</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Number of cities</td>
<td>67</td>
<td>67</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Average city size</td>
<td>328,253</td>
<td>401,000</td>
<td>415,500</td>
<td>551,000</td>
<td>614,000</td>
</tr>
<tr>
<td>Minimum population</td>
<td>36,184^o</td>
<td>43,000^p</td>
<td>34,000^p</td>
<td>40,000^p</td>
<td>35,000^p</td>
</tr>
<tr>
<td>Maximum population</td>
<td>4,514,000</td>
<td>5,561,000</td>
<td>6,779,000</td>
<td>9,226,000</td>
<td>11,174,252</td>
</tr>
</tbody>
</table>

*^The number of cities (67) is adjusted to 81 according to the method used by Marin (2007). This method is as follows: P_{1,990} = (P_{1,985} / (1 + G_{1990–2007})), where G is the growth rate of the city between 1990 and 2007 and P_{1,980} show the population of each city in the related years.

**The number of cities is 73 in 1990. However, TURKSTAT takes 2000 as the base and adjusts the statistics according to 81 cities. ^Istanbul; ^Istanbul, Ankara; ^Ankara; ^Ankara, Izmir; ^Izmir; ^Adana, Izmir; ^Adana, Bursa; ^Adana, Bursa, Gaziantep, Konya; ^Bursa, Adana, Konya, Gaziantep, Antalya, Içel; ^Adana, Bursa, Gaziantep, Konya; ^Bursa, Gaziantep, Konya, Içel; ^Konya, Içel, Gaziantep, Balıkesir, Kayseri, Antalya, Diyarbakır, Manisa, Kocaeli, Sanlıurfa, Hatay, Samsun; ^Antalya, Sanlıurfa, Diyarbakır, Kayseri, Kocaeli, Manisa, Samsun, Balıkesir, Hatay, Erzurum, Eskisehir, K.Maras, Malatya, Aydın; ^Sanlıurfa, Diyarbakır, Kocaeli, Kayseri, Manisa, Samsun, Erzurum, Balıkesir, K.Maras, Van, Eskisehir, Malatya, Trabzon; ^Tunceli; ^Ardahan; ^Bayburt. They are the names of cities in Turkey.
3. Theoretical Framework of Zipf’s Law

Zipf’s law (Zipf, 1949) for cities is one of the empirical facts in the area of economics, or in the social sciences in general. The significance of this law is that, given very strong empirical support, it makes up a minimum criterion of acceptability for any model of local growth (see also Gabaix, 1999). Therefore, Zipf’s law is also one of the well-known approaches to explain the size distribution of cities for many countries (see Gabaix, 1999; Soo, 2005, 2007 for details). Zipf’s law, also known as “Rank-Size Rule”, is based on the Pareto distribution which was first suggested by Auerbach (1913). He introduced the Pareto distribution as follows:

\[ R_i = AS_i^{-\beta}, \]  

(1)

where \( R \) is the rank of the cities ordered from the largest to the smallest, \( S \) is the population of city \( i \) and \( A \) is the expected population of the largest city (\( A \) and \( \beta \) are constants). The size distribution of cities should not only have a Pareto distribution, but also Pareto exponent (\( \beta \)) should be equal to 1. If the Pareto exponent is equal to 1, Zipf’s law holds which means the cities show a parallel growth (Eaton & Eckstein, 1997). On the other hand, if the value of the Pareto exponent is larger than 1, the population of cities in the urban system is more even and if the value of the Pareto exponent is smaller than 1, the distribution of city size is more uneven (Soo, 2005).

Zipf’s law in the city distribution system indicates that the second largest city is half the size of the largest, the third largest city a third the size of the largest and the \( n \)th largest city is the \( n \)th size of the largest one. Then, the number of cities whose population is greater than \( S \) is proportional to \( \frac{1}{SP(\text{Size} > N)} = AS^{-\beta} \) and \( \beta = 1 \) (Gabaix & Ioannides, 2004; Nitsch, 2005).

There is a considerable amount of literature about Zipf’s law. These studies have attempted to derive Zipf’s law for city-size distributions (see, for example, Rosen & Resnick, 1980; Glaeser et al., 1995; Eaton & Eckstein, 1997; Gabaix, 1999; Overman & Ioannides, 2000; Eechout, 2004; Soo, 2005, 2007; Gabaix & Ibragimov, 2008; Giesen & Suedekum, 2009; Ioannides & Skouras, 2009).

Glaeser et al. (1995) carried out their study for 135 cities in the USA, and Eaton and Eckstein (1997) conducted a study for 39 cities for the period 1876–1990 for France and 40 cities for Japan for the time period 1925–1985 regarding city-size distribution. Both studies indicate that the size distribution of the cities is stable and Zipf’s law holds. Also, Gabaix (1999) theoretically proves that city-size distribution converges to a power law if all cities follow some proportional growth process. Soo (2007) carried out a research to test Zipf’s law for Malaysian cities. The author concludes that there is some evidence that Zipf’s law holds for Malaysia. Giesen and Suedekum (2009) found that the Pareto exponent ranges from 0.87 to 1.22 in the national and regional level in Germany. They indicated that this range does not show deviation from Zipf’s law because the exact Zipf law is only achieved in limit. Ioannides and Skouras (2009) showed that the estimated exponent for US urban places is not exactly 1, but it is not far and Zipf’s law provides a good fit. However, like Krugman (1996), they still believe that the power law of city sizes and its exponent is still discussable.
As mentioned before, there are only a few studies related to urbanization growth regarding Turkey. Turk and Dokmeci (2001) studied the distribution of city population in terms of geographical regions and Turkey as a whole regarding Zipf’s law. They found parallel growth of city centres for the time period 1980–1997. Gedik (2003) studied the growth of the cities which have a population of 125,000 and over with regard to urbanization and polarization for the time period 1955–2000. She concludes that small and big cities have different growth rates. Filiztekin (2006) investigated the city-size distribution and its evolution in Turkey for the time period 1950–2000 by applying Zipf’s law and the Markov process. He concludes that the distribution of city sizes is right-skewed and quite stable, especially after 1960. He also states that the coastal cities tend to grow faster. Marin (2007) studied Zipf’s law in the transformation process of the Turkish urban system after 1985. He concluded that the Turkish urban system experienced uneven development after 1985 and deviated from Zipf’s law because of wrong liberalization policies.

In order to test the validity of Zipf’s law, equation (1) can be estimated in the double-logarithmic form as follows:

\[ \ln R_i = \alpha - \beta \ln S_i + u_i, \]

where \( \alpha \) represents \( \ln A \), and \( u \) shows the error term.

The Zipf regression in equation (2) can be estimated by the ordinary least squares (OLS) method. However, it has been argued that the OLS estimation of Zipf’s law may cause biased coefficients in small samples. There are several approaches to correct the bias of the Zipf regression, such as the Hill (1975) estimator and the rank-minus-half rule. On the other hand, the Hill estimator is also criticized since it is also found to be biased in small samples (see Gabaix & Ioannides, 2004 for the details).

The rank-minus-half rule that is proposed by Gabaix and Ibragimov (2008) is as follows:

\[ \ln (R_i - 1/2) = \alpha - \beta \ln (S_i) + u_i. \]

They also proposed unbiased standard errors \( (2/n)\hat{\beta} \) of the Pareto exponent, where \( n \) is the corresponding sample size.

### 4. Empirical Results

#### 4.1. Data

The census data for this study have been obtained from Turkish Statistical Institute (TURKSTAT) for different years. We have used the population data belonging to the 81 cities for the time period 1980–2007. As mentioned before, city size is measured as the population of the city excluding the population of the villages in this study. In Turkey a city can be defined as the administrative centre of a province. In this respect, there are 81 provincial centres including the population of city centres and town centres in Turkey, and in this study, we have used those centres as the city. In other words, a city is an administrative unit regardless of its population size (see also Gedik, 2003). In the regression analysis, to estimate the determinants of city growth, the following variables
are used: net migration rate, the number of hospital beds per 100,000 population (as a health indicator), dummy variables for the location of the city \( (D = 1 \) if coast, \( D = 0 \) otherwise), secondary schooling rate, fertility rate, crime rate and per capita income by using cross-sectional data for the years 1980–2007 on average for the estimation. We also calculate agglomeration, specialization and competition in the manufacturing industry, and agglomeration and specialization in the services sector for the purpose of the study.

4.2. Zipf’s Law

Our empirical results are based on the OLS estimation of Zipf’s law and the rank-minus-half rule introduced by Gabaix and Ibragimov (2008).

We rank the cities according to the size of population from the biggest one for the time period 1980–2007 and give numbers beginning from 1 for the biggest city (Istanbul = 1, Ankara = 2, Izmir = 3, ... Bayburt = 81 etc.). The change in the city-size distribution is followed by the cross-section data for the years 1980, 1985, 1990, 2000 and 2007. Then, we regress log-rank on log-population to estimate equation (2), and it is given as OLS 1 in the results.

Table 2 presents the parameter estimates related to the cross-section regression analysis. As can be followed from the table, the value of the Pareto exponent \( b \) changes through the years. Although it is less than 1, the \( b \) is not found to be significantly different from 1, indicating that we could not reject Zipf’s law. We find some evidence that Zipf’s law holds in Turkey. After 1990, the coefficient is declined, which indicates that the size distribution of cities is becoming less equal over time.

Table 2 further presents the results of some diagnostic tests. According to the diagnostic test results, the evidence of heteroscedasticity and autocorrelation is found in the residuals. Therefore, we have used Newey–West standard errors in OLS 1 regressions. In addition, in order to address the potential endogeneity problem, we have used the instrumental variable estimator by taking the lagged population of cities as an instrument for further analyses. The results are quite similar to the OLS estimator results and therefore are not presented here.

In Table 2, we also present the Gabaix–Ibragimov (2008) estimates using equation (3) or the rank-minus-half rule and their associated standard errors for all regressions (given as OLS 2).

In OLS 2, the Pareto exponent \( b \) is closer to 1 compared with OLS 1 estimates. This indicates that Gabaix–Ibragimov estimates and standard errors reduce the biased estimator and standard error problem. The coefficients still are not significantly different from 1. The decline of the coefficient after 1990 can also be followed through corrected coefficients in OLS 2. Hence, we have found strong evidence on the validity of Zipf’s law for Turkish cities; however, the cities became less equal after 1990. The decrease in the value of the Pareto exponent after the 1990s can well be explained by the structural change in the Turkish economy as explained in second section (see also Marin, 2007).

4.3. Determinants of City Growth

In recent years, there has been some interest to investigate the determinants of city growth and population distribution for many countries. For example, Rosen and Resnick (1980)
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</tr>
</thead>
<tbody>
<tr>
<td>ln(Pop)</td>
<td>-0.875</td>
<td>-0.896</td>
<td>-0.925</td>
<td>-0.977</td>
<td>-0.917</td>
<td>-0.917</td>
<td>-0.896</td>
<td>-0.954</td>
<td>-0.865</td>
<td>-0.921</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.91</td>
<td>0.92</td>
<td>0.93</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.93</td>
<td>0.91</td>
<td>0.93</td>
<td>0.89</td>
</tr>
<tr>
<td>Heteros.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Autocorr.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>RESET</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>$W$</td>
<td>0.14</td>
<td>0.11</td>
<td>0.27</td>
<td>0.23</td>
<td>0.15</td>
<td>0.15</td>
<td></td>
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</tbody>
</table>

**Table 2.** The estimation results for Zipf’s law regression

Notes: Standard errors are in parentheses. For OLS 1 regressions, Newey–West standard errors are reported. $W$ has a Wald statistic under the null hypothesis of $\beta = 1$. Autocorrelation is a Lagrange multiplier test for the first-order serial correlation. The White heteroscedasticity test has F-statistic under the null of the homoscedastic error. RESET $F$ is a regression specification test. It tests the null correct specification of the original model.

*10% significance level.
**5% significance level.
***1% significance level.
expressed that the Pareto exponent which measures population distribution is positively related to per capita GNP, total population and rail–road density, but it is negatively related to land area. Alperovich (1993) showed that the Pareto exponent is positively related to per capita GDP, population density and land area, but it is negatively related to the government share of GDP, and the share of manufacturing value added in GDP. Soo (2005) tried to explain variations in Pareto exponents using the economic geography and political variables in regression analysis. He found that the political variables are more important than the economic geography variables in determining the size distribution of cities. Anderson and Ge (2004) investigated the determinants of city growth in China. The results of their study show that economic reforms played an important role in accelerating city growth in China. Also, the results indicate that the city’s openness to foreign direct investment, industrial structure and human capital accumulation has a positive impact on city growth.

Da Mata et al. (2007) examined the determinants of Brazilian city growth and found out that decreases in rural income opportunities, increases in market potential for goods and labour force quality and reduction of intercity costs have strong impacts on city growth. Filiztekin (2006) investigated the evaluation of city population and concluded that the main determinants of city growth were being a coastal town and having a large market potential.

In order to investigate determinants of city growth in Turkey, we have used economic, social, cultural and geographical variables as explanatory variables of the city population growth rate. Economic variables are per capita income, agglomeration index, specialization index and competition index in the industrial and services sectors. Social variables are migration rate, health indicators, crime rate, and fertility rate. A cultural variable is the schooling rate, and a geographical variable is the location of the city in Turkey.

In determining the choice variables, we have considered the previous theoretical and applied studies in the literature and availability of the data. In this context, Beeson et al. (2001) indicated that the location and weather have promoted population growth in the USA. Henderson and Au (2004) found that the benefit of urban agglomeration, which is real income per worker, is higher in larger cities. Also the cities where industrial and commercial activities are intensive may have a high population growth because of the job opportunities, mass production, knowledge spillover or positive externalities (Glaeser et al., 1992). Therefore, agglomeration, specialization, and competition structure of cities in Turkey can be seen as main factors of city growth.

Hence, in order to study the determinants of city growth in Turkey, we have estimated the following equation:

\[
\text{NAH}_i = \alpha + \beta_1 \text{FERT}_i + \beta_2 \text{LOC}_i + \beta_3 \text{MIG}_i + \beta_4 \text{HEALTH}_i + \beta_5 \text{SCHOOL}_i + \beta_6 \text{AGGLOMI}_i + \beta_7 \text{SPECI}_i + \beta_8 \text{COMPI}_i + \beta_9 \text{AGGLOMS}_i + \beta_{10} \text{SPECS}_i + \beta_{11} \text{PERC}_i + \beta_{12} \text{CR}_i + u_i.
\]  

(4)

In this model, NAH represents the average population growth, FERT is the fertility rate, LOC is the dummy variable for the location of the city (\(D = 1\) if coast, \(D = 0\) otherwise), MIG is the net migration rate, HEALTH is the number of hospital beds per 100,000 population, SCHOOL denotes secondary schooling rate, AGGLOMI is the agglomeration in manufacturing industry, SPECI is the specialization in manufacturing industry, COMPI
indicates the competition in manufacturing industry, AGGLOMS is the agglomeration in services, SPECS is the specialization in services, PERC shows per capita income and CR denotes the crime rate in the $i$th city for the time period between 1980–2007, on average.

We have followed Glaeser et al. (1992) and Porter (1990) to obtain the agglomeration index, specialization index and competition index used in equation (1) as the explanatory variables.\(^8\)

Hence, we have derived the indices as follows:

$$\text{AGGLOM} = \ln \left( \frac{\text{SE}_{\text{current}}}{\text{SE}_{\text{base}}} \right), \quad (5)$$

where $\text{SE}_{\text{current}}$ shows the city’s sectoral employment in the current year, while $\text{SE}_{\text{base}}$ shows the city’s sectoral employment in the initial year. The agglomeration index shows an increase in employment in the sector and therefore indicates an increase in the population of the city.

$$\text{SPEC} = \ln \left( \frac{\text{SE}/\text{TE}}{\text{TSE}/\text{TTE}} \right), \quad (6)$$

where $\text{SE}$ shows the employment in the city’s related sector, $\text{TE}$ represents total employment in the city, $\text{TSE}$ indicates total employment in the Turkish manufacturing industry or services sector and $\text{TTE}$ is total employment in Turkey.

The specialization index measures how specialized a city is in that specific sector relative to the related sector across the country. High specialization of a sector in a city should speed up growth of that sector and population in that city (Glaeser et al., 1992).

$$\text{COMP} = \ln \left( \frac{\text{CMF}/\text{CME}}{\text{TMF}/\text{TME}} \right), \quad (7)$$

where $\text{CMF}$ shows the number of firms which employ 10 or more workers in the city’s manufacturing industry and $\text{CME}$ shows the employment in the city’s manufacturing industry while $\text{TMF}$ represents the number of firms in the Turkish manufacturing industry, and $\text{TME}$ indicates the employment in the Turkish manufacturing industry.\(^9\) If the competition index has a value greater than one, it means the city is more competitive than other cities regarding manufacturing industry (Glaeser et al., 1992).

Table 3 gives the estimation results for the main determinants of city growth regarding Turkey.

As can be seen from the table, fertility rate, location and net migration rate have a positive and significant effect as expected, while schooling rate has a negative and significant effect on city growth on average. The negative effect related to schooling rate may be indirectly explained by the relationship between education and fertility. As the education level increases, the fertility rate decreases (Miah & Rahman, 1993; Deliktas¸, 2001), so city growth rate decreases.\(^{10}\) Moreover, the coefficients of the agglomeration index related to the services sector and the specialization index in manufacturing industry are both positive and significant. Therefore, one may think that agglomeration in the services sector and specialization in manufacturing industry have positive effects on the growth of cities.
On the other hand, the estimated coefficients of variables, namely, per capita income, health indicators, crime rate, competition and agglomeration indexes in manufacturing industry are statistically insignificant. That means they do not have any impact on city population growth in Turkey.

### 5. Conclusion

This article has two main contributions. Firstly, we have estimated Pareto exponents of Zipf’s law using both the OLS and a relatively new technique, namely, rank-minus-half rule for different years for 81 cities in Turkey. Secondly, we have estimated the effects of determinants of city growth in Turkey by using the data set for the time period 1980–2007.

The results of the study showed some evidence that Zipf’s law holds in Turkey. However, after 1990, the coefficient has declined, indicating that the size distribution of cities has become less equal over time. According to the results based on the rank-minus-half rule, there is stronger evidence on the validity of Zipf’s law for Turkish cities. However, the size of cities became less equal after 1990.

According to the regression results, fertility rate, location of the city, migration, agglomeration index for the services sector and specialization index for manufacturing industry have a positive impact, while schooling has a negative effect on the average city population growth rate.

As the results show, metropolitan cities in Turkey grow faster relative to the other cities. The most important reason why some cities grow faster than the others is that these cities offer more economic advantages due to agglomeration, specialization and the factors mentioned before compared with the other cities.

Hence, we can say that the government can play a key role to solve the problems created by uneven city-size distribution. For instance, the government can develop better and coordinated planning and administration to solve the problems of the cities. Also, the govern-

| Table 3. The estimation results for the determinants of city growth in Turkey |
|---------------------------------|-----------------|------------------|
| **Method**: Least squares (cross-section) | **Dependent variable**: (NAH), n = 81 |
| **Explanatory variables** | **Coefficient** | **t-Statistic** |
| Constant | 0.01949 | 3.5918*** |
| FERT | 0.43940 | 4.5198*** |
| LOC | 0.00350 | 1.9317* |
| MIG | 0.00787 | 3.2738** |
| SPECI | 0.00678 | 2.0838** |
| SCHOOL | −0.02066 | −2.1367** |
| AGGLOMS | 0.03152 | 5.1492*** |
| $R^2$ | | 0.665 |
| $F$-statistic | | 24.507*** |

*10% significance level.
**5% significance level.
***1% significance level.
ment can devote more investment especially in the form of infrastructure services to the relatively less developed cities.

We need to mention that as a result of data limitation, we were restricted to explanatory variables for which the data were available. For example, it could be interesting to find out the effects of the cultural and sociological determinants of city growth in detail. However, the data for that type of research can be obtained by survey. In this respect, further research can be carried out to investigate the other city-specific determinants.

Acknowledgements

This paper is based on the project supported by TUBITAK. The project number is 106K 283.

Notes

1. City population indicates the population of municipal areas of the province and the district centres in Turkey (see TURKSTAT, 1980–2008). The population of the cities indicates urban population and, therefore, there are 81 provinces and 81 cities with regard to the data provided by TURKSTAT.
2. The share of the agricultural sector in GDP was around 40% in 1968, and it was around 9% in 2008, and the sectoral breakdown of labour force in the agricultural sector was around 55% in 1980, and it was around 33% in 2003 (see TURKSTAT, Turkey in Statistics, 1980–2008).
3. Nota and Song (2008) used both OLS and the rank-minus-half rule methods to estimate the Pareto exponent for the same sample, and they found that the estimated coefficients of cities by using the rank-minus-half rule are bigger than the estimated coefficients of cities by using the OLS method.
4. A test for nonlinearity is to include a quadratic term to equation (2) as in Black and Henderson (2003). We have also estimated the equation with the quadratic term and found some evidence on the significance of this term. However, Gabaix and Ioannides (2004) show that the estimated coefficient of this quadratic term will turn out to be statistically significant in situations where Zipf’s law perfectly holds. Therefore, the results are not presented here.
5. We have also used the Hill approach to estimate the Pareto exponent, but we have found that the Hill estimator is always smaller than the OLS estimator as in Soo (2007), indicating that the Hill estimator is unable to correct the downward bias of the OLS estimate. The results are available upon request.
6. Deliktas (2008) finds less evidence of supporting Zipf’s law using the standard OLS method. As Gabaix and Ioannides (2004) argue, the standard estimation of OLS may cause biased coefficients. Therefore, we have used more recent techniques as suggested by Gabaix and Ioannides and found stronger evidence for Zipf’s law.
7. The indices are calculated by authors in the study.
8. These indices are computed for the manufacturing industry and the service sector separately by using the same formula.
9. We could not calculate the competition index for the service sector due to lack of data for the firm level in Turkey.
10. We conducted multicollinearity diagnostic through calculation of the variance inflation factor (VIF). Although the results show that the relationship between the two variables are negative, the VIF number which is smaller than 3 does not sign a multicollinearity problem between the variables in the regression.

References

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