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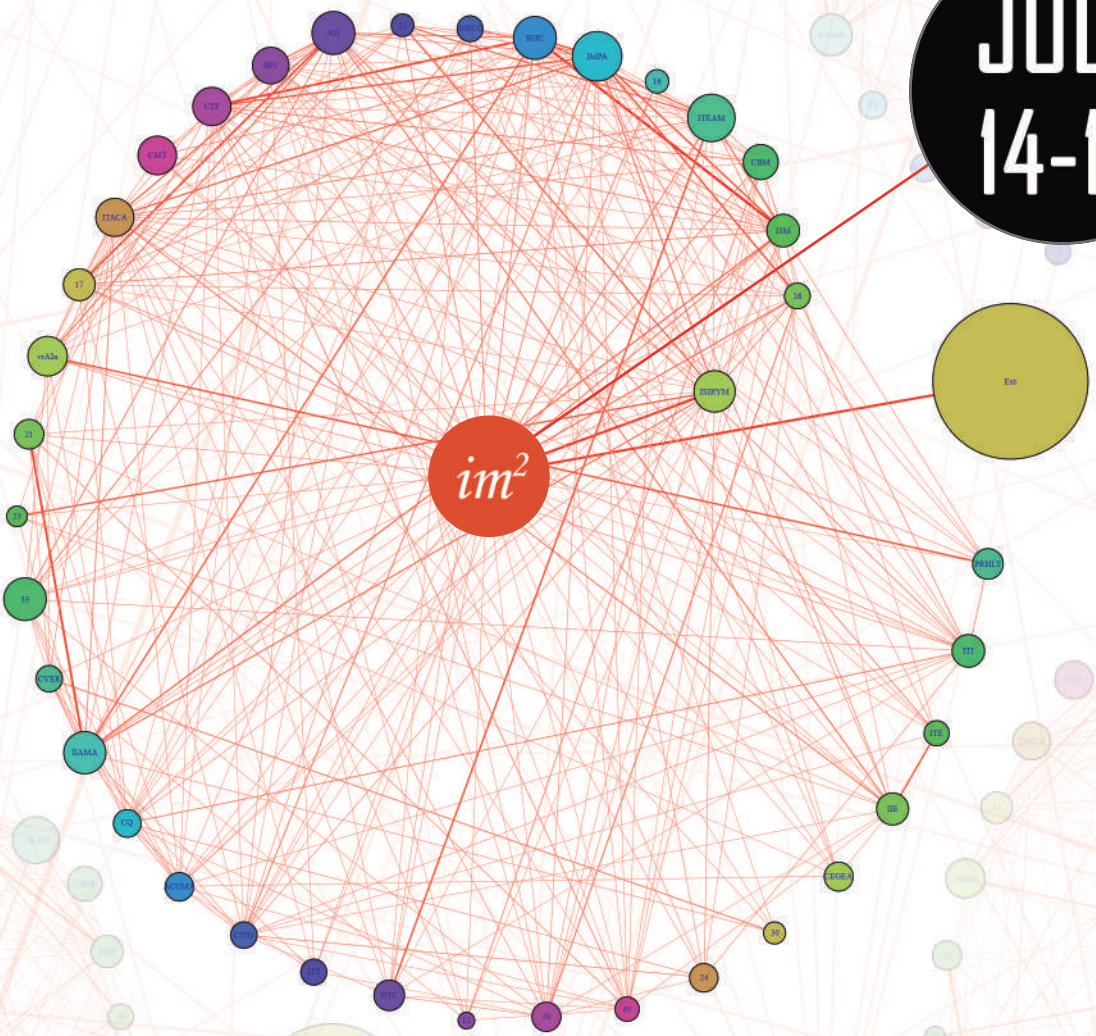

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Mathematical Modeling about Emigration/Immigration in Spain: Causes, magnitude, consequences

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1 Introduction

Recently, Spain has become one of the most important entry points for immigrants in Europe, causing usually humanitarian problems, due to people is taking the risk of losing their lives once they decide to cross the strait in those small boats, however these problems persist once they are able to get in Spain. There are also national security problems such as the ones occurred recently in Ceuta, even it was spoken about invasion of Spanish territory. These problems in most of the cases do not appear randomly, but they are encouraged by the interests of the sending countries or by the political relations between the sending and receiving countries.

In this context, it is important to point out that it is increasingly difficult to quantify this type of immigration. It has been distinguished two kinds of immigration; the legal and the irregular. It is also necessary to distinguish two kinds of irregular immigration, due to the problem that arises is different whether it is an adult, or panied man unaccominor. For that immigration population is divided into three compartments: unaccompanied immigrant minors (MENAS) $M(n)$, irregular immigrants $I(n)$ and regular immigrants $L(n)$, where n denotes the time step.

The aim of this paper is to build a discrete population model, described by a system of difference equations that allows to quantify the size of the immigrant population flow in Spain in a short period of time,

$$Z(n+1) = A(n) * Z(n) + W(n)\,, \tag{1}$$

where $Z(n+1) = [M(n), I(n), L(n)]^T$ and $A(n) \in \mathbb{R}^{3\times 3}$ and $W(n) \in \mathbb{R}^{3\times 1}$ will be defined later.

Starting from known initial data of the stratified population, in this case the second semester of 2018 [1] the objective of the present work is to estimate the population's variation from one semester to another, taking into account how some relevant factors could affect to this immigration

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flow. These factors are of economic type, [2] the economy is especially linked to legal immigration, because the better the economy of a country does, the job offers increase and therefore, the immigrant population is attracted, regulation laws, not all the governments of the country have the same policy regarding the problem and this, as it will be seen, influences the development of immigration, and the changes between the groups of migrant population. The sending countries, for instance Morocco, somehow end up using illegal immigration for political and economic purposes.

Once, it has been seen the populations and the study period, a series of hypotheses should be taken into consideration in order to obtain values which normally are uncertain, as in this type of problem there is no transparency in the data. In this case, it has been studied what has happened in the entry of illegal immigrants by sea during the last years, subsequently making a least squares adjustment, see figure 1, where it has been captured both the general trend and the peaks that have occurred on a specific basis.

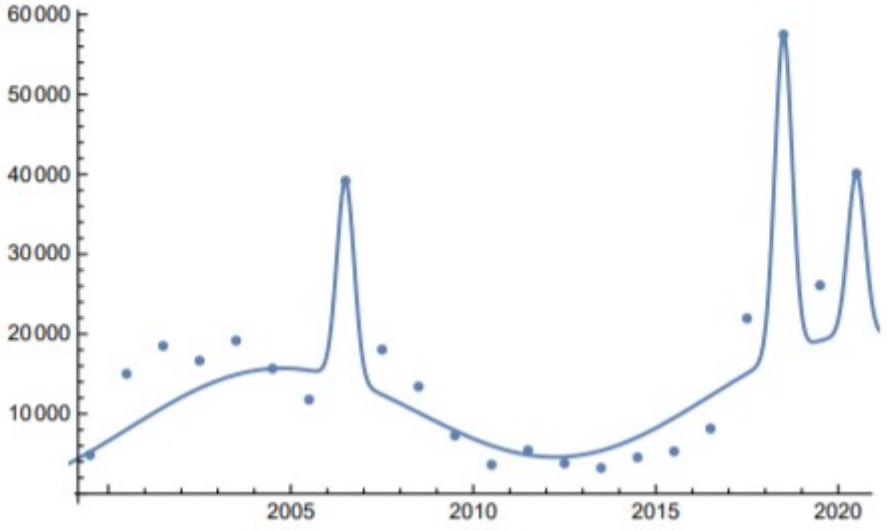

Figure 1: Least squares adjustment of the illegal immigration

It has been proposed a function that has a linear part, a periodic part as well as Gaussian exponential terms with very small standard deviation. This adjustment has allowed to estimate the inflows of illegal immigrants in future years.

$$\begin{aligned} f(x) = {} & 15.675 + a(x\text{–}2004,5)\text{–}b\left(\sin\left(\frac{\pi(x-2004.5)}{16}\right)\right)^2 \\ & + c\,e^{3(x-2006.5)^2} + d\,e^{3(x-2018.5)^2} + g\,e^{3(x-2020.5)^2}. \end{aligned} \tag{2}$$

These peaks which can be observed in the figure 2 match with moments of crisis, such as the crisis of the cayucos in 2006, the crisis of the Aquarius in 2018 or the migratory crisis that recently occurred in Ceuta. In addition, it has been observed that, recently, these crises occur with a shorter time of difference. On the horizontal axis, which is the temporal, it is pointed out in red

when the PSOE has governed in Spain, while in blue when the PP has governed. Assuming that from now on there will be no change of government.

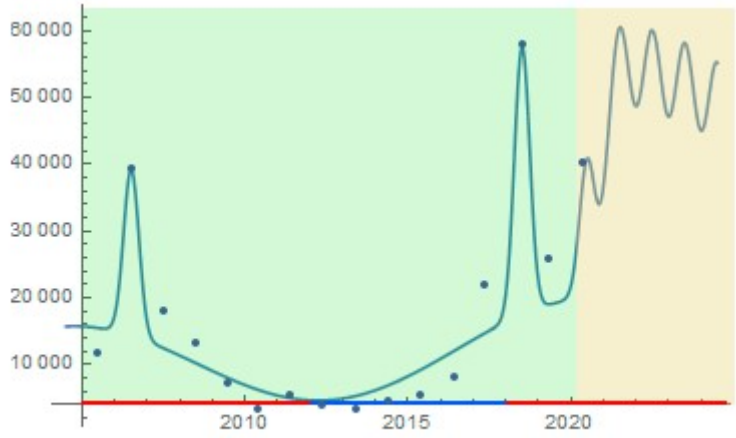

Figure 2: Least squares adjustment of the illegal immigration and prevision

In the model, constant coefficients have been considered although they are susceptible to variation. It is important to point out that since the values are uncertain, our model allows to study its sensitivity to these coefficients. Matrix $A(n)$ in (1) takes the form

$$A(n) = \begin{bmatrix} 1-\beta_{age} & 0 & 0 \\ 0 & 1-\beta_{legal} & 0 \\ \beta_{age} & \beta_{legal} & 1 \end{bmatrix} \tag{3}$$

where β_{legal} refers to the proportion of illegal immigrants who manage to legalize their situation from one semester to another. Making a bibliographic review, it has been concluded that a first estimate would be that 1 in 100 illegal immigrants become legal. Regarding the second coefficient, β_{age}, in this case it refers to the proportion of MENAS that become legal when they reach the age of majority. It has been estimated that 9 out of 100 MENAS became legal. It has been observed that among the MENAS there is an increasingly high percentage that is close to 18 years of age because they are interested in transitioning to legality. Obviously, it is a very difficult proportion to calculate among other things because of the difficulty of knowing the real ages.

Let us denote α_m as the relationship between the MENAS and the entries of illegal immigrants, it means, that in our case, it could be translated to out of every 10 illegal entries, 4 are MENAS. This estimate has been obtained taking into consideration recent historical data. According to new entries, as it has already been said, on one hand, we have those of illegal immigrants $B(n)$, and on the other hand, the net migratory balance of legal immigrants, whose term is $C(n)$ [1]

In the expression (1) the term $W(n)$ is:

$$W(n) = \begin{bmatrix} \alpha_m B(n) \\ (1-\alpha_m)B(n) \\ C(n) \end{bmatrix} \tag{4}$$

The semi-annual net migratory balance of legal immigrants is closely related to the economy. In this particular case, the economic indicator that it has been used, has been the unemployment rate. Referring to the case of illegal entries, it has been studied a recent historical data and subsequently an adjustment, in this case as linear, obtaining a correlation coefficient close to -1, which means that we have an almost functional relationship. In the figure 3 it is important to highlight that in this graph the abscissa axis is not time, but rather the percentage of unemployment.

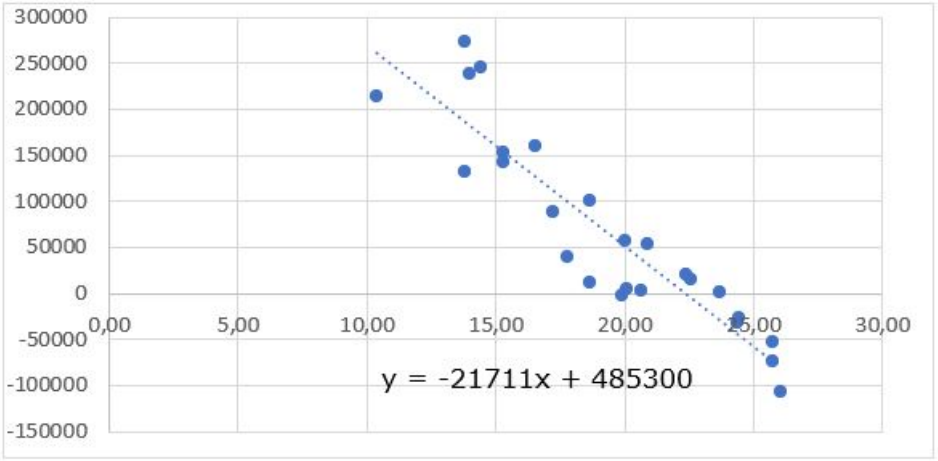

Figure 3: Adjustment of the legal immigration and economy

Therefore, taking into consideration the institutions' forecasts on the unemployment rate, it was possible to forecast the migratory balance in the future, [3]. In the other hand, the population of MENAS from the beginning of the study to the present, it has been multiplied approximately by three, however the expectations are that it will be multiplied by 10 by the end of 2025. Moreover, as it already was mentioned previously, due to some values are uncertain, it is important to highlight that it is possible to study the sensitivity of the model, to the variation of the coefficients.´

In the graphic 4, it can be seen the specific example of the β_{age}, coefficient, which, as it was commented, is the proportion of MENAS that transition to legal status when they reach the age of majority. However, this study could also be carried out on the rest of the coefficients. In this case, where it has been assumed that 9 out of 100 MENAS become legal when they reach the age of majority, it means 9% it has been applied a range of variability between 6% and 12%. It is also observed that the model is robust against this coefficient, because of the small variations in the coefficient lead to small changes in the results.

Taking into consideration the population of MENAS obtained previously in each period and the cost that this would entail, it could be estimated the necessary budget to meet this social need. In this particular case, it has been made a downward estimate of € 2000 / month, due to this cost is

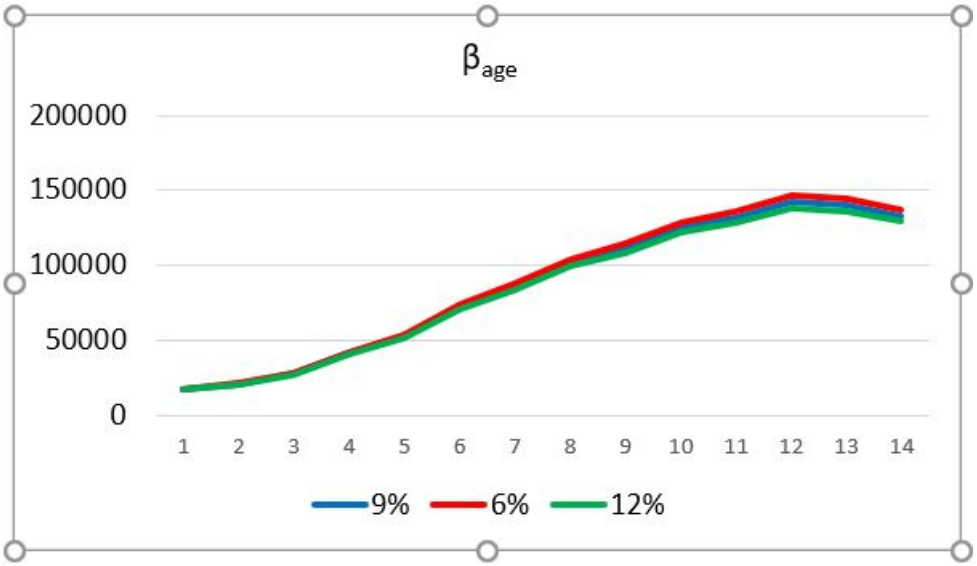

Figure 4: Sensitivity on the coefficient β_{age}

not uniform throughout the country, because it depends on the different autonomous communities. Therefore, in this study, it has not been taken into consideration the amount of deportation of immigrants, which currently is around € 1600 per person. Getting at the end of the studied period, it could be reached the figure of 2000 million euros. For instance, in order to get an idea, the state budget for this year 2021, destined to student scholarships is around 2000 million euros and the one destined to the vital minimum of 3000 million euros [4]

2 Conclusions and future work

In the first place, the increase in the legal immigrant population is related to the economic situation in which Spain finds itself. Second, following a series of hypotheses, the estimated population has been obtained in a short period of time from the different study subpopulations, these data is providing the possibility to estimate the economic cost that this entails for the country. On the other hand, it is unquestionable that the peaks in the entry of immigrants depend fundamentally on specific political events or intentions. Finally, it is important to point out that the model is exportable to other scenarios, taking into consideration the peculiarities of borders and policies between countries.

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