Title	Doctorate holders' careers in Spain: Does international mobility matter?
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Abstract	PhD programmes are considered as transmission channels to provide specialisation and skills to students who will be employed as highly-qualified workers or researchers. Focusing on the Spanish case, they are exerting a positive influence on workers' careers since doctorate holders have a privileged situation in the labour market. This article analyses international mobility's effects on some aspects associated with doctorate holders' careers such as their wages and how their current employment is related to their doctoral studies. The methodology applied consists in developing, on the one hand, a wage econometric specification and, on the other, a probit model, taking into account the possible mismatch between the training acquired in the doctoral studies and the educational requirements of the current job. In both cases, the dependent variables are explained by a set of regressors and a dummy variable showing whether doctorate holders have spent time in another country once completed their doctoral studies.
Statement	

1. INTRODUCTION

The completion of a PhD program is understood as a transmission channel to provide specialization and skills to students pursuing to be employed as highly-qualified workers or researchers. The Bologna Process and the EU Horizon 2020 (EU Research and Innovation programme for the period 2014 to 2020) has enhanced and launched the role of the PhD program as an instrument to achieve the long-standing objectives of innovation proposed by the construction of the "Europe of Knowledge". In this context, the Europe 2020 strategy is considered as one of the main European Union's instrument to reinforce the importance of innovation, promote the knowledge-based economy, and increase the competitiveness and the economy growth. These legislative efforts are having a positive impact on the educational system and on the economy: for example, the total R&D expenditure in EU (28 countries) has increased by 38.32% during the period 2006-2015. However, the results obtained by country show a significant dispersion: thus, the growth recorded in Germany or Denmark is about 48%, which contrast with the 11% observed in Spain during the same period (2006-2015). One of the key target of the Europe 2020 strategy is to devote 3% of GDP to R&D activities, which has been practically achieved in Germany with a 2.8% in 2015, but other countries as Spain (1.3% of GDP) are currently quite far from this target.

In this setting, tertiary education is also considered as a primary source to create human capital and increase the productivity through the improvement of the competitiveness and the creation of a path of sustained economic growth with better jobs and more social cohesion; thus, another key target of the EU Horizon 2020 is that the tertiary education attainment reaches the 40% in the EU (28 countries). The relevance given to innovation and research has also been understood by the education community since students have increased their participation in PhD programs. For example, the number of doctoral degrees raised by 38% during the past decade in the OECD countries. In Spain, the doctorates account for 1% in 2009, which is still away from the figures registered in other European countries (for example, in Switzerland, doctorate holders stand at 3.4% of the population).

The research literature has focused on the analysis of the tertiary education's effects on the students' professional careers from different perspectives. McCormick (1997) proves that highly educated individuals have more probability of experiencing upward labour market mobility. This is also related to their higher capacity and motivation to receive training and finance its monetary costs, which improves their productivity and competitiveness in the firm (Brooks and Everett, 2008). Moreover, some studies have analysed the interrelationship between human capital and social mobility: for example, Caparrós (2016a) proves that higher education is a mechanism to achieve an upward intergenerational occupational mobility. In particular, the probability of upward intergenerational occupational mobility is around 26 percentage points higher for individuals with higher education than the one corresponding to those with primary studies. Moreover, these individuals show an absolute predicted probability of moving up the occupational ladder of 60%. From a different point of view, the economic literature has also highlighted some negative effects that must be taken

into account when assessing the effectiveness and benefits of higher education. Thus, Walker and Zhu (2008) show the existence of mismatch between the knowledge acquired in the educational system and the needs of productive system, causing high rate of over-education among highly educated people.

Focusing in the Spanish case, PhD programs are exerting a positive influence on workers' careers since doctorate holders have a privileged situation in the labour market in relation to other employees. For example in 2015, the unemployment and employment rates of the Spanish population were 21% and 58%, respectively; whereas, for the doctorate holders, these percentages were 5% and 80%. Moreover, these workers earn wages that are 60% higher than those received by workers with only primary education. To date, unfortunately not much economic literature discussing Spain has addressed the doctorate holders' careers in the Spanish labour market; likely, the main reason for that is the lack of suitable databases with enough information to tackle this topic. Anyway, it is possible to highlight some exceptions that use data from 2006 Survey on Human Resources in Sciences and Technology (INE 2007). On the one hand, Canal and Wall (2014) study the factors affecting the success of the doctorate holders careers and find that the most important aspects are the satisfaction with the promotion opportunities or the responsibility degree. On the other hand, Canal and Dominguez (2016) analyse how the PhD program influences on the professional career and on the time to get the first suitable job. Their findings are that men get a suitable job faster than women, and that this is related to the academic field.

This paper analyses the influence of having had a post-doctoral stay abroad on aspects associated with the doctorate holders' careers such as their wages and how their current employment is related to the education acquired in the doctoral studies. To the best of our knowledge, these topics are unprecedented in the literature discussing Spain and are related to interesting issues for students and policymakers that could help increasing the knowledge of the transition between the doctoral studies and the labour market. To reach the objectives proposed, the methodology applied consists in developing, on the one side, a wage econometric specification and, on the other side, a probit model taking into account the possible mismatch between the training acquired in the doctoral studies and the needs of the current job. In both cases, the dependent variables are explained by a set of explanatory that collects personal and job-related characteristics, and a dummy regressor showing whether the doctorate holder has had a stay in another country once completed her/his doctoral studies, this binary variable is considered as an endogenous regressor in the econometric specifications proposed and is also explained through a probit model. Data used in this analysis come from the 2009 Survey on Human Resources in Science and Technology, provided by the Spanish National Institute of Statistics (INE, 2010). At present, this survey offers the most recent information to examine the topic previously mentioned.

The remainder of the article is structured as follows. Next section discusses the data set and how the variables used in the empirical analysis have been generated. Sections 3 and 4 present the methodological approach and the results, respectively. Finally, section 5 summarises the findings and concludes.

2. DATA

The EU Commission regulation 753/2004 promoted the implementation of harmonised statistics about science, technology and innovation to fill the lacks of information about the careers of PhD graduate workers. In the context of the Lisbon Strategy, these statistics are an useful instrument to support the EU policies on human resources. Following this European legislation, the Spanish Office for National Statistics (INE) conducted the 2009 Survey on Human Resources in Science and Technology (INE, 2010). This survey aimed to know the professional activity of doctorates holders and follow their international mobility.

The number of respondents in the 2009 Survey on Human Resources in Science and Technology rises to 4,123 individuals, but the analysis only focuses on doctorate holders who are wage earners in 2009. Moreover, the survey only offers information about annual wages so it is necessary to homogenize the individuals who participate in the analysis to ensure that they have been working throughout the 2009 year (that is, without unemployment or inactivity spells); in particular, the sample only includes wage earners who start their current labour relationship before the beginning of 2009. Taking into account these considerations, the final sample is composed by 3,585 individuals once the anomalous and missing values of the variables used in the analysis have been dropped.

The annual wages are tabulated in the survey by intervals and their distribution according to the postdoctoral mobility status (international mobility or not) is provided in table 1. The result associated with the Pearson's Chi-square test reveals that the distribution of individuals among the different wage intervals is not homogenous according to the international mobility status, which supports the interest of analysing the influence of the postdoctoral international mobility on the doctorate holders' wages.

[INSERT TABLE 1]

The second main objective of this article is to analyse how the current job is related to the doctoral studies according to the individual's perspective. In this way, table 2 displays how the wage earners are distributed according to the education-job mismatch and the international mobility status. The most interesting aspect is the existence of a positive pattern between the international mobility and the quality of the education-job matching. Thus, 80% (60%) of doctorate holders with (without) international mobility have a current job whose tasks are medium-high related to the doctoral studies.

[INSERT TABLE 2]

The set of explanatory variables used in the econometrics specifications is divided in two groups. The first one corresponds to the regressors influencing on the probability of having had a stay abroad. This group is composed by the following variables: starting age of the PhD program, gender, family background (approximated by the maternal and the parental educational attainment), characteristics of the PhD program such as the research fields (classified by the following knowledge areas: Natural Sciences, Engineering and

Technology, Medical Sciences, Agriculture Sciences, Social Sciences and Humanities), the type of research conducted during the PhD program (non-oriented research or not, applied research or not, experimental development or not), regressors describing how the students have financed their doctoral studies (Spanish grant, foreign grant, earned income working as research assistant or not, loans or savings) and the time to the doctorate. The second group of explanatory variables includes those regressors that are supposed to affect wages and the education-job matching. This set is composed by the following variables: gender, research field of the PhD program, type of research, tenure, type of contract (open-ended or fixed-term contract), sector (firm, public administration, higher education institution or private non-profit institution), tenure, a binary variable showing if the individual is working or not as a researcher, regional dummy variables to control by the regional labour market differences and, finally, a dummy regressor indicating if the individuals have had or not a postdoctoral stay abroad. This last variable is considered as an endogenous regressor.

The descriptive statistics corresponding to the first group of covariates distinguishing by individuals who have moved abroad or not appear in table 3.

[INSERT TABLE 3]

Concerning personal characteristics, first, the average starting age of the PhD program for students with abroad stay is three years lower than the rest of individuals (26 years *versus* 29 years). Second, it is highlighted that the rate of women is slightly higher in the group of individuals with international mobility (46% *versus* 44%). In relation to the parental educational background, it is noted that the percentages of people moving to abroad increase along with the educational level of parents and mothers. For example, individuals whose mother has primary studies or less stand at 72% in the group without international mobility, that is, 12 percentage points higher than the one corresponding to individuals who have moved outside Spain.

Regarding the characteristics of the PhD program, first, it is remarkable that the knowledge areas of Natural Sciences and Medical Sciences show the highest difference but in opposite directions. In the group of individuals moving abroad, Natural Sciences (Medical Sciences) represents the 53% (9%), whereas in the other group this percentage accounts for 31% (23%). Second, individuals who have financed their doctoral studies with a grant stand for 59% in the group of individuals with international mobility, which is 33 percentage points higher than the ratio in the group without mobility. Third, doctorate holders who have not had a stay abroad need on average 10 months more to complete their PhD program than those who have moved outside Spain.

The descriptive statistics for the explanatory variables included in the wage and education-job matching models are shown in table 4. This information has been displayed, on the one hand, grouping the wage intervals in two sets of four and, on the other hand, distinguishing the quality of the matching between doctoral studies and job in low or not. In relation to the position of individuals according to the wage distribution, the examination of the results reveals that there is a clear segmentation by personal and labour characteristics.

Thus, male doctorate holders in Medical Sciences and with open-ended contracts are more represented in the group of individuals located at the top of the wage distribution. For example, wage earners with a PhD program in Medical Sciences stand at 25% (12%) of the collective with wages above (below) 35,000 €. From a different perspective, the percentage of individuals with postdoctoral international mobility is higher in the collective with lower wages (27% *versus* 17%), but it is not possible to conclude a causality relationship from this finding because the assignment of individuals to the wage distribution is strongly influenced by the rest of characteristics. In particular, tenure is a significant variable as the number of years with the same employer reaches 14.5 (8.8) years on average for individuals with wage above (below) 35,000 €.

When observing the distribution of individuals associated with the quality of the matching between doctoral studies and job tasks, some different patterns are found. First, it is observed that knowledge areas of Natural Sciences, Engineering Technology and Social Sciences improve their percentages within the collective with a good match in relation to the group with bad education-job matching. In particular, this is observed for doctorate holders in Social Sciences (23% *versus* 13%). On the contrary, the percentage of wage earners with Medical Sciences PhD program shows a sharply decrease from 30% to 15%. On the other hand, there are not differences according to the job tenure (around 12 years on average for all individuals) and the type of contract (around 80% of open-ended contract). In contrast, the distribution according to the type of sector is not homogenous as the percentage of individuals working in higher institution increases 40 percentage points when observing the collective with good education-job matching (from 21% to 61%), and the opposite occurs for wage earners in the public administration with a decrease of 35 points (from 56% to 21%). Finally, it is worth noting that doctoral studies and educational requirements of the job are very related for individuals working as researchers: in particular, the percentages of researchers increases from 20% to 80% for the groups of individuals with bad and good education-job matching, respectively.

[INSERT TABLE 4]

3. METHODOLOGICAL APPROACH

This section is divided into two subsections, in each one of them the wage econometric model and the probit model taking into account the mismatch between doctoral studies and current job are presented, respectively. A key characteristic of both models is the inclusion of an endogenous regressor showing if the individual has had a temporary postdoctoral stay abroad.

3.1 Econometric wage model

The wage econometric model proposed is formulated in equation 1:

$$\mathrm{Y}_{1i}^{*} = x_{1i}^{'}\beta + \alpha_0 \mathrm{Y}_{2i} + \varepsilon_{1i} \qquad (1)$$

where Y_{1i}^{*} is the log wage for the individual i, x_i is a vector of regressors (β is its vector of unknown parameters) composed by the following explanatory variables: gender, research field of the PhD program, type of research, tenure, type of contract (open-ended or fixed-term contract), an indicator of whether the individual is working as a researcher or not, sector (firm, public administration, higher education institution or private non-profit institution), tenure, and regional dummy variables taking into account the characteristics of the local labour markets. Y_{2i} is a dummy endogenous regressor equals to 1 if the individual has made a stay abroad and 0 otherwise, and α_0 is the unknown coefficient that captures the causal interdependence between international mobility and wages. Finally, ε_{1i} is an independent and identically distributed error term that follows a normal distribution.

The endogenous regressor Y_{2i} has values 1 or 0 depending on Y_{2i}^{*}, which is the unobserved individual's propensity to the international mobility and can be interpreted as the net value on utility that each individual assigns to her/his temporary migration choice. Y_{2i}^{*} is supposed to follow equation 2:

$$Y_{2i}^{*} = z_i^{'}\delta + \varepsilon_{2i} \tag{2}$$

In particular, Y_{2i} is 1 if $Y_{2i}^{*} > 0$ and 0 otherwise. In equation 2, z_i is a vector of explanatory variables influencing the propensity to move outside Spain. This group of regressors is composed by the following variables: starting age of the PhD program, gender, maternal and the parental educational attainment, research field, type of research during the PhD program, and way of financing the doctoral studies. ε_{2i} is an independent and identically distributed error term with a distribution $N(0,\sigma_2^2)$.

It is assumed that $E(\varepsilon_{1i} \mid \varepsilon_{2i}) = \rho_0 \varepsilon_{2i}$, with $\rho_0 = \frac{E(\varepsilon_{2i}\varepsilon_{1i})}{E(\varepsilon_{2i}^2)}$; therefore, the expectations of (1) and (2) conditional on y_{2i} appear in equations 3 and 4, respectively:

$$E(Y_{1i}^{*} \mid Y_{2i}) = x_{1i}^{'}\beta + \alpha_0 y_{2i} + E(\varepsilon_{1i} \mid Y_{2i}) \tag{3}$$

$$E(Y_{2i}^{*} \mid Y_{2i}) = z_i^{'}\delta + E(\varepsilon_{2i} \mid Y_{2i}) \tag{4}$$

By the law of iterated expectation:

$$E(\varepsilon_{1i} \mid Y_{2i}) = E(E(\varepsilon_{1i} \mid \varepsilon_{2i}) \mid Y_{2i}) = \rho_0 E(\varepsilon_{2i} \mid Y_{2i}) \tag{5}$$

Plugging equation 5 into equation 3 gives expression 6:

$$\mathrm{Y}_{1i}^{*} = x_{1i}^{'}\beta + \alpha_0 Y_{2i} + \rho_0 E(\varepsilon_{2i} \mid Y_{2i}) + u_i \tag{6}$$

As $u_i = Y_{1\mathrm{i}}^{*} - E(Y_{1\mathrm{i}}^{*} \mid \mathrm{Y}_{2\mathrm{i}}) = \varepsilon_{1i} - \rho_0 E(\varepsilon_{2i} \mid \mathrm{Y}_{2\mathrm{i}})$, $\mathrm{Y}_{2\mathrm{i}}$ is now an exogenous regressor since $E(u_i \mid \mathrm{Y}_{2\mathrm{i}}) = 0$, and $E(\varepsilon_{2i} \mid \mathrm{Y}_{2\mathrm{i}})$ is controlling the endogeneity $\mathrm{Y}_{2\mathrm{i}}$, this is the control function approach proposed by Heckman (1978). $E(\varepsilon_2 \mid \mathrm{Y}_{2i})$ is unobserved, so it must be estimated using the generalized residuals for the probit model associated with equation 2. This method was proposed by Gourieroux *et al*. (1987) and generates the following residuals:

$$e_{2i}(\hat{\delta}) = \frac{\phi(z_i^{'}\hat{\delta})}{\Phi(z_i^{'}\hat{\delta})[1-\Phi(z_i^{'}\hat{\delta})]}[Y_{2i} - \Phi(z_i^{'}\hat{\delta})] \tag{7}$$

where Φ and ϕ are the cumulative distribution function and the probability density function of the standard normal distribution, respectively. These residuals are included as a regressor in the wage model:

$$\mathrm{y}_{1i}^{*} = x_{1i}^{'}\beta + \alpha_0 \mathrm{y}_{2i} + \rho_0 e_{2i}(\hat{\delta}) + u_i^{*} \tag{8}$$

Consequently, the implementation of the previous econometric procedure requires two steps: the first one is the estimation of a probit model to calculate the generalized residuals, and the second one is to estimate equation 8 including this generalized residuals as an additional regressor. For the identification of the system of equations, the vectors of regressors X_i and Z_i must differ in at least one variable, and this condition is met in this case.

To estimate equation 8, an additional problem arises because the information about wages are shown as ranges in the 2009 Survey on Human Resources in Science and Technology (INE, 2010). One solution proposed to this point by the econometric methodology is to take the midpoint of the wage interval and estimate the log-wage equation by ordinary squares. This solution is not appropriate in this case because the lower and upper wage intervals are open, that is, there are left and right unbounded, respectively. Moreover, even if it were possible, OLS has not desirable properties when the dependent variable is in ranges of values as the estimates are inconsistent (Stewart, 1983). A better approach from an econometric point of view is to estimate an interval regression model, which is a generalization of a Tobit model and allows the dependent variable to be expressed both as a data point and as interval data (Daniels and Rospabe, 2005). In particular, the likelihood function to be maximized is:

$$L=\prod_{i=1}^{N_1}[\Phi\left(\frac{L_{1,i}-x_{1i}^{'}\beta-\alpha_0 y_{2i}-\rho_0\hat{e_{2i}(\delta)}}{\sigma_{u^*}^2}\right)^{d1}]*\prod_{i=1}^{N_2}[\Phi\left(\frac{M_i-x_{1i}^{'}\beta-\alpha_0 y_{2i}-\rho_0\hat{e_{2i}(\delta)}}{\sigma_{u^*}^2}\right)-\Phi\left(\frac{m_i-x_{1i}^{'}\beta-\alpha_0 y_{2i}-\rho_0\hat{e_{2i}(\delta)}}{\sigma_{u^*}^2}\right)^{d2}]*$$
$$*\prod_{i=1}^{N_3}[1-\Phi\left(\frac{L_{1,i}-x_{1i}^{'}\beta-\alpha_0 y_{2i}-\rho_0\hat{e_{2i}(\delta)}}{\sigma_{u^*}^2}\right)^{1-d1-d2}] \quad (9)$$

where d_{1i} is 1 if the individual is observed in the first left-unbounded wage interval; d_{2i} is 1 if the unobserved wage is within the range (m_i, M_i). In all other cases, workers are observed in the last right-unbounded wage interval. Finally, u_i^* is assumed to be $N(0,\sigma_{u^*}^2)$.

3.2 Probit model for the education-job match

This section presents the econometric specification used to analyse the match between doctoral studies and the educational requirements of the job. The degree of relationship between the human capital acquired with the PhD program and the skills required to performance the job tasks can be thought as an unobservable dependent variable Y_{3i}^*:

$$Y_{3i}^* = x_{1i}^{'}\beta^* + \alpha_1 Y_{2i} + \varepsilon_{3i} \quad (10)$$

A dummy variable Y_{3i} is generated such that it is equal to 1 if the doctoral studies are closely related to the job, $Y_{3i}^* > 0$, and 0 otherwise. In equation 10, Y_{3i}^* is function of a set of regressors (that coincides with the one corresponding to the wage model) and an endogenous regressor Y_{2i} that depends on Y_{2i}^* and controls if the individuals has had a stay abroad. Then, Y_{3i} and Y_{2i} can be expressed as:

$$Y_{3i} = 1(x_{1i}^{'}\beta^* + \alpha_1 Y_{2i} + \varepsilon_{3i} \succ 0) \quad (11)$$

$$Y_{2i} = 1(z_i^{'}\delta + \varepsilon_{2i} \succ 0) \quad (12)$$

1(.) is the indicator function equals to 1 if the statement in the brackets are true and 0 otherwise. ε_{3i} and ε_{2i} are error terms that follow a normal distribution. Similarly to the previous subsection, it is assumed

$E(\varepsilon_{3i} \mid \varepsilon_{2i}) = \rho_0 \varepsilon_{2i}$, with $\rho_0 = \frac{E(\varepsilon_{3i}\varepsilon_{2i})}{E(\varepsilon_{2i}^2)}$. Therefore, in the same way as in the wage model, it is possible to define the probability of having a good education-job match as follows:

$$P(Y_{3i} = 1 \mid Y_{2i}, X_{2i}) \cong \Phi\left[x_{1i}^{'}\beta^{*} + \alpha_1 \mathrm{Y}_{2i} + \rho_0 E(\varepsilon_{2i} \mid \mathrm{y}_{2i})\right] \cong \Phi\left[x_{1i}^{'}\beta^{*} + \alpha_1 \mathrm{Y}_{2i} + \rho_0 e_{2i}(\hat{\delta}))\right] \quad (13)$$

To estimate the unknown parameters, first, the probit model corresponding to the probability of international mobility is regressed and, subsequently, the probit model corresponding to the degree of matching between doctoral studies and job is computed including the residuals $e_{2i}(\hat{\delta})$ as a regressor.

4. RESULTS

This section presents and discusses the estimates of the wage model and the probit model for the education-job matching; in this way, it is possible to achieve the primary objective of this article, that is, to analyse the influence of having had a stay abroad on some aspects of the doctorate holders' careers such as their wages and education-job matching.

The previous section has shown the econometric procedure to obtain a proper estimate of the international mobility's effects on the above topics. This methodological process involves to estimate previously a probit model to explain international mobility and to compute subsequently its generalized residuals. Table 5 displays the marginal effects obtained from this model and allows us to observe how the probability of moving outside Spain depends on different characteristics. First, it is remarkable that gender has not a significant influence on the dependent variable, which can be explained because the individuals are in an early stage of their professional careers and are more released of family duties. Hence, the gender differences that appear later in the labour market are not yet detected. This argument is supported by the negative effect associated with the variable age (an additional year decreases 1.2 percentage points the probability of international mobility), and shows how the costs associated with moving outside Spain increase when the individuals grow into the adulthood. Moreover, temporary migration abroad can be thought as a type of human capital investment and its benefits depend negatively on the time horizon. In relation to the family background, there is an asymmetric influence since only maternal education has a positive effect on the probability of international mobility. For example, doctorate holders whose mothers have long higher education or doctoral studies show a probability of having had a stay abroad that is 10 points higher than the one corresponding to the reference category (individuals whose mothers have primary studies or less). This is an evidence on how the human capital effects can be transferred between generations and also reveals mothers

are the strongest models for children as they have a greater impact on their behaviour and decisions than fathers (Behrman and Rosenzweig, 2002). Third, individuals with PhD program in the knowledge areas of Natural Sciences, Engineering and Technology and Agriculture Sciences are most likely to move outside Spain once completed their doctoral studies. In particular, the highest difference is observed for Medical Sciences doctorates who have 11 percentage points lower than the above research fields. Moreover, PhD program with applied research has a negative influence on the probability of international mobility. On the other hand, doctorates holders who have financed their studies with a grant (Spanish or foreign) are most likely to have a postdoctoral stay abroad. In this case, the personal and academic characteristics determining the grant awards are closer to a research profile and can explain that these individuals wish to continue their research training with a postdoctoral stay abroad. Finally, the marginal effect corresponding to the time to the doctorate indicates a negative effect on the probability of international mobility. Several reasons could explain this finding. On the one hand, individuals could take more time in completing their PhD program because they do not have enough research skills or not have made a good match of the academic field. On the other hand, the initial motivation of individuals who take more time in finishing the doctorate could be different from that of being employee as a researcher, for example, they could use the doctorate to find a better job, to get a promotion, to expand their knowledge or just for personal fulfilment. All these arguments might discourage postdoctoral to stay abroad and continue their research career.

[INSERT TABLE 5]

Table 6 provides the estimates of the interval wage model for doctorate holders. The predicted model is semilogarithmic (equation 1) and, with the exception of the variable "tenure", the rest of regressors are binary variables, so the dummy variables' effects are computed by calculating the exponential of its coefficient and subtracting 1 (Halvorsen and Palmquist, 1980).

[INSERT TABLE 6]

The coefficient of the dummy variable "international mobility" quantifies the average impact of having had a postdoctoral stay abroad and, in econometric terminology; it denotes the average treatment effect. This variable is not relevant whether the wage model is regressed without taking into account its endogeneity; but the result changes when the interval wage model includes as regressor the generalized residuals obtained from the estimate of the probit model used to explain the international mobility. In particular, the estimated coefficient shows that wage earners who have moved outside Spain once completed their PhD program earn, on average, 8.32% more than individuals who have stayed in Spain over the period from the completion of the doctoral studies to the access to the current job. From a different point of view, figure 1 plots the average predicted probability of being located in a particular wage interval according to the international mobility status. As can be seen from this graph, the probability of being observed in a wage interval above 40,000 € is higher for wage earners with a postdoctoral stay abroad. For example, they have a probability of receiving a

wage above 50,000 € that is 2 percentage points higher than the one corresponding to the rest of employees. This positive relationship between international mobility and wages is in line with previous empirical research (see, for example, Di Cintio and Grassi, 2016) and is coherent with the predictions of the economic theory as individuals make the decision of going beyond the national borders whether the expected benefits outweigh the cost of moving (see, for example, Borjas 1987). Several factors can be motivating the positive influence of international mobility on wages. First, individuals who take the decision of moving abroad are showing a high versatility and adaptability to different cultural and socioeconomic environments and these abilities can be valuable by the firms. Second, in most cases, stays abroad are accompanied by training and an improvement of the proficiency in a foreign language that increase the workers' competences. Third, these individuals are prone to mobility and this characteristic is a desirable aptitude by firms extended along different geographical areas. Nevertheless, the estimate of the coefficient ρ_0 corresponding to the generalized residuals has a negative sign what means that the error terms of the wage and mobility models are correlated negatively, that is, there is a negative selection on unobservable traits. This result is in line to other studies (see, for example, Parey *et al.*, 2015 or Di Cintio and Grassi, 2016) and could show that doctorate holders could use temporary migration as a mechanism to compensate some unobservable inefficiency or training lacks detected during their PhD programs.

[INSERT FIGURE 1]

In relation to the rest of regressors, interestingly, the estimates obtained with and without correcting endogeneity bias are very similar in magnitude and significance level. On the one hand, male wage earners' wages are 8.32% higher than their female counterparts, this result shows gender differences in the job conditions of the doctorate holders, and supports the evidence of the gender inequality observed in other aspects of the Spanish labour market (see, for example, Guner *et al*. 2014). On the other hand, the knowledge area is a significant factor to explain the wage gap between doctoral holders. In particular, the main positive differences are observed for PhD graduates in Medical Sciences or Engineering and Technology doctorates whose wages are 16.18% and 4,5% higher that the those corresponding to the PhD graduates in Agriculture Sciences, Natural Sciences or Social Sciences. On the contrary, Humanities is the knowledge area worse remunerated, for example, doctorates in this scientific field receive a wage that is 11 percentage lower than the one corresponding to the reference category. In relation to the job-related characteristics, first, the number of years in the paid employment (tenure) has a positive influence on wages, which is in line with previous research (see, for example, Altonji and Williams, 2005 or Caparrós, 2016b). This positive association could be explained because tenure is a proxy of the unobserved specific human capital received by the workers in the firm, which has a direct effect on their productivity and, as a consequence, on their wages. Second, workers with open-ended contract earn 24% more than those with fixed-term contract, this finding reveals the stability of the labour relationships is a relevant variable to explain the success of the doctorate holders' careers, and is consistent with the predictions of the theory of the dual labour markets that suggests the existence of a

labour market separated into a primary and a secondary market, the individuals with fixed-term contracts would be in the second one and would have low wages and few opportunities of getting a promotion. Third, the wage is increased in 5 percentage points whether the individual performs research tasks. In this case, the doctorate holders are likely to have a better job matching, which would cause higher salaries. Finally, the geographical areas where the PhD graduates are earning higher wages are East, Madrid and Norheast that are the most economically developed Spanish regions.

Table 7 shows the marginal effects computed once estimated the probit model to assess the matching between the doctoral studies and the job tasks.

[INSERT TABLE 7]

The dependent variable takes value 1 whether the doctoral studies are closely related to the job and 0 otherwise, like the wage model, table 7 presents the results obtained considering the dummy variable "international mobility" as an endogenous regressor or not, that is, correcting or not the endogeneity bias. The differences are quite significant when comparing both econometric specifications, in particular, the correction of the endogeneity bias on the variable "international mobility" implies to triple the positive effect on the probability of having a good education job-matching. In particular, doctorate holders with a postdoctoral stay abroad increase their probability of having a current job medium-high related to the doctoral studies in 33 points with respect to PhD graduates without international mobility. Several arguments can explain this result. From the standpoint of labour demand, international mobility is a valuable characteristics for firms to fill highly-qualified job vacancies. From the perspective of the individuals, as mentioned previously, a postdoctoral stay abroad can be considered as an additional investment in human capital, so doctorate holders with international mobility can make a better selection of their job offers to generate a higher return on such investment. Similar to the estimates corresponding to the wage model, the coefficient associated with the generalized residuals from the probit model specified to analyse international mobility is significant and has a negative sign. This finding could indicate the existence of a negative selection, that is, individuals moving outside Spain can be trying to compensate the lacks of their PhD programs to get a good education-job matching.

Concerning to the rest of regressors, and focusing on the model that correct the endogeneity bias, it is possible to highlight some interesting results. First, the doctorate in Medical Sciences or Social Sciences show the highest probability of getting a job medium-high related to their doctoral studies. This result is particularly remarkable for the doctorate holders in the knowledge areas of Natural Sciences and Engineering and Technology that offer highly specialized PhD program. This could reveal that there is not enough room in the Spanish labour market for all PhD graduates in these scientific fields, which would indicate inefficiencies in the assignment of resources to the tertiary education and an inadequate adjustment of the education system to the real needs of the labour market.

Focusing on the job-related characteristics, first, it is observed that those individuals working as researchers show a probability of having a good education-job matching that is 40 percentage points higher than the one corresponding to the rest of doctorate holders. This result is reasonable because one of the competences acquired by the PhD program is the capacity to innovate; thus, a good education-job matching can be expected whether the individual is performing research tasks in his current employment. Second, according to the type of sector, the best matches between doctoral studies and jobs are observed in the higher education institutions. For example, in comparison to those individuals working in firms, they have a probability of having a good education-job matching that is higher in 29 percentage points. This finding shows that the educational mismatch of the doctorate holders is more pronounced in the private company, which leads us to think about the need for improvement the knowledge transfer between the PhD programs and the productive activity. Finally, it is worth highlighting that Madrid is the Spanish region where the PhD graduates can find jobs that are closely related to their education attainment.

5. CONCLUSION

The socio-economic importance of the PhD program in Europe and, particularly, in Spain is currently in a sustained growth as consequence of the targets proposed by EU Horizon 2020. In this context, this article has analysed the effects of having a postdoctoral stay abroad on some questions related to the doctorate holders' careers such as wages and the quality of the education-job matching. Data used has been the 2009 Survey on Human Resources in Science and Technology (INE, 2010), which offers the most recent information to examine the topics, and the econometric specifications proposed are the most suitable to address the endogeneity of the decision of moving outside Spain.

The main conclusions obtained can be grouped in three parts. First, it is possible to highlight some facts about the variables affecting the decision of a postdoctoral temporary migration. In particular, educational mother is positively related to the probability of moving abroad. Second, individuals with a PhD program in Natural Sciences, Engineering and Technology, and Agriculture Sciences and who financed their studies with a grant have the highest probability of international mobility; finally, it is negatively related to the time to the doctorate. Second, international mobility has a significant impact on wages as PhD graduates moving abroad earn 8.32% more than the rest and have more probability of being located at the top of the wage distribution. This conclusion confirms the prediction of the human capital theory as individuals make the decision of staying abroad whether the investment's benefits outweighs its costs. Other interesting findings concerning the rest of explanatory variables are, on the one hand, that males and doctorate holders in Medical Sciences or Engineering and Technology receive the highest wages. On the other hand, job-related characteristics are relevant to explain earnings. In particular, long-tenure workers with open-ended contracts and performing research tasks have the highest salaries. Third, international mobility has also an important effect on education-job matching because individuals with postdoctoral stay abroad show a probability of having an occupation medium-high related to their doctoral studies that is 33 percentage points higher than the rest of doctorate

holders. In relation to the rest of regressors, PhD graduates in Medical Sciences or Social Sciences working as researchers in higher education institutions are more likely of being employed in jobs that are quite related to the training acquired in the PhD program.

The findings obtained in this paper has revealed that, in the current Spanish education system, international mobility once completed the doctoral studies has a positive and significant effect on the doctorate holders' careers. Therefore, policies leading to promote and finance international mobility of Spanish doctorate holders would involve improvements in their careers and in the labour market as a whole. However, one should not lose sight that the findings also show a negative sample selection of the individual who stay abroad, that is, they could be using international mobility to cover some weakness of the Spanish PhD programs. In sum, the promotion of postdoctoral stay abroad should be accompanied by the improvement of Spanish doctoral studies' quality.

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TABLE 1 Annual wage distribution according to international mobility status

Annual wage (10^3 €)	**International mobility (%)**	**Not international mobility (%)**
Less than 10	0.95	0.84
10-20	5.82	3.79
20-30	23.68	14.44
30-35	17.96	13.95
35-40	16.64	14.16
40-45	12.99	14.13
45-50	8.66	12.51
More than 50	13.40	26.18
Observations	739	2,846
Pearson's Chi-square test	93.63***	

Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

TABLE 2. Education-job matching and international mobility status

Degree of relation between current job and PhD program	International mobility (%)	Not international mobility (%)
Not high	19.89	39.78
High	80.11	60.22
Observations	739	2,846
Pearson's Chi-square test	101.06***	

Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

TABLE 3 Regressors' descriptive statistics used to explain the probability of moving abroad

Variables	International mobility		Not international mobility	
	Mean	**St. Dev.**	**Mean**	**St. Dev.**
Age	26.06	5.67	29.06	7.07
Gender				
Male	0.54	0.49	0.56	0.49
Female	0.46	0.49	0.44	0.49
Parental educational level				
Primary education or less	0.46	0.45	0.52	0.50
Low technical education	0.03	0.19	0.03	0.16
Secondary education	0.08	0.27	0.08	0.27
Upper technical education	0.05	0.21	0.04	0.19
Short higher education	0.15	0.35	0.12	0.32
Long higher education and doctoral studies	0.25	0.40	0.21	0.38
Maternal educational level				
Primary education or less	0.60	0.40	0.72	0.30
Low technical education	0.02	0.15	0.01	0.11
Secondary education	0.10	0.30	0.09	0.29
Upper technical education	0.02	0.13	0.01	0.11
Short Higher education	0.13	0.33	0.10	0.30
Long Higher education and doctoral studies	0.13	0.33	0.07	0.27
Knowledge area				
Natural Sciences	0.52	0.40	0.31	0.30
Engineering and Technology	0.08	0.27	0.08	0.28
Medical Sciences	0.09	0.29	0.23	0.42
Agricultural Sciences	0.03	0.18	0.03	0.17
Social Sciences	0.16	0.37	0.20	0.40
Humanities	0.12	0.33	0.15	0.35
Type of research				
Non-oriented research	0.79	0.40	0.70	0.45
Applied research	0.55	0.49	0.65	0.47
Experimental research	0.38	0.48	0.36	0.48
Studies' financing sources				
Spanish grant	0.59	0.49	0.33	0.47
Foreign grant	0.02	0.15	0.01	0.09
Earned income working as research assistant	0.20	0.40	0.26	0.43
Earned income working as not research assistant	0.05	0.22	0.19	0.39
Loans or savings	0.11	0.32	0.20	0.40
Time to doctorate (months)	62.36	23.73	72.42	36.32
Observations	739		2,846	

Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

TABLE 4 Regressors' descriptive statistics used to explain wages and education-job matching

Variables	Wage intervals				Relationship between doctoral studies and job			
	Below 35,000 €		Above 35,000 €		Low		Not low	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Gender								
Male	0.47	0.50	0.61	0.49	0.53	0.50	0.58	0.49
Female	0.53	0.50	0.39	0.49	0.47	0.50	0.42	0.49
Knowledge area								
Natural Sciences	0.40	0.35	0.31	0.40	0.32	0.42	0.36	0.32
Engineering and Technology	0.07	0.25	0.10	0.29	0.07	0.26	0.10	0.29
Medical Sciences	0.12	0.32	0.25	0.43	0.30	0.45	0.15	0.35
Agricultural Sciences	0.03	0.17	0.03	0.18	0.03	0.17	0.03	0.17
Social Sciences	0.18	0.38	0.21	0.40	0.13	0.34	0.23	0.42
Humanities	0.20	0.40	0.11	0.31	0.15	0.36	0.13	0.34
Type of research								
Non-oriented research	0.80	0.40	0.68	0.46	0.70	0.45	0.73	0.44
Applied research	0.60	0.50	0.66	0.47	0.62	0.48	0.64	0.47
Experimental research	0.38	0.48	0.36	0.48	0.39	0.48	0.35	0.47
Tenure (years)	8.79	6.86	14.52	8.06	12.60	8.91	12.36	7.66
Type of contract								
Open-ended contract	0.65	0.45	0.92	0.27	0.84	0.36	0.81	0.38
Fixed-term contract	0.35	0.45	0.08	0.27	0.16	0.36	0.19	0.38
Working as a researcher								
Yes	0.61	0.48	0.62	0.48	0.29	0.45	0.80	0.40
Not	0.39	0.48	0.38	0.48	0.71	0.45	0.20	0.40
Type of sector								
Firm	0.11	0.31	0.10	030	0.19	0.39	0.05	0.23
Public administration	0.39	0.49	0.41	0.49	0.56	0.49	0.31	0.46
Higher education institution	0.45	0.35	0.43	0.33	0.21	0.30	0.61	0.42
Private non-profit institution	0.05	0.23	0.03	0.17	0.04	0.20	0.03	0.19
Current Spanish regions of residence								
Canarias	0.03	0.16	0.05	0.21	0.04	0.19	0.04	0.20
Centre	0.11	031	0.09	0.29	0.10	0.30	0.10	0.29
East	0.20	0.40	0.24	0.43	0.23	0.42	0.23	0.41
Madrid	0.17	0.37	0.18	0.38	0.18	0.38	0.18	0.38
Northeast	0.12	0.32	0.12	0.32	0.13	0.33	0.12	0.32
Northwest	0.13	0.33	0.13	0.33	0.12	0.32	0.13	0.34
South	0.24	0.42	0.19	0.37	0.20	0.35	0.20	0.35
International mobility								
Yes	0.27	0.44	0.17	0.37	0.11	0.32	25.67	0.44
Not	0.73	0.44	0.83	0.37	0.89	0.32	74.33	0.44
Observations	1,297		2,288		1,279		2,306	

Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology

TABLE 5 Estimates of the probability of international mobility

Variables	Marginal effects[a,b]	
Gender		
Male	0.005	
Age	-0.012	***
Parental educational level		
Low technical education	0.090	
Secondary education	0.017	
Upper technical education	0.060	
Short higher education	0.033	
Long higher education and doctoral studies	0.009	
Maternal educational level		
Low technical education	0.116	*
Secondary education	0.041	*
Upper technical education	0.060	
Short Higher education	0.053	**
Long Higher education and doctoral studies	0.099	**
Knowledge area		
Engineering and Technology	-0.031	
Medical Sciences	-0.110	***
Agricultural Sciences	-0.033	
Social Sciences	-0.037	**
Humanities	-0.034	*
Type of research		
Non-oriented research	0.010	
Applied research	-0.034	**
Experimental research	-0.006	
Studies' financing sources		
Spanish grant	0.081	***
Foreign grant	0.211	**
Earned income working as research assistant	0.021	
Earned income working as not research assistant	-0.065	***
Time to doctorate (months)	-0.001	***
Observations	3,585	

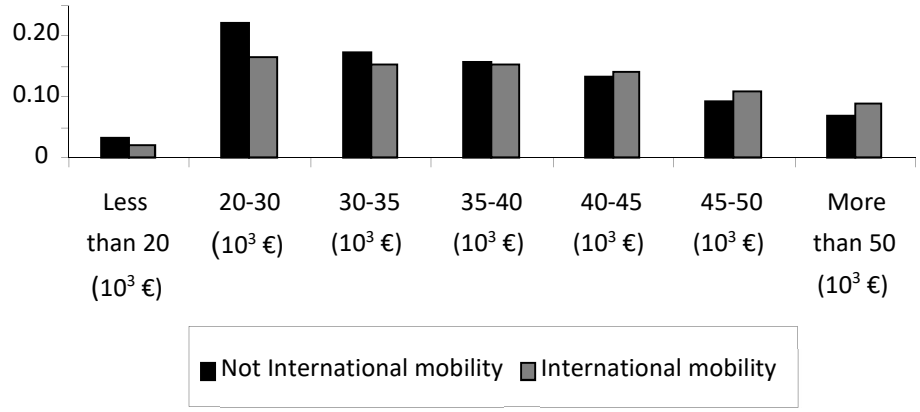
Notes:
(a) The individual of reference is a woman, doctorate in Natural Sciences that financed her studies working as not research assistant and whose father and mother have not completed the primary studies.
(b) (***) significant at 1%, (**) at 5%, (*) at 1%.
Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

TABLE 6 Estimates of the wage model

Variables	Coefficient[a,b]			
	Without correcting endogeneity bias		Correcting endogeneity bias	
International mobility	-0.001		0.080	*
Gender				
Male	0.079	***	0.080	***
Knowledge area				
Engineering and Technology	0.038	**	0.044	**
Medical Sciences	0.143	***	0.157	***
Agricultural Sciences	0.026		0.031	
Social Sciences	0.004		0.006	
Humanities	-0.119	***	-0.110	***
Type of research				
Non-oriented research	-0.036	**	-0.037	**
Applied research	-0.004		0.001	
Experimental research	-0.025	**	-0.025	**
Tenure (years)	0.009	***	0.009	***
Type of contract				
Open-ended contract	0.217	***	0.216	***
Working as a researcher				
Yes	0.050	***	0.048	***
Type of sector				
Firm	0.001		0.001	
Public administration	0.007		0.008	
Private non-profit institution	-0.070	**	-0.069	**
Current Spanish regions of residence				
Canarias	0.067	**	0.068	**
Centre	-0.006			
East	0.076	***	0.076	***
Madrid	0.078	***	0.077	***
Northeast	0.047	**	0.046	**
Northwest	0.025		0.024	
Residuals			-0.048	**
Chi-Squared test	1182.73***		1101.11***	
Observations	3,585			

Notes:
(a) The reference is a woman living in the South region, doctorate in Natural Sciences and working in a higher education institution as not researcher and with a fixed term contract.
(b) (***) Significant at 1%, (**) at 5%, (*) at 10%.
Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

FIGURE 1 Average predicted probability by wage interval and international mobility



Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.

TABLE 7 Estimates of the probit model to explain the matching between doctoral studies and job

Variables	Marginal effects[a,b]			
	Without correcting endogeneity bias		Correcting endogeneity bias	
International mobility	0.096	***	0.284	***
Gender				
Male	0.047	***	0.049	***
Knowledge area				
Engineering and Technology	-0.009		0.009	
Medical Sciences	0.026		0.065	**
Agricultural Sciences	0.022		0.034	
Social Sciences	0.095	***	0.118	***
Humanities	-0.009		0.016	
Type of research				
Non-oriented research	-0.001		-0.005	
Applied research	0.031	*	0.044	**
Experimental research	-0.036	**	-0.034	*
Tenure (years)	-0.001		0.007	
Type of contract				
Open-ended contract	0.002		0.001	
Working as a researcher				
Yes	0.407	***	0.400	***
Type of sector				
Firm	-0.288	***	-0.287	***
Public administration	-0.189	***	-0.185	***
Private non-profit institution	-0.145	***	-0.142	***
Current Spanish regions of residence				
Canarias	-0.034		-0.033	
Centre	0.020		0.019	
East	0.008		0.008	
Madrid	0.044	*	0.042	*
Northeast	-0.003		-0.006	
Northwest	0.031		0.028	
Residuals			-0.144	**
Chi-Squared test	1,111.4***		1,111.8***	
Observations	3,585			

Notes:
(a) The reference is a woman living in the South region, doctorate in Natural Sciences and working in a higher education institution as not researcher and with a fixed term contract.
(b) (***) Significant at 1%, (**) at 5%, (*) at 10%.
Source: Own elaboration from 2009 Survey on Human Resources in Science and Technology.