



Luis ROSERO-BIXBY^{*,**} Teresa CASTRO-MARTÍN^{°,**}
David REHER^{◇,**} and María SÁNCHEZ-DOMÍNGUEZ^{◇,**}

Estimating the Number of Immigrants in Spain: An Indirect Method Based on Births and Fertility Rates

The number of immigrants in a given country can be estimated through a variety of methods, and a comparison of the estimates obtained can shed light on their respective merits and limitations. Since 1996, Spain has set up a population register that aggregates the data from all the municipal registers. As it includes all immigrants residing in the country, their number can be determined directly. In addition, the 2007 National Immigrant Survey allows the estimation of immigrants' fertility rates. Starting out from these immigrant fertility rates by sex and age, Luis ROSERO-BIXBY, Teresa CASTRO-MARTÍN, David REHER and María SÁNCHEZ-DOMÍNGUEZ deduce the number of immigrants in Spain by country of origin from the number of births to immigrants recorded in the Spanish birth registry. By comparing their results with the count of immigrants given in the population register, they put their method to the test and point up the inaccuracies of the register, notably the probable over-counting of immigrant men.

Spain, for centuries a country of emigration, has experienced a fast transition to a country of immigration in the last two decades (Arango, 2000; Cebolla and González-Ferrer, 2008). According to census and population register data, Spain hosted 350,000 foreigners in 1991, 1.5 million in 2001 and 5.7 million in 2011. In other words, the relative weight of foreigners in the total population increased from 0.9% in 1991 to 12.2% in 2011, a proportion comparable to countries with a much longer immigration tradition. Since 2000, Spain has received about a third of all the immigrants reaching the European Union

* Universidad de Costa Rica.

° Centro de Ciencias Humanas y Sociales, CSIC, Spain.

◇ Universidad Complutense de Madrid.

** Grupo de Estudios Población y Sociedad, GEPS, Spain.

Correspondence: Luis Rosero-Bixby, Centro Centroamericano de Población, Universidad de Costa Rica, San Pedro 2060, San Jose, Costa Rica, e-mail: lrosero@mac.com

(Eurostat, 2009), although the current economic crisis has slowed down the most recent immigration flows (Martin, 2009; Reher et al., 2011b). The demographic effects of these trends are evident in the increasing contribution of immigration to population dynamics (Izquierdo and López de Lera, 2006). Over the past decade, net migration has accounted for approximately 90% of Spain's population growth. Natural increase is also considerably influenced by immigrants' birth rates (Roig and Castro-Martín, 2007). In 2009, 20.7% of all live births were to foreign mothers, and 23.9% to either a foreign mother or a foreign father.

The aim of this article is to provide independent estimates of the stock of immigrants in Spain by following the footprints they leave behind, i.e. by combining information on the number of births (the footprints) by parents' origin in the birth registry with information on immigrants' fertility rates calculated from the 2007 National Immigrant Survey (Encuesta Nacional de Inmigrantes, ENI). If our estimates do not differ from the count of immigrants in the Spanish municipal population register, this will be an important validation check of the register, the estimation procedure and the data inputs we are using.

The Spanish *padrón municipal* is a municipal population register in which all residents of the municipality are listed, regardless of citizenship or legal residence status. These lists are generated and maintained by the respective town councils. In 1996, a new continuous and computerized management system for all municipal registers was established, coordinated by the National Statistical Institute (Instituto Nacional de Estadística, INE), which carries out the appropriate checks to correct errors and duplicates, and generates a centralized file. The information contained in the centralized population register file is used to determine the official annual population figures for municipalities, provinces, autonomous communities, and for the country as a whole.

This population register is a more reliable source of information on the immigrant population than alternative sources such as the Ministry of Interior Foreign Yearbook, which only covers immigrants with legal residence permits. Many foreigners do not hold the proper documentation required for residing and working in Spain (Moreno, 2005). For instance, in early 2009, approximately 4.5 million foreigners had a valid residence permit, 1.1 million below the number of foreigners enumerated by the population register.⁽¹⁾ In the last regularization campaign carried out in mid 2005, 560,000 undocumented immigrants were granted a residence permit conditional on a labour contract,

(1) Only one-third of this difference can be attributed to the presence of EU citizens, who are not required to hold a residence permit. The overall percentage of immigrants living in Spain without a proper residence permit was estimated to represent up to 70% of the total foreign population in 2002, 40% in 2005, and 24% in 2007 (Cebolla and González-Ferrer, 2008).

but there has not been any extraordinary regularization programme since then.⁽²⁾

The coverage of municipal population registers is assumed to be high, since registration provides automatic access to education and health services,⁽³⁾ and for those who do not have legal residence permit upon arrival, it is a prerequisite for obtaining one. In fact, Spain is the only European country that allows and encourages irregular immigrants to record their names in a population register (González-Enríquez, 2009) and, hence, its estimates of the overall immigrant population are probably more accurate than in other countries. However, municipal population registers are probably not flawless. Despite the positive incentives to register, prior research suggests that certain groups – particularly those engaged in seasonal agricultural work or those who fear deportation – tend to be under-counted, and that there is a time lag between arrival and registration (Devolder et al., 2003). Under-registration is also likely among children, although it decreases at ages when school admission requires a certificate from the municipal population register. Some studies, however, suggest that the population register is liable to somewhat over-estimate the number of current immigrants in the country (Ródenas and Martí, 2009). This may happen because double-registration is difficult to detect among foreign residents without a unique identity document,⁽⁴⁾ and because immigrants do not usually de-register when they return to their country of origin or move on to another country. Since the annual funds allocated to the municipalities by the central government partly depends on their population figures, it has been traditionally easier to register than to de-register from the municipal population register. Also, while registration is voluntary and associated with positive incentives, there are no such incentives for de-registration. As often occurs with administrative registers, detecting and eradicating errors is exceedingly difficult and they often become embedded structural components of the system. In order to address this problem, a legal reform (14/2003, 20 November 2003) introduced an important change: all non-EU foreigners without a permanent residence permit are required to re-register every two years, or else be deleted

(2) Special regularization programmes were implemented in 1986, 1991, 1996, 2000-2001 and 2005. They granted temporary residency permits and allowed a significant proportion of immigrants in the informal economy to move into the formal labour market. A total of 1.1 million immigrants have benefitted from these regularizations, 52% of them in the last one in 2005 (González-Enríquez, 2009).

(3) Since 2000, all foreigners included in a municipal register, regardless of their legal status, are granted free access to public education from age 3 to 16, and public healthcare. Foreigners not included in the register only have access to emergency healthcare, except if they are foreign minors or pregnant women. To register, the only documents required are proof of identity (Spanish national identity card, residence permit or passport) and proof of residence at the declared address (property title, rental contract, utility bills, or a letter from the first adult already registered at the address).

(4) For example, foreign residents can register initially with their passport number and later on with their residence permit number in another municipality.

“ex-officio” from the register. This measure has probably reduced over-registration since 2006, two years after the new procedure was introduced.⁽⁵⁾

Although there is a strong tradition in demography of developing indirect measurement techniques, these methods usually focus on the study of mortality and fertility. The classic United Nations manual on indirect techniques for demographic estimations (United Nations, 1983), for example, completely ignored migration. An IUSSP working group examined and developed indirect methods for the study of international migration, but its work focused only on out-migration flows (Zaba, 1985). There are, nonetheless, some examples of indirect techniques developed to estimate the number of unauthorized or illegal immigrants in the United States, using information on sex ratios (Bean et al., 1983), on death rates (Robinson, 1980; Borjas et al., 1991) or on school enrolment information (Muller and Espenshade, 1985). This article builds on an earlier study estimating the number of Nicaraguans in Costa Rica (Rosero-Bixby et al., 2002), and proposes to estimate the immigrant stock in Spain using data on births from the birth registry and on fertility rates from survey data. We believe this method could be used in a variety of situations.

I. Data and methods

The number of births to immigrant parents is our starting point. Immigrants in this study are individuals residing in Spain who were not born in Spain, independently of their legal status, nationality at birth or current nationality. Although data on births by parents’ nationality have been readily available in Spain in the web pages of the National Institute of Statistics (www.ine.es) since 1996, the classification by parents’ country of birth has been available only since 2007. We chose to base our analysis of immigrants on country of birth rather than nationality in order to avoid potential discrepancies between data sources due to naturalization dynamics (González-Ferrer and Cortina, 2011). Coverage of birth statistics is virtually complete in Spain and there is no reason to believe that the registration of births to immigrants is any different.

The proposed method also requires an estimate of immigrants’ fertility rates in order to move backwards from the aforementioned births to the population that produced them. We estimated the fertility rates of immigrants with data from the National Immigrant Survey (Encuesta Nacional de Inmigrantes, ENI hereafter), conducted by the National Institute of Statistics in 2007 (INE, 2009). The target population of the sample comprised persons born abroad and aged 16 years old and over who, at the time of the survey, had resided in Spain for at least one year or who intended to do so, regardless of legal status.⁽⁶⁾

(5) Approximately a quarter of a million foreigners were de-registered “ex-officio” in 2006 as a result of the new law (González-Ferrer, 2009).

(6) 11.2% of respondents required to hold a legal residence permit (non-citizens, non-EU) did not have one, and another 6.5% were still waiting to receive one.

The ENI followed a three-stage sampling design to select dwellings in which at least one resident was a foreign national. The first stage units were census sections, grouped into strata according to municipality size. The sections were selected with a probability proportional to the size measured by the number of eligible foreign nationals. The second stage units were family dwellings, which had equal probability of being selected via systematic sampling after classification by the predominant nationality of occupants. As the third stage unit, an individual was selected with equal probability from among the list of persons born abroad and who resided in each dwelling (INE, 2008). A total of 15,465 valid questionnaires were obtained from the fieldwork, for which 32,541 dwellings were visited. Among family dwellings where at least one resident was born abroad and hence was eligible for the interview (17,700), the response rate was 87.37%. Survey weighting factors correct for over-sampling in some regions and for differential non-response rates by age, sex and region. Detailed presentations of survey methodology and data reliability have been published by INE (2008) and Reher and Requena (2009a). Data from this survey have already been used in a number of publications on immigration in Spain.⁽⁷⁾

Fertility estimates obtained from retrospective birth histories in demographic surveys often tend to be upward-biased because of the higher non-response rates of childless women, who are usually more difficult to find at home for a survey interview (Festy and Prioux, 2002). In the ENI, this potential bias is somewhat lessened by the fact that any household member could provide information about those hard-to-find individuals. Such bias might exist, however, for one-person households and for persons with tenuous ties to households. It is worth noting that once eligible persons were identified, the non-response rate of 12.6% was well within the 7-20% range of non-response considered by Festy and Prioux (2002, p. 19) to represent an acceptable quality level in fertility survey data.

We used the survey microdata and Stata-10 software to estimate fertility rates (Statacorp, 2007). Although the ENI's large sample size produces reliable estimates for the total immigrant population and for some large subgroups by origin, sampling errors in age-specific fertility rates limit the level of disaggregation we can reach and introduce substantial uncertainty in our estimates. In exploratory analyses of fertility levels and patterns, we used smoothed single-age fertility rates of immigrants by groups of country of birth. However, in our estimate of immigrants we used five-year age-specific fertility rates at ages 25-35 for women, and ages 30-40 for men, excluding extreme ages for which the survey's fertility rates were not reliable. All of our fertility estimates used the sampling weights provided in the ENI database. In addition to the customary fertility rates for women, we also estimated fertility rates for immigrant men.

(7) See, for example, Reher and Silvestre (2009), as well as the articles contained in Reher and Requena (2009b) and in Reher et al. (2011a).

With the series of age-specific fertility rates, we used the following identity to estimate, for each sex, the number of immigrants in reproductive ages (NR) from country/region i :

$$NR^i = \sum_a \frac{B_a^i}{f_a^i}$$

where:

- B is the number of births to mothers/fathers of origin i , and age group a (source: birth registration data);
- f is the age-specific fertility rate of immigrants by country of origin i , and at age group a (estimate from the ENI survey by sex).

To capture the heterogeneity of the immigrant population, the estimation procedure is conducted separately for sending countries with a strong immigrant presence in Spain (Morocco, Ecuador, and Romania), and for the major groups of sending countries. We first defined 11 groups of immigrants by origin, as shown in Table 1, conditional upon a minimum ENI sample size of around 200 observations in each group. After regression models showed no significant differences in fertility levels and patterns among some of these groups, we reordered the countries of origin into seven groups: (1) Ecuador, (2) other Latin American countries, (3) Morocco, (4) other African countries, (5) western Europe, (6) Romania, and (7) eastern Europe and Asia.⁽⁸⁾

We estimated fertility rates for the period 2004-2006, i.e. the three years before the ENI interview. To do this, we built a complete birth history for each respondent above 15 years of age⁽⁹⁾ with the information available in the survey for the following three groups of children:

1. Children living in the household, from the ENI rosters of household members, which includes information on the children's age, birth year and country of birth, as well as a matrix of kinship relationships among all members.
2. Living children who do not live with the respondent, from the ENI roster for these children, which provides information on their age and country of birth.
3. Deceased children (4% of children ever born). The ENI inquired about the number of children deceased but not about their date of birth. We imputed these birth dates with a random number generator and using information about the respondent's age and a simple age fertility pattern.⁽¹⁰⁾

(8) Because of the small sample size of Asians (about 100 women and 200 men), the ENI has very limited statistical power to identify significant fertility differences for this group, which must be merged with other groups. We found that Eastern Europeans were the closest group to merge them with.

(9) ENI interviewed immigrants aged 16 and over. However, it is possible to estimate rates for age 15 in the period 2004-2006 with the birth histories of participants aged 16-18.

(10) The pattern assumes that women's fertility is null below age 15 and above age 45, and that fertility in the age brackets 15-18 and 33-44 is half that for ages 19-32.

Table 1. Size of ENI samples used to estimate fertility and stock of immigrants

Country of birth	For TFR estimates		For immigrant estimates	
	Women age 16-44	Men age 20-49	Women age 25-39 ^(a)	Men age 30-44 ^(a)
Ecuador	620	519	536	441
Colombia	522	278	463	226
Peru and Bolivia	422	285	365	234
Argentina, Uruguay and Chile	413	403	361	340
Rest of Latin America	793	472	692	398
Morocco	574	760	506	651
Rest of Africa	184	415	168	375
Western Europe ^(b)	1,180	1,157	1,024	1,048
Romania	632	557	555	444
Rest of Europe ^(c)	515	342	461	288
Asia	115	204	95	174
Total	5,970	5,392	5,226	4,619

(a) Individuals with exposure at these ages during the three years preceding the interview.
(b) Andorra, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom. Canada, USA, Australia and New Zealand, which account for only 4% of immigrants, are also included in this group.
(c) Albania, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Montenegro, Poland, Serbia, Slovakia, Slovenia, Ukraine.
Source: ENI (2007).

For example, for a 20-year old respondent, the birth date of a dead child must be in the 2002-2006 period and for a 60 year old female respondent, the birth year of a dead child is most likely to be in the period 1967–1981, when she was in the peak reproductive ages (it cannot be before 1962 or after 1992, i.e. outside the reproductive ages). Of the 1,088 dead children, only 33 were imputed to have been born in the period of interest (2004-2006), 29 of them after migration to Spain.

Only children born in Spain are included in the fertility rate computation, and only the time spent in Spain is considered for the denominator. For example, an immigrant who is exactly 30 years old at the time of interview, who arrived in Spain 18 months before, will have half a year of exposure at age 28, a full year of exposure at age 29, and zero exposure at all other ages.

We used the above formula to obtain point and interval estimates of the total fertility rate (TFR computed by sum of the single-age fertility rates), and of the expected numbers of immigrants. The 95% confidence intervals (CI) were estimated using bootstrapping procedures (Efron, B. and Tibshirani, 1993; Poi, 2004), replicating 500 samples comprising 11,600 individuals for the TFRs and 9,100 for the numbers of immigrants. The percentiles 2.5 and 97.5 of the distribution of results for the 500 simulated bootstrapping samples provided exact estimates of the 95% CI. It is worth noting that the relative CIs

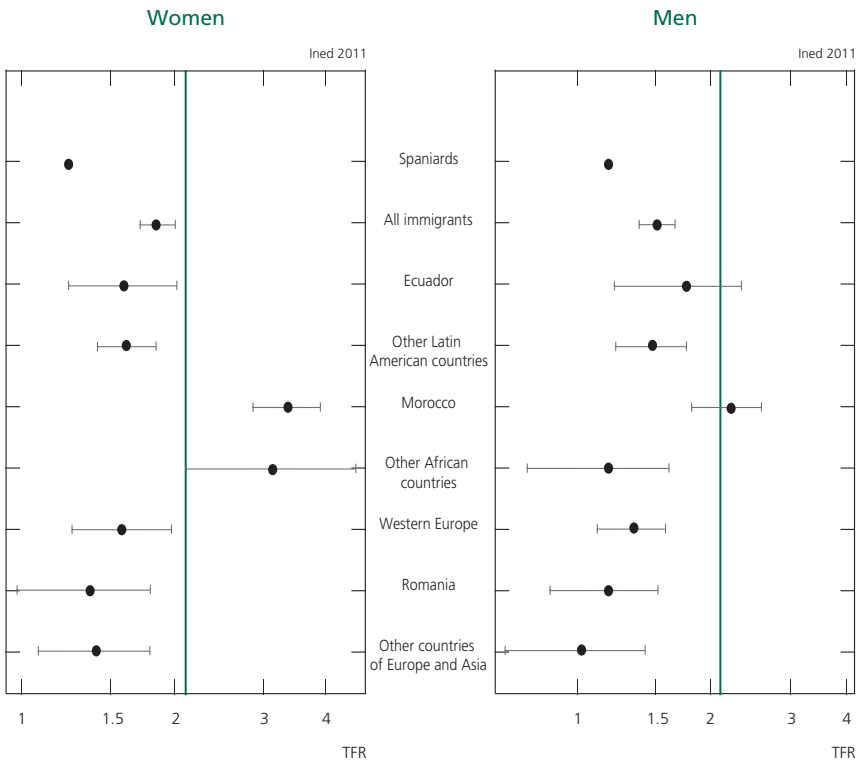
estimated with bootstrapping are slightly larger than the relative CIs of the general fertility rate determined assuming a Poisson distribution.

II. Results

Immigrant fertility

Figure 1 shows the TFR for both women and men, computed with single-year, age-specific fertility rates from the ENI, and the 95% CI estimated with bootstrapping resampling. Fertility levels in almost all groups of immigrants are low. As found in prior studies (Castro-Martin and Rosero-Bixby, 2011), only Moroccan men and women, and women from other African countries – mostly sub-Saharan Africa – show above-replacement fertility levels. Total fertility in other groups ranges from 1.4 children per woman among Romanians to 1.6 among Latin American and Western European women. These fertility levels are higher than those for Spanish women (1.26 births in the same period),

Figure 1. Total fertility rate (TFR) by sex of Spaniards and immigrants by country/region of birth, 2004-2006.



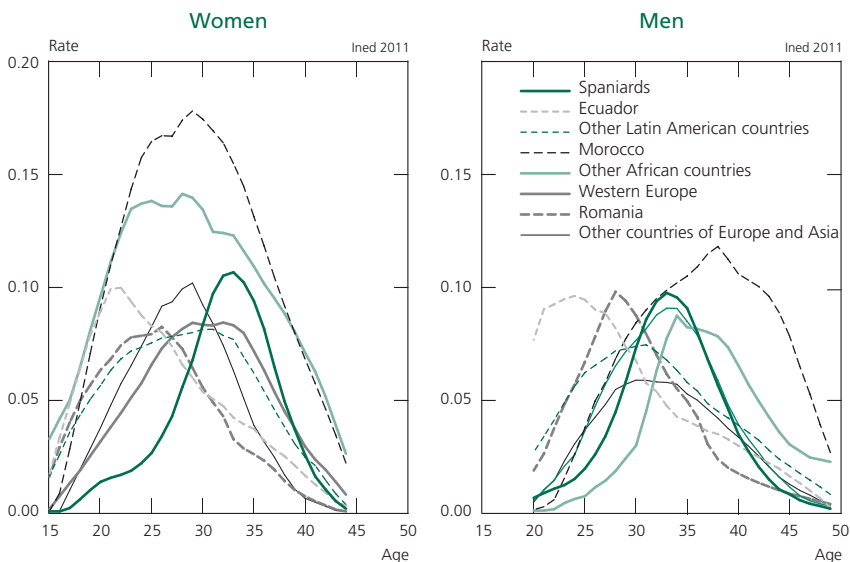
Note: The TFR estimates and 95% confidence intervals are shown on a log scale.

Source: ENI (2007) for immigrants, official vital statistics for Spaniards.

but typically lower than fertility levels in most of their origin countries. An in depth analysis of immigrant fertility based on ENI data is provided elsewhere (Castro-Martin and Rosero-Bixby, 2011).

Fertility of immigrant men is lower than that of women, except among Ecuadorians. The gender gap in fertility is substantial among Moroccans and other Africans, groups that also have the highest gender imbalance in the stock of immigrants (according to the 2007 population register, the corresponding sex ratios in the reproductive ages are 2.5 and 3.3, whereas sex ratios in all other groups are lower than 1.3). The exceptionally low fertility of immigrant men from Africa might be related to the shortage of women of the same origin, low rates of intermarriage and long waiting times for family reunification. The same is not true for female fertility, however. A relative shortage of men of the same origin (such as among other Latin Americans, who have a sex ratio of 0.7) does not result in lower than expected fertility for women. The lower fertility of men may be due to under-reporting of children in the ENI – the problem of men’s incomplete reporting of fertility in surveys is acknowledged in the demographic literature (Rendall et al., 1999). However, the inverse association with the sex ratios among adults suggests that these fertility gender gaps are not merely the outcome of under-reporting. Latin American and Moroccan men have significantly higher TFRs than men born in Spain. The remaining male immigrant groups do not differ significantly in their fertility from Spaniards.

Figure 2. Age-specific fertility rates of immigrants and Spaniards by sex, 2004-2006



Source: ENI (2007) (smoothed) for immigrants, official vital statistics for Spaniards.

Figure 2 shows smoothed⁽¹¹⁾ age-specific fertility rates derived from the ENI survey for the seven groups of immigrants. For comparison purposes, Figure 2 also includes the fertility curve for Spanish natives in 2005. Among women, we identify four distinct age patterns of fertility:

- Spaniards (the reference group) with a late fertility schedule;
- Western Europeans with a pattern similar to Spaniards after age 30 and slightly higher fertility before this age;
- African immigrants (including Moroccans) with substantially higher and earlier fertility;
- Other nationalities (Latin America and other European countries) with higher fertility than Spaniards at young ages and lower rates after about age 30.

For men, we identify five distinct patterns:

- Spaniards and Western Europeans;
- Moroccans with higher fertility rates than Spaniards at all ages, especially after age 35;
- Other Africans, with lower fertility than Spaniards until about age 35 and higher fertility after that age;
- Ecuadorians and, to some extent, Romanians and immigrants from other countries of Europe and Asia, with substantially higher early fertility and lower late fertility than Spaniards;
- Other Latin Americans with relatively high fertility rates at older ages (after 40) and intermediate rates (between Spain and Ecuador) at young ages.

In general terms, female immigrants have a moderately higher TFR of 1.86 (95% CI [1.72 – 2.02]), versus 1.26 for Spanish women, and a substantially earlier mean age at childbearing: 28.8 years compared to 32.3 years for Spanish women. Immigrant men, with a TFR of 1.52 (95% CI [1.38 – 1.66]), also have higher fertility than their Spanish counterparts (1.19), although the difference is smaller than for women. The fertility age-pattern of male immigrants (mean childbearing age of 33.6 years) differs little from Spaniards (34.0 years), with the important exception of men from Ecuador who have their children at substantially younger ages.

The estimated number of immigrants

The estimated numbers of immigrants of reproductive age (Table 2) is obtained by dividing the numbers of births to immigrant mothers or fathers given in the Spanish vital registration system by the age-specific fertility rates (Appendix). Although fertility rates correspond to the period 2004-2006, registered births are for 2007, the first year with information about parents' country of birth. The estimate of the number of immigrants is thus for mid-2007. Since the reference date for the population register is 1 January of each

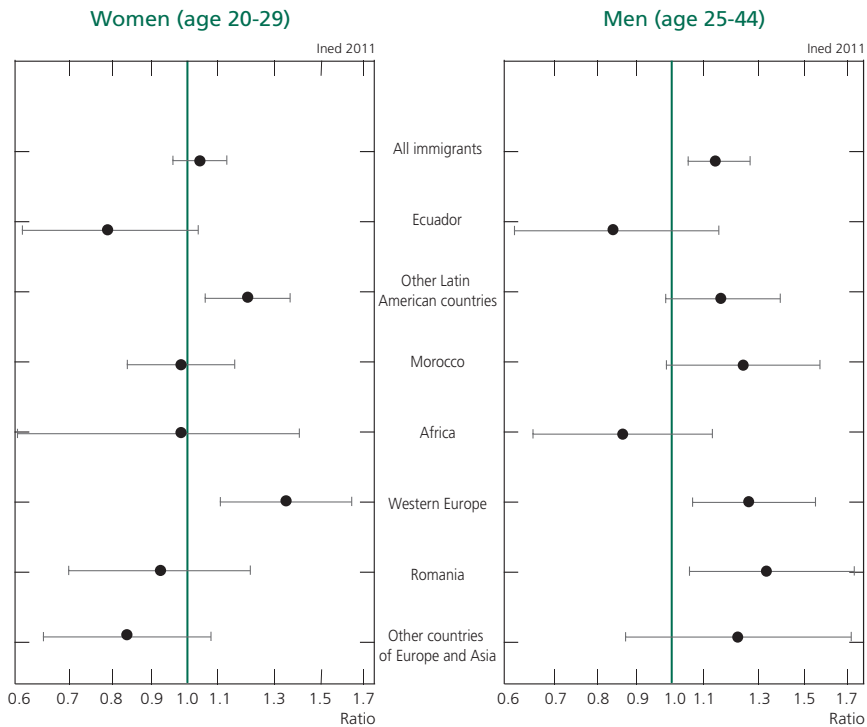
(11) The age-specific fertility curves were smoothed out with local regression procedures (Stata `lowess` command, with a bandwidth of 0.25).

Table 2. Immigrants in Spain in mid-2007 recorded in the municipal population register and estimates derived from data on births and fertility rates.

Country of birth	Number of immigrants (thousands)				Register-to-estimate ratio	
	Women 20-39		Men 25-44		Men	Women
	Register	Estimate	Register	Estimate		
Ecuador	126.4	159.7	121.0	145.0	0.79	0.83
Other Latin America	488.0	405.3	402.0	346.6	1.20	1.16
Morocco	113.1	114.7	237.6	189.9	0.99	1.25
Africa	41.6	42.0	127.4	147.0	0.99	0.87
Western Europe	203.8	150.7	270.6	214.9	1.35	1.26
Romania	178.5	193.5	188.7	140.8	0.92	1.34
Eastern Europe-Asia	171.1	204.5	219.4	179.3	0.84	1.22
Total	1,322.5	1,270.5	1,566.8	1,363.5	1.04	1.15

Note: Ratios in **bold** are significantly different from 1.0.
Source: ENI (2007) for immigrants, official vital statistics for Spaniards.

Figure 3. Register-to-estimate ratios of numbers of immigrants in Spain, 2007



Note: The ratios and the 95% confidence intervals are shown on a log scale.

Source: ENI (2007), official vital statistics.

year, the comparable figure is the average of the 2007 and 2008 population registers. Figure 3 shows the ratio of registered-to-estimated immigrants and its 95% confidence interval. Ratios of 1.0 and confidence intervals overlapping 1.0 mean that there is no significant difference between the two figures.

With a ratio of 1.04 (95% CI [0.96 – 1.13]), the number of female immigrants is practically equivalent in the population register and in our estimate derived from data on births and fertility rates (Table 2 and Figure 3). However, the size of the male immigrant population is 15% higher in the register than in our estimate (95% CI [4% – 26%]).

The results by immigrants' country or region of origin reveal that, among women, Western Europeans (1.35 ratio) and other Latin Americans (1.20 ratio) show a significantly higher count in the population register than this article's estimate. In the case of Western Europeans, these results may not reflect a problem of over-registration but rather the fact that some women go back to their country to give birth, so those births are not registered in the Spanish vital registration system. For immigrant men, the excess count in the population register occurs in all groups, except Ecuadorians and sub-Saharan Africans, although the difference is statistically significant for Western Europeans and Romanians only.

III. Discussion

This article has presented a simple, indirect method of estimating the number of immigrants in reproductive ages from information on births classified by parents' origin and immigrants' fertility rates. It had been used successfully before to estimate the number of Nicaraguans in Costa Rica (Rosero-Bixby et al., 2002), and was applied to Spanish data in 2007. Our results differ by gender. Among women, our results validate both the count in the population register in 2007 and the proposed indirect method of estimating the number of immigrants: the two figures are virtually the same. Among men, however, the population register counts 15% more immigrants than our estimate, and this difference is statistically significant.

The discrepancy in the number of immigrant men could be interpreted as evidence that the Spanish population register over-counts the number of immigrants (Ródenas and Martí, 2009). Although the population register has tightened the procedures to avoid duplicate entries and to detect departures from the country since 2006, it is plausible that over-counting still occurred in 2007. An alternate, or complementary, explanation is that our estimates of the number of immigrants could be downward biased because fertility estimates from the ENI, as in other surveys, tend to be upward biased (Festy and Prioux, 2002). However, this raises the question of why this potential fertility bias occurs only among men. Moreover, the fact that the ENI yielded very low TFRs for men would be at odds with the hypothesis of over-estimated fertility levels. Nevertheless, the quality of male fertility data is an under-developed topic in

demographic studies and our estimates of male immigrants may therefore be less robust.

An indirect way of reassessing the discrepancy in the number of male immigrants is to compare the sex ratio in several data sources. If there was an over-count of immigrant men in the population register, their sex ratio would appear inflated when compared with the sex ratio from other sources. This is precisely what Table 3 shows. The sex ratio of immigrants in the population register is much high than those derived from the unweighted samples of National Immigrant Survey (ENI) and from the Labour Force Survey (EPA), carried out quarterly and based on nearly 200,000 interviews. After weighting, the ENI gives a sex ratio similar to that of the register for the ages considered, but this is because the survey sample is post-stratified precisely to ensure that its sex ratio is identical to that of the register, which we believe to be biased.

Table 3. Sex ratio of immigrants in the Municipal Population Register, the National Immigrant Survey (ENI) and the Labour Force Survey (EPA)

Data source	Sex ratio
2005-2006 Municipal population register, ages 20-49	1.22
2007-2008 Municipal population register, ages 20-49	1.19
2006-2007 ENI, ages 20-49 weighted	1.20
2006-2007 ENI, ages 20-49 unweighted	0.90
2005-2006 EPA, ages 16-44	1.02

Western European women and men (mostly from France, Portugal and Germany), and Romanian men were the groups with the highest ratio of registered-to-estimated numbers of immigrants. This result may be related to transnational residence patterns of some of these persons, which is facilitated by the fact that EU citizens are entitled to live and work in Spain without applying for a residence or work permit. We should also keep in mind that EU nationals are not affected by the legal reform requiring re-registration every two years and so they are more likely to be listed in the Spanish population register while not actually residing in Spain on a continuous basis. Our results may also point to high levels of temporary or seasonal migration, particularly for Romanians. The relative proximity between European nations makes these strategies much more feasible. In addition, if some Europeans residing temporarily or permanently in Spain choose to give birth and register their children in their country of origin, our estimates of the immigrant stock will be downward-biased and hence lower than the count in the population register. In these cases, neither the population register nor our fertility-based estimate of the immigrant population can capture this complex reality.

The opposite pattern, i.e. a ratio of register-to-estimated number of immigrants lower than one, is found for Ecuadorian men and women and African men, suggesting that these groups might be under-counted in the

population register, although observed differentials between the register count and the indirect estimate are not statistically significant.

Applying the proposed method to Spanish data has its limitations, however, in that the classification of births by parents' country of birth is available only from 2007, whereas the fertility estimate from the 2007 ENI survey corresponds to the period 2004-2006. We are thus assuming that immigrants' fertility did not change significantly over a two year period. If, for example, immigrants' TFR had declined by 10% in these two years, we would be under-estimating the number of immigrants by 10% and this would be an alternative explanation for the higher count of immigrant men in the population register. There are no indications, however, that this was the case. According to estimates of the National Institute of Statistics, the TFR for the foreign population actually increased slightly, from 1.34 in 2005 to 1.39 in 2007.

In sum, despite all the limitations mentioned, the indirect method proposed in this article has proved to be a useful tool to estimate the size of the immigrant population and to validate existing counts from the population register. The indirect method yielded results that suggest that the population register counts female immigrants accurately but that there is an over-count of male immigrants (in the order of 15%, although the confidence interval ranges from 4% and 26%). These estimates refer to 2007, and it is possible that over-registration diminished thereafter, as the procedure to remove from the records those immigrants who did not re-register after two years became more systematic. Nevertheless, our main message regarding the importance of validating population register data with external sources continues to be pertinent.

Acknowledgements. An earlier version of this article was presented at the 26th IUSSP International Conference, Marrakech, 27 September – 2 October, 2009. Financial support for this research from the Spanish Ministry of Science and Innovation, under projects CSO2008-03616/SOCI and CSO2009-11883/SOCI, is gratefully acknowledged. The authors also thank Andreu Domingo and the anonymous reviewers for their helpful comments.

APPENDIX

Age-specific fertility rates of immigrants in Spain 2004-2006 from the ENI and births to immigrant parents in the official vital statistics

	Immigrants' country of birth						
	Ecuador	Other Latin America	Morocco	Africa	Western Europe	Romania	Other Europe and Asia
Fertility rate							
Women							
Age 20-24	0.118	0.087	0.139	0.175	0.043	0.061	0.064
Age 25-29	0.056	0.075	0.202	0.123	0.086	0.084	0.104
Age 30-34	0.056	0.084	0.162	0.131	0.094	0.041	0.085
Age 35-39	0.033	0.050	0.128	0.139	0.058	0.019	0.018
Men							
Age 25-29	0.090	0.071	0.064	0.011	0.053	0.092	0.061
Age 30-34	0.042	0.072	0.091	0.069	0.108	0.080	0.056
Age 35-39	0.042	0.058	0.112	0.091	0.070	0.024	0.059
Age 40-44	0.028	0.030	0.149	0.046	0.024	0.020	0.023
Births							
To immigrant mothers							
Age 20-24	1,846	6,444	5,231	1,049	834	3,593	2,577
Age 25-29	3,176	9,451	5,844	2,134	2,037	3,895	4,658
Age 30-34	2,592	8,938	4,397	1,733	4,561	2,141	3,555
Age 35-39	1,356	4,942	2,692	750	3,428	684	1,397
To immigrant fathers							
Age 25-29	2,881	6,647	3,383	850	1,524	3,727	3,108
Age 30-34	2,495	7,130	5,985	1,795	4,608	3,083	3,491
Age 35-39	1,362	4,849	5,638	1,786	4,420	1,214	1,954
Age 40-44	593	2,109	3,126	1,106	1,928	223	757

Sources: ENI (2007) for immigrants, official vital statistics for Spaniards.

REFERENCES

- ARANGO J., 2000, "Becoming a country of immigration at the end of the twentieth century: The case of Spain", in King R., Lazaridis G., Tsardanidis C. (eds.), *Eldorado or Fortress? Migration in Southern Europe*, London, Macmillan, pp. 253-276.
- BEAN F. D., KING A. G., PASSEL J. S., 1983, "The number of illegal migrants of Mexican origin in the United States: Sex ratio-based estimates for 1980", *Demography*, 20(1), pp. 99-109.
- BORJAS G. J., FREEMAN R. B., LANG K., 1991, "Undocumented Mexican-born workers in the United States: How many, how permanent?", in Abowd J. M., Freeman R. B. (eds.), *Immigration, Trade, and the Labor Market*, Chicago, National Bureau of Economic Research, The University of Chicago Press, pp. 77-100.
- CASTRO-MARTÍN T., ROSERO-BIXBY L., 2011, "Maternidades y fronteras. La fecundidad de las mujeres inmigrantes en España", in Reher D., Requena M., Sanz-Gimeno A. (eds.), *La inmigración en España: perspectivas innovadoras*, special issue of the *Revista Internacional de Sociología*, 69(M1), pp. 105-138,
<http://revintsociologia.revistas.csic.es/index.php/revintsociologia/article/view/388/398>
- CEBOLLA H., GONZÁLEZ-FERRER A., 2008, *La inmigración en España (2000-2007). De la gestión de flujos a la integración de los inmigrantes*, Madrid, Centro de Estudios Políticos y Constitucionales, 318 p.
- DEVOLVER D., DOMINGO A., GARCÍA J., 2003, "Fecundidad diferencial y potencial de reagrupación familiar de la población extranjera de la Comunidad de Madrid a partir del Padrón continuo a 1/1/1999", Bellaterra, Centre d'Estudis Demogràfics, *Papers de Demografia*, 224, 32 p.,
<http://www.ced.uab.es/publicacions/ArticlesPDF/Text224.pdf>
- EFRON B., TIBSHIRANI R. J., 1993, *An Introduction to the Bootstrap*, New York, Chapman & Hall/CRC, 443 p.
- EUROSTAT (2009), *Europe in Figures. Eurostat Yearbook 2009*, Luxemburg, European Communities,
http://epp.eurostat.ec.europa.eu/portal/page/portal/publications/eurostat_yearbook
- FESTY P., PRIoux F., 2002, *An Evaluation of the Fertility and Family Surveys Project*, Geneva, United Nations, United Nations Publication number G.V.E.01.II.E.23, 74 p.
- GONZÁLEZ-ENRÍQUEZ C., 2009, "Spain, the cheap model. Irregularity and regularisation as immigration management policies", *European Journal of Migration and Law*, 11(2), pp. 139-157.
- GONZÁLEZ-FERRER A., 2009, *Country Report Spain, Promoting Comparative Quantitative Research in the Field of Migration and Integration in Europe* (PROMINSTAT), 26 p.,
http://ec.europa.eu/ewsi/UDRW/images/items/doc1_9019_550544131.pdf
- GONZÁLEZ-FERRER A., CORTINA C., 2011, *Naturalization decisions in Spain. The importance of legal asymmetries*, Paper presented at the Annual Meeting of the Population Association of America, Washington DC, March 31 - April 2, 2011,
<http://paa2011.princeton.edu/download.aspx?submissionId=112356>
- INSTITUTO NACIONAL DE ESTADÍSTICA (INE), 2008, *Metodología general de la Encuesta Nacional de Inmigrantes*, 34 p.,
http://www.ine.es/en/daco/daco42/inmigrantes/inmigra_meto_en.pdf

- INSTITUTO NACIONAL DE ESTADÍSTICA (INE), 2009, *Encuesta Nacional de Inmigrantes 2007: una monografía*,
<http://www.ine.es/prodyser/pubweb/eni07/eni07.htm>
- IZQUIERDO A., LÓPEZ DE LERA D. (eds.), 2006, *Demografía de los extranjeros: incidencia en el crecimiento de la población*, Bilbao, Fundación Banco Bilbao Vizcaya Argentaria, 333 p.
- MARTIN P., 2009, "Recession and migration: A new era for labor migration?", *International Migration Review*, 43(3), pp. 671–691.
- MORENO FUENTES F. J., 2005, *The Regularisation of Undocumented Migrants as a Mechanism for the 'Emerging' of the Spanish Underground Economy*, CSIC, Unidad de Políticas Comparadas, Working Article 05-06,
http://www.ipp.csic.es/en/content/the_regularisation_of_undocume
- MULLER T., ESPENSHADE T. J., 1985, *The Fourth Wave: California's Newest Immigrants*, Washington, D.C., The Urban Institute Press.
- POI B. P., 2004, "From the help desk: Some bootstrapping techniques", *Stata Journal*, 4(3), pp. 312–328.
- REHER D., SILVESTRE J., 2009, "Internal migration patterns of foreign-born immigrants in a country of recent mass immigration: Evidence from new micro data for Spain", *International Migration Review*, 43(4), pp. 815–849.
- REHER D., REQUENA M., 2009a, "The National Immigrant Survey of Spain: A new data source for migration studies in Europe". *Demographic Research*, 20(12), pp. 253–278,
<http://www.demographic-research.org/Volumes/Vol20/12/20-12.pdf>
- REHER D., REQUENA M. (eds.), 2009b, *Las múltiples caras de la inmigración en España*, Madrid, Alianza Editorial, 321 p.
- REHER D., REQUENA M., SANZ-GIMENO A. (eds.), 2011a, *La inmigración en España: perspectivas innovadoras*, special issue of the *Revista Internacional de Sociología*, 69(M1), 292 p.,
<http://revintsociologia.revistas.csic.es/index.php/revintsociologia/article/view/385/395>
- REHER D., REQUENA M., SANZ-GIMENO A., 2011b, "¿España en la encrucijada? Consideraciones sobre el cambio de ciclo migratorio", in Reher D., Requena M., Sanz-Gimeno A. (eds.), *La inmigración en España: perspectivas innovadoras*, special issue of the *Revista Internacional de Sociología*, 69(M1), pp. 9–44,
<http://revintsociologia.revistas.csic.es/index.php/revintsociologia/issue/view/29>
- RENDALL M. S., CLARKE L., PETERS E., RANJIT N., VERPOULOU G., 1999, "Incomplete reporting of men's fertility in the United States and Britain: A research note", *Demography*, 36(1), pp. 135–144.
- ROBINSON J. G., 1980, "Estimating the approximate size of the illegal alien population in the United States by the comparative trend analysis of age-specific death rates", *Demography*, 17(2), pp. 159–176.
- ROIG, M. AND CASTRO MARTÍN, T. (2007), "Childbearing patterns of foreign women in a new immigration country, The case of Spain". *Population, English Edition* 62(3), pp. 351–380.
- RÓDENAS CALATAYUD, C. AND MARTÍ SEMPERE, M. (2009), "Estimating false migrations in Spain", *Population, English Edition* 64(2), pp. 361–376.
- ROSETO-BIXBY L., BRENES G., CHEN M., 2002, "Fecundidad diferencial e inmigrantes nicaragüenses en Costa Rica", *Notas de Población*, 74, pp. 27–52,
http://www.eclac.org/publicaciones/xml/6/11066/lcg2148p_3.pdf
- STATA CORP., 2007, *Stata Statistical Software: Release 10*, Texas, College Station, Stata Corporation.
- UNITED NATIONS, 1983, *Manual X: Indirect Techniques for Demographic Estimation*, New York, United Nations, Department of International Economic and Social Affairs.
- ZABA B., 1985, *Estimación de la emigración mediante la utilización de técnicas indirectas*, Liège, Ordina Editors/IUSSP, 170 p.

Luis ROSERO-BIXBY, Teresa CASTRO-MARTÍN, David REHER, María SÁNCHEZ-DOMÍNGUEZ
• ESTIMATING THE NUMBER OF IMMIGRANTS IN SPAIN: AN INDIRECT METHOD BASED ON BIRTHS AND FERTILITY RATES

This article proposes an indirect method to validate existing estimates of immigrants' stock from the Spanish municipal population register, which some believe might be over-counting immigrants who double register in different municipalities or fail to deregister when leaving the country. The proposed method uses two pieces of information: births to immigrants and their fertility rates. Data on births by parents' origin come from the Spanish birth registry; fertility rates are estimated with data from the 2007 National Immigrant Survey. For female immigrants, the indirect estimate does not differ significantly from the count in the register, which can be taken as a validation of both sources. Among men, however, the population register counts 15% more immigrants than the indirect estimate, and this difference is statistically significant. Western European men and women, and Romanian men are immigrant groups with substantial and statistically significant excess count in the population register compared to this article's estimate. The opposite pattern, i.e. ratio of register-to-estimated number of immigrants lower than one, is found for Ecuadorian men and women and African men, suggesting that these groups might be under-counted in the population register, although the observed differentials are not statistically significant.

Luis ROSERO-BIXBY, Teresa CASTRO-MARTÍN, David REHER, María SÁNCHEZ-DOMÍNGUEZ
• ESTIMATION INDIRECTE DU NOMBRE D'IMMIGRÉS EN ESPAGNE À PARTIR DES TAUX DE FÉCONDITÉ ET DES NAISSANCES

Cet article propose une méthode indirecte pour valider les décomptes du nombre d'immigrés en Espagne établis à partir des registres municipaux de population, qui pourraient surestimer le nombre d'immigrés du fait de doubles enregistrements et de défauts de radiation en cas de départ du pays. La méthode proposée utilise deux types d'informations : le nombre de naissances issues d'immigrés et leurs taux de fécondité. Les statistiques de naissances par origine des parents proviennent de l'état civil espagnol ; les taux de fécondité sont estimés à partir de l'Enquête nationale sur les immigrés de 2007. Pour les femmes, l'estimation indirecte ne diffère pas significativement du décompte dans le registre, ce qu'on peut considérer comme une validation des deux sources. Pour les hommes, le registre de population dénombre 15 % d'immigrés de plus que l'estimation indirecte, avec un écart statistiquement significatif. Comparés aux estimations proposées dans cet article, les dénombrements des hommes et femmes provenant d'Europe occidentale et des hommes de Roumanie présentent un excédent important et statistiquement significatif. À l'inverse, le rapport dénombrement / estimation est inférieur à 1 pour les hommes et femmes d'Equateur et les hommes d'Afrique, ce qui suggère un sous-enregistrement de ces groupes par le registre de population, bien que les écarts ne soient pas statistiquement significatifs.

Luis ROSERO-BIXBY, Teresa CASTRO-MARTÍN, David REHER, María SÁNCHEZ-DOMÍNGUEZ
• ESTIMACIÓN INDIRECTA DEL NÚMERO DE INMIGRANTES EN ESPAÑA A PARTIR DE LAS TASAS DE FECUNDIDAD Y DE LOS NACIMIENTOS

Este artículo propone un método de estimación indirecta para validar las cifras de inmigrantes en España establecidas a partir de los registros municipales de población, que podrían sobreestimar el número de inmigrantes a causa de las inscripciones dobles y de la ausencia de supresión del registro en caso de salida del país. El método propuesto utiliza dos tipos de información: el número de nacimientos de los inmigrantes y sus tasas de fecundidad. Las estadísticas de nacimientos según el origen de los padres provienen del estado civil; las tasas de fecundidad han sido estimadas a partir de la Encuesta nacional sobre los inmigrantes de 2007. Para las mujeres, la estimación indirecta no difiere significativamente de las cifras del registro, lo que se puede considerar como una validación de las dos fuentes. Para los hombres, la cifra del registro de población es 15% más elevada que la estimación indirecta, con una diferencia estadísticamente significativa (intervalo de confianza [4%-26%]). Comparadas con las estimaciones propuestas en este artículo, las cifras del registro para los hombres y las mujeres viniendo de Europa occidental y para los hombres de Rumanía presentan un excedente importante y estadísticamente significativo [26% a 35%]. Al contrario, para los hombres y mujeres de Ecuador y para los hombres de África el registro de población da resultados inferiores a las estimaciones indirectas, lo que sugiere un subregistro de estos grupos, aunque las diferencias no sean estadísticamente significativas.

Keywords: International migration, immigrant stock, indirect estimation techniques, Spain, population register, National Immigrant Survey, immigrant fertility