UNIVERSITAT JAUME I

Regional changes in bone marrow donations: the government role

by

Julia Mateo González
al285545@uji.es

Supervised by

Maite Alguacil Marí

A thesis submitted in partial fulfillment for the degree in economics in the

Facultat de Ciències Jurídiques i Econòmiques
Department of economy

May 31, 2017

Declaration of Authorship

I, Julia Mateo González, declare that this thesis titled, 'Regional changes in bone marrow donation: the government role' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a bachelor degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: ____

Date: ____

“Siempre existe en el mundo una persona que espera a otra, ya sea en medio del desierto o en medio de una gran ciudad. Y cuando estas personas se cruzan y sus ojos se encuentran, todo el pasado y todo el futuro pierde su importancia por completo, y sólo existe aquel momento y aquella certeza increíble de que todas las cosas bajo el sol fueron escritas por la misma Mano. La Mano que despierta el Amor, y que hizo un alma gemela para cada persona que trabaja, descansa y busca tesoros bajo el sol. Porque sin esto no habría ningún sentido para los sueños de la raza humana”

Paulo Coelho

Abstract

Leukemia is a very particular case of illness, where a donor can greatly improve the life expectancy of the patients. According to Kater et al. (2014) promotions campaigns are necessary for recruiting potential donors and thus to increase the likelihood that a leukemia patient will find a compatible marrow for a successful treatment of her disease. Since the creation of the Bone Marrow Donor Registry (REDMO from the Spanish name) more than 25 years ago (by the Josep Carreras Foundation and the collaboration of the Spanish Ministry of Health), Spain stands as one of the countries where these donations have a more pronounced trend. Recently, this growth has been accentuated following the approval of the National Bone Marrow Plan in 2013. The aim of this paper is to analyze to what extent a greater government intervention, in terms of health expenditure and/or the establishment of new information centers, influences the number of donors and hence the probability of potential matches for a bone marrow transplant. With this purpose, we estimate a Poisson model using panel data for the Spanish Autonomous Communities during the period 2010-2015. In this estimation, we have also taking into consideration other factors that may influence marrow donations, such as education and per capita income. Our findings show a positive and significant effect of the health expenditure on the number of donations across communities. However, the effect of opening a new information center is negative. This is probably because the general population uses other media in order to get information about bone marrow donations. We also find a positive influence of GDP and education per capita.

Keywords: bone marrow donors, health expenditure, GDP per capita, education level.
JEL Classification: I10, I18, H76

Acknowledgements

I want to thank Maite Alguacil Marí for its patience and recommendations as my supervisor.

And, the most important thank you goes to my family, they have been helping me for a long time before this thesis, with their unconditional support and patience, and I am sure that will keep on with it, I would surely not be where I am without them.

Contents

List of Figures

List of Tables

Abbreviations

GDP	**G**ross **D**omestic **P**roduct
INE	**I**nstituto **N**acional de **E**stadística
INEGI	**I**nstituto **N**acional **de** **E**stadística, **G**eografía e **I**nformática
MECD	**M**inisterio de **E**ducación, **C**ultura y **D**eporte
MSASI	**M**inisterio de **S**anidad, **A**suntos **S**ociales e **I**gualdad
OECD	**O**rganization for **E**conomic **C**o-operating and **D**evelopment
ONT	**O**rganización **N**acional de **T**ransplantes
PCT	**P**rimary **C**are **T**rust
REDMO	**R**egistro de **D**onaciones de **M**édula **Ó**sea
SEOM	**S**ociedad **E**spañola de **O**ncología **M**édica

Dedicated to my family, specially to my son Pablo

Chapter 1

Introduction

Leukemia is a special kind of cancer where a bone marrow donor can improve or even completely cure the illness against leukemia, according to the data provided by *Fundación Josep Carreras* against leukemia. There are more than one kind of leukemia, such as LMA, that after being treated first with chemotherapy and then with bone marrow transplant, the 99 per cent of the patients achieve full recovery of the disease and the 85 per cent of the patients have add 5 years to their life expectancy (*Fundación Josep Carreras*, 2017). This paper aims to study a modern topic, very important in social concern, which is bone marrow donations. The question that we make and that we try to answer are which factors determine the donations of bone marrow and how government may influence these donations? To do that we empirically study the relationship between health expenditure and bone marrow donors enrolled in REDMO (*Registro de Donaciones de Médula Ósea*). This analysis uses annual data on 17 Spanish autonomous communities from 2010 to 2015. The autonomous communities of Ceuta and Melilla are not considered because of their low level of significance.

Despite their importance and the low aggressiveness of the treatment, there are few donations of bone marrow. It may be due to lack of information. It is very common for people not to know what becoming a bone marrow donor implies, but it is way less intrusive than people think. The first step is getting information through the information centers or the web pages provided by *Organización Nacional de Trasplantes y de la Fundación Internacional Josep Carreras* (REDMO). Once a person has decided to donate, she has to go to the reference center where a blood test will be carried out and then the consent will be signed. If everything is in order and you are accepted as a donor, the donor will receive a letter in his house confirming his registration on the world record of bone marrow donors.

Then, if a person affected by any disease that can be cured through bone marrow needs it and the donor is compatible, using a syringe a little bit of bone marrow blood is extracted from the hip. Of course, this is done under the effects of anesthesia. Usually, people think that the bone marrow donation is like a kidney donation, where the intervention is much more aggressive and ends with the loss of a vital organ (*Fundación Renal Iñigo Álvarez de Toledo*, 2017). Since the creation of the Bone Marrow Donor Registry (REDMO from the Spanish name) more than 25 years ago (by the Josep Carreras Foundation and the collaboration of the Spanish Ministry of Health), Spain stands as one of the countries where these donations have a more pronounced trend. Recently, this growth has been accentuated following the approval of the National Bone Marrow Plan in 2013.

After researching the existing literature that analyses the effect that a rise on the health expenditure has on life expectancy, it is noteworthy the lack of information regarding the case on bone marrow donations. According to the studies carried on by the *Fundación Josep Carreras*, these donations have a fundamental role on curing leukemia (F. Carreras, 2016). This thesis aims to advance on this issue and more specifically on the literature that relates to an efficient expenditure with the quality of life of the population. While doing so it will try to answer whether a rise on health expenditure by the governments implies an increase on donations, so that more people affected by leukemia can get a transplant and get cured or at least improve their quality of life.

According to Evans and Pritchard (2000), cancer is one of the biggest problems on developed countries, and fighting it has become one of the priorities of governments. In Spain, the number of people affected by cancer has exceeded the estimations that had been made for the year 2020 (Lucio, 2017). The last report of the *Sociedad Espanõla de Oncología Médica* (SEOM) of 2015, states that in our country 247771 new cancer cases were registered, exceeding by more than one thousand cases the predictions based on demographic growth. That same report shows that in the last 20 years cancer cases have raised, specialists warns that this due to the raise in population, the maturity of the population and to the new techniques that allow us to detect this illness sooner. However, it also states that in these two past decades the mortality index has been decreased. As reported by Jurado et al. (2012), nowadays 50 per cent of the people affected by cancer survives it.

An example that reveals the importance of social networks in marrow donations is the viral phenomenon of Pablo Ráez. A leukemia patient who got bone marrow donations in Málaga and Andalucía to increase by 1000 per cent. For everything stated above it is within my understanding that a study on the impact of health expenditure regarding information campaigns on bone marrow donations is very important. Additionally, and to the best of my understanding, a study of this kind has never been done. Our findings show a positive and significant effect of the health expenditure on the number of donations across communities. However, we obtain that once this effect has been considered, that the opening of new information centers in the different communities is not compensated by the historical trajectory of donations across autonomous communities.

This paper is organized in the following sections. In the second chapter, we present a review of the literature in this topic. In the following chapter, we try to explain the evolution of the most important variables over time. In the fourth chapter, we make a detailed description of our data description with summary statistics. We also describe the methodology used, the model specification and results obtained. Finally, we present the conclusions on which we justify the result obtained and encourage to carry out more extensive and deeper studies.

Chapter 2

Literature review

According to Evans and Pritchard (2000), one of the main concerns that governments and the general population has been how to improve the quality of life of cancer affected people. What is more, the main focus has been on hematopoietic cancer. It is the cancer originated in the bone marrow commonly known as leukemia. This disease affects young people between 0 and 19 years old, according to the data provided by *Instituto Nacional de Estadística, Geografía e Informática* (INEGI). Despite being a common disease, and to the best of my knowledge, there are not studies done on this topic. The literature that seems to us to be closer to our subject is the influence of economic factors on the life expectancy of the population. For this reason, we have found it interesting to review the following papers. These can be divided into four groups.

In the first group, we find the study of Lichtenberg (2004) that studies the influence in the cure of diseases when the pharmaceutical companies develop new drugs. In the second group are classified studies by Crémieux et al. (1999), Nixon and Ulmann (2006), Jaba et al. (2014), Martin et al. (2008) and Cutler et al. (2006). These authors study the impact of increased health expenditure on life expectancy and child mortality. In the third group, it is worth noting the work done for the OECD countries. These paper study how to measure life expectancy and the relationship between health care expenditure and income. The authors are Mohan and Mirmirani (2007) and, Baltari and Moscone (2010). And in fourth group, Evans and Pritchard (2000) and Bayari et al. (2013), that focus on the comparison of different regions on the investment in health and the increase of the life expectancy.

The influence of the pharmaceutical companies.

Lichtenberg (2004), estimates models of cancer mortality using annual longitudinal data, cancer-site-level, for 2.1 million people diagnosed with cancer during the period of 1975-1995. Lichtenberg (2004) concludes that the effect of new drugs against cancer seem to have lengthen the life of the patients in around one year, ceteris paribus. The conclusion has an additional note saying that in that additional year the quality of life might not have been very good. The cost of this additional year is under $3000.

The impact of increased health expenditure on life expectancy and child mortality.

Crémieux et al. (1999), analyses the impact that increase on health expenditure has on the life expectancy and child mortality on ten Canadian provinces over the period of 1978-1992, that is a total of 15 years. This model concludes that despite the difference of health expenditure per capita between the different Canadian provinces although small, it is significant when determining the life expectancy and the child mortality rates. A reduction of a 10 per cent on health expenditure can be tied to a child mortality rate bigger than 0.5 per cent on men and 0.4 per cent on women, as well as a life expectancy reduction of around 6 months on women and 3 months on men. Nixon and Ulmann (2006), studies the relationship between total health care expenditure and health outcomes. It uses life expectancy and infant mortality as the dependent variable for 15 members of the European Union over the period of 1980-1995, using a fixed effects model with panel data. The conclusion of this study is that even though a rise on health expenditure can be tied to a child mortality, the relation with life expectancy is only marginal. Jaba et al. (2004), determines the factors that increase mortality or reduce life expectancy. In this paper review the factors that over time have led to a reduction in mortality. The data are collected for 175 world countries grouped according to its geographical region and income level per capita over a period of 16 years, 1995-2010. This study confirms that the inequality in health expenditure explains the different results of health systems for the distinct groups of countries defined by their income level and their geographical situation. One of the conclusions of this paper is that for developed countries, the health expenditure per capita rose significantly together with an increase of longevity. The results of this investigation show that the variation on health expenditure per capita is more important between developed countries and developing countries. A second conclusion is that the health policies should focus on reduce the inequality between the countries of the world. Martin et al. (2008), uses data of the budget of programs prepared by 295 English Primary Care Trusts (PCT) to model the link between two specific attention programs: cancer and circulatory system diseases. The authors try to study how a good assignment of resources entails a reduction on the cost of both programs, with the use of instrumental variables. The conclusion of this paper is that health expenditure has a strong positive effect in both studied programs. Cutler et al. (2006), presents a review of the determinants of the mortality. The conclusion is that, as a country invests in medical care, mortality is decreasing. There are others factors that over time have had an impact on life expectancy increase, such as vaccines, public health, and a higher level of education.

OECD countries.

In the third group, Mohan and Mirmirani (2007) analyze, using panel data, the importance that multiple economic factors and social have when measuring life expectancy when born and child mortality. This analysis is carried out on 25 OECD countries, excluding Korea, Luxembourg, Norway, Slovak Republic, and Turkey due to the lack of some observations during the period of 1990-2002. The empirical results show that a rise on health care expenditure per capita increments the life expectancy but has no impact over child mortality. At the educational level was significant at the 5 per cent. As a conclusion, the empirical results of this study suggest that the levels of education, more specifically the education of the mothers that take care of the children, are highly significant on life expectancy as well as in child mortality reduction. Baltari and Moscone (2010), using panel data study the long-run economic relationship between health care expenditure and income in 20 OECD countries during the period of 1971-2004. Specifically, in this paper, the non- stationary and co-integration properties between health care expenditure and income per capita in a panel data context that controls both cross-section dependence and unobserved heterogeneity is studied. The results show that health care is not a luxury it is a necessity.

Comparison of different regions on the investment in health and the increase of the life expectancy.

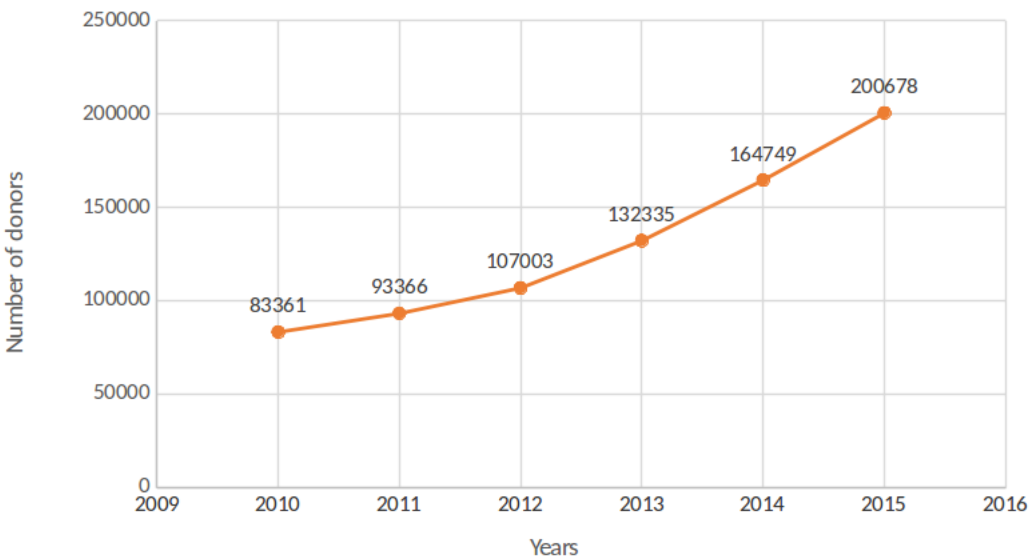
Evans and Pritchard (2000), focuses on a comparison of England, Gales, USA, Denmark, Netherlands, Finland, France, Italy, Spain, and Switzerland over the period of 1980-1990, focusing on cancer survival rates and GDP expenditure on health. It concludes saying that due to the low health expenditure on England and Gales, the survivability rates for people with cancer are below the rest of industrialized countries. Bayati et al. (2013), centers its attention to the Eastern Mediterranean Region, and studies the determinant of life expectancy through a health production function, based on the theoretical model by Grossman (1972). The main purpose of the Grossman model is that we can think of health as if it was a long-lasting stock that produces healthy living time. Supposedly individuals inherit an initial stock of health that loses its value with age, but that can be rose with an investment on health. Panel data is used to determine the link between health expectancy, economical, social and environmental factors. This data is from 21 countries from Eastern Mediterranean Region between 1995 and 2007. A fixed model effect is used. The main conclusion of this study is that, to improve the health on those countries, the ones in charge of health policies should also focus factors that are outside the health system. It would be very interesting that health policies had productivity, economic growth and a decrease on unemployment were the focus to improve population health quality.

Chapter 3

Donations of bone marrow in Spain

In this chapter, we show some stylized facts about donation of bone marrow in Spain. Figure 3.1 represents the number of donors registered on REDMO through the years. This data is from Spanish autonomous community during the period of 2010-2015[1].

FIGURE 3.1: Bone marrow donors over the years.



Source: Own elaboration based on the *Fundación Josep Carreras* website.

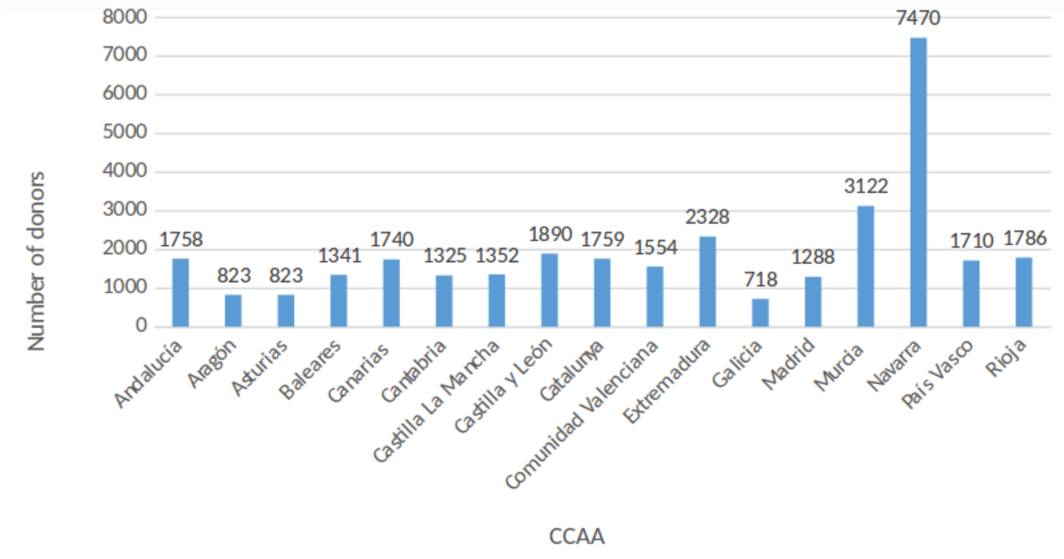
The data has been provided by the web page of *Fundación Josep Carreras*. As we can see on Figure 3.1, the growth of bone marrow donors has a positive tendency. According to the data in 2010 there were only 83361 donors and 5 years later, in 2015 there are

[1] This variable measure the number of donors per 100000 inhabitants.

200678. Thus, there has been a growth of 117317 donors in 5 years, that is a growth of 41.54 per cent. It is also noteworthy seeing how the *Plan Estratégico de Donación de Médula Ósea*, approved in 2013, affects the number of donors on the period of 2013-2014. The main objective of this plan was, among others, provide accurate information about bone marrow donations to the population, so that they could become donors knowing what it implies.

The total number of bone marrow donors for 2015 across autonomous communities is shown in Figure 3.2. This data, is the number of donors per 100000 inhabitants and by autonomous community. As can be appreciated, the analysis by autonomous community is unequal for the whole Spanish territory. The graph shows that the autonomous community that has a higher number of donors is Navarra, ahead of the rest with over 7470 donors per 100000 inhabitants, this represents the 22.78 per cent of the total of donors. In second place we find Murcia with 3122 donors per 100000 inhabitants, 9.52 per cent of the total and then Extremadura with 2328 donors per 100000 inhabitants a 7.10 per cent of the total. There is a big difference between Navarra and the next two communities in terms of number of donors. This data has been obtained through the *Fundación Josep Carreras* website.

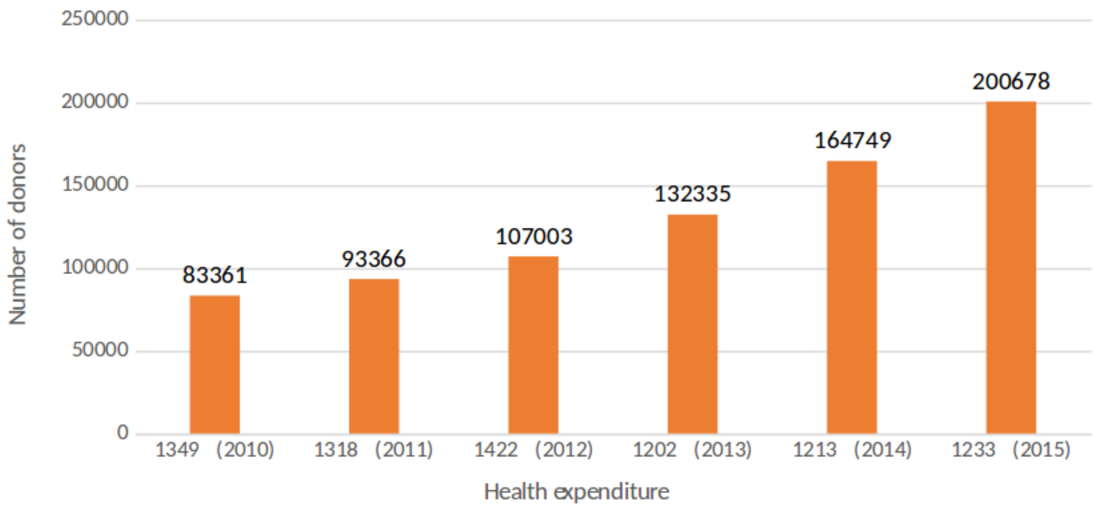
FIGURE 3.2: Total bone marrow donors in 2015.



Source: Own elaboration based on the *Fundación Josep Carreras* website.

In Figure 3.3 we can see the evolution that health expenditure per capita has had over the last 6 years. Health expenditure is expressed as thousands of euros per capita. This variable represents the expenditure that the government makes in health per habitant and for autonomous community. As seen in Figure 3.3, during the years 2010, 2011 and 2012 there is a rise on the yearly health expenses and a rise on the number of donors. However, we can see that in 2013 there is an important reduction on health expenditure but despite of that the number of donors keeps growing. We can see that, in 2013, in spite of the fact there is an important reduction on health expenditure, the number of donors keeps growing. Indeed, this tendency is always positive regardless of the government expenditure[2].

FIGURE 3.3: Number of donors respect to the total heath expenditure per year.



Source: Own elaboration based on *Ministerio de Sanidad, Asuntos Sociales e Igualdad* website.

The number of information centers is the second variable of interest, as long as, it reflects the commitment of the authorities to bring bone marrow donation to the citizen. According to Table 3.1 there is not a direct connection between the number of information centers and the number of donors.

[2]This data has been extracted from *Ministerio de Sanidad, Asuntos Sociales e Igualdad* website.

TABLE 3.1: Number of information centers and total bones marrow donors 2015.

Community	**Number of centers**	**Number of donors**
Andalucía	9	1758
Aragón	1	823
Asturias	1	1658
Baleares	1	1341
Canarias	3	1740
Cantabria	1	1325
Castilla la Mancha	1	1352
Castilla y León	14	1890
Catalunya	12	1759
Comunidad Valenciana	13	1554
Extremadura	2	2328
Galicia	14	718
Madrid	1	1288
Murcia	2	3122
Navarra	1	7470
País Vasco	4	1710
Rioja	1	1786

Source: Own elaboration based on the *Fundación Josep Carreras* website.

For example, in Galicia, the number of information centers is 14 but the number of donors is as low as 718, the lowest of all autonomous communities. We can also see that Navarra the autonomous community that has the higher number of donors, a total of 7470, there is only one information center. This can be due to the tools that are used to convince people to become bone marrow donors are, according to *Organización Nacional de Transplantes* (ONT, 2012), not only the information centers in each autonomous community but some other media:

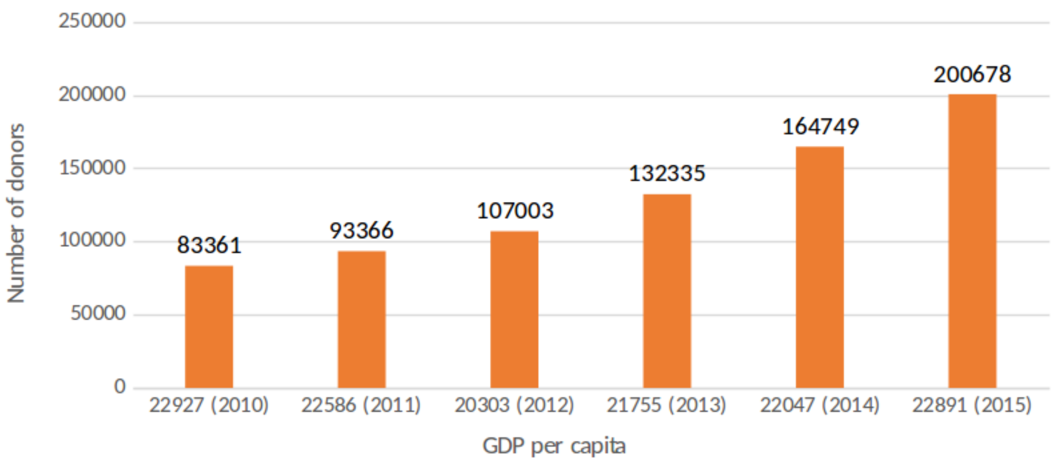
- Web pages from *Organización de Transplantes, Fundación Internacional Josep Carreras-REDMO*, *Conserjerías de Sanidad* of the autonomous communities and the *Asociaciones de Pacientes y Donantes*.
- Posters on health centers, such as hospitals, in blood transfusion centers and other public and private centers such as sport facilities and workplaces.

- Pamphlets with all the information available on web pages that can be easily send via e-mail. Also printed pamphlets that can be distributed on special events.
- The existence of patient associations or donor associations that collaborate with autonomous communities or with *Organización Nacional de Transplantes* if they act in more than one community.

Because of these and other factors, we find that there are autonomous communities that traditionally have an average of above or below average donors, as Andalucía, Cantabria, Castilla-La Mancha, Castilla y León, Navarra y País Vasco. (Antena 3, 2015). However, given the impossibility of measuring these factors we have not included them in our empirical model.

In Figure 3.4, we can see the evolution of bone marrow donors with respect the GDP per capita per year. This variable is expressed in thousands of euros[3]. This graph shows that in the year 2010, even though the GDP per capita is the higher for these series, the number of donors is lower than in any other year where the GDP per capita is lower. The conclusion of this graph is that the income level of a person or community is not important to determine if that person will become a bone marrow donor.

FIGURE 3.4: Number of donors respect to the GDP per capita per year.

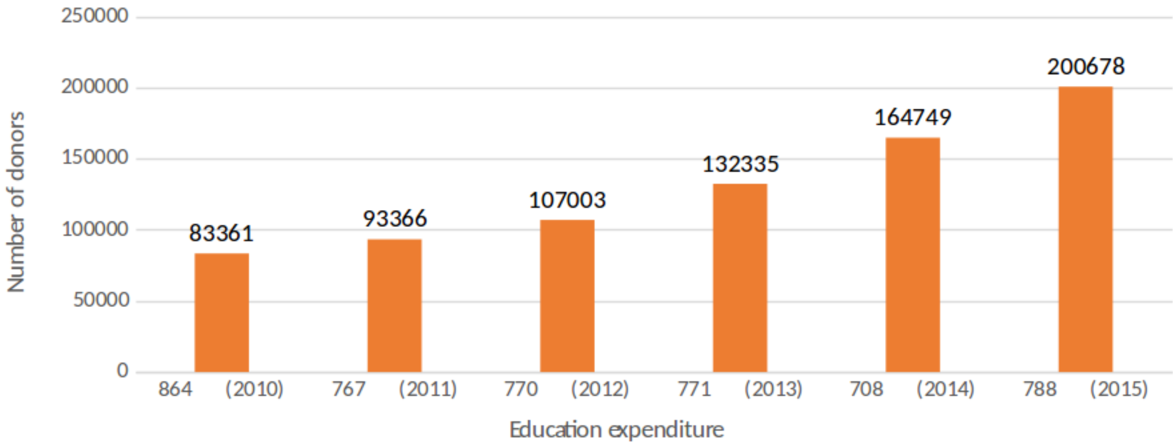


Source: Own elaboration based on the *Instituto Nacional de Estadística* website.

Finally in Figure 3.5 we can see the evolution of donors respect the education expenditure that the government does. This variable is also expressed in thousands of euros. In this graph, the year 2010 has the higher education expenditure of the series but it also has the

[3]To get this data, all the income per capita of all autonomous communities has been added and has been divided by the number of autonomous communities, to get the average per community and year.

FIGURE 3.5: Number of donors respect to the education per capita expenditure per year.



Source: Own elaboration based on the *Fundación Josep Carreras* website.

lower number of donors. Despite the fact that the education expenditure is lowering, the number of bone marrow donors is increasing. It is possible that it is due to the existing correlation with the variable health expenditure. This data has been extracted from the *Instituto Nacional de Estadística* (INE) website.

Chapter 4

Data description and main statistics

4.1 Data description

In this paper, we empirically study the relationship between health expenditure and bone marrow donors enrolled in *Registro de donaciones de médula ósea* (REDMO). This analysis uses annual data on 17 Spanish autonomous communities ($N = 17$) from 2010 to 2015 ($T = 6$). The autonomous communities of Ceuta and Melilla are not considered because of their low level of significance. In this section we describe the data we use in this analysis, the variables, the sources, and the main statistics of those variables.

The biggest problem when proposing these models has been the difficulty to find the data. Sometimes because this data contains sensitive information and, as such, there is a lot of people that do not want this data published, and sometimes because this data is incomplete. Firstly, this was intended to study bone marrow donation worldwide, comparing the bone marrow donations in OECD countries, but after a long period of searching for this information, phone calls and e-mail exchanges it was given up because information was always incomplete.

For the regression analysis, we employ the following variables:

Number of donors ($numdon_{it}$). The number of bone marrow donors is the dependent or explained variable of the model. This represents the number of registered donors in the *Registro de Donantes de Médula Ósea* (REDMO) per 100000 population. The data has been obtained from the REDMO website (*Fundación Josep Carreras*, 2017).

Health expenditure per capita ($health\_spend_{it}$). This is the main explanatory variable of the model. It indicates the amount of money the government spends per capita on health, expressed in thousands of euros. It is achieved by dividing the total health expenditure on health expenditure by autonomous community by the number of inhabitants of it. This variable is expressed in natural logarithms. It is included on our model because we believe that the investment on health care that the government does is important for the number of donors, it is possible that there is a bigger investment on improve the knowledge of the specialists so they can inform the possible future donors. The data has been extracted from the *Ministerio de Sanidad, Asuntos Sociales e Igualdad* (MSASI) website.

Number of Information centers (NDC_i). This is the other important explanatory variable of the model. It is expressed in units. This variable indicates us the number of centers enabled to give information about bone marrow donation. The number of centers has not changed over time. Is important to include this variable in our model because all donors must be properly informed on what becoming a bone marrow donor implies, more specifically what does the donation process entail, the risks, which compromises the donor has to do and of course his rights. Information centers are one of the places we can find such information although it is also available from the web pages of *Organización Nacional de Transplantes* and *Fundación Internacional Josep Carreras - REDMO*. This information is also available through a phone call to *Organización Nacional de Transplantes*. The datahas been obtained from the REDMO website (Fcarreras, 2017).

GDP per capita (gdp_pc_{it}). This variable is expressed in thousands of euros. The GDP per capita is a measure of total output of a country that takes gross domestic product (GDP) and divides it by the number of people in the country. It is especially useful when comparing one country, region, and autonomous community to another, because it shows the relative performance of the countries. An increase in GDP per capita indicates growth in the economy and tends to reflect an increase in productivity. In this study, the GDP per capita is the total nominal GDP per autonomous community divided by the total population of the autonomous community. This variable has been expressed in natural logarithms so it can be interpreted in a more simple and precise way. This variable has been included to see if the GDP per capita depends on whether or not he will become a donor. The data has been extracted from the *Instituto Nacional de Estadística* (INE) website.

Expenditure on education per capita ($educ\_spend_{it}$). This is expressed in thousands of euros. It collects expenditure on education per individual from each autonomous community. Expenditure on education per capita is achieved by dividing the total expenditure on education by autonomous community by the number of inhabitants of it. This variable is also expressed in natural logarithms. This variable has been included on the model to see whether the investment that the government does on education by individual has an impact over the number of donors. That is, we want to see if an increase by the government in education causes donors to increase. The data has been extracted from the *Ministerio de Educación, Cultura y Deporte* (MECD) website (MECD, 2017)

Education level ($level\_studies_{it}$**)** is a binary variable. Is a percentage of the population over 16 years old according to formation level, sex and autonomous community. If the level is higher, excluding PhD, the variable will have a value of 1, otherwise its value will be 0. To obtain these values the average level of education was computed and, if the individual value was higher than the average, this variable was set to 1 and if it was lower to 0. We think this variable is important to our model to be able to tell if a different level of studies makes a difference on the number of bone marrow donors. The data has been extracted from the *Instituto Nacional de Estadística* (INE) website.

In all regressions, we have also included time dummies to control for potential year tendencies. The base year is 2010.

In this study we will be using four models. The first model is the basic model, whose explained variable will be the number of donors ($numdon$) and its explicative variables will be health expenditure per capita ($health\_spend$), number of information centers (NDC), GDP per capita (gpd_pc), expenditure on education per capita ($educ\_spend$) and time dummies. The second model is the extended model, which is similar to the basic model adding the level of education ($level\_studies$). The third and fourth models will be robustness basic model and robustness extended model, which are the same as the two first models but one period later.

In Table 4.1, we present a summary of the variables, number of years and number of autonomous communities.

TABLE 4.1: Description of the variables.

Variable	Description	N	T
numdon	Number of marrow bone donors registered in REDMO	17	6
health_spend	Health expenditure per capita	17	6
NDC	Number of information centers	17	6
gdp_pc	GDP per capita	17	6
educ_spend	Education expenditure per capita	17	6

Source: Own elaboration using REDMO.

In Table 4.2 we present the main statistics of the different variables. The mean number of bone marrow donors that are subject to this study between the period of 2010-2015 is 327.56 donors per year, with a standard deviation of 271.91. It is also observed that there is a great difference between the minimum and the maximum, this means that the lowest number of donors in a community is 75.85 while the highest number of donors in other community is 1600. Regarding the government health expenditure, we can see that there is also a big difference between the maximum and minimum, around 775 euros per person and autonomous community. The GDP also shows a big gap between maximum and minimum, being 31812 euros the maximum and 15278 the minimum. Its mean is of 22355.39 euros per capita and the standard deviation is of 4416.07. Besides the highest GDP per capita is 31812 euros and the lowest in 15278 euros. Lastly, the education expenditure per capita from the government shows a really big difference between the maximum and the minimum, with a difference of 1092 euros, being the maximum 1278 euros and the minimum 186 euros.

TABLE 4.2: Descriptive statistics for 102 observations.

Variable	Mean	Standard deviation	Minimum	Maximum
Number of bone marrow donors	327.56	271.91	75.85	1600
Health expenditure per capita	1289.44	187.60	978	1753
Information centers	4.77	5.12	1	14
GDP per capita	22355.39	4416.07	15278	31812
Education expenditure per capita	792.63	151.31	186	1278

Source: Own elaboration using REDMO.

We use Pearson's correlation coefficient. This coefficient is good to measure the linear relation that exists between two random quantitative variables and it is independent of the scale of those variables. The correlation is given by a value between -1 and 1, where 0 means no correlation and 1 and -1 show a perfect correlation.

If the correlation has a positive sign, both variables increase or decrease simultaneously therefore, if the sign is negative, one of the variables will increase while the other one will decrease. So, the closer the correlation is to the absolute value of 1, the stronger the correlation between the variables will be. If the correlation is close to 0 the variables will have little to no correlation. That is why in our correlation analysis there is a 1 when the variable is correlated to itself.

Results in Table 4.3, show a weak correlation among the variables used in our analysis, except for the correlation between GDP per capita and the level of studies. This is a perfect situation to estimate our models, since a lower correlation gives better estimations when computing the economic model.

TABLE 4.3: Matrix correlation

	numdom	**health_spend**	**GDP_pc**	**educ_spend**	**level_studies**
numdom	1.000				
health_spend	0.089	1.000			
GPD_pc	0.172	0.171	1.000		
educ_spend	0.199	0.352	0.147	1.000	
level_studies	0.142	0.361	0.670	0.094	1.000

Source: Own elaboration from REDMO.

4.2 Methodology

In this research, because we have information of the different communities over time we use panel data. As it is well known, panel data allows us to control cross-section dependence and unobserved heterogeneity. Given that our dependent variable is the number of donations, we cannot estimate the model by the standard ordinary least squares methodology because our equation is not linear in its parameters. This counting variable is a non negative variable, that will take integer non negative values. Therefore, we assume that our model follows a Poisson probability distribution, which is a discrete probability distribution that expresses the probability of an event occurring in a certain interval of time, with a known average rate and independence from the last observer event. The Poisson distribution is actually a limiting case of Binomial distribution when the number of trials gets very large and the probability of success is small. Poisson probability distribution is characterized by the number of times that an even happens in an interval. For example, it can be used by counting the number of patients that enter in a hospital, number of trips a person does and, in our case, number of bone marrow donors that are registered in REDMO. The main objective of the Poisson distribution is to estimate the probability that the counting variable Y takes a specific value, given the values of X.

$$P(Y = y|X) = P(y = 1|X_1, X_2, X_3, ..., X_k)$$

In its limit, the Binomial distribution converges to the Poisson formula:

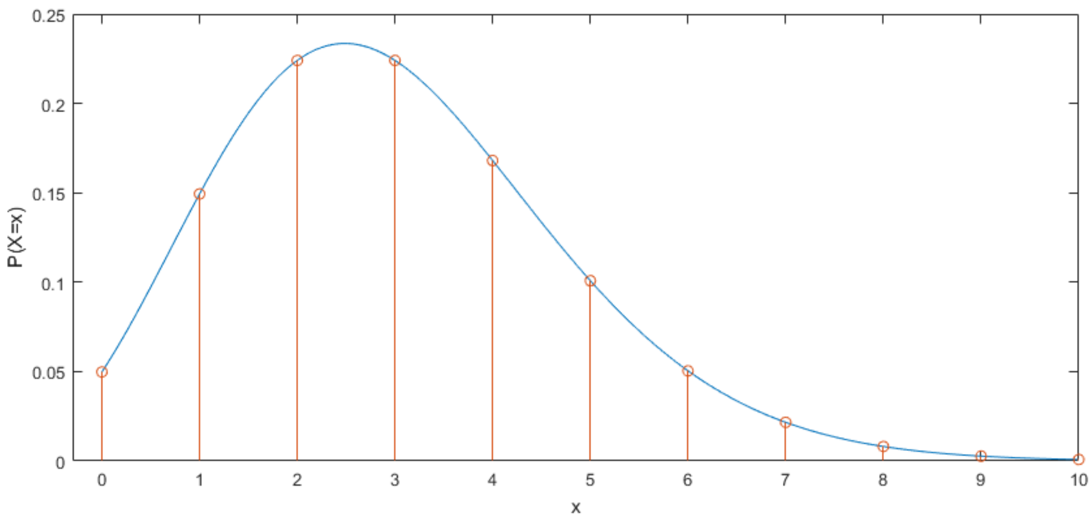
$$P(Y = h) = e^{-\lambda}\frac{\lambda^h}{h!} \quad h = 0, 1, 2, 3, ...$$

Where

- Y is a Poisson random variable.
- h is the number of events whose probability we are calculating.
- λ is the average number of events that occur per time interval.

The Poisson distribution is characterized by only one parameter, λ which is the mean and the variance of Y. This distribution has a positive bias and the random variable does not have an upper limit.

FIGURE 4.1: Poisson distribution ($\lambda = 3$).



Source: Own elaboration using Matlab.

As can be seen in Figure 4.1, the curve of the Poisson function is similar to the binomial, asymmetric, where the mean of the random variable is equal to the distribution parameter:

$$\overline{x} = \lambda$$

And the variance is also equal to the distribution parameter:

$$\sigma^2 = \lambda$$

Therefore the standard deviation is:

$$\sigma = \sqrt{\lambda}$$

We cannot obtain the logarithm of a counting variable, because it would be 0. So we have to model the value to an exponential function:

$$E(Y) = \lambda = exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k)$$

But this does not allow us to use linear regression methods, because the previous equation is not lineal. And because the counting distribution present heteroskedasticity, we cannot use the non linear least squares method. With a Poisson regression model we will have to turn to a maximum likelihood estimation.

Let's assume that we have a simple regression model $\beta_0 + \beta_1 X_1$, we then have to find the values for β_0 and β_1 that maximize the following expression:

$$L(\beta_0, \beta_1) = lnL(\beta_0, \beta_1) = lnP(Y = 0) + lnP(Y = 1) + lnP(Y = 2)$$

Next, we maximize the log likelihood function an thus we can easily obtain the standard errors.

The prediction of the value for Y conditioned to the X values is direct, but because Poisson regression model is not lineal we cannot obtain the marginal effect of the change of a continuous variable X over Y, so we have to change those parameter by the maximum likelihood estimations.

As we have mentioned before, one of the main characteristics of Poisson distribution is that the mean and the variance are the same, λ. This assumption is very restrictive, but we assume that out estimators are consistent. In case they are not we will say that the estimation is quasi maximum likelihood.

$$Var(Y|X) = \sigma^2 E(Y|X)$$

If $\sigma^2 = 1$: The assumption about the Poisson variance is true.

If $\sigma^2 > 1$: There is over dispersion, variance is greater than the mean.

If $\sigma^2 < 1$: There is under dispersion, variance is lower than the mean.

What we would have to do in the case that there is over dispersion is to compute a negative binomial regression. Negative binomial regressions can be used when the conditional variance is greater than the conditional mean, meaning that if a general case of Poisson regression. This is because the mean structure is the same than in a Poisson regression, but has an additional parameter so that over dispersion can be adjusted. If the result variable has a conditional distribution that is too disperse, it may happen that the confidence intervals for the negative binomial regression are thinner than those on the Poisson regression.

4.3 Model specification and results

As stated above, we estimate estimate four models: the basic model, the extended model, the robustness basic model and the robustness extended model. In all of them our dependent variable, $numdom$, represents the number of bone marrow donors registered in REDMO per autonomous community per 100000 inhabitants. Our explicative variables are $health\_spend$, health expenditure per capita, NDC number of centers of information, gdp_spend, GDP per capita, $educ\_spend$, expenditure on education per capita, $educ\_level$ education level of the individuals and time dummies.

To explain the number of bone marrow donors firstly we estimate two different regressions: a basic model and an extended model. In the first model, we include as explanatory variables $health\_spend$, NDC, gpd_pc, $educ\_spend$ and time dummies. In the second, we add the variable $level\_studies$.

Through the estimation of these equations we seek to identify the individual relation between number of donors and the rest of variables. Specifically, we want to study how an increase on any of these variables generates a rise on the number of bone marrow donors. According to the statistics previously shown, we might predict a positive sign in all the coefficients for the independent variables.

Assuming that our models are correctly specified, next we need to check if our model has over dispersion. To do so we will to compute the likelihood ratio test of the over dispersion parameter α, using for this end a negative binomial distribution over the same model where we have used the Poisson distribution.

Our null hypothesis is that the α parameter is equal to 0, $(H_0 : \alpha = 0)$ and the alternative hypothesis is that is different than 0, $(H_1 : \alpha \neq 0)$. According to the results of this test, we cannot reject the null at 1 per cent. Therefore, we can use Poisson regression.

In the following regressions, we test in the null hypothesis that the coefficient on the different indicators is equal to zero $(Ho : \beta = 0)$ and the alternative that the coefficient is different to zero $(H1 : \beta \neq 0)$. The chosen levels of significance are 1% (*), 5% (**) and 10% (***).

The basic model and the extended model, they are defined by the following equations:

Basic model equation.

$$\begin{aligned} numdon_{it} = \beta_0 + \beta_1 health\_spend_{it} + \beta_2 NDC_i + \beta_3 GDP\_pc_{it} \\ + \beta_4 educ\_spend_{it} + \delta_{11} d11_{it} + \delta_{12} d12_{it} + \delta_{13} d13_{it} \\ + \delta_{14} d14_{it} + \delta_{15} d15_{it} + \varepsilon_{it} \end{aligned}$$

Extended model equation.

$$\begin{aligned} numdon_{it} = \beta_0 + \beta_1 health\_spend_{it} + \beta_2 NDC_i + \beta_3 GDP\_pc_{it} \\ + \beta_4 educ\_spend_{it} + \delta level\_studies_{it} + \delta_{11} d11_{it} + \delta_{12} d12_{it} \\ + \delta_{13} d13_{it} + \delta_{14} d14_{it} + \delta_{15} d15_{it} + \varepsilon_{it} \end{aligned}$$

TABLE 4.4: Results of the basic and extended regression models.

MODELS: Estimation by Poisson regression. Period 2010-2015

VARIABLES	BASIC	EXTENDED
DEPENDENT		
numdon		
INDEPENDENTS		
health_spend (1)	0.238 (*)	0.396 (*)
	(0.053)	(0.060)
NDC	-0.027 (*)	-0.026 (*)
	(0.001)	(0.001)
GDP_pc (1)	0.456 (*)	0.600 (*)
	(0.028)	(0.039)
educ_spend (1)	0.918 (*)	0.861 (*)
	(0.035)	(0.037)
educ_level	—	-0.095 (*)
	—	(0.017)
δ_{11}	0.986 (*)	0.106 (*)
	(0.022)	(0.022)
δ_{12}	0.369 (*)	0.361 (*)
	(0.029)	(0.022)
δ_{13}	0.548 (*)	0.568 (*)
	(0.021)	(0.021)
δ_{14}	0.769 (*)	0.797 (*)
	(0.021)	(0.022)
δ_{15}	0.930 (*)	0.950 (*)
	(0.020)	(0.021)
Constant	-6.990 (*)	-9.146 (*)
	(0.371)	(0.547)
Observations	101	101
R-squared	0.327	0.329

Robust standard errors in parenthesis.

(*), (**) and (***) represent significance at 1%, 5% and 10% respectively.

(1) These variables have been converted to logarithms.

In the Table 4.4 we can see the obtained results after making the regressions for the basic model and the extended model. There is a statically strong evidence at the 1 per cent level of significance for all the variables. The obtained results for the basic model are the expected one with one exception, the variable on the number of centers of information, NDC gives a negative relation. As we can see, an increase of 1 per cent in health expenditure, $health\_spend$ from the government increases the number of donors in 0.238 per cent while keeping the rest of the variables constant. The result obtained was the expected one. Since the *Plan Nacional de Donación de Médula Ósea* was launched in 2013, the number of donors has increased. This Plan has had financing from the *Ministerio de Sanidad, Servicios Sociales e Igualdad*, about 830000 euros per year to finance jointly with the autonomous communities the typologies (MSSSI, 2016).

Regarding the NDC variable, we can see a negative relationship with the number of donors, $numdon$. Probably this happens because NDC is a time-invariant variable and may be collecting the fixed or specific effects of each autonomous community. The conclusion from all of this is that the variable of the number of information centers, NDC gathers the differential behavior that the different autonomous communities which is kept throughout time. The relationship between GDP per capita and the number of donors is positive and significant. If GDP increases 1 per cent we expect a rise in the number of donors of 0.456 per cent, if we keep all the rest of the variables constant. The variable of education expenditure, $educ\_spend$ also has a positive relationship with the number of donors. If the government invests on education increases by 1 per cent, we expect a rise in the number of donors of 0.918 per cent, ceteris paribus. The constant has a direct relationship with the number of donors variable and tells us which value will $numdon$ take in the absence of the other variables, meaning when the other variables take zero as their value. In this case, the value of the constant is negative, meaning that in the absence of the other variables there would not be any bone marrow donor. In our model, the R-squared value has a value of 0.327 which means that our model has an explicative capacity which respect of the number of donors of 32.70 per cent.

In the extended model, we added a new variable with the level of studies, $educ\_level$ to see whether or not it gave us statistical signification information to our model. As we can see from the obtained results, all the variables except the level of studies and the number of information centers confirm our expectations. If the government increases on health expenses per capita by 1 per cent, we expect a rise in the number of donors of 0.396 per cent, keeping the rest of the variables constant. This is a bigger increase than the one in the basic model. Regarding the variable on the number of information centers,

NDC, as in the basic model, the relationship with the number of donors in negative and with a very similar value. The obtained value for the GDP per capita is bigger than in the basic model. If the GDP per capita increases by 1 per cent, we expect a rise in the number of donors of 0.600 per cent, while keeping all the other variables constant. The new variable, education level, which is the new variable that we introduce in this model shows a negative sign with respect the number of donors. That means that the more educated the population is, the less donors that will register. The constant in this model is telling us that if the rest of the variables were zero, there would not be any bone marrow donors. The R-squared value is 0.329, very similar to the one on the basic model, which means that this model has an explicative capacity with respect the number of donors of 32.90 per cent.

To interpret the values of our dummy time variables we have set as the base year 2010. The interpretation that we can make out of those coefficients is, in the basic model, that in the year 2011 the number of donors has increased in 0.098 donors, in 2012 there has been a raise of 0.369 donors, in 2013 the increase has been of 0.548 per cent, in 2014 it has been of 0.769 donors and in 2015 the raise with respect to 2010 has been of 0.930. This positive growing tendency is what we could see in Figure 3.1. In the extended model, the results are similar confirming the increasing tendency over time in the number of bone marrow donors. Every year from 2010 there is an increase on bone marrow donors. Always keeping the rest of the variables constant.

To check the robustness of our results, we next estimate both models, the basic and the extended, including our explanatory variables with a lag. We do that to try and capture any dynamic effect.

Robustness basic model equation.

$$\begin{aligned} numdon_{it} = \beta_0 + \beta_1 health\_spend_{it-1} + \beta_2 NDC_i + \beta_3 GDP\_pc_{it-1} \\ + \beta_4 educ\_spend_{it-1} + \delta_{11} d11_{it} + \delta_{12} d12_{it} + \delta_{13} d13_{it} \\ + \delta_{14} d14_{it} + \delta_{15} d15_{it} + \varepsilon_{it} \end{aligned}$$

Robustness extended model equation.

$$\begin{aligned} numdon_{it} = \beta_0 + \beta_1 health\_spend_{it-1} + \beta_2 NDC_i + \beta_3 GDP\_pc_{it-1} \\ + \beta_4 educ\_spend_{it-1} + \delta level\_studies_{it-1} + \delta_{11} d11_{it} + \delta_{12} d12_{it} \\ + \delta_{13} d13_{it} + \delta_{14} d14_{it} + \delta_{15} d15_{it} + \varepsilon_{it} \end{aligned}$$

TABLE 4.5: Results of the both robustness regression models basic and extended.

MODELS: Estimation by Poisson regression. Period 2010-2015

VARIABLES	BASIC	EXTENDED
DEPENDENT		
numdon		
INDEPENDENTS		
health_spend (1)	0.199 (*)	0.302 (*)
	(0.053)	(0.060)
NDC	-0.028 (*)	-0.027 (*)
	(0.001)	(0.001)
GDP_pc (1)	0.484 (*)	0.589 (*)
	(0.030)	(0.041)
educ_spend (1)	0.828 (*)	0.793 (*)
	(0.037)	(0.038)
educ_level	—	-0.067 (*)
	—	(0.018)
δ_{11}	0.915 (*)	-0.931 (*)
	(0.019)	(0.020)
δ_{12}	-0.704 (*)	-0.721 (*)
	(0.018)	(0.019)
δ_{13}	-0.432 (*)	-0.455 (*)
	(0.019)	(0.020)
δ_{14}	-0.207 (*)	-0.203 (*)
	(0.016)	(0.016)
Constant	-5.406 (*)	-6.919 (*)
	(0.396)	(0.557)
Observations	84	84
R-squared	0.301	0.301

Robust standard errors in parenthesis.

(*), (**) and (***) represent significance at 1%, 5% and 10% respectively.

(1) These variables have been converted to logarithms.

As shown in Table 4.5, we obtained results when doing the regressions on the robustness basic model and robustness extended model. The results are very similar to the ones obtained on the regressions of the basic model and the extended model. All our variables are significant at 1 per cent. The relationship between independent and dependent variables is positive, except with NDC where it is negative. The same result was obtained in the regression of the basic model. This result may be due to the fact that people are informed by other means, such as websites, associations and organizations.

For every 1 per cent that the government invests on health expenditure per capita, the number of bone marrow donors increases in 0.199 per cent, keeping all other variables constant. The variable number of information centers, NDC gives us a negative relationship with the number of donors, $numdon$, meaning that for every new information center that is opened, the number of donors will decrease in 0.028 individuals. With respect the GDP per capita, GDP_pc, there is statistical evidence that for every 1 per cent that the GDP per capita increases, the number of donors will increase a 0.484 per cent, ceteris paribus. As we can see on our results, if we keep the rest of the variables constant, a rise of 1 per cent in health expenditure per capita means an increase of 0.828 per cent on donors. The constant tells us that if all the variables were zero, there would not be any bone marrow donors. The R-squared value has a value of 0.301, which means that our model has a explicative capacity respect of the number of donors of 30.10 per cent.

The robustness extended model, in this case, gives us similar results that the one previously estimated. All the variables are significant at 1 per cent and with the expected signs.

Chapter 5

Conclusion

One of the biggest factors and very difficult or near impossible to define is the empathy that every individual has with a person that has cancer. Related with this fact, in this paper we try to answer the following questions: which factors determine the donations of bone marrow and how government may influence these donations? In spite of the importance of this issue, there is not many works that study this phenomenon.

In this paper we try to fill this gap by evaluating the role of government in bone marrow donations. To do that, we estimate a Poisson model for the number of donors. Explanation variables are health expenditure per capita, the number of information centers, the GDP per capita, the education expenditure per capita and the level of studies of the individuals of every autonomous community.

Despite the difficulties to acquire valuable data on this topic, we obtained very consistent results. The information published by the *Ministerio de Sanidad, Servicios Sociales e Igualdad* tells us that there has been a higher number in donations since the start of the *Plan Nacional de Médula* in 2013. According to this study, this increase was due to the assistance given by the Government to the autonomous communities to promote bone marrow donations. The results obtained in our work confirm that information. We can see that an investment on health expenditure implies a rise on the number of bone marrow donors. Furthermore, the time effects estimated confirm this tendency. Regarding the variable of the number of information centers, the estimated coefficient is negative. Probably this is because the donors get their information through other media. Other sources can be informative web pages, such as the web page from *Organización de Transplantes*, from *Fundación Internacional Josep Carreras-REDMO* and information posters in *Asociaciones de Pacientes*. Moreover, as this variable remains stable across time its effect can be captured by the local factors that autonomous communities have.

Besides it is reasonable to expect that with all the new information tools, such as Internet or TV, new donors get their information from those not depending on only one option. It would probably be more interesting to fund campaigns that can be done in such media instead of investing in opening new information centers.

Additionally, the autonomous communities with a higher income are the ones that have a higher percentage of donors. The education expenditure per capita shows a similar behavior, the more the government invests on it, the bigger the number of donors. This is most likely due to a better understanding of the campaigns from the point of view of the future donors, that are able to know the possible risks and benefits of becoming donors.

The level of education has a negative impact on number of donors. This is an unexpected result because it may seem that a person with higher education would be more interested in finding accurate information and, thus, would know better the little risks that a donation has. It is possible that this result is obtained by the correlation between this variable and GDP.

For all the above, we can conclude that a greater expenditure in health and education by governments implies an increase in the number of bone marrow donors. Since this paper is dealing with a topic of vital importance and we are aware of the limitations of our work given the lack of information, we encourage other institutions and researchers to follow a similar framework of study and to provide more data.

References

Antena 3 (2015) *'España Mantiene el Liderazgo Mundial en Donación y Trasplante de Órganos'* [online] available from: http://www.antena3.com/noticias/salud/espana-mantiene-liderazgo-mundial-donacion-trasplante-organos_201501135717958b6584a84d7bf431f9.html [30 April 2017].

Baltagi B., and Moscone F. (2010) *'Health Care Expenditure and Income in the OECD Reconsidered: Evidence from Panel Data'*. Economic Modelling, 2010, vol. 27, no 4, p. 804-811.

Bayati, M., Akbarian, R. and Kavosi, Z. (2013) '*Determinants of Life Expectancy in Eastern Mediterranean Region: A Health Production Function'*. International Journal of Health Policy and Management, vol. 1, no. 1, p. 57-61.

Carreras, E. (2016) *'Guía del Trasplante de Médula Ósea para el Paciente'*. Fundación Carreras contra la Leucemia [online] available from: http://www.fcarreras.org/es/trasplante [30 April 2017].

Crémieux P-Y., Quellette P. and Pilon C. (1999) *'Health Care Spending as Determinants of Health Outcomes'*. Health Econ 8:627-639.

Cutler, D., Deaton, A., and Lleras-Muney, A. (2006) *'The Determinants of Mortality'*. Journal of Economics Perspectives, vol. 20, no. 3, p. 97.

Evans, BT. and Preitchard, C. (2000) *'Cancer Survival Rates and GDP Expenditure on Health: a Comparison of England and Wales and the USA, Denmark, Netherlands, Finland, France, Germany, Italy, Spain and Switzerland in the 1990s'*. Public Health, vol. 114, p. 336-339.

Fundación Josep Carreras (2017) *'Registro de Donantes de Médula Ósea'* (REDMO) [online] available from: http://www.fcarreras.org/es [7 March 2017].

Fundación Josep Carreras (2017) *'Dona Médula Ósea, Dona Vida. Guía del Donante de Médula Ósea'* [online] available from: http://www.fcarreras.org/es/guia-del-donante-de-medula-osea_4792.pdf [29 April 2017].

Fundación Josep Carreras. Registro de Donantes de Médula Ósea (REDMO) (2015) *'Memoria Anual 2015'* [online] avaible from: http://www.fcarreras.org/es/memorias [April 2017].

Fundación Renal Iñigo Álvarez de Toledo (2017) (FRIAT) [online] available from: https://www.friat.es [10 March 2017].

Grossman, M. (1972) *'On the Concept of Health Capital and the Demand for Health'* The Journal of Political Economy, vol. 80, no. 2, p. 223-255.

Instituto Nacional de Estadística (INE) (2017) [online] available from: http://www.ine.es [8 March 2017].

Instituto Nacional de Estadística y Geografía [INEGI] (2016) *'Estadísticas a Propósito del día Mundial del Cáncer'* AGUAS CALIENTES, AGS [Online] available from: http://www.inegi.org.mx/saladeprensa/aproposito/2016/cancer2016_0.pdf [17 March 2017].

Jaba E., Balan C.B. and Robu I.B. (2014) *'The Relationship between Life Expectancy at Birth and Health Expenditures Estimated by a Cross-country and Time-series Analysis'*. Procedia Econimics and Finance, vol. 15, p. 108-114.

Jurado, J., Pérez, M., and Ortega, J. (2012) *'Oncología Clínica para Atención Primaria'*. 1ª edición. Ed. Varios.

La Opinión de Málaga (2017) *'El Fenómeno Ráez Dispara la Donación de Médula Ósea en Málaga y Andalucía'* [online] available from: http://www.laopiniondemalaga.es/malaga/2017/01/17/donacion-medula-osea-crecio-1300/903406.html [23 April 2017].

Lichtenberg F. (2004) *'The Expanding Pharmaceutical Arsenal in the War on Cancer'* NBER Working Paper Series, No. 10328.

Lucio, G.C. (2017) *'Los Casos de Cáncer en España Superan ya los Previstos para 2020'* El Mundo [online] available from: http://www.elmundo.es/salud/2017/01/30/588f277a22601dbc438b4666.html [23 April 2017].

Martin, S., Rice, N. and Simth, P.C. (2008) *'Does Health Care Spending Improve Health Outcomes? Evidence from English Programme Budgeting Data'*. Journal of Health Economics, vol. 27, p. 826-842.

Ministerio de Educación, Cultura y Deporte (2017) [online] available from: http://www.mecd.gob.es [8 March 2017].

Ministerio de Sanidad, Asuntos Sociales e Igualdad (2017) [online] available from: http://www.msssi.gob.es [8 March 2017].

Mohan, R. and Mirmirani, S. (2007) *'An Assessment of OECD Health Care System Using Panel Data Analysis'*. Bryant University. Southwest Business and Economic Journal.

Nixon J. and Ulmann P. (2006) *'The Relationship between Health Care Expenditure and Health Outcomes'*. Eur J Health Econom 7:7-18.

Organización Nacional de Trasplante [ONT] (2012) *'Plan Nacional de Donación de Médula Ósea'* [Online] available from http://www.ont.es/infesp/DocumentosDeConsenso/Plan%20Nacional%20M%C3%A9dula%20%C3%93sea.pdf [21 April 2017].

Sociedad Española de Oncología (SEOM) (2017) *'Las Cifras del Cáncer en España'* [online] available from: http://www.seom.org/seomcms/images/stories/recursos/Las_cifras_del_cancer_en_Esp_2017.pdf [23 April 2017].

Wooldridge, J.M. (2010) *'Introducción a la Econometría: Un Enfoque Moderno'*, 4ª edición. Ed. CENGAGE Learning.