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## Article

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# The Zipf's law and the effects of free trade: The case of Guatemala

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## Abstract

The aim of this study is to investigate the impacts of trade policy changes on the order of the size of cities and economic growth of Guatemala between 1921 and 2002. The Pareto coefficient was estimated and an index was used to measure the degree of urban concentration. Finally, a model of the impact of trade liberalization on economic growth was estimated. The main results obtained showed a slight growth in inequality and divergence, although the urban concentration index showed a gradual decline since 1964 (the golden age of the CACM by the year 2002). It was found that the urban concentration has an inverse relationship with the commercial opening and positive economic growth during the period from 1921 to 1964. It was concluded that major cities reduced their growth and that small and medium-sized cities grew at a faster rate than big cities, driven by the growth of international trade. © 2014 National Association of Postgraduate Centers in Economics, ANPEC. Production and hosting by Elsevier B.V. All rights reserved.

*JEL classification:* F15; R11; R12

*Keywords:* Cities; Pareto distribution; Zipf's law

## Resumo

O objetivo desse estudo é investigar os impactos das mudanças na política comercial sobre a ordem no tamanho das cidades e crescimento econômico da Guatemala entre 1921 e 2002. Foi estimado o coeficiente de Pareto e utilizado um índice para medir o grau da concentração urbana. Por fim, estimou-se um modelo de impacto da abertura comercial sobre o crescimento econômico. Os principais resultados obtidos apontaram um leve crescimento na desigualdade e divergência, apesar de que o índice de concentração urbana mostrou uma queda gradual desde o ano de 1964 (época de ouro do MCAC) até o ano de 2002. Verificou-se que a concentração urbana tem uma relação inversa com a abertura comercial e positiva com o crescimento econômico do período 1921-1964. Conclui-se que as maiores cidades reduziram seu crescimento e as pequenas e medianas cidades cresceram a um ritmo mais acelerado do que os grandes centros, impulsionadas pelo crescimento do comércio internacional.

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*Palavras-chave:* Cidades; Distribuição de Pareto; Lei de Zipf

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## 1. Introduction

There is a particular importance in investigating the effects of free trade agreements on urban and regional growth, because the life-span of a free-trade agreement can affect the size of cities, favoring a drop in urban concentration and reverberating on the size of the less unequal population.

Guatemala participated in several free trade agreements, over the decades, which especially involved Central American countries, and also with countries in other regions. Such trade liberalization favored Guatemala by stimulating the economic growth of the country because, in recent years, there has been a significant change in the size of the population of the major cities of Guatemalan departments due to emigration, mainly toward the United States, and to the relocation of industries within the country.

According to the New Economic Geography (NGE), the size distribution of cities can be represented by a Pareto distribution, which derives from an empirical regularity called Zipf's law. This law explains how agglomeration forces interact in urban centers promoting economic activity and international trade in general.

In recent decades, surveys were published seeking explanations for an empirical verification of Zipf's law. Among the most important are the works of [Rosen and Resnick \(1980\)](#), written more than 20 years ago, which are based on demographic data of the 1970s. Recently, the work of [Soo \(2005\)](#) became prominent by making various econometric models with current data to explain how changes in urban centers in various parts of the world can be explained by Zipf's law. In this work, the author applies a "test" for Guatemala and it was found that it did not empirically corroborate with the Zipf's law. Other important empirical works are by [Monasterio \(2004\)](#) for the State of Rio Grande do Sul and [Oliveira \(2004\)](#) for all Brazil. For the case of the effects of a free trade treaty on economic growth are the studies of [Azevedo \(2004\)](#), who worked on the case of the Mercosul and, for the specific case of Guatemala, emphasized by the works of [Naranjo \(2003\)](#), [Rodriguez \(2005\)](#) and that of the [Banco de Guatemala \(2006a,b\)](#).<sup>1</sup>

Accordingly, the aim of this study is to investigate empirically how the life of a free-trade agreement can affect the size of cities (the population of urban areas) and how this influenced the overall economic growth of Guatemala between 1921 and 2004. The data is provided by the Census of the National Institute of Statistics (INE) and the Latin American Demographic Centre (CELADE). Specifically, this work focused on the economic and urban specificities and tries to find correlations between the rule of the order of the cities, free trade or trade liberalization, and the effects of agglomeration forces over the urban concentration and economic growth. Taking into account that for Guatemala there is no shortage of studies that address urban growth related to trade liberalization, thus it is relevant to such investigation since this study may serve to provide guidance on the formulation of public policies to promote the economic growth of this country.

This work is divided into six parts aside from this introduction (part one). The second part is a summary about the performance of the Guatemalan economy. The third part discusses the Guatemalan trade integration. The fourth part closes the theoretical review, urban economic geography models, free trade impact models on economic growth and the database. The fifth part exposes the empirical evidence and, finally, the last part is devoted to the final conclusions.

## 2. Guatemalan economy

During the fifties, Guatemala joined the model promoted by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC)<sup>2</sup> and the economic model in force in the country was known as an "import substitution" and aimed to improve the country's external position. This model was upheld during the process of Central American economic integration that began in the 1960s and later was known as the "Central American Common Market" (CACM).

In the late eighties, Guatemala began changing to a model based on a more open trade with the rest of the world and, at the beginning of the 1990s, it began a diversification process of its economy based on a trade policy that was geared to negotiate free trade agreements with other countries.<sup>3</sup> The exchange-rate policy has changed permanently:

<sup>1</sup> Among the studies about the new economic geography (NGE), [Fujita et al. \(2002\)](#), [Gabaix \(1999\)](#), [Henderson \(2000, 2003\)](#), [Ades and Glaeser \(1994\)](#), [Ottaviano and Marti \(2001\)](#), [Venables \(2003\)](#), [Meardon et al. \(2001\)](#), [Brakman et al. \(2005\)](#) are included.

<sup>2</sup> For more details, see [Estrelha \(2007\)](#).

<sup>3</sup> More in line with the 1986 "Uruguayan Round".

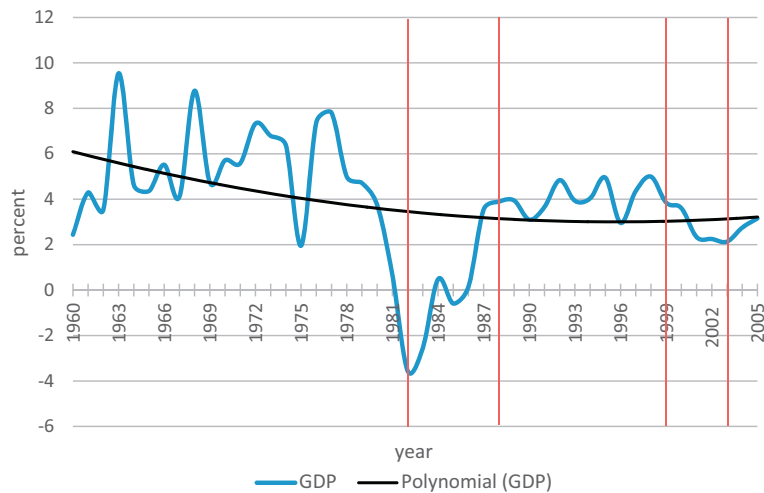


Fig. 1. Change of GDP 1960–2005–Guatemala.

Source: Bank of Guatemala-BANGUAT.

the exchange rate and the interest rate were no longer regulated by the Monetary Authority as they were until 1989. The prices of the basic basket of goods were released in 1986 and completed the process in 1991. Then, taxes were gradually eliminated on exports contained within the Central American System (SAC).<sup>4</sup> Fiscal deficits were financed by the Monetary Authority until the end of the 1980s and in 1994 a constitutional norm was issued which banned the Monetary Authority the right to finance the fiscal deficit.

In the external sector, there was a current account deficit of the payment balance, with a structural character and, the main sources of financing of the current account deficit, used by successive Governments until the eighties, were the International Monetary Reserves (RIN) and the External Public Debt, but these were changed in the 1990s, when the flow of private capital was the main source of funding and the reserves were increased considerably reaching record levels.

It is worth mentioning that the Guatemalan economy, compared with most of the countries of Latin America, did not experience very severe inflationary processes or hyperinflation, mainly in the 1980s. Two significant inflationary spikes can be highlighted in 1985 and 1986 that have been associated with the excess liquidity in the economy, caused by the high fiscal deficits described earlier and the expansive policies of unsustainable spending. However, the highest inflation was registered in December 1990 due to the expansive monetary policy and the inconsistent democratic Government of President Vinicio Cerezo Arévalo (1986–1990). From the nineties, the monetary policy generally restricted the monetarist line and, the obsession in the fiscal deficit reduction, allowed to achieve smaller inflation rates and mainly to reduce the volatility, but achieved GDP growth rates of 3.9% average from 1990 to 2006.

### 2.1. Economic performance during the period between 1960 and 2006

Guatemala's economic growth rate for the period 1960–2006 can be seen in Fig. 1, below. The growth rate of gross domestic product (GDP) shown in Fig. 1 allows the observing of five subperiods of development in Guatemalan economic activity: 1960–1980; 1981–1986; 1987–1998; 1999–2003 and 2004–2006.

In the mid-seventies, the first oil crisis, due to the increase in oil prices imposed by the Organization of Petroleum Producing Countries (OPPC), was experienced. This fact deteriorated the terms of Exchange, causing a big drop in the economic activity (about 2.0% in 1975). There was a second oil crisis in 1979 and a mass flight of private capital in 1980, which caused a sharp drop of private domestic investment (–12.3% in 1979 and –22.4% in 1980). During

<sup>4</sup> Official document where the nomenclature of all classified products, with all of the records of import tariffs, for the Central American countries.

this period, the balance of foreign debt grew by approximately \$ 2000 million and became known as the External Debt Crisis.

### 3. Regional opening: commercial trade integration policy

#### 3.1. Guatemala: Central American Common Market (CACM)

The duration of the Treaty for the creation of the Central American Common Market (CACM) began in June 4, 1961, initial date for Guatemala, El Salvador and Nicaragua. In April 27, 1962 it started for Honduras and on September 23, 1963 for Costa Rica.

The CACM has its origin in the General Treaty for Central American Economic Integration (1960) and the Central American countries undertook the establishment of a five-year common market, to adopt a uniform Central American import policy and to establish free trade for products originating in their respective territories, with some exceptions.

According to Rosenthal (2005), the most obvious results of this regional integration process were expressed in the growth of intra-regional trade which increased from 30 million dollars in 1960 to 136 million in 1965 and rose successively to 286 million in 1970, 536 million in 1975 and, finally, to more than 1100 million in 1980. However, due to the mix-up of economic and political agents that participated in this process, the goals and objectives were not fulfilled, such as the conformation of a common external tariff due to the fact that Honduras suspended its activities from the integration process. Also, it was not possible to undertake the creation of the “integration industries”<sup>5</sup> due to the influence of the opposing interests of foreign capital and, in particular, of multinational companies.

In addition, the crisis of the 1980s, known as the “Debt Crisis”, was more serious in Central America because of the civil war that not only diverted investment incentives, but also led to the decline of intra-regional trade, agreements and instruments adopted to strengthen integration.

In 1980 several initiatives were established between the Central American Presidents to reactivate the conformation of the CACM process, and signed the “Declaration of San Jose”, with the aim of coordinating the actions of the Ministers and Deputy Ministers for restructuring the CACM. In the year 1988, Honduras proposed to study the possibility of multilateralizing the bilateral agreements they already had with the Member countries of the Central American Common Market, which, in fact, meant to request their return to the CACM. In 1990, it was agreed with an Economic Action Plan for Central America (PAECA), whose objectives were: (a) the restructuring, strengthening and reactivating of regional economic integration, (b) evolution for an integrated production system at a regional level, (c) delineation of the external debt problem and, (d) a better distribution of social costs and of necessary adjustment of economies. The signing of this agreement by the Presidents of Central America has resulted in a series of efforts directed toward strengthening the Central American integration. In 1993, the Protocol of the General Treaty on Central American integration was approved, whose goal was to reach the Central American Economic Union.

From there on, the advancement in the liberalization of trade in the Central American market has been substantial, because practically all the products produced in the CACM have zero tax and more than 90% of the import record tariffs applied the same Common External Tax. When comparing the CACM with other regional integration processes, such as the MERCOSUR, the trading has been much more complicated due to conflicts between national interest and the Bloc’s standards (Azevedo, 2003).

#### 3.2. Bilateral preferential agreements

In recent years, the countries of Central America started making bilateral free trade negotiations with other countries, which are shown in Fig. A1, in the Appendix. Specifically in the case of Guatemala, several free trade agreements were signed (bilateral, in whole or partially) with Colombia (1980), Venezuela (1985), France (1988), Cuba (1999), Panama

<sup>5</sup> The “integration industries” are defined as all those composed of one or more manufacturing plants, which require having access to all the Central American market to work at least at their minimum capacity.

(1999), Chile (1999), Mexico (2000), and Taiwan (2005). Guatemala has also actively participated in various working groups of the Free Trade Area of the Americas (FTAA) and has also signed several agreements for the protection and promotion of investment, particularly with France, in 1998.

At the beginning of the year 1984, Guatemala also benefited from unilateral trade preferences granted by the United States, by the so-called “Caribbean Basin Initiative” (CBI). The United States granted a unilateral tax free treatment of selected products that followed the “strict rules of origin” and Guatemala took advantage of the trade preferences granted by the United States. Consequently, this explains a major proportion of export growth registered during the 1990s due to those standards.

The main effects of DR-CAFTA are the ability to diversify the export products basket of the country and thus achieve an expansion of trade levels; a profit derived from the “advantage of distance”,<sup>6</sup> an improvement of the investment climate, which allows a faster growth, and poverty reduction. The huge growth potential embedded in the DR-CAFTA is due to a combination of two complementary forces: the Treaty as a magnet for investment and as a catalyst for institutional change.

#### 4. Theoretical review

##### 4.1. *The New Economic Geography (NGE)*

The New Economic Geography (NGE) is a field of study within the regional economy itself, but it is also a descendant of the theory of international trade, with the models featured increasing incomes of mobility and transport costs.

According to [Brakman et al. \(2005\)](#), with the NGE, began a shift in thought about the regional policy, which perhaps should not continue focusing on the outskirts lagging behind, but to channel funds to the local settlements that have a realistic opportunity to hold on to the economic activity. Companies and workers are subject to centripetal and centrifugal market forces and the location of the decisions depends on the balance of those forces that, in turn, depend on the cost of trade. The agglomeration of equilibrium is characterized by a salary structure.

The advantages of agglomeration materialize in higher wages in major regions. On the other hand, the causality of the selection is that the balance is circular, that is to say: first, that companies and workers prefer the central core, as it has the largest market and is home to many companies and workers. Therefore, if the agglomeration of balances is the rule, regional disparities are difficult to contract with traditional regional policy. Second, [Brakman et al. \(2005\)](#) say, the explanation is that the peripheral regions lack natural resources and institutional conditions to keep within the economic activity, so the regional policy can succeed temporarily to attract economic activity to the periphery, but in the long run, end in the central core.

##### 4.2. *International trade and agglomeration*

[Venables \(2003\)](#) indicates that the spatial inequality in developing countries is due to the natural advantages of some regions in relation to others and to the presence of agglomeration forces, leading to the Group of activities. The presence of increasing returns to scale in the cities gives rise to urban structures that are not great in size. For [Ades and Glaeser \(1994\)](#), the factors that explain the concentration of an urban population of a nation in a single city are the high taxes, high costs of internal trade and the low levels of international trade that increase the degree of concentration.

According to [Ades and Glaeser \(1994\)](#), countries with high GDP percentages and low trade barriers and tariffs for imports (including an intensity of a constant level), rarely have their population concentrated in one city. Urban centralization also falls into the development of transport networks.

[Wheaton and Shishido \(1981\)](#) and [Rosen and Resnick \(1980\)](#) argue that the urban concentration is negatively related to the country's population. [Ades and Glaeser \(1994\)](#) are in complete agreement with [Krugman and Elizondo \(1996\)](#)

<sup>6</sup> “Remote” understood the capacity to respond quickly, such as fashion trends and delivery demands “Just in time”, besides the obvious geographical closeness to the United States.

hypothesis about the fact that the urban concentration is negatively related with international trade, because in the first place, commerce and cities are connected, although it may be that the urban concentrations are causing low levels of trade, contrary to the assumption that the low levels of trade lead to concentration.

For Brakman et al. (2005) the program logic of the single market rests mainly on the exploitation of comparative advantage, resulting in a change of economic activity among the Member States in such a way that the location of the production is in accordance with the location of the factors of production. According to these authors, companies want to be where the biggest markets are and, in turn, the large markets, where many companies are located, so there is a “circular causation” and free trade is crucial, where the intermediate levels of crowding tend to be stable.

#### 4.3. Urban and economic geography models and database

##### 4.3.1. Size distribution models of cities

When trying to perform an empirical description of an urban system you can check the rank size rule called “rule of countries”. In the case of many countries, cities can be small, with successive larger cities that gradually come to be so. The result can be a function of the distribution of urban areas that are classified or sorted according to the size of each individual urban area, and which will tend to be induced to the left.

According to McCann (2001) the extensive urban areas have crucial importance in the behavior and overall performance of the economy due to the presence of agglomerated economies. The result of this is that those urban and regional economies put a great emphasis on the behavior and performance of these larger urban groupings, which are relatively small in number.

Within the theories of urban growth in the economic literature, with an emphasis on regional economy, a way of explaining how these changes happen in city sizes is through “Zipf’s law”, which is used to refer to the idea that the size of cities follows a Pareto distribution.

George Kingsley Zipf (1902–1950)<sup>7</sup> improved the inspiring work of Auerbach (1913), which proposes that the distributions of sizes of cities are much wider depending on the original idea of Pareto, but always keeping the original idea that the same has an exponent equal to 1. The same became known as Zipf’s law, which is simply the product of the population of any city multiplied by its position in the ordering of a region of the geographical territory and product that shall be equal to the population of the largest city. Therefore, the second-largest city has half the population, and the third will have a third, and so on.

Monasterio (2004) explains that, according to Zipf, there is a diversification force in the way in which the cities are distributed due to the location of the population in the vicinity of areas supplying raw materials as a means of minimizing costs and, another force, is unification of space, which derives from the minimization of transport cost of goods of final products to the consumer markets. These two agglomeration forces would be opposed. Diversification or centrifugal forces lead to an increasing number of cities with declining population, while the unified messaging or centripetal force leads to a smaller number of cities with growing population. As a result of the tension of the two forces the hierarchical system of cities can be deduced.

According to Zipf’s considerations, this phenomenon makes it possible to have a linear relationship with regard to the relationship between the rank or the order of cities and its size. Thus, the size distribution of cities is determined by a Pareto distribution as follows (Oliveira, 2004):

$$y = Ax^\alpha \quad (1)$$

where the variable  $x$  indicates the population size of a given city; the variable  $y$  is the number of cities with a population greater than  $x$ ; the coefficient  $A$  is the value of a constant and the Pareto exponent is  $\alpha$ .

The original idea is born of a Pareto cumulative distribution, where the size of the population of a city is a random variable  $X$ , with one act  $x$ , such that the probability of discovering a city, less than  $x$  is given by a cumulative distribution function  $Prob(X \leq x) = F(x) = 1 - (A/x^\alpha)$ . Therefore, the probability of discovering a city with a population greater than  $x$  is given by:

$$Prob(X \leq x) = 1 - F(x) = \frac{A}{x^\alpha} \quad (2)$$

<sup>7</sup> See: Zipf (1949).



If  $y = 1 - F(x)$  and getting the logarithms of Eq. (2), the size of urban areas can be calculated by means of logarithmic transformation econometrically:

$$\log y = \log A - \alpha \log x \quad (3)$$

The model that will be estimated in this work is based on Eq. (3) and is prepared as follows:

$$\log y_{it} = \log A_{it} - \alpha \log x_{it} + \varepsilon_{it} \quad (4)$$

where,  $i = 1, \dots, n$  represents the cities;  $t = 1921, 1950, 1964, 1981, 1999, 2000, 2001, 2002, 2003$  and  $2004$  are the census dates and the periods in which the regression is estimated;  $x$  is the population of a specific city;  $y$  represents the number of cities with a population greater than the same  $x$ . The constants or estimated model parameters are  $A$  and  $\alpha$  and, finally,  $\varepsilon_{it}$  is the error normally distributed with zero mean and constant variance  $\sigma_\varepsilon^2$ .

According to Monasterio (2004), to check the Zipf's law, there is a requirement that  $\alpha$  is near  $-1$ . So, the crucial question about the empirical evidence of the size of the cities is: why, in any area, the number of large cities is low in relation to the number of small towns?

#### 4.3.2. Variation of the Pareto exponent

In accordance with Soo (2005), the Pareto exponent can be seen as a measure of inequality, the exponent to a higher value would have to understand how populations more equal in urban systems (in the limit  $\alpha = \infty$ , all cities have the same size). For Brakman et al. (2003), the Zipf's law holds if, and only if  $\alpha = 1$ , the largest city is  $k$  times larger (as the biggest city being  $k$ ).

The  $\alpha$  signal should always be negative, because the greater the population of an urban center the lower the probability or the chance to find a city with a larger population. Additionally, for the higher the  $\alpha$  value, there is a small inequality for distribution of cities, and when  $\alpha \rightarrow \infty$  all the cities in the region have the same size. In contrast, the smaller the  $\alpha$  value, there is great inequality in the distribution of the size of cities, and when  $\alpha \rightarrow 0$  there is a full migration to the larger urban centers. Finally,  $\alpha = 1$ , you can check the rule of the order of the cities rules, where the parameter  $A$  the means the population of the largest urban centers in the region or country of study.

To evaluate the possibility that there is a linear relationship between the order of cities, the following Rosen and Resnick (1980) model is proposed:

$$\log y_{it} = \log A_{it} + \alpha \log x_{it} + \beta(\log x)^2 + \varepsilon_{it} \quad (5)$$

This modified version must evaluate the parameter  $\beta$ , it means to evaluate the signal of the  $\partial \log y^2 / \partial \log x$ , so, if  $\beta > 0$ , the curve that relates the order and size of the cities has a convex shape. Then, there is a larger population in the larger urban centers and smaller towns are more numerous in the original proposal known as Zipf's law or the rule of the order of the cities size law. If  $\beta < 0$ , the interpretation would be that the order and size of the cities has a concave shape where the biggest urban centers or cities are less populous and the smaller towns are less numerous. To conclude, if  $\beta = 0$ , it turns out as Gibrat's law, in which the evolution in the growth of a city is independent of its size.

#### 4.3.3. Models of impact of free trade on economic growth

The model proposed by the Bank of Guatemala aims to estimate the effect on the country's economic growth rate, derived from the DR-CAFTA in 2006:

$$\Delta GDP_t = \alpha_1 + \alpha_2 \Delta GDP_{t-1} + \alpha_3 \Delta X_t + \alpha_4 \Delta M_t + \alpha_5 \Delta DFI_t + \varepsilon_t \quad (6)$$

where,  $\Delta GDP_t$  is the rate of change in real GDP in the year  $t$ ;  $\Delta GDP_{t-1}$  is the rate of change in real GDP in the year  $t-1$ ;  $\Delta X_t$  is the rate of change of the exports of goods in the year  $t$ ;  $\Delta M_t$  is the rate of change of the importation of goods in year  $t$ ;  $\Delta DFI_t$  is the rate of change in direct foreign investment in the year  $t$ ;  $\alpha_i$  are the parameters to estimate ( $i = 1, 2, \dots, 5$ )  $\varepsilon_t$  is the error term.



Table 1  
Guatemala-population distribution (2006).

Regions	Towns	More than 100 thousand inhabitants	More than 50 thousand inhabitants	More than 25 thousand inhabitants	More than 25 thousand inhabitants	Less than 5 thousand inhabitants	Number of intermediate cities
Republic	331	4	11	24	153	139	16
Metropolitan	17	3	5	3	5	1	0
North	24	0	1	0	14	9	1
Northeast	34	0	1	2	12	19	3
Southeast	38	0	0	3	17	18	2
Central	45	0	2	4	34	5	4
Southwest	109	1	1	9	46	52	4
Northwest	52	0	0	2	16	33	2
Peten	12	0	0	1	9	2	0

Source: Moran (2006, p. 4).

#### 4.3.4. Urban concentration

To measure the urban concentration the Herfindahl-Hirschman Index (HHI) is used, which is built from the sum of the square of every town in the country's urban population. This index is commonly used to measure the degree of concentration of markets in industrial economy and to estimate the degree of concentration of a variable is as follows:

$$HHI = \sum \left( \frac{P_j}{P_{tot}} \times 100 \right)^2 \quad (7)$$

where the population of a country is formed by  $j = 1, \dots, n$  towns and cities in particular ( $P_j$ ) and the total urban population of a country  $P_{tot}$ . If the index reaches a maximum value of 10,000, the value is completely concentrated in one city when the value tends to zero there is no concentration. So, when approaching zero, there is a greater weight in the medium and small localities.

#### 4.3.5. Database

Census data were obtained through the National Institute of Statistics (INE) of Guatemala, that belongs to the Direction of Censuses and Surveys in the records of the National Census of Population and Housing. The census data used corresponded to the urban populations of municipalities for the years 1921, 1950, 1964, 1973, 1981, 1994 and 2002.

The data of the censuses designed jointly by the INE and the Latin American Demographic Centre (CELADE) for the years 1999, 2000, 2001, 2003 and 2004 were also used. The data can be seen in [Table A1](#) in the Appendix.

## 5. Empirical results

### 5.1. Zipf model test

[Table 1](#) shows the distribution of the Guatemalan population. It is seen that in the metropolitan region there are 3 cities over 100 thousand inhabitants and the smallest towns are in the Southeast and Northwest of the country.

The following will be exposed to the results of Eqs. (4) and (5) estimated by means of the statistical method known as Ordinary Least Squares (MQO).<sup>8</sup> The regressions obtained are presented in [Table 2](#) and show that Zipf's law is not the case. For the coefficient  $\alpha = -1.11$  the hypothesis is rejected that  $\alpha = -1$ .

In the following 20 years, the distribution of city sizes is more egalitarian until 1950, but then begins to become more unequal. This result is contrary to [Gabaix \(1999\)](#) explanations, which proposes that the order of the cities rule remain stable over time.

<sup>8</sup> In order to check for heteroscedasticity in the models, the White Test was made with cross-terms that confirmed the rejection of the null hypothesis.

Table 2

Pareto exponents ( $\alpha$ ) between 1921 and 2004 to Eq. (4).

Years	A	$\alpha$	$R^2$ Adjusted	N
1921*	1.050687 (0.139212)	−0.848925 (0.020721)	0.827868	351
1950*	1.404643 (0.231459)	−1.119049 (0.027733)	0.840926	310
1964*	1.102154 (0.117685)	−0.875549 (0.016366)	0.898872	324
1973*	1.144644 (0.104314)	−0.878409 (0.013644)	0.927703	325
1981*	1.162292 (0.132446)	−0.882842 (0.016983)	0.892941	326
1994*	1.196084 (0.114309)	−0.881020 (0.013962)	0.924111	329
1999	1.201348 (0.110708)	−0.854452 (0.013025)	0.929185	330
2000	1.209998 (0.112669)	−0.865913 (0.013276)	0.928415	330
2001	1.210709 (0.112153)	−0.864362 (0.013179)	0.92915	330
2002*	1.211108 (0.111748)	−0.862437 (0.013095)	0.929695	330
2003	1.211588 (0.111266)	−0.860639 (0.013003)	0.930343	330
2004	1.211958 (0.110830)	−0.858734 (0.012917)	0.930916	330

Source: Prepared by the authors.

Note: Standard deviation in parenthesis.

\* Year of the official census of the National Institute of Statistics (INE) of the Republic of Guatemala.

For the Guatemalan economy, during the first half of the last century the economy was closed, and the economic activities were concentrated in the region of the Pacific coast or in cities located in the Central and Northwestern regions.

In accordance with the NGE, the increase in inequality is due to the centripetal forces acting and overriding the centrifugal force because as Table 2 shows, the Pareto coefficient is 0.85, therefore showing the supremacy of the central city.

Considering the extent of urban concentration through the Herfindahl-Hirschman Index (HHI) in Table A2 in the Appendix, it turns out that it has been increasing since 1921 by 4.76 reaching a level of 16.66 in 1964, although it has fallen after that until reaching 7.41 in the year 2002. Apparently, the effect of the Central American Common Market (CACM) in the sixties favored the centrifugal forces. Thus, it turns out that the facts that Krugman and Elizondo (1996) reveal, in which urban concentration is negatively associated with international trade,<sup>9</sup> is correct.

In Guatemala, there is no general railway network provision which allows an alternate means of transport, in spite of other ways than the carriage of goods by means of containers to customs and ports of entry. However, the creation of paved roads from 1935 linking several cities in the country and the capital of Guatemala caused a lower dependence on transport of goods by train.

The Pareto coefficient increased from −0.84 to −1.11 between 1935 and 1938, so the strength of diversification has grown significantly due to some roads built in the country. In 1959 the migration to Guatemala's capital increased, reflecting the decrease in the Pareto coefficient of until −0.87, suggesting that the concentration forces of this period overlapped. Finally, the passenger transport by railways increased greatly until 1988. This may be another explanation

<sup>9</sup> According to the HHI the urban populations in cities located in the eastern region of Huehuetenango and Quiché which are situated near the Mexican border and the DR-CAFTA, should increase, as well as the cities located in the central region: Escuintla, Chimaltenango and Santa Lucía Cotzumalguapa, finally in the Northwest, particularly, Chiquimula that has registered a strong commercial activity with El Salvador and Puerto Barrios next to Puerto Santo Tomás de Castilla.

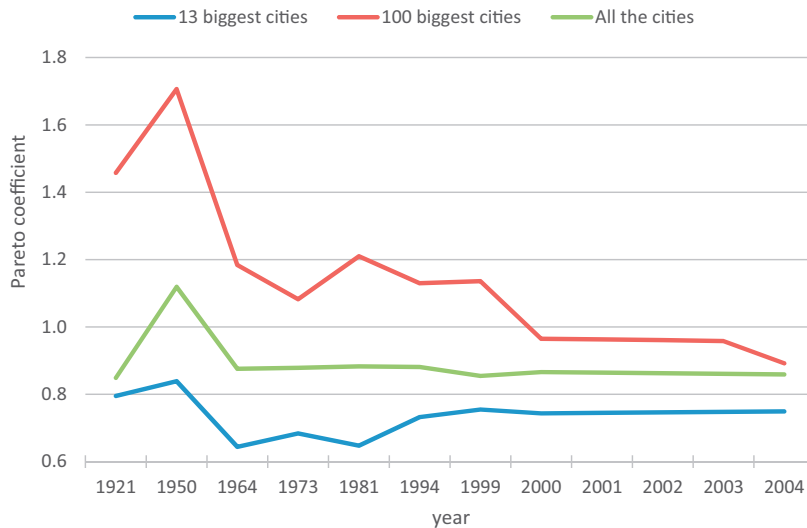


Fig. 2. Pareto coefficient in Guatemala (1921–2004).

Source: Prepared by the authors based on censuses at the National Institute of Statistics (INE) of Guatemala.

for the increasing urban concentration and inequality between the cities.<sup>10</sup> This urbanization trend significantly has not reverted up to the present, because the Pareto coefficient has not changed significantly.<sup>11</sup> Therefore, concluded that there is an inverse relationship between the importance and use of the railway stations to increase the Guatemalan highway network.

The results are also presented for three possible scenarios of Eq. (4) using only 13 major cities and the 100 largest (Table A3 in the Appendix). Comparing the Pareto coefficient of  $-0.7287$  found by Soo (2005) for the year 1994 for a sample of 13 cities with the result that his work was  $-0.7324$ , we can infer that the distribution of cities in Guatemala has changed a lot and become more egalitarian than what was estimated by Soo (2005).

For a sample of 100 cities, the coefficient goes to  $-1.1295$  and we can see that the values of the Pareto coefficient are larger when restricted to 100 major cities, showing that the inequality between cities is lowest among the largest urban centers. In Fig. 2,<sup>12</sup> below, it can be observed there is a decreasing function of the Pareto coefficient in the period 1950–2002 for 13 major cities. When you analyze the 13 largest cities, inequality increases because the Pareto coefficient is smaller. Thus, the larger cities are not reaching a maximum level yet.

Doing the exercise for the 13 and the 100 largest cities which make up the upper portion of the distribution of the order of the cities using the estimation of Eq. (5) (see Table A4 in the Appendix), the results indicate that it complies with the Gibrat's law. If all the cities are used, the results are ambiguous, as in many cases from 1973, Gibrat's law, which indicates that there is an independence between the growth and the size of a city, or in other words, the Zipf's law would be in its steady state.

## 5.2. Tests for the model of trade liberalization

The trade liberalization model was estimated from Eq. (6). It is necessary to highlight that the model was estimated based on annual data from the period between the years of 1960 and 2006. In this sense, Table 3 below, presents the results obtained by using the reference year.

To improve the effects DR-CAFTA in economic growth, we transformed Eq. (6) into:

$$\Delta GDP_t = \alpha_2 \Delta GDP_{t-1} + w_t \quad (8)$$

<sup>10</sup> International Guatemala Railroads company (IRCA).

<sup>11</sup> For more details, see Cifuentes (2006).

<sup>12</sup> We added the estimation for all cities in Fig. 2 for comparison.

Table 3  
Regression of model – final result.

Variable	Coefficients	T statistical	Probability
$\Delta GDP_{t-1}$	0.364221	3.61859	0.000900
$\Delta X_t$	0.085046	3.874551	0.000400
$\Delta M_t$	0.061964	3.279247	0.002300
$\Delta DFI_t$	0.001778	0.513167	0.611000
$R^2$	0.708222	F-statistical	21.84542
$R^2$ Adjusted	0.675803	Probability	0.000000

Source: Prepared by the authors from data of BANGUAT (2008).

where,  $w_t = \alpha_1 + \alpha_3 \Delta X_t + \alpha_4 \Delta M_t + \alpha_5 \Delta DFI_t + \varepsilon_t$ . For  $t + 1$ , Eq. (8) turns into:

$$\Delta GDP_{t+1} = \alpha_2 \Delta GDP_{t-1} + w_{t+1} = \alpha_2(\alpha_2 \Delta GDP_{t-1} + w_t) + w_{t+1}$$

$$\Delta GDP_{t+1} = \alpha_2^2 \Delta GDP_{t-1} + \alpha_2(w_t) + w_{t+1} \quad (9)$$

By Eq. (9) it is possible to estimate the effect on  $\Delta GDP_{t+1}$  to a commercial opening due to a change in  $w_t$ , assuming that  $w_{t+1}$  remains constant. This effect can be calculated as follows:

$$\frac{\partial \Delta GDP_{t+1}}{\partial w_t} = \alpha_2$$

It is also possible to calculate the effect of a unit increase in exports  $X_t$ , imports  $M_t$  and direct foreign investment  $DFI_t$ , respectively:

$$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta X_t} = \frac{\partial \Delta GDP_{t+1}}{\partial w_t} \cdot \frac{\partial w_t}{\partial \Delta X_t} = \alpha_2 \alpha_3$$

$$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta M_t} = \frac{\partial \Delta GDP_{t+1}}{\partial w_t} \cdot \frac{\partial w_t}{\partial \Delta M_t} = \alpha_2 \alpha_4$$

$$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta DFI_t} = \frac{\partial \Delta GDP_{t+1}}{\partial w_t} \cdot \frac{\partial w_t}{\partial \Delta DFI_t} = \alpha_2 \alpha_5$$

Thus, the effect on economic growth by a one percent increase in exports  $X_t$ , imports  $M_t$  and direct foreign investment  $DFI_t$  are in Table 4.

To verify economic growth for year of DR-CAFTA, some scenarios were developed considering the estimates for imports and exports made by the United States International Trade Commission (USITC) and the International Monetary Fund (IMF). For foreign direct investment (DFI), we used the estimates made by the Bank of Guatemala (BANGUAT). The reader can see estimates in Table 5.

Two scenarios were created to observe the economic growth per year of DR-CAFTA: the first considers the estimates for imports and exports made by the USITC, the second scenario considers IMF estimates. Estimates for the DFI are from BANGUAT. Additionally, the effects of an increase in imports, exports and foreign direct investment on GDP,

Table 4  
Effects on indicators.

Effects on the indicators	Calculation of the effects on the indicators
$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta X_t} = \alpha_2 \alpha_3$	$(0.364221 \times 0.085046) = 0.0309755$
$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta M_t} = \alpha_2 \alpha_4$	$(0.364221 \times 0.061964) = 0.0225686$
$\frac{\partial \Delta GDP_{t+1}}{\partial \Delta DFI_t} = \alpha_2 \alpha_5$	$(0.364221 \times 0.001778) = 0.0006476$

Source: Prepared by the authors from data of BANGUAT (2008).

Table 5  
Estimates for some indicators and scenarios.

Indicators	Estimates			Scenarios on GDP	
	USITC	IMF	BANGUAT	I	II
$X_t$	3.46%	7.78%		0.241820002	0.490959826
$M_t$	4.09%	9.20%			
$DFI_t$			65.34%		

Source: Prepared by the authors.

Table 6  
Pearson correlation coefficient ( $r$ ).

Number of census towns	The reason of trade intensity $e(X + M)/GDP: \alpha$	Terms of trade TIC: $\alpha$	Rate of change of the gross domestic product (GDP): $\alpha$	Rate of change of the (GDP) and trade liberalization $\alpha$	HHI: $\alpha$
13 cities	0.338566	−0.521529	0.444945	−0.491882	−0.293447
100 cities	0.830224	−0.539865	0.390141	0.338732	−0.225601
All cities	0.776483	−0.722287	0.502868	0.352037	−0.350211

Source: Prepared by the authors.

Note:  $\alpha$  is the Pareto coefficient.

made previously, are used in the scenarios (see Table 4). The results of the scenarios on GDP can be checked in Table 5.<sup>13</sup>

Comparing the results obtained with the BANGUAT (2006) calculations for the USITC, the estimated value in this work reaches half (0.24%) in comparison to the value of 0.48%. In the case of the IMF estimates, the estimated value in this work is less (0.49%) than 0.85%. The difference may be due to the sample period. In the case of the BANGUAT model, in the 1990–2004 period, where the Guatemalan economy experienced a greater intensity of trade, and in the case of this study, it was in the longer period 1960–2006 where it began a more open trade with the CACM.

### 5.3. Correlation tests

To determine the correlation between a commercial opening, as the life of a free-trade agreement, and the size of the correlation proof is: “the Pearson correlation coefficient”. To calculate the Pearson correlation coefficient, we used the following expression:  $r = \sigma_{XY} / \sigma_X \sigma_Y$ , where  $\sigma_{XY}$  is the  $X$  and  $Y$  covariance from the quantitative variables.

For the Guatemalan case, we used the Pareto coefficients for the 13 largest cities, 100 major cities and all cities, and the open trade index and terms of trade. The quantitative variables that were correlated are the Pareto coefficient ( $\alpha$ ) and the following indicators: (i) trade intensity ratio expressed as the sum of exports and imports divided between GDP:  $(X + M)/GDP$ ; (ii) terms of trade (TIC); (iii) General GDP growth rate; (iv) percentage effect on the rate of GDP economic growth with the duration of a commercial opening; and (v) HHI that is the measure of urban concentration.

Analyzing each one of Table 6 correlation coefficients, then it is seen that in the case of correlation between trade intensity ratio and the Pareto coefficient in all three cases the relationship is positive. Soon, increasing the ratio of trade intensity, the Pareto coefficient must be greater, and therefore the distribution inequality in the size of the cities must be less. In the case of the 100 largest cities, the level of correlation is high, 0.83.

<sup>13</sup> Note that the results on the GDP scenarios shown in Table 5 are based on Eq. (6), using the data from Table 4 and the estimators to indicators from Table 5.

Considering the correlation between TIC<sup>14</sup> and the Pareto chart, there is a negative sign. So, when TIC increases, the Pareto coefficient decreases in a certain proportion.

Therefore, an increase or an improvement in terms of exchange would lead to an increase of the population's capacity consumption, but also greater inequality in the urban centers, because centripetal forces would create a larger migration to urban centers, causing an increase in urban concentration and also a more extended local market to other manufacturing activities with the international market.

In the case of the correlation between GDP rate of change and the Pareto coefficient, the relationship is positive, whereas the three samples of cities and reaching 0.50 in the case of all cities is not. When changing the size of the sample, the correlation coefficient of the urban centers of large cities will tend to decrease their population due to the reduction of inequality.

On the other hand, when one considers the correlation coefficient HHI and the Pareto coefficient for all cities, the coefficient reaches  $-0.35$ , that is, there is a negative relationship when urban concentration increases and the cities will be more unequal, migrating to the cities with the largest urban centers.

## 6. Conclusions

The objective of this work was to investigate empirically the impact of a free trade treaty on Guatemala's economic growth and the size of the cities between 1921 and 2004.

The results obtained for the Pareto coefficient showed that there are no significant variations in the order of size of the cities between the censuses for the period 1921–2004, because in the year 1921 the coefficient was relatively low, increased by the year 1950, which leads to the conclusion that the rule applies.

Therefore, there was an important change in the size of cities, during this period of almost 30 years, since the inequality in the size of the cities was significantly reduced, in which the centrifugal agglomeration forces were dominant.

From the late sixties and in the middle of the Central American Common Market (CACM), the Pareto chart is reduced and centripetal agglomeration forces dominated and the cities were more likely to be more unequal. However, the results change when varying the size of the samples, that is, the Pareto coefficient relies heavily on the sample size.

With the intention of measuring the relocation of the population in the urban space by calculating Gibrat's law, the possibility might be considered that the growth of the cities is independent of their size, specifically in the period 1973–2004 and that the growth of the cities has a convergent behavior or diverse difference. There is a clear trend toward the concentration of the economic activity in the major urban centers or intermediate cities.

The urban concentration measurement by HHI exhibited a fall between 1921 and 1950, coinciding with the Pareto coefficient. Soon, the forces of agglomeration dominated centrifugally and favored an increase in the size of the less populous cities. Already in 1964 due to the full duration of the CACM and high rates of GDP growth, urban concentration increased significantly. In the following years, the value of the index fell gradually until 2004.

With respect to trade liberalization and size of the cities, it was found that the Pareto exponent is positively correlated with the ratio of trade intensity. For all cities, the value of the correlation coefficient was high, thus, increasing international trade, i.e. cities tend to be less unequal. Additionally, this result is supported by the HHI with positive value.

Finally, we found that the urban concentration had a negative relationship with international trade, since the urban concentration fell between 1964 and 2004 and trade increased intensity. With the full duration of the DR-CAFTA, it is possible to predict to what degree that urban concentration tends to increase the centrifugal forces, thus the increase of foreign trade and economic growth.

<sup>14</sup> As Larrain and Sachs (2002): "The terms of trade represent the price of a country's exports relative to the price of their imports, where is an index of export prices, the same applies to. By either an increase or an improvement in the terms of Exchange which means that rose in relation to which translates to the same physical amount of exports can import a greater quantity of goods. In addition to a transient elevation in aggregate savings and increased by stabilization in consumption."

## Appendix.

Fig. A1.

Type of agreement	Participants	Negotiation State	Subscription date	Ratified and Validity
FTA and protocols Central America and Dominican Republic	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and República Dominicana.	Completed	Normative part Completed April 16, 1998	Guatemala approved the FTA and its Protocol by Decree published in 26 May 18, 2000 and entered into force on 15 October 2001.
FTA: Central America and Chile	Chile, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua.	Completed	October 18, 1999	Ratified in January 1, 2000.
FTA: El Salvador, Guatemala, Honduras (CA-3) with Mexico	El Salvador, Guatemala, Honduras e México.	Completed	June 29, 2000	Ratified from March 15, 2001
FTA: Central America and Panama	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua e Panamá.	Completed	May 16, 2001	Ratified and in validity from January 1, 2002.
Partial reach agreement of Economic Complementation and Customs preferences for: El Salvador, Honduras-Andean Community.	El Salvador, Guatemala, Honduras, Bolivia, Colombia, Ecuador, Peru and Venezuela.	Completed	September 13, 1997	
FTA: between El Salvador, Honduras, Guatemala and Nicaragua Taiwan.	El Salvador, Honduras, Nicaragua Guatemala e Taiwan.	Completed	January 1, 2006	Ratified and in validity from January 1, 2006.
RD-CAFTA and Dominican Republic	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, República Dominicana and Estados Unidos.	Completed	January 1, 2006	Ratified and in validity from June 1, 2006.

Fig. A1. State of negotiations by treated bilateral free trade and the others commercial approximations between Guatemala and/or the rest of the world.

Source: Secretariat of Central American Integration (SIECA), 2007.

## Tables A1–A4.

Table A1  
Guatemala-descriptive statistics.

Variable	Years	N	Minimum value	Maximum value	Average	Standard deviation	Coefficient of variation	Average deviation
Population of cities	1921*	351	17	112,086	1541.2222	6122.9393	3.9728	1376.6445
	1950*	310	244	284,276	6173.9194	16,415.4555	2.6588	4224.8969
	1964*	324	88	454,433	3473.6019	25,324.2492	7.2905	3913.9982
	1973*	325	153	700,504	5778.9538	39,484.9807	6.8325	6781.1442
	1981*	326	114	754,243	6076.4509	41,923.3006	6.8993	6619.9092
	1994*	329	324	823,301	8825.2036	47,391.2019	5.3700	9579.9855
	1999	330	476	1,006,953	12,088.6779	58,957.9982	4.8771	13,104.0589
	2000	330	498	1,015,303	11,970.7086	59,624.4494	4.9809	12,997.7102
	2001	330	516	1,022,000	12,254.8822	60,268.9918	4.9180	13,310.0471
	2002*	330	533	1,027,141	12,546.5075	60,860.3391	4.8508	13,625.7140
	2003	330	552	1,030,548	12,841.1510	61,393.9076	4.7810	13,946.3904
	2004	330	571	1,030,962	13,139.0809	61,823.2614	4.7053	14,268.7687

Source: Prepared by the authors.

\* Year of the official census of the National Institute of Statistics (INE) of the Republic of Guatemala.



Table A2  
Number of countries: urban concentration (HHI).

Country	Census	Herfindahl-Hirschman Index (HHI)
Costa Rica	1984	2.468611
	2000	5.562983
	2006	5.580318
El Salvador	1992	7.141112
	2007	3.812698
Estados Unidos	1980	2.596704
	1990	2.324380
	2000	1.893696
Guatemala	2007	1.817705
	1921	4.768669
	1950	2.595683
	1964	16.662702
	1973	14.627715
	1981	14.863320
	1994	9.042273
	1999	7.489174
	2000	7.798124
	2001	7.610005
	2002	7.411744
	2003	7.208777
Honduras	2004	6.991733
	1974	19.420835
	1998	18.430050
Nicaragua	2001	16.696744
	1971	25.659417
	1995	18.545451
Mexico	2005	15.275473
	1990	6.938736
	1995	5.610312
	2000	5.259623
	2006	4.828907

Source: Developed by authors.

Table A3  
Guatemala-results of Eq. (4) to the largest cities.

Cities	Years	A	$\alpha$	$R^2$ Adjusted	N
Population of the 13 largest cities in Guatemala	1921*	8.877387 (0.844798)	−0.795089 (0.093610)	0.867695	13
	1950*	1.021330 (1.724627)	−0.838772 (0.170176)	0.688329	13
	1964*	7.995465 (0.884990)	−0.643998 (0.090522)	0.821466	13
	1973*	8.872373 (0.672599)	−0.683684 (0.064116)	0.911791	13
	1981*	8.396302 (1.049984)	−0.647450 (0.101565)	0.786977	13
	1994*	9.761984 (0.607744)	−0.732482 (0.055239)	0.941124	13
	1999	1.027127 (0.604204)	−0.754857 (0.053241)	0.948118	13
	2000	1.014134 (0.551838)	−0.743233 (0.048611)	0.955059	13
	2001	1.018107	−0.744760	0.956253	13

Table A3 (Continued)

Cities	Years	A	$\alpha$	$R^2$ Adjusted	N
Population of 100 largest cities in Guatemala	2002*	(0.546670)	(0.048029)	0.957161	13
		1.021848	−0.746101		
	2003	(0.957161)	(0.047591)	0.958889	13
		1.025870	−0.747705		
	2004	(0.534049)	(0.046680)	0.960205	13
		1.029642	−0.749102		
	1921*	(0.527381)	(0.045981)	0.916968	100
		1.507774	−1.457578		
	1950*	(0.348790)	(0.044306)	0.883961	100
		1.926633	−1.706372		
	1964*	(0.572889)	(0.062452)	0.920155	100
		1.348906	−1.184066		
	1973*	(0.294333)	(0.035234)	0.957989	100
		1.314757	−1.082291		
	1981*	(0.202084)	(0.022895)	0.914056	100
		1.443094	−1.209977		
	1994*	(0.335444)	(0.037479)	0.957005	100
		1.418513	−1.129596		
	1999	(0.226666)	(0.024186)	0.965786	100
		1.466746	−1.135697		
	2000	(0.210422)	(0.021593)	0.757598	100
		1.294775	−0.964665		
	2001	(0.533967)	(0.055120)	0.757722	100
		1.295517	−0.962783		
	2002*	(0.534209)	(0.054994)	0.756788	100
		1.296094	−0.960665		
	2003	(0.535895)	(0.055013)	0.755739	100
		1.296042	−0.957980		
	2004	(0.537389)	(0.055015)	0.703082	100
		1.231168	−0.892046		
		(0.571688)	(0.058558)		

Source: Developed by authors.

\* Year of the official census of the National Institute of Statistics (INE) of the Republic of Guatemala.

Table A4  
Guatemala-results of Eq. (5).

Cities	Years	A	$\alpha$	$\beta$	$R^2$ Adjusted	N
Population of the 13 largest cities in Guatemala	1921*	37.94216	−6.751540	0.300138	0.978494	13
		(4.065064)	(0.830803)	(0.041816)		
	1950*	120.9439	−20.95627	0.901819	0.965887	13
		(1.229036)	(2.231042)	(0.099977)		
	1964*	38.71868	−6.365624	0.260514	0.988400	13
		(2.572040)	(0.477577)	(0.021717)		
	1973*	31.61958	−4.724226	0.176613	0.989613	13
		(2.639080)	(0.467369)	(0.020404)		
	1981*	48.21069	−7.673939	0.303905	0.957531	13
		(6.301895)	(1.109795)	(0.047956)		
	1994*	27.44219	−3.777804	0.129646	0.970539	13
		(5.613616)	(0.964662)	(0.041031)		
	1999	26.46692	−3.476205	0.113205	0.966528	13
		(6.924563)	(1.161251)	(0.048271)		
	2000	23.60810	−3.009584	0.094417	0.968650	13
		(6.485694)	(1.089289)	(0.045346)		
	2001	22.94606	−2.889809	0.089247	0.968072	13
		(6.652904)	(1.115760)	(0.046388)		
	2002*	22.22452	−2.760749	0.083717	0.967259	13

Table A4 (Continued)

Cities	Years	A	$\alpha$	$\beta$	R <sup>2</sup> Adjusted	N
Population of the 100 largest cities in Guatemala	2003	(6.854836)	(1.148052)	(0.047672)	0.967576	13
		21.60388	−2.648882	0.078909		
	2004	(6.949200)	(1.162343)	(0.048210)	0.967488	13
		20.90448	−2.524511	0.073609		
	1921*	(7.105194)	(1.187007)	(0.049181)	0.980655	100
		32.89423	−5.593167	0.236284		
	1950*	(1.011257)	(0.232421)	(0.013222)	0.968134	100
		52.93112	−8.512012	0.340695		
	1964*	(2.124666)	(0.426437)	(0.021284)	0.984471	100
		26.82237	−4.071818	0.153232		
	1973*	(0.677903)	(0.144921)	(0.007645)	0.994127	100
		23.81157	−3.292161	0.112364		
	1981*	(0.443032)	(0.090858)	(0.004599)	0.97888	100
		30.13977	−4.405178	0.159709		
	1994*	(0.925620)	(0.186117)	(0.009256)	0.992876	100
		28.20426	−3.883324	0.133144		
	1999	(0.641111)	(0.124999)	(0.006025)	0.991098	100
		27.64016	−3.606574	0.116094		
	2000	(0.788554)	(0.149193)	(0.006991)	0.993078	100
		29.21781	−3.921532	0.131132		
	2001	(0.696608)	(0.131763)	(0.006166)	0.993223	100
		29.18236	−3.904054	0.130107		
	2002*	(0.695448)	(0.131267)	(0.006130)	0.993167	100
		29.20808	−3.897172	−3.897172		
	2003	(0.705737)	(0.132914)	(0.006194)	0.993316	100
		29.15831	−3.876994	0.12839		
	2004	(0.704580)	(0.132422)	(0.006158)	0.993282	100
		29.06109	−3.848569	0.126894		
Population of all cities in Guatemala	1921*	(0.712821)	(0.133705)	(0.006206)	0.936734	351
		4.746776	0.953452	−0.137106		
	1950*	(0.407563)	(0.116553)	(0.008279)	0.936734	310
		0.740534	2.060582	−0.18824		
	1964*	(0.967791)	(0.228215)	(0.013449)	0.90289	324
		7.204587	0.176429	−0.07828		
	1973*	(0.360978)	(0.098050)	(0.006417)	0.950874	325
		7.309062	0.166925	−0.064627		
	1981*	(0.346595)	(0.085568)	(0.005244)	0.929269	326
		6.185634	0.486103	−0.084586		
	1994*	(0.435701)	(0.107180)	(0.006567)	0.954143	329
		6.241948	0.475524	−0.078993		
	1999	(0.401386)	(0.093475)	(0.005406)	0.963998	330
		5.375186	0.666002	−0.08552		
	2000	(0.381593)	(0.086009)	(0.004809)	0.959575	330
		5.840287	0.56704	−0.080575		
	2001	(0.403297)	(0.090809)	(0.005075)	0.960379	330
		5.801971	0.574931	−0.080705		
	2002*	(0.401615)	(0.090192)	(0.005027)	0.961124	330
		5.749898	0.585691	−0.08098		
	2003	(0.399997)	(0.089599)	(0.004981)	0.961963	330
		5.698872	0.596224	−0.081248		
	2004	(0.397827)	(0.088886)	(0.004928)	0.962767	330
		5.643700	0.607559	−0.081555		
		(0.395668)	(0.088181)	(0.004876)		

Source: Developed by authors.

\* Year of the official census of the National Institute of Statistics (INE) of the Republic of Guatemala.

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