Zipf's and Gibrat's laws for migrations

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Abstract: This paper analyses the evolution of the size distribution of the stock of emigrants in the period 1960-2000. Has the distribution of the stock of emigrants changed or has there been some convergence? This is the question discussed in this work. In particular, we are interested in testing the fulfillment of two empirical regularities studied in urban economics: Zipf's law, which postulates that the product between the rank and size of a population is constant; and Gibrat's law, witch states that growth rate of a variable is independent of its initial size. We use parametric and non-parametric methods and apply them to absolute (stock of emigrants) and relative (migration density, defined as the quotient between the stock of emigrants of a country and its total population) measurements.

Keywords: Migration distribution, Zipf´s law, Gibrat´s law.

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1. Introduction

In the study of the economic landscape the influence of location of the productive factors on economic activity is an important element. Some of these factors cannot be moved from one geographical space to another (natural resources, amenities, etc.) but others, such as physical capital, human capital or technology, can. Therefore, the analysis of the distribution of the population in space is an extremely interesting question. From the point of view of urban economics, the attention given to the study of city size is particularly notable and it is focused on the analysis of the concentration of the labor factor in certain areas.

Two laws have been widely considered: Zipf's and Gibrat's. The first refers to the size distribution of cities and the second to population growth (see Eeckhout [2004] for a good description of both phenomena, although we show the content of both laws below). Recently Rose [2006] analyzed whether other phenomena associated with the size of population, such as the number of inhabitants of countries, also follow a characteristic distribution, and conclude that the size distributions of cities and of countries are similar. Rose's paper suggests that both laws are associated with different stocks of inhabitants. In this context, in our work, we analyze the distribution of the number of immigrants by countries from the perspective both of stock and of the percentage of this stock over the total population of the country, the migration density.

The recent evolution of migratory flows has led to a considerable growth in the stock of immigrants in some cities and countries. Therefore, given that the total population is the sum of natives and immigrants, it is useful to analyze whether Zipf's and Gibrat's laws hold for both groups. In fact, because the native population grows due to natural causes, it is the evolution of the immigrant population which determines the final size of cities or countries. We can represent the growth of the stock of immigrants in country i by the following function:

$$\frac{M_{it}}{M_{it-1}} = f\left(a_+\left(M_{it-1}\right), b_-\left(M_{it-1}\right)\right),$$

where $a_+\left(M_{it-1}\right)$ and $b_-\left(M_{it-1}\right)$ represent, respectively, the positive and negative external effects of the stock of immigrants on growth rate. The positive external effects are associated with the so-called scale effect and the social network effect, while the negative external effect is related to the negative influence that the stock of immigrants has on migratory flows according to traditional theoretical models, for instance through wages. Therefore, the net sign of the combined effect would be a priori undetermined.

In this context, the determinants of migration are of key importance. The traditional model of Harris and Todaro [1970] predicts that migrations will disappear due to the mobility of the factors leading to convergence in expected wages between countries. However, empirical studies do not support this conclusion, as shown by Ghatak and Wheatley [1996]. Authors such as Carrington et al. [1996] indicate the importance of the presence of social networks, that is, the existence of a stock of immigrants in the host country prior to the individuals' decisions to emigrate. The stock of immigrants reduces the cost of emigration, increasing the rate of migration. Additionally, authors such as Larramona and Sanso [2006] show that the differences that exist between countries do not always disappear in the long term, so the convergence achieved is limited or conditional because it does not necessarily imply the equalization of per capita income, the capital/labor ratio and of wages. Thus, the final result of the size distribution of the immigrant population is an open question which may be important in order to explain the size countries.

Another useful perspective for this type of analysis is that adopted by Alesina et al. [2000] and Spolaore and Wacziarg [2005]. These authors find empirical evidence in favor of the so-called scale effect, that is, that countries with larger populations or GDPs have a larger potential market and their income present greater growth rates. In this context, the migratory stock contributes to increasing the market potential and would have positive effects on the productivity of the country, partly canceling out the tendency to the equalization of wages predicted by the traditional models. This perspective introduces interesting elements related to the effects at the aggregate level of immigration from the point of view of developed economies which present lower birth rates, because of immigration increases the market potential.

Thus, it is interesting to study if there are variations in the distribution of the stock of immigrant population. This is because the mobility of the labor factor is usually associated with differences in socioeconomic characteristics such as wages and the previous stock of immigrants. From this point of view, the flows of the labor factor tend to equalize the labor conditions of the different countries, so there would be some decrease in the stocks of immigrants and a tendency to a lower migration density.

Furthermore, migration is a phenomenon closely related to the job market, because it increases the labor supply in the host country. However, labor mobility has more restrictions than capital mobility. Until the mid 20th century, most of these restrictions were imposed by the transport technology. Since then, the reduction of these costs has been enormous. This decrease has recently been counterbalanced in many countries with the rise of protectionist legislation directed at foreigners. So, the cost is decreasing but the legislation has an influence in the opposite direction, and the question is: has the distribution of the size of the stock of immigrants become more uneven or has there been some convergence? This is the topic discussed in this work.

To answer it, the article is structured as follows. In Section 2 there is a descriptive analysis. In Section 3, the results relative to Zipf's and of Gibrat's laws are presented. Finally, the last section concludes.

2. – Data and descriptive analysis.

The data correspond to the total stock of emigrants by country and the source is the Department of Economic and Social Affairs of the Population Division of the United Nations. The Population Division maintains a data bank on international migration statistics covering most countries of the world. The data bank includes information from censuses on the number of foreign-born individuals or, in some cases, the foreign population living in a country. These data provide the basis for estimating the number of international migrants in the world at different points in time.

The sample is formed by the 214 United Nations member countries[1]. The period considered is from 1960 to 2000, presenting information by decades. The data on the total population of the countries was taken from the same source.

A first analysis consists of describing the evolution of the stocks of immigrants and of the migration density. Panel a of Table 1 shows the total stock by geographical areas and panel b its growth in the period 1960-2000. The most relevant point is the rise in the number of emigrants, which increased by 130.48% during these 40 years. There was a particularly marked increase in North America and Oceania, while Europe is slightly above the mean. In Latin America and the Caribbean the stock has decreased. Thus, the evolution of foreign population by country is not homogeneous.

[1] Including the former USSR as a single country (the disintegration of the USSR in 1991 produces a transformation of internal migrants into international migrants generating data discontinuity).

If we look at the density of immigration, panel c of Table 1, we see that this impression is corroborated. The variable grows in North America, in Oceania and, to a lesser extent, in Europe, while it decreases in Africa and Asia. So, we can conclude that there is a change in the behavior of international migration.

Returning to the growth rates of the stocks of immigrants, (panel b of Table 1), we can also point out that the rate never reaches the maximum observed in each area in the last decade (1990-2000), so it appears that total immigration has not increased notably. A clear example is Europe, where the rate grows faster in the decade 1960-1970 than in 1990-2000. This fact, together with the increased migration density, which rose 3%, indicates that the birth rate of European countries is responsible for this situation.

Having determined the evolution of the stock worldwide, we may wonder whether its distribution has varied if we consider the countries individually. This is a relevant question because the countries which present a greater foreign population may not be the same in different sample periods. If the distribution of size of stock of immigrants has not remained stable, there will be countries rising in the ranking while others fall. We use the non-parametric approach proposed by Quah [1996] and Ioannides and Overman [2001] and Figure 1 shows the evolution of the ranking.

On the axis of abscissas, the 214 countries are ordered from smaller to larger according to the ranking of 1960, while the axis of ordinates shows $\ln\left(E_{i2000} \middle/ \sum_i E_{i2000} \right)$, where E_i is the stock of immigrants in country i in the year 2000. The peaks and troughs show the countries which rise or fall in the ranking in the period being considered, while the changes in the slope inform us of variations in the inequality of distribution. We see that the countries which experience the greatest variations in the ranking are some African countries (Morocco, Equatorial Guinea or Burkina Faso) and some Arab countries (Saudi Arabia or United Arab Emirates), while the most developed countries do not present relatively high variations.

Additionally, the slope tends to be constant, so we can conclude that there have not been significant changes in the unevenness of the distribution. To corroborate this impression, Table 2 presents Spearman's rank correlation coefficients for the data corresponding to each possible pair of decades an for the total sample for the stock of immigrants and migration density, both for the total sample and for the 50 countries with the highest population at the beginning and the end of the period analyzed.

The Spearman coefficient of the stock of immigrants and migration density is clearly positive in the three sub-samples considered, so we can conclude that the ranking of countries according to criteria of migration has not varied significantly. If we order by rates of variation of stock or growth, although the coefficient continues to be positive if all the countries are considered, its value clearly decreases, so we can affirm that these are more noticeable changes. Furthermore, if the sub-sample selected corresponds to the countries with higher growth in 2000, a negative coefficient appears, which would support a certain degree of convergence between these countries. Thus, in conclusion, we can affirm that, although there have been changes in the order of the countries regarding the growth of stocks, these changes have not been enough to change, the order of the total volume of immigrants in the second half of the 20th century.

Regarding the immigration density, in Figure 2, the order of 1960 is compared with that of 2000, presenting a profile with greater variability than that of the absolute stock, although the countries with greater variations coincide. In this case, a slight change in the slope appears, which indicates increasing inequality.

3. Data and estimation: Zipf's law and Gibrat's law

The aim of this work is to analyze the structure of the size distribution of the immigrant population. In this section, we present an analysis of two laws traditionally associated with the populations of cities and, recently, with the size of nations. These two laws can be studied from the point of view both of volume and of migration density.

3.1.- Zipf's law

In this section, we examine the size distribution of stock and of migration density in order to see if there has been convergence or divergence between the different countries of the world. To do this, we use Pareto's distribution [1896], also known as power law. If E denotes the stock of emigrants and R the rank, a power law links both as follows:

$$R(E) = aE^{-b}, \qquad (1)$$

where a and b are parameters. This expression has been used extensively in urban economics to study the size distribution of cities (see, for example, Eeckhout [2004] and Ioannides and Overman [2003]). It has also been used recently to study the size distribution of countries (Rose [2006]), and a theoretical justification as to why the population of cities follows this distribution can be found in Eeckhout [2004] and Duranton [2006].

A particular case which is widely known as Zipf's law [1949], which appears when $b = 1$ and which means that, ordered from larger to smaller, the stock of emigrants of the second country is half that of the first, the stock of the third is a third of that of the first and so on, successively (the product between rank and size of stock is constant). Another empirical regularity related to Zipf's law and Pareto's distribution is Gibrat's law [1931], which postulates that the growth of the variable is a random variable independent of its initial size. However, both Eeckhout [2004] and Duranton [2006] demonstrate that there is a possibility that only the upper tail adapts to this distribution and that, when the total sample is considered, the distribution which fits best is the lognormal. In this work, we contrast these results for the stock of emigrants. It is also interesting to test whether Pareto's parameter is more or less than the unity, and the evolution of this coefficient in time, that is, for the different cross-sections available. Effectively, the greater (smaller) the coefficient, the more (less) homogeneous the stocks of immigrants by countries. Also, a growing (decreasing) evolution would mean a process of convergence (divergence) in the immigrant stock.

More specifically, the expression (1) of Pareto's distribution is usually estimated in its doubly logarithmic version:

$$\ln R = \ln a - b \cdot \ln E \,. \qquad (2)$$

Different sample sizes have been used, considering the 50, 100 or 150 countries with the biggest stock of immigrants, and the estimation has also been made with the total countries[2]. Table 3 presents the results of the OLS[3] estimation (the values of the corrected standard error are shown in brackets[4]).

The estimation of the parameter is significantly different to one except when we consider only the 50 largest stocks of immigrants. It is very close to one in the upper tail

[2] We also consider the possibility of differentiating immigrants by sex. The estimations made show that differentiated behaviours do not exist.

[3] Gabaix and Ioannides [2004] show that the Hill (maximum likelihood estimator) is more efficient if the underlying stochastic process is really a Pareto distribution. As we show below, this is not the distribution that the data follow, and so we use the OLS estimator.

[4] The residues resulting from this regression usually present problems of heteroskedasticity so, to analyze the significance of the parameters, the typical corrected deviation proposed by Gabaix and Ioannides [2004] is used: $\mathrm{GI\,s.e.} = \hat{b} \cdot (2/N)^{1/2}$, where N is the sample size.

of the distribution, obtaining a good adjustment level (R^2 oscillates between 0.97 and 0.98), while, as the size of the sample increases, the estimated value of b and the degree of adjustment evidently decrease. We also observe that the value of the coefficient increases over time, so some convergence can be detected with a Pareto distribution, especially when we consider the 100 countries with the biggest stock of immigrants.

The presence of a decreasing Zipf coefficient with the sample size, as shown in Eeckhout [2004], may be because distribution is lognormal, and so, on selecting the countries with higher stock only the upper tail is being considered, which is a good approximation to a Pareto distribution.

In order to test whether the distribution is lognormal throughout the sample, in Figure 3, we present the adaptive kernels which represent the estimated distribution (the scale is the same in all the figures in order to make comparisons easier, the axis of ordinates represents the estimated density or probability and the axis of abscissas the logarithm of the stock of immigrants). We observe an approximation to lognormal distribution in Figure 4. Additionally, the Kolgomorov-Smirnov normality test, Table 4, shows that this hypothesis is never rejected, providing evidence against Zipf's law.

Finally, we analyze the distribution of migration density. If we consider the earlier results referring to the stock of immigrants, as well as those obtained by Rose [2006] for the total population, it is to be expected that the difference between the logarithms of the two variables follows a lognormal distribution. The results of the estimation of the Pareto exponent are shown in Table 5.

Again, if we take the whole sample, the distribution is uneven, although not as much as in the case of the stock of immigrants. We reject Zipf's law, and the estimated parameter tends to decrease, which means that inequality has increased. The graphic representation of the adaptive kernel of migration density, Figure 4, also shows an evolution towards a lognormal distribution, starting from a very leptokurtic distribution in 1960 (again the scale is the same in all the figures in order to permit comparisons). The centre of distribution has lost importance compared to the tails, which indicates that growth was not convergent.

However, the Kolgomorov-Smirnov test, Table 6, shows that the hypothesis of normality is not rejected, providing evidence against Zipf's law when considering all the countries of the sample.

Therefore, we can conclude that both the stock of immigrants and migration density follow similar distributions to those found in Eeckhout [2004] and Rose [2006] for the size of US cities and of countries, respectively, confirming the presence of an empirical stylized fact when the spatial distribution of the population is considered. Moreover, given the value of the estimated coefficient of the Pareto distribution and that Spearman's coefficient is high, we can affirm that no sign of convergence appears in the stock of immigrants and in migration density. This may be considered as evidence in favor of the theoretical models which find long term migration rates different to zero, recognizing the presence of factors such as technology or social costs, which compensate the effects of traditional factors such as income or wages. However, the question of convergence must be analyzed in the framework of Gibrat's law, which we do in next section.

3.2.- Gibrat's law

The above section has shown that there is a certain stability in the distribution of the immigrant population size and in migration density, although a certain tendency towards divergence was observed in the latter. However, for a more rigorous dynamic analysis we have to use growth rates. In particular, we were interested in verifying whether Gibrat's law holds or not, meaning that the growth of a population variable does not depend on the initial situation[5]. In parametric terms, this relationship between growth and size is usually estimated as:

$$\frac{Y_{t+1}}{Y_t} = K + a \cdot Y_t , \qquad (3)$$

where Y_t is the corresponding variable (in our case, stock of immigrants or migration density) and K is a constant. If the parameter a is not significant, we can conclude that the growth is independent of the initial level of the variable.

Table 7 shows the results of the OLS estimation of (3) for all possible combinations of sample periods considered, both for the overall sample and for the 100 countries with the greatest stock of immigrants or migration density. The first conclusion is that all the coefficients are negative, which would imply an inverse relationship between size and growth. Thus, countries with larger initial stocks present less growth, producing

[5] Gibrat [1931] observed that the distribution of size (measured by sales or the number of employees) of firms tends to be lognormal, and his explanation was that the growth process of companies can be multiplicative and independent of the size of the company.

convergence. But the second conclusion is that all the estimated coefficients are non-significant, meaning that the null hypothesis can not be rejected and Gibrat's law is accepted.

Quah [1993] indicates that this type of parametrical analysis so habitually used to study economic growth is too simple, because the problems of regressions towards the mean, and proposes the use of non-parametrical methods, precisely, transition matrices. We will use the methodology followed by Eeckhout [2004] and Ioannides and Overman [2003]. It consists of taking the following specification:

$$g_i = m(S_i) + \varepsilon_i\,, \qquad (4)$$

where g_i is the normalized growth rate (subtracting the mean and dividing by the standard deviation) and S_i is the logarithm of the stock of immigrants, and instead of making suppositions about the functional relationship of m and supposing a linear relationship, as in equation (3), $\hat{m}(s)$ is estimated as a local average around point s and is smoothed using a kernel, which is a symmetrical, weighted and continuous function around s.

In order to analyze the period 1960-2000, the Nadaraya-Watson method is used, exactly as it appears in Härdle [1990], based on the following expression[6]:

$$\hat{m}(s) = \frac{n^{-1}\sum_{i=1}^{n} K_h(s - S_i)g_i}{n^{-1}\sum_{i=1}^{n} K_h(s - S_i)}\,, \qquad (5)$$

where K_h denotes the dependence of the kernel K (in this case an Epanechnikov kernel) on the bandwidth h (0.5). Starting from this calculated mean $\hat{m}(s)$, the variance of the growth rate g_i is also estimated, again applying the Nadaraya-Watson estimator starting from:

$$\hat{\sigma}(s) = \frac{n^{-1}\sum_{i=1}^{n} K_h(s - S_i)(g_i - \hat{m}(s))^2}{n^{-1}\sum_{i=1}^{n} K_h(s - S_i)}\,. \qquad (6)$$

[6] The calculation was done with the KERNREG2 stata module, developed by Cox et al. (1999), available online at http://ideas.repec.org/c/boc/bocode/s372601.html. This program is based on the algorithm described by Härdle [1990] in Chapter 5.

The estimator is very sensitive, both in mean and in variance, to atypical values. Thus, we eliminate 5% of the lowest observations of the distribution, both for the stock of emigrants and for migration density, as these observations are characterized by a very high dispersion both in mean and in variance[7]. For the case of stock, four more very atypical values are eliminated[8].

If growth were independent of size, the estimated kernel would be a straight line on the zero value. Values different to zero imply deviations with respect to the mean. Supposing that variance does not depend on the size of the variable analyzed, it would be around one.

For each size of the stock of immigrants, Figure 5 represents the estimation of the mean growth and Figure 6 that of the variance of that growth. Bootstrapped 95% confidence bands are also displayed. They have been calculated using 500 random samples with replacement. For the calculation, the 809 available observations covering the entire sample period have been taken into account. Some conclusions can be highlighted from the results obtained. First, the estimated kernel of the mean is close to zero. However, the trend is slightly decreasing; the bigger the size, the smaller the growth rate[9]. But the null hypothesis of this mean being equal to zero can be rejected at a 5 % significance level only for some values in the upper tail, so, except for these values of the distribution, Gibrat's law holds in the period examined. Thus, we find evidence of slight convergence in the stock of immigrants because the biggest countries have had less mean growth.

For migration density, we have 813 observations available. Figures 7 and 8 present the kernels corresponding to the mean and the variance of its growth. Although the estimated kernel is close to zero and we cannot reject the null hypothesis of this mean being equal to zero at a 5% significance level. Moreover, we observe two clearly differentiated behaviors: the countries with a lower rate have grown more slowly than those that began with a higher rate. Therefore we find divergence. And it is also

[7] The majority of these 43 excluded observations for the stock of immigrants correspond to African countries and islands which constitute independent states. In the case of migration density, Asian countries also appear (China, Vietnam, for example), which, due to their high population, have low migration density.
[8] These four observations correspond to United Arab Emirates (1960-1970), Djibouti (1970-1980), Mozambique (1970-1980) and Somalia (1970-1980).
[9] Although clusters of countries are detected that differ from the trend, both in mean and in variance (although we cannot reject to be equal to one).

observed that variance is independent of size, except for some upper tail distribution values, so evidence against Gibrat's law in countries' migration density is not found.

If we interpret the two variables together, we can say that, although the growth of the stock of immigrants does not appear to have been especially relevant when establishing the distribution of size, migration density is. This may be because the host countries have lower birth rates than the origin countries so that, while the stock of immigrants grows at the same or a similar rate, migration density increases.

This may be important for several reasons. The first is that less population growth in the host countries may be generating a scarcity in the labor supply, which creates wage differences that encourage migration. As long as these differences are maintained, migration will continue. On the other hand, the stock of immigrants reduces immigration costs and, as long as the importance of this fact is greater than the rate at which wages converge, migration will continue. Finally, in a context where a scale effect of population on economic growth is important, as discussed in Alesina [2000] and Spolaore and Wacziarg [2005], this result may be useful for understanding the existence of persistent differences in wages. Furthermore, it may help us to understand why migratory patterns are maintained and to give new perspectives on the mechanisms by which migration affects the economic growth and welfare of the host countries.

4. Conclusions

This paper studies the evolution of the worldwide distribution of the stock of immigrants, centering on two empirical regularities which are well-known in the ambit of urban economics, Zipf's law and Gibrat's law. We use parametric and non-parametric methods and obtain the following results.

First, for the stock of immigrants, the estimated Pareto exponent is about 1/3 if we consider the whole sample, which indicates that the distribution is very uneven. The estimation of the parameter remains almost constant throughout the period examined. Also, the estimated kernels show that the distribution that fits best is lognormal, while the upper tail is represented by a Pareto, a statistical regularity already shown in Eeckhout [2004] for the case of the North American cities. We show that growth is independent of size, and the non-parametric estimation corroborates this result, although we found a weak convergence in the stock of immigrants.

We have repeated the analysis for migration density, defined as the percentage of immigrants over the total population of the country. The estimated Pareto exponent for the entire sample in this case is about ½, but presents a tendency to decrease, which would indicate divergence between countries. This coincides with the results offered by the estimated kernels, which show a loss of kurtosis in the distribution. Although the estimated kernel of the growth of migration density is close to zero, we observe two clearly differentiated behaviors: the countries with a lower rate have grown more slowly than those that began with a higher rate. Consequently, in the period examined, we observe a divergent behaviour. We also observe that variance is independent of size, except for some upper tail distribution values, so evidence against Gibrat's law in countries' migration density is not found.

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Tables:

Table 1.- Descriptive Analysis

Panel a: Total Stock

Area	Stock of Immigrants				
	1960	1970	1980	1990	2000
ASIA	29,280,680	28,103,771	32,312,541	41,754,291	43,761,383
EUROPE	14,015,392	18,705,244	22,163,201	26,346,258	32,803,182
NORTHERN AMERICA	12,512,766	12,985,541	18,086,918	27,596,538	40,844,405
AFRICA	8,977,075	9,862,987	14,075,826	16,221,255	16,277,486
LATIN AMERICA AND THE CARIBBEAN	6,038,976	5,749,585	6,138,943	7,013,584	5,943,680
OCEANIA	2,134,122	3,027,537	3,754,597	4,750,591	5,834,976
TOTAL	75,900,698	81,527,177	99,783,096	154,005,048	174,933,814

Panel b: Stock of Immigrants Growth

Area	Stock of Immigrants Growth (%)				
	1960-1970	1970-1980	1980-1990	1990-2000	1960-2000
ASIA	-4.02	14.98	29.22	4.81	49.45
EUROPE	33.46	18.49	18.87	24.51	134.05
NORTHERN AMERICA	3.78	39.29	52.58	48.01	226.42
AFRICA	9.87	42.71	15.24	0.35	81.32
LATIN AMERICA AND THE CARIBBEAN	-4.79	6.77	14.25	-15.25	-1.58
OCEANIA	41.86	24.01	26.53	22.83	173.41
TOTAL	7.41	22.39	54.34	13.59	130.48

Panel c: Migration Density

Area	Migration Density (%)				
	1960	1970	1980	1990	2000
ASIA	1.76	1.34	1.25	1.35	1.21
EUROPE	3.30	4.08	4.59	5.28	6.42
NORTHERN AMERICA	6.13	5.60	7.06	9.73	12.93
AFRICA	3.24	2.76	3.00	2.61	2.05
LATIN AMERICA AND THE CARIBBEAN	2.77	2.02	1.70	1.59	1.14
OCEANIA	13.43	15.57	16.45	17.80	18.80
TOTAL	2.51	2.21	2.25	2.93	2.88

Table 2.- Spearman Rank Coefficients

	All countries (214)				Top 50 (population in 1960)				Top 50 (population in 2000)			
Migrations	1970	1980	1990	2000	1970	1980	1990	2000	1970	1980	1990	2000
1960	0.97	0.91	0.89	0.87	0.95	0.87	0.83	0.82	0.93	0.77	0.71	0.54
1970		0.94	0.92	0.91		0.94	0.90	0.89		0.85	0.78	0.63
1980			0.97	0.94			0.98	0.94			0.88	0.73
1990				0.97				0.98				0.81
Migration Density	1970	1980	1990	2000	1970	1980	1990	2000	1970	1980	1990	2000
1960	0.93	0.82	0.77	0.72	0.80	0.75	0.65	0.51	0.83	0.67	0.62	0.51
1970		0.92	0.87	0.83		0.90	0.74	0.62		0.89	0.75	0.64
1980			0.94	0.89			0.91	0.79			0.89	0.77
1990				0.95				0.89				0.88
Growth	All countries (214)				Top 50 (growth in 1960)				Top 50 (growth in 2000)			
	70-80	80-90	90-00		70-80	80-90	90-00		70-80	80-90	90-00	
1960 - 1970	0.47	0.15	0.15		0.28	0.00	-0.11		0.19	-0.29	-0.27	
1970 - 1980		0.32	0.23			0.39	0.35			-0.28	-0.05	
1980 - 1990			0.30				0.12				-0.01	

Table 3.- Pareto coefficients by decade for the Stock of Immigrants

	50			100		
Year	b < 0	(GI s.e.)	R^2	b < 0	(GI s.e.)	R^2
1960	0.966	0.193	0.981	0.641	0.091	0.915
1970	0.939	0.188	0.973	0.685	0.097	0.935
1980	1.035	0.207	0.983	0.719	0.102	0.931
1990	0.925	0.185	0.982	0.726	0.103	0.947
2000	0.939	0.188	0.981	0.743	0.105	0.952
	150			214		
Year	b < 0	(GI s.e.)	R^2	b < 0	(GI s.e.)	R^2
1960	0.523	0.060	0.909	0.333	0.032	0.790
1970	0.551	0.063	0.916	0.348	0.033	0.787
1980	0.572	0.066	0.910	0.354	0.034	0.780
1990	0.580	0.067	0.921	0.352	0.034	0.780
2000	0.569	0.066	0.912	0.343	0.033	0.770

(GI s.e.) Gabaix-Ioannides (2004) corrected standard error.
All coefficients are significantly different from zero at the 0.05 level.

Table 4.- Kolmogorov-Smirnov test for the Stock of Immigrants (ln scale)

	1960	1970	1980	1990	2000
Kolmogorov-Smirnov Z	0.617	0.464	0.544	0.696	0.597
Asymp. Sig. (2-tailed)	0.841*	0.982*	0.929*	0.718*	0.868*

* Normality null hypothesis not rejected at the 0.05 level

Table 5.- Pareto coefficients by decade for Migration Density

Year	50			100		
	b < 0	(GI s.e.)	R^2	b < 0	(GI s.e.)	R^2
1960	1.327	0.265	0.916	1.118	0.158	0.944
1970	1.363	0.273	0.909	1.071	0.152	0.931
1980	1.449	0.290	0.877	1.047	0.148	0.898
1990	1.654	0.331	0.904	1.106	0.156	0.893
2000	1.713	0.343	0.890	1.071	0.151	0.874
Year	150			214		
	b < 0	(GI s.e.)	R^2	b < 0	(GI s.e.)	R^2
1960	0.941	0.109	0.935	0.558	0.054	0.775
1970	0.874	0.101	0.915	0.535	0.052	0.773
1980	0.843	0.097	0.895	0.541	0.052	0.794
1990	0.838	0.097	0.872	0.521	0.050	0.776
2000	0.804	0.093	0.862	0.499	0.048	0.771

(GI s.e.) Gabaix-Ioannides (2004) corrected standard error.
All coefficients are significantly different from zero at the 0.05 level.

Table 6.- Kolmogorov-Smirnov test for Migration Density (ln scale)

	1960	1970	1980	1990	2000
Kolmogorov-Smirnov Z	0.689	0.567	0.469	0.611	0.679
Asymp. Sig. (2-tailed)	0.730*	0.905*	0.980*	0.849*	0.745*

* Normality null hypothesis not rejected at the 0.05 level

Table 7.- Results of estimations of parametrical growth regressions

Stock of Immigrants parametrical growth regressions

		All countries (214)			Top 100		
Initial Year	Final Year	a < 0	(s.e.)	R^2	a < 0	(s.e.)	R^2
1960	1970	-1.45E-07	1.27E-07	0.006122	-4.96E-08	4.34E-08	0.013158
1960	1980	-1.04E-06	1.53E-06	0.00217	-2.09E-07	2.08E-07	0.01022
1960	1990	-1.65E-06	3.00E-06	0.001434	-3.27E-07	4.45E-07	0.005471
1960	2000	-2.00E-06	3.70E-06	0.001388	-3.69E-07	5.42E-07	0.004705
1970	1980	-3.31E-07	5.17E-07	0.001926	-9.23E-08	9.23E-07	0.010095
1970	1990	-2.64E-07	2.08E-07	0.005981	-1.02E-07	1.91E-07	0.002884
1970	2000	-4.40E-07	4.07E-07	0.005473	-1.78E-07	2.49E-07	0.00516
1980	1990	-2.37E-08	7.41E-08	0.00048	-2.72E-08	5.45E-08	0.002527
1980	2000	-9.56E-08	1.91E-07	0.001211	-2.58E-09	6.70E-08	0.000015
1990	2000	-9.40E-09	1.57E-08	0.001699	-9.61E-09	1.54E-03	0.003975

None of the coefficients is significantly different from zero at the 0.05 level.

Migration Density parametrical growth regressions

		All countries (214)			Top 100		
Initial Year	Final Year	a < 0	(s.e.)	R^2	a < 0	(s.e.)	R^2
1960	1970	-1.46E-02	1.28E-02	0.006122	-4.99E-03	4.37E-03	0.013158
1960	1980	-1.04E-01	1.54E-01	0.00217	-2.10E-02	2.09E-02	0.010122
1960	1990	-1.66E-01	3.01E-01	0.001434	-3.28E-02	4.47E-02	0.005471
1960	2000	-2.01E-01	3.71E-01	0.001388	-3.71E-02	5.45E-02	0.004705
1970	1980	-3.32E-02	5.21E-02	0.001926	-9.28E-03	9.28E-03	0.010095
1970	1990	-3.66E-02	3.25E-02	0.005981	-1.02E-02	1.92E-02	0.002884
1970	2000	-4.42E-02	4.10E-02	0.005473	-1.79E-02	2.50E-02	0.00516
1980	1990	-2.38E-03	7.48E-03	0.00048	2.73E-03	5.48E-03	0.002527
1980	2000	-9.61E-03	1.90E-02	0.001211	-2.59E-04	6.73E-03	0.000015
1990	2000	-9.45E-04	1.58E-03	0.001699	-9.66E-04	1.54E-03	0.003975

None of the coefficients is significantly different from zero at the 0.05 level.

Figures

Figure 1.- Changes in the ranking of Stock of Immigrants: 1960-2000

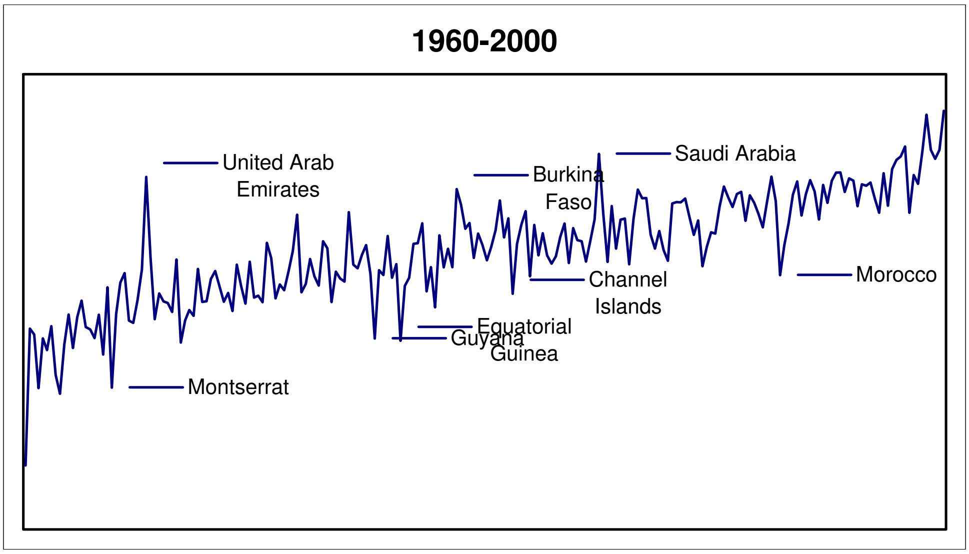

Figure 2.- Changes in the ranking of Migration Density: 1960-2000

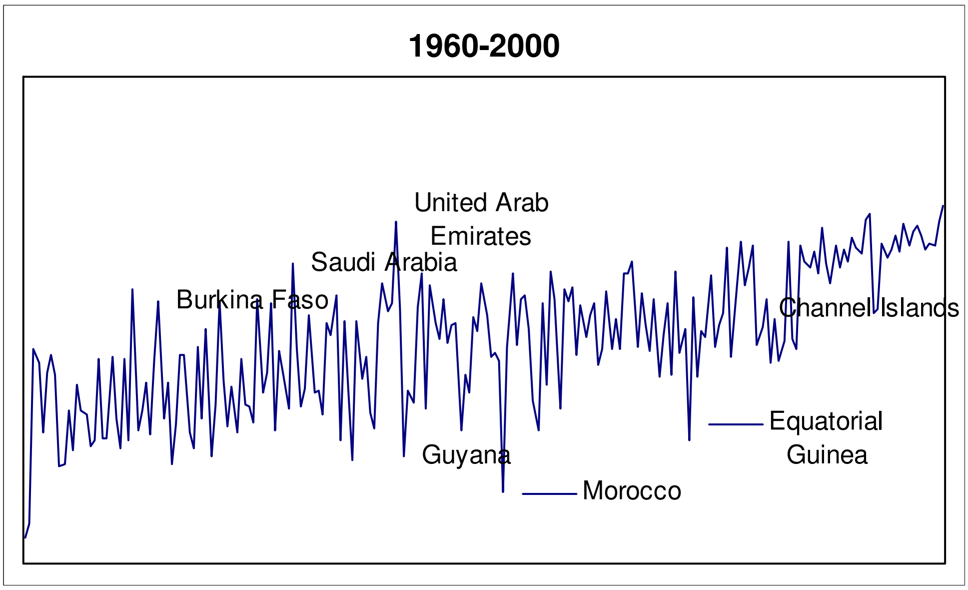

Figure 3.- Adaptive kernels of the Stock of Immigrants (ln scale)

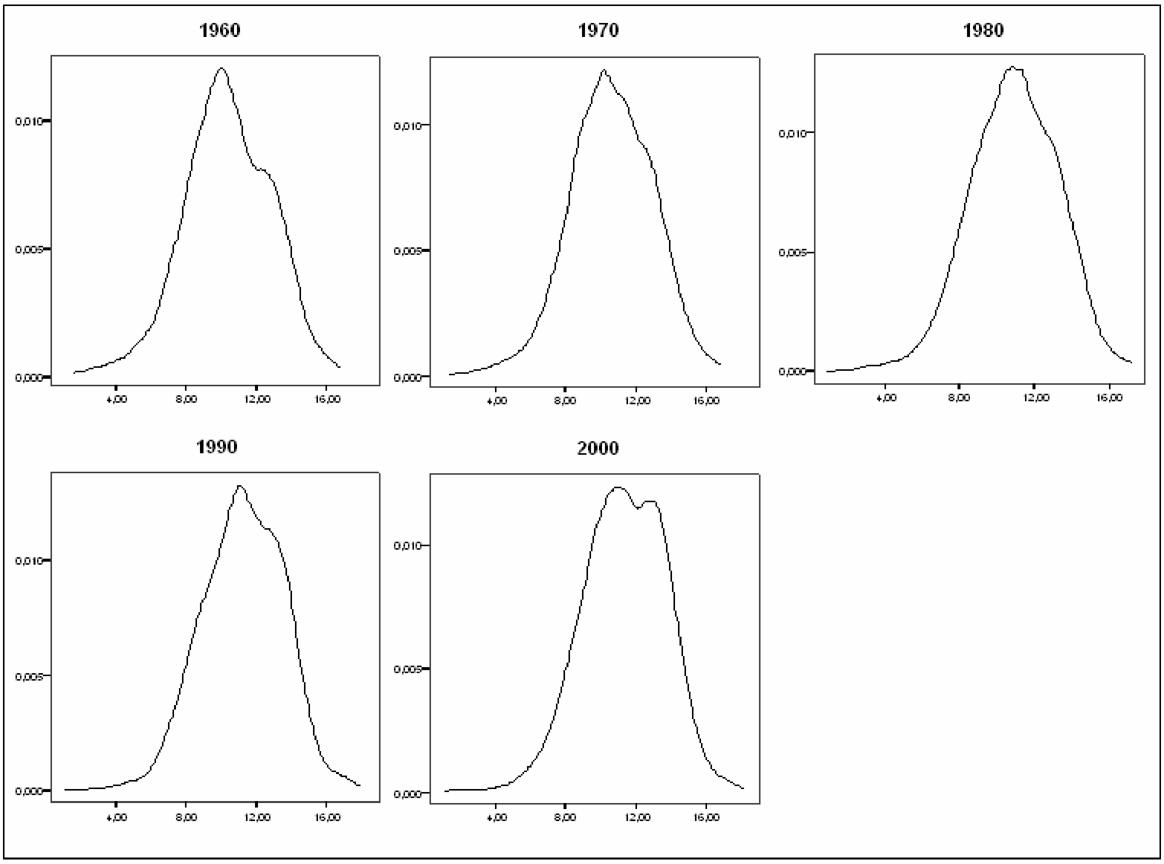

Figure 4.- Adaptive kernels of Migration Density (ln scale)

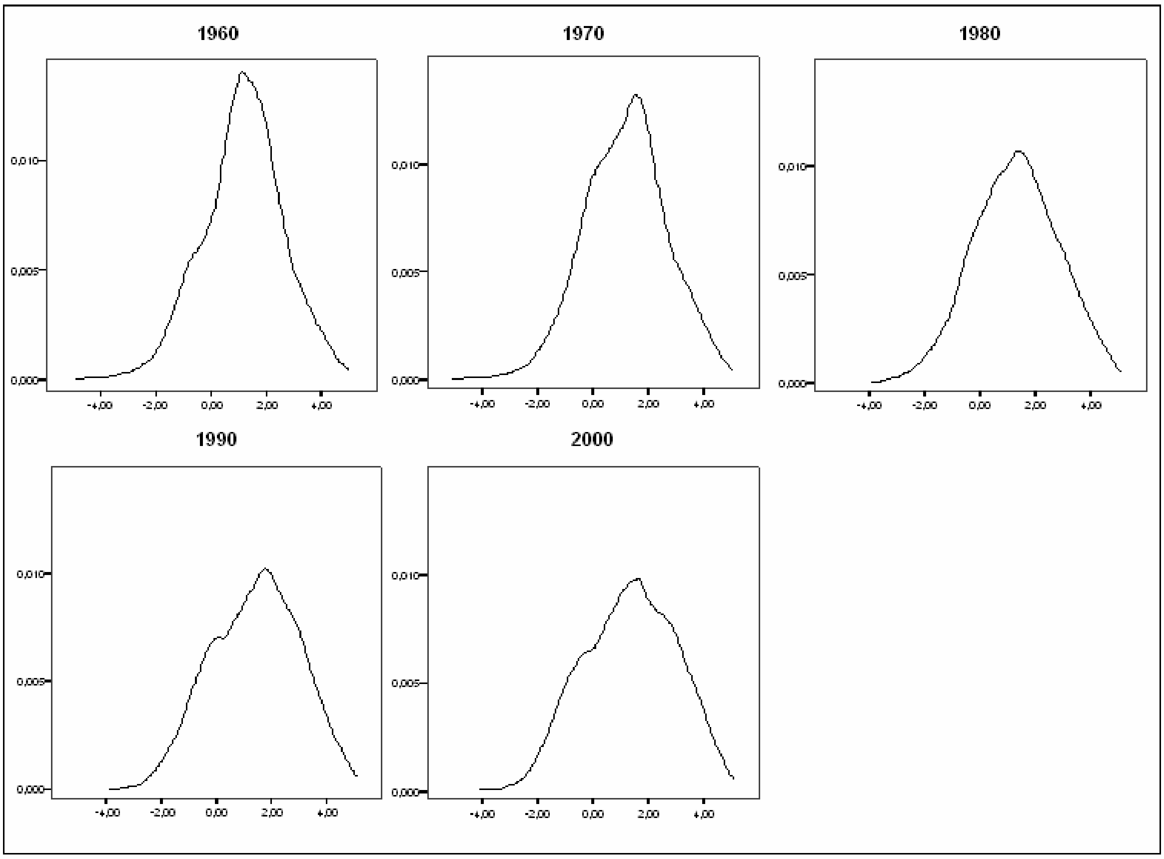

Figure 5.- Kernel estimate of Stock of Immigrants Growth 1960-2000 (Bandwidth 0.5)

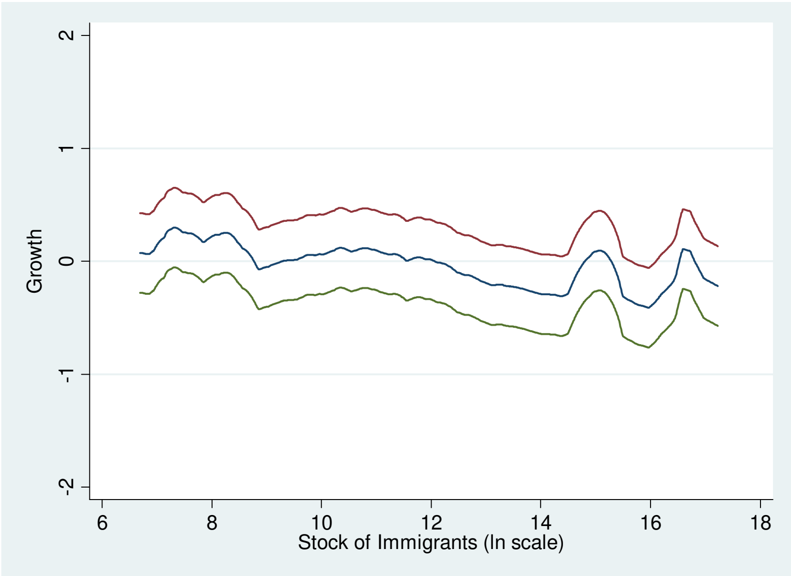

Figure 6.- Kernel estimate of the Variance of Stock of Immigrants Growth 1960-2000 (Bandwidth 0.5)

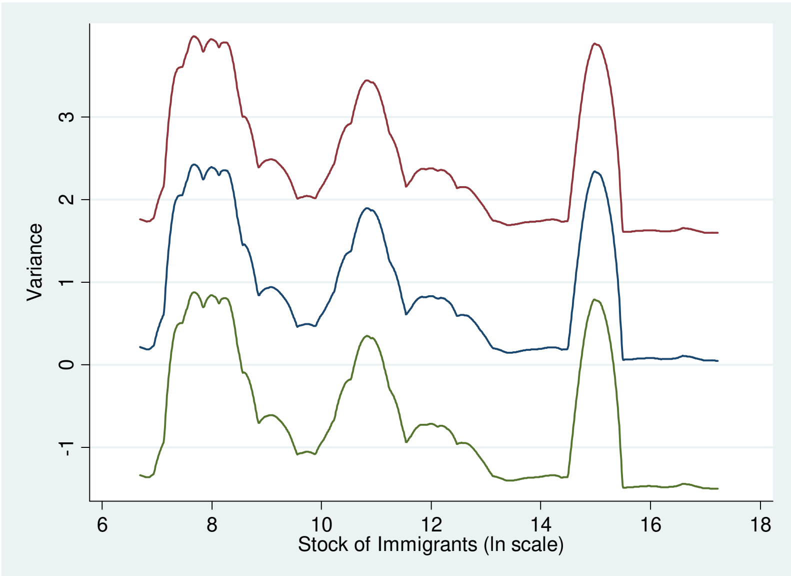

Figure 7.- Kernel estimate of Migration Density Growth 1960-2000 (Bandwidth 0.5)

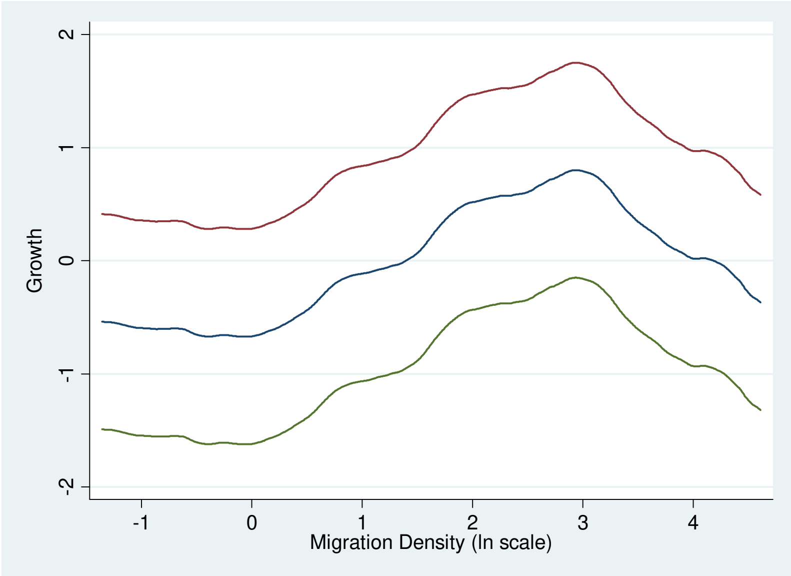

Figure 8.- Kernel estimate of the Variance of Migration Density Growth 1960-2000 (Bandwidth 0.5)