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Private returns to an university education: An instrumental variables approach

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Abstract. This article examines the determinants of the salaries that Spanish university graduates earn on the labor market. Different earnings equations are estimated that allow us to measure the economic returns to investment in human capital at the university level, demonstrating that: on the one hand, considering schooling to be an exogenous variable gives a downward bias to the estimations of the private rates of return to an university education; on the other hand, not taking into account the aspects of the demand-side of the labor market in the traditional Mincerian earnings function, even though schooling is considered as an endogenous variable, the rates of return estimated for an university education would be given an upward bias. The problem concerning the endogeneity of schooling has been corrected in this article by using the instrumental variables technique.

Keywords: demand for schooling, earnings differential, human capital, rate of return

Introduction[1]

Education and earnings are positively linked. "The universality of this positive association between education and earnings is one of the most striking findings of modern social science." (Blaug 1972, p. 54). Ever since the precursory works of Becker (1964) and Mincer (1974), numerous contributions to the field of Economics of Education have shown, for different countries and time periods, that an individual's academic qualifications play an important role in establishing the salary he or she receives. In addition, particularly following Card and Krueger's (1992) influential publication demonstrating that there is a positive significant association between the quality of schools – measured using indices such as the teacher/pupil ratio or teachers' income – and the incomes students earn on the labor market, a great number of research papers in recent years have concentrated on analyzing the influence the quality of the schooling received has on an individual's earnings (James et al. 1989; Jones and Jackson 1990; Betts 1995, 1996a, b;

Brewer et al. 1996; Grogger 1996; Heckman et al. 1996; Johnson and Stafford 1996; Card and Krueger 1998).[2]

The fact is that, today, there is a wealth of literature regarding the estimation of education's rates of return. The empirical tool used in most of this research has been the traditional Mincerian earnings function (Psacharopoulos 1994; Cohn and Addison 1998; Asplund and Pereira 1999; Harmon et al. 2001, 2003). This function, proposed by Mincer (1974), is a semi-logarithmic function, such that an individual's earnings vary linearly with the time dedicated to education and quadratically with experience.[3]

However the estimations of the rates of return to education have been controversial right from the outset. The criticisms concern the main econometric problems we come across when using the Mincerian function, as mentioned by Griliches (1977). These problems arise when: (i) certain variables are not included in the human capital earnings function – for example, an individual's ability or aptitude, which is supposedly correlated to education; (ii) the quantity of schooling is not measured correctly; (iii) schooling is treated as an exogenous variable. For these reasons, a large proportion of the most recent literature on education returns has concentrated on attempting to estimate returns that are free of the bias that could affect them when these econometric problems are not taken into account. The works of Blackburn and Neumark (1993, 1995), Angrist and Krueger (1994, 1995), Card (1994, 2000), Murnane et al. (1995), Ashenfelter and Rouse (1997), and Heckman and Vytlacil (2000) are important in this respect.

This article looks precisely at the last point. More specifically, our objective is to obtain returns to education that are consistent for a sample of Spanish graduates, demonstrating that the private returns to graduate education would have a downward bias if schooling were not treated as an endogenous variable. Furthermore, we also attempt to demonstrate that the "pure" human capital model, even if schooling is treated as an endogenous variable, does not provide a true estimation of the private rate of return to investment in higher education, since it does not contemplate variables that, from the demand-side of employment, also have an influence on earnings.[4]

Conceptual framework

We are interested in estimating the private rate of return for university studies. To achieve this goal, we propose four models.

Model 1: Mincerian earnings function

The human capital theory has been widely used, both theoretically and empirically, to analyze the earnings differences among individuals with varying educational stocks (Becker 1964). Based on this theory, wage differences observed among individuals would be explained exclusively by differences in their human capital: formal human capital, such as education, or that acquired in the workplace, such as experience. The most prevalent proposal for estimating returns to investment in human capital, within the framework of this theory, is that which uses the Mincerian earnings function:

$$\mathrm{Ln}\, W_i = \beta_0 + \beta_1 S_i + \beta_2 E_i + \beta_3 E_i^2 + u_i, \tag{1}$$

where W_i are the earnings of individual i; S_i the number of years spent in formal education; E_i the years of job experience; u_i the random disturbance term; and $\beta_j (j = 0, 1, 2, 3)$, the parameters to be estimated.

In order to develop his human capital model, Mincer (1974) established the following simplified assumptions: (i) investment costs in schooling are solely opportunity costs – forgone earnings – and not direct costs; (ii) the length of time an individual remains on the labor market is independent of the level of studies he or she has achieved, and it is assumed that his or her presence is continuous; in other words, he or she does not leave the labor market either voluntarily or involuntarily; and (iii) individuals begin working immediately after finishing their studies.

The coefficient estimated by ordinary least squares (OLS) associated with the schooling variable can be interpreted as the (average) rate of return to education. In terms of the coefficients associated with experience and its square, positive and negative estimated coefficients, respectively, are expected. This would reveal that additional experience time units lead to higher earnings, but that each extra year of experience has a lower effect on earnings than the previous year.

Model 2: Simultaneous equations model with no selectivity

When estimating education returns using model 1, the literature has generally considered schooling as an exogenous variable. However, schooling may be endogenous as a result of the individual's optimal choice. Therefore, we would view the Mincerian equation as part of a system of simultaneous equations:

$$\mathrm{Ln}\,W_i = \beta_0 + \beta_1 S_i + \beta_2 E_i + \beta_3 E_i^2 + u_i \quad S_i = X_i\gamma + v_i. \qquad (2)$$

This model integrates educational attainment and schooling returns into a unified framework. The variable S (schooling) is an independent variable in one equation but, at the same time, a dependent variable in another equation. Consequently, the education level is now determined from within the model and, hence, must be taken as an endogenous variable. In model 2: X_i is a vector of variables that affect the total years of education achieved; v_i, a random variable with a zero mean and constant variance; and γ, the vector of parameters to be estimated.

If schooling were an endogenous variable, then the use of the OLS technique to estimate model 1 would give us a biased estimation of the returns to education. One method that would allow us to tackle this problem is the use of instrumental variables (or instruments). The coefficient obtained after estimating the wage equation using instrumental variables will be a good measure of the rate of return (Levin and Plug 1999). To be effective, the instruments should be: (i) highly correlated with the endogenous variable; and (ii) non-correlated with the error term of the earnings equation (see Section "*Wage determinations and the private rates of return*").[5]

Model 3: Supply-demand model of earnings determination

Even if we do treat schooling as an endogenous variable, the human capital model is still incomplete in regards to explaining wage determinants. Why? The human capital model is an approach to explaining salaries from the supply-side of the labor market. According to the human capital theory, which focuses on characteristics of the worker, education creates human capital which enhances the productivity of the worker. Since workers are paid their marginal product, more formal education leads to higher earnings. The basic assumption of the human capital theory is that whatever jobs the worker performs the productivity will equal the market return on the worker's investment in education. Conversely, the job competition theory of Thurow (1975) links earnings to job characteristics: wages are predominantly determined by characteristics of the job (demand-side of the labor market). More education only indirectly leads to higher earnings through a higher probability of occupying a more complex job. The characteristics that individuals can offer, such as schooling, have little importance in determining their potential productivity on the job, since productivity is an attribute of the job and not of the person.

However, if we want to examine the relationship between education and the labor market, these theories only offer a one-sided framework. Both the human capital theory and the job competition theory lack the interaction between characteristics of the worker and characteristics of the job. Just as the assignment theory maintains (Sattinger 1993), both the supply and demand sides of the labor market matter. The assignment theory takes explicit account of this interaction by addressing the issue of whether the applicability of a person's knowledge and skills is context-specific. This theory shows how heterogeneous individuals are allocated to jobs that require varying qualifications on the basis of the qualifications that they possess. It is assumed that the knowledge and skills which individuals possess give them comparative advantages in certain types of occupations. Hence, graduates of some fields of education have better job opportunities in occupations strongly related to their field of education.

We should specify a model that combines variables from both sides (human capital variables and variables related to the jobs), which we can call the supply-demand model of earnings determination:

$$\mathrm{Ln}\, W_i = X_i\beta + e_i, \tag{3}$$

where W_i is the salary of individual i; X_i a vector of human capital variables (schooling and experience) and other relevant variables (type of firm, sectors of activity,...) that affect salaries; e_i a random variable with a zero mean and constant variance that reflects non-observable characteristics that affect salaries; and β the vector of parameters to be estimated. Here, in order to make a comparison with model 1, we still treat schooling as an exogenous variable.

Model 4: Supply-demand model of earnings determination with schooling as an endogenous variable

Finally, model 4 measures the "true" private rate of return[6] since it considers the schooling variable as an endogenous variable and, at the same time, includes variables from the demand-side of the labor market that also have an influence on salaries.

$$\mathrm{Ln}\, W_i = X_i\beta + e_i, \quad S_i = X_i\gamma + v_i. \tag{4}$$

Data and variables

Dataset

Higher education in Spain consists almost exclusively of universities. At present, there are 50 public and 19 private officially recognized universities in Spain. Spanish universities follow a career system, which means that Spanish students begin their studies with their major already selected and take courses that are pre-assigned for their entire major, with only a few electives available each year. There are three basic types of university programs: short-cycle programs, which are more vocationally oriented and last three years; long-cycle programs, which last four, five, or six years; and third cycle programs (doctoral programs), which add two years of course work and require the preparation of a research-oriented thesis after a long-cycle degree.

During the 1960s, the economic benefits of a college education were found to be substantial in Spain: good jobs and a quick transition to the labor market. However, these economic advantages of college graduates relative to high school graduates started to decline in the subsequent decades due to a spectacular growth in the number of higher education students – since the 1960s, growth has almost doubled each decade. As a result, university graduate unemployment has become the main concern of higher education policy and education planning during the last decades. Counseling, information, and employment centers have been set up in various universities as a result of agreements between the corresponding university and the National Institute for Employment. These centers guide and provide information to graduates in their search for employment. Additionally, some universities have conducted their own studies about the transition of university graduates to the labor market. For example, during the 1996–1997 academic year the University of Granada began to research the situation of university graduates in the employment world, collecting information *ad hoc* via a postal survey addressed to university graduates who were registered in the Professional Schools of the city of Granada.[7] A questionnaire was sent to each of the graduates registered with the Official Schools of Doctors, Nurses, Economists, Lawyers, Architects, Quantity Surveyors, and graduates in both Letters and Sciences.[8] The surveys were sent out during the months of December 1996 and January 1997 and cross-sectional data was received from almost 2000 graduates.[9] The data used in this article were drawn from the aforementioned survey.[10]

Variables

Models 1 and 3 will be estimated using the OLS technique. These models for determining the return to an university education consider the salaries that individuals receive on the labor market as a dependent variable. In our case, this variable will be LN_NHWAGE: the logarithm of the net per-hour earnings obtained by the graduate.[11] In the questionnaire we have information both on the length of the working week as well as on the net monthly earnings (after taxation and social security contributions). Since the latter appear in the questionnaire divided up by intervals, we decided to take earnings as the middle point of the interval, except for the first and the final divisions, where we took the lower and the upper extremes, respectively. Therefore, the dependent variable has been constructed as:

$$\text{LN\_NHWAGE} = \text{Ln}\left[\frac{Y}{Hx4}\right]$$

where H are the weekly hours in the current job and Y the net monthly earnings (in euros).

We consider as independent variables not only human capital variables (education and experience), but also variables from the demand-side of the labor market, such as skill mismatch in the job, sector of activity, or type of firm the graduate works for:

- Years of university education (EDUC). We have opted for constructing a continuous variable which is assigned the optimum number of years of study needed to graduate.[12] This variable takes the value of 3 if the individual completed Nursing or Quantity Surveying (short-cycle university studies); it takes the value of 5 for those who finished long-cycle university studies in: Law, Economics, Philosophy, Geography and History, Languages, Education, Biology, Geology, Mathematics, Physics, and Chemistry; it takes the value of 6 for long-cycle studies in Medicine or Architecture; and it takes the value of 8 in the case of a PhD in any of the aforementioned degree courses – except for Nursing and Quantity Surveying.[13]
- Years of real work experience on the labor market (EXPER),[14] and work experience squared (EXPER^2).
- Utilization of individual skills. Although for most graduates (95.2%) a university degree was requested by the employers for their current job,[15] it is true that some graduates do not make use

of the university-level skills they have developed. We define three dummies which reflect skill mismatches according with the respondents' judgments of skill utilization: (i) graduates that hold jobs requiring lower know-how than they can actually provide (UNDERUTI); (ii) graduates that hold jobs requiring greater know-how than the graduates can actually provide (DEFICIT); and (iii) graduates matched (MATCH).

- Variables that define the type of firm, included in the model by means of a group of dummy indicators: (i) Public Sector workers, be they civil servants or hired staff (PUSECTOR); (ii) private sector hired workers in large firms (LARGECO);[16] and (iii) private sector hired workers in small- and medium-sized enterprises (SMALL-CO).
- Variables that define the sector of activity (industries), recoded in the following dummy variables:[17] (i) Agriculture, Trade, Hostelry, Transportation, Communications and Industry (SECTOR1); (ii) Banks, Savings Banks and Insurance (SECTOR2); (iii) Health and Social Services (SECTOR3); (iv) Education (SECTOR4); (v) Real Estate and Rental activities, and Construction (SECTOR5); (vi) Other activities (SECTOR6);[18] and (vii) Defense (SECTOR7).[19]

However, models 2 and 4 are to be estimated using two-stage least squares (2SLS) since this is a regression technique that helps us correct the problem of the endogeneity of schooling. In the first stage, we regress education in terms of the instrumental variables. In the second stage, the predicted values of education are then used in the wage equation. The first stage, therefore, requires the use of instrumental variables (or instruments) to predict the determinants of the quantity of university education accumulated by the individuals, once they have completed secondary education. We are going to use the following instrumental variables in this study:

- Father's occupation (OCCUFA), which is a proxy for the family income – this is not reported in our dataset. This is a binary variable, with a value of 1 if the father was an entrepreneur, or managerial personnel in the private sector, or a group A Public Administration civil servant; it takes a value of 0 otherwise.
- A dummy indicator to proxy the expenditure on education, in terms of distance from the campus and the financial opportunities for covering the costs of studying (COST). It takes a value of 1 for students with low expenditure on education and high financial opportunity. Here, we include those students who, during the

academic year, lived in the family home and had a high capacity for financing studies.[20] It takes the value of 0 otherwise.[21]

- The mother's years of schooling completed (EDUCMO).[22]
- Respondent's gender (FEMALE). This is a dichotomous variable, with a value of 1 in the case of females and of 0 in the case of males.[23]

Empirical findings

The determinants of schooling attainment

This subsection looks directly at schooling attainment. Table 1 presents first-stage estimates to demonstrate that the instruments have predictive power in the first stage and that they have the expected signs.

First, we observe that the estimated coefficient associated to the variable EDUCMO is positive and statistically significant. Therefore, the family cultural factors, approximated using the mother's level of schooling, have a positive influence on the attainment of higher levels of university studies.[24]

Second, the family income also has a significant influence on the investment decisions in higher education. The estimated coefficient associated with the variable OCCUFA, that measured the ability to finance additional years of university education, is positive and statistically significant. We can state, therefore, that choosing longer degree courses is favored by a higher level of family income.[25] An omnipresent empirical regularity that emerges from the literature on determinants of schooling is the strong correlation between family income and schooling attainment (Cameron and Heckman 1998, 2001).

Third, the estimated coefficient associated with the variable FEMALE is negative and statistically significant, which reveals that gender is one of the individuals' characteristics that has an effect on the demand for university education. In our study, males accumulate a greater amount of higher education than females.

Lastly, the lower the direct monetary cost of higher education is and the greater the financial opportunities are for covering university schooling costs, the greater are the possibilities for following university degree courses of longer duration: the estimated coefficient associated with the variable COST is positive and statistically significant.

Even though Card (1993) used college proximity as an instrument to estimate the return to schooling, however, to explain student behavior

Table 1. The reduced-form schooling equation (first-stage regression) [a, b, c]

Variable	Model 2			Model 4		
	Coefficient		*t*-ratio	Coefficient		*t*-ratio
Constant	4.2462	**	31.22	4.6684	**	20.64
OCCUFA	3.78E−01	**	3.59	3.67E−01	**	3.69
COST	2.35E−01	**	2.57	1.84E−01	**	2.13
EDUCMO	5.25E−02	**	5.16	5.15E−02	**	5.37
FEMALE	−8.07E−01	**	−9.13	−9.14E−01	**	−10.61
EXPER	1.52E−02		1.06	−1.95E−03		−0.14
$EXPER^2$	8.46E−05		0.20	4.67E−04		1.16
UNDERUTI				6.90E−02		0.45
DEFICIT				6.51E−01	**	7.51
MATCH				Reference		
PUSECTOR				−7.79E−02		−0.43
LARGECO				−1.53E−01		−0.67
SMALLCO				Reference		
SECTOR1				−9.41E−01	**	−2.73
SECTOR2				1.98E−02		0.06
SECTOR3				−2.79E−01	**	−1.96
SECTOR4				Reference		
SECTOR5				−2.0966	**	−10.12
SECTOR6				−6.11E−01	**	−2.88
SECTOR7				−4.22E−01		−0.74
Adjusted R^2	0.1246			0.2283		
F	32.32	**		25.40	**	
Observations	1321			1321		

[a]**Indicates significance at the 5% level.
[b]Ordinary least squares regression (OLS).
[c]Dependent variable is EDUC.

at an university level in the Spanish case, this geographical variable is not enough because the individuals in our dataset, when they finished high school, had to decide between short-cycle (3 years) and long-cycle universities studies (5 or 6 years, depending on the degree),[26] and in their educational decisions the borrowing constraints played a key role – capital markets are imperfect. In our sample, students from higher economic backgrounds who lived near the university where they studied did not have problems (at least in economic terms) to register for university studies of a longer duration. Nevertheless, although for students from families with low incomes the opportunity to have the parental residence close at hand while in college yields a substantial financial advantage, we observe that these students tended to choose long-cycle degrees only when they were able to get a study grant; otherwise, students demanded a lower quantity of education.[27] Therefore, direct costs of schooling (monetary cost of tuition, books, etc.) affect schooling choices differently for credit-constrained and unconstrained individuals.[28]

Wage determinants and the private rates of return

The results of estimating the four models specified in Section "Conceptual framework" can be seen in Table 2.[29] Not surprisingly, the results show that the estimated rates of return to education are different when different models and methods are used.

We can observe how the contributions of schooling and experience to earnings are positive, while the estimated coefficient on years-of-experience-squared is negative (a parabolic relationship between income and age). The results indicate that earnings are higher according to the level of studies attained: the years spent in university education have an impact that is both positive and significant on salaries.

Let's concentrate on the schooling-earnings linkage. Models 1 and 2 show that the rate of return to graduate education is 7.75% and 13.07%, respectively, which demonstrates, therefore, that the returns to education will be biased downward if we use OLS to estimate the Mincerian equation. Hence, an instrumental variables approach increases the estimation of the private rate of return to graduate education.[30] However, the 2SLS used to estimate model 2 is appropriate only if the instruments satisfy the two following conditions: (i) there is a strong correlation between the instruments and schooling (instrumental quality);[31] and (ii) instruments are uncorrelated with the error term in the second stage (wage) equation (instruments are valid).[32] The bottom of Table 2 reports some test results proposed by Bound et al. (1995) to shed light on the quality and validity of our instruments. The first requirement can be tested using the F-test (partial) in the first stage reduced-form regression. We find that the instruments: gender, mother's years of education, father's occupation, and educational costs are satisfactorily correlated with the variable EDUC.[33] To test the second

Table 2. Testing the four alternative specifications of the earnings functions [a,b,c,d]

Variable	Model 1			Model 2			Model 3			Model 4		
	Coefficient		*t*-ratio	Coefficient		*t*-ratio	Coefficient		*t*-ratio	Coefficient		*t*-ratio
Constant	1.5580	**	43.536	1.3342	**	16.371	1.6928	**	25.637	1.4776	**	14.697
EDUC	0.0775	**	13.083	0.1307	**	7.024	0.0720	**	12.002	0.1206	**	6.657
EXPER	2.71E-02	**	7.023	2.58E-02	**	6.543	2.51E-02	**	6.832	2.45E-02	**	6.476
$EXPER^2$	−3.34E−04	**	−2.831	−3.38E−04	**	−2.864	−3.02E−04	**	−2.677	−3.20E−04	**	−2.769
UNDERUTI							−8.09E−02		−1.903	−8.69E−02	**	−2.031
DEFICIT							4.88E−02	**	2.283	8.45E−03		0.334
MATCH							Reference			Reference		
PUSECTOR							8.04E−02		1.357	7.93E−02		1.331
LARGECO							9.03E−02		1.243	9.42E−02		1.293
SMALLCO							Reference			Reference		
SECTOR1							−0.2710	**	−2.833	−0.2414	**	−2.453
SECTOR2							−0.1070		−0.841	−0.1222		−0.950
SECTOR3							−0.2105	**	−5.329	−0.1887	**	−4.584
SECTOR4							Reference			Reference		
SECTOR5							−0.1357	**	−2.144	−4.57E−02		−0.669
SECTOR6							−0.1708	**	−2.463	−0.1465	**	−2.092
SECTOR7							−0.1380		−1.679	−0.1297		−1.545

Regression	OLS		2SLS		OLS		2SLS	
Hausman test of exogeneity (*t*-values)			(−3.09)	**			(−2.91)	**
Sargan overidentification test (*p*-values)			(0.1729)				(0.1635)	
F−test of excluded variables			41.30	**			47.49	**
Partial R^2 of excluded variables			0.1117				0.1271	
Adjusted R^2	0.2493		0.2062		0.2701		0.2378	
F	147.10	**	115.28	**	38.57	**	32.69	**
Observations	1321		1321		1321		1321	

[a]**Indicates significance at the 5% level.
[b]Results corrected for heteroscedasticity.
[c]Dependent variable is LN_NHWAGE.
[d]Instruments for EDUC (models 2 and 4) are: OCCUFA, COST, EDUCMO, and FEMALE.

condition, we undertake the overidentification test (Sargan test). Our instrumental variables pass the overidentification test. So, we have valid instruments. But is instrumenting necessary in our wage equations? The answer is yes; the Hausman test (1978) reveals that the variable EDU is indeed endogenous.[34]

On the other hand, it is revealed that the labor market for university graduates is not fully competitive. Our findings in Table 2 suggest that a worker's industry – which reflects differences in working conditions – exerts a substantial impact on his wage even after controlling for human capital variables and a variety of job characteristics.[35] The fact that the estimated coefficients are negative shows us to what extent the salaries are lower in comparison with the Education sector. Thus, all else being constant, this latter sector is where graduates obtain higher incomes.[36] We can see that variables of skill mismatches also have an influence on earnings. Underutilization of skills shows the expected negative effect on wages,[37] and a skill deficit appears to have a positive effect on wages. Regarding the rate of return to education, we observe that it drops in comparison with the estimated rate in the human capital model, where we only bore in mind the graduates' university schooling and experience. Therefore, if we do not consider the aspects from the demand-side of the labor market to explain wage differences, even when considering schooling as an endogenous variable, the rates of return would show an upward bias.

Further discussion

The findings above are, therefore, the central results of this work; that is, that not taking into account the aspects of the demand-side of the labor market in the traditional Mincerian earnings function, even though schooling is considered as an endogenous variable, the rates of return estimated for an university education would be given an upward bias. Several questions remain, however. The first pertains to the evidence that we have on the effect of schooling on earnings for females. The second relates to the effect of several variables, such as ability, on the impact of schooling on earnings. These questions will be discussed below.

We observe that the estimated return to education is lower for women than for men.[38] In the light of the results, could we maintain that the labor market discriminates against women? We cannot categorically say that there is wage discrimination for reasons of gender. This discrimination would appear if males and females, with the same productive capacity, earned different salaries in the same (or similar) job. In our case, what occurs is that, in the sample, there are a high number of women with Diplomas (mainly nurses) who work in the Public Sector as group B civil servants and whose salaries are lower than those earned by the group A degree holders (of which a large number are men). Group A has a higher wage assignation, since access to it requires a long-cycle degree course; group B follows behind, with lower earnings and the requisite of short-cycle studies for access to it and so on. Therefore, in the Public Sector, earnings are related, more than to productivity criteria, to the group (and Corps) one gains access to. The public employer designs the job posts and assigns them a wage, which varies in terms of the group.[39]

The role of ability in affecting earnings is a more difficult concept which, nevertheless, is the subject of a large and growing body of literature. Early efforts of Becker (1964) recognized that the usual wage equations overestimated the "true" contribution of education because of the observed correlation between measured ability and years of school completed. Ordinary least squares (OLS) regressions of earnings on schooling have long been believed to be biased upward as a result of "ability bias".[40] Several approaches in the applied works attempt to eliminate omitted-ability bias.[41] A very common practice consists of directly including proxies for the unobserved ability (e.g., IQ test scores) in the wage equations. Including such measures in cross-sectional regressions tends to reduce the estimated return to schooling. Since there are no IQ or similar test-scores in our dataset, we built a proxy for the (academic) ability using the grades students got in their degrees.[42] Although the main result of the literature is that omitting ability leads to an overestimate of the rate of return to education, our findings (see Table A3 in Appendix) are that this variable is not related with the earnings of graduates – and the rates of return do not change (or only slightly).[43]

Finally, we should raise the following question: are the earnings of graduates associated with their fields of study? To address this issue we can use the standard Mincer-type specification incorporating dummies for the different degrees instead of using a continuous variable for the education. In our study, using eight schooling dummies,[44] we observe that the economic returns to higher education in terms of enhanced earnings are important among medical doctors, lawyers, and architects (see Table A4 in Appendix). The wage premium for medical doctors relative to economists is 18.5%, compared with 29.4% for lawyers and

58.6% for architects.[45] The degree effect is slightly lower using the supply-demand model.

Conclusions

Estimates of the rate of return to a university degree provide one measure of the net monetary benefits from higher education. Information on the rate of return can be useful for understanding individuals' decisions on whether to attend university and overall trends in participation in university education; and it can also provide policy-makers with a measure of the value of providing extra funds to higher education relative to other types of government expenditure.

The main objective of this paper was to provide estimates of the average rate of return to university education in Spain. The estimations obtained from the Mincerian earnings equations reveal that the amount of university education received by graduates and the total number of years of experience on the labor market are important determinants of their salaries. These estimations allow us to measure the economic returns to the investment in human capital at the university level. The private rate of return obtained of 7.75% would give us the percentage variation in an individual's earnings when he invests an extra year in university schooling, but it does not take into account the educational level to which this additional year of schooling refers. The results provide us with a verification of the human capital theory, in such that the greater the individual's educational stock is, the greater are his wage remunerations on the labor market. In this sense, we can state that long-cycle university studies are profitable educational investments.[46]

Likewise, and taking education as an endogenous variable, it can be seen that the estimation of education's effect on salaries by means of two-stage least squares is greater than that provided by ordinary least squares. The use of instrumental variables increases the returns to an university education by 13.07%.

However, the human capital model is an approach from the supply-side of the labor market to explain salary determinants and it ignores other variables from the demand-side that also have an influence on salaries. We observe that the private returns to an university education are lower when a mixed supply–demand model is estimated that takes into account other relevant variables – such as the sector of activity or the type of firm – when determining the salaries of university graduates, variables that were not considered by the semi-logarithmic functional form adopted in Mincer (1974). Thus, it can be seen that the labor market is not fully competitive.[47]

Obviously, additional methodological improvements in this area would be desirable. Although we have corrected the problem of endogeneity, we still have the problem of the sampling selection that is present in the observations. These only provide us with information on the choice of degree of those individuals that decided to enter university but we have no observations referring to those who, once they completed their secondary education, decided "not" to go to university. By using a more wide-ranging sample with national representativeness, and which included not only university students, models that gave more overall information of educational investments and their returns could be tested.[48]

Notes

1. The author would like to thank two anonymous referees for their helpful comments and suggestions on an earlier version of this paper.
2. Other studies also reflect the impact of socio-economic background on an individual's earnings (Lam and Schoeni 1993; Altonji and Dunn 1996).
3. Work experience – measured by number of years in the labor force after completion of schooling – is a significant predictor of earnings as it reflects post-school investments in skill acquisition.
4. The "pure" (or basic) human capital model of wage assumes that wages are completely determined by human capital variables like formal education and work experience (supply-side of the labor market).
5. Apart from endogeneity of schooling, selection bias can also be a problem. Potentially, selection bias in this model would be due to using only the working individuals – wage offers for those not working are not observed. Heckit method (Heckman 1979) provides a solution for selectivity. However, we assume that there is no sample selection problem in this model.
6. Assuming that schooling is measured correctly and omitted variable bias (e.g., ability) is not a serious problem.
7. A copy of the questionnaire (in Spanish) is available from the author upon request.
8. This latter School includes graduates in the following degrees: Philosophy, Geography and History, Languages, Education, Biology, Geology, Mathematics, Physics, and Chemistry.
9. In this project, 11991 graduates were approached, of which 1909 responded. The response rate was around 16%. The non-response rate is due to the fact that there were graduates who did not return the questionnaire and who, therefore, were not prepared to co-operate. But we believe that those who answered and those who didn't do not differ much. In this situation, the bias due to non-response is small and independent of its size (Platek 1988).
10. We only consider in the analysis of this paper wage-earners (we exclude self-employed). This is the common procedure in the research papers to estimate the

private rates of return to education. As a result, the analysis is limited to 1321 individuals.

11. Although most authors support the logarithmic transformation of the earnings (Dougherty and Jimenez 1991), there is not, however, agreement as to whether they should be yearly, monthly, or hourly (salary rate). Most empirical studies use yearly wage income since no other information is available. But we should point out that the use of yearly income mixes up the work–leisure choice, which is reflected in the fact that the years of schooling are positively correlated to the number of hours worked (Mincer 1975). Furthermore, working days differ from one job to the next or from one company or sector to the next. It is, therefore, preferable to use hourly earnings (Griliches 1977). Why net? By using net income, the estimated coefficient associated with the schooling variable, multiplied by 100, measures the private rate of return to education.
12. See Kenny et al. (1979) with a similar methodology.
13. In Spain, short-cycle degree graduates do not have access to doctoral programs leading to a PhD qualification.
14. This variable is more accurate that a measure of potential experience (e.g., potential experience is equal to age minus schooling minus six) because if the potential experience depends directly on schooling and schooling is endogenous then potential experience would be endogenous as well.
15. Nearly all of them (98%) had employers who requested for the specific degree they earned.
16. More than 50 workers.
17. In order to balance the observations within each category and decrease the number of dummy variables, we combined some industrial categories.
18. Mainly comprised of consulting firms.
19. We did not introduce length of time in the job (tenure), since, if we had done, we would have come across serious problems of collinearity, given that job rotation is very low in the sample we were working with.
20. Individuals belonging to a high social class or individuals from a lower social class but who receive study grants.
21. Living away from the family home implies a higher expenditure on education and we would expect these students, ceteris paribus, to demand a lower quantity of education. However, it is not only the territory variable in itself that determines the optimum quantity of university education. The disparity in the individuals' educational achievements can be worsened if there are unequal financial opportunities.
22. In this case, this variable takes values from 0 (no schooling) to 20 (PhD).
23. See Appendix (Table A1) with the descriptive statistics for the variables of interest in this study.
24. Various studies carried out in Spain, with representative data on a national level, demonstrate the positive influence that family cultural factors have on attaining higher levels of schooling. The schooling levels of the head of the family and his partner are the main variables that explain the acquisition of an university education by a young person (Mora 1997; González and Dávila 1998; Albert 2000).

25. If father's occupation is a reliable proxy of his income, then we observe a significant influence of the household's level of welfare on the educational choices of the children.
26. The individuals in our sample were able to choose between two basic types of university degrees: short-cycle degree, obtained after three years at the university, and a long-cycle degree, obtained after five or six years in a faculty or higher technical school.
27. We cannot directly observe credit access for individuals, so identification of the extent of borrowing constraints is indirect.
28. Direct costs need financing during periods of school enrollment and present a larger challenge to credit-constrained persons; forgone earnings, by contrast, do not have to be financed during school (Cameron and Taber 2004).
29. The standard errors, though not shown, are corrected in their heteroscedasticity following the procedure used by White (1980). The Breush–Pagan test (1979) revealed that the random perturbance structure was heteroscedastic.
30. OLS estimate of the rate of return is unbiased only if measured schooling is exogenous. The results from studies of instrumental variables are wide-ranging, but the majority of them point towards the presence of a downward bias in the OLS estimations (Ashenfelter et al. 1999; Card 2001).
31. Weak instruments can induce greater bias than OLS.
32. The essence of this approach is to provide suitable instruments for schooling which are not correlated with earnings.
33. In addition, we can use partial R^2, whose value is relatively high compared with other studies on instrumental variables. See for example Pons and Gonzalo (2002) for the Spanish case.
34. Since OLS is preferred to IV, we should test for endogeneity problem. We can use the Hausman test: (i) save the residuals from the first stage; (ii) include the residual in the wage equation; if the coefficient on the residual is statistically different from zero, reject the null of exogeneity (see Wooldridge 2003).
35. The adjusted R^2 also increases, indicating that including more explanatory variables is preferable.
36. The existence of wage differentials is also confirmed by the Krueger and Summers' study (1988) that found workers with identical characteristics receiving different wages across industries.
37. Allen and van der Velden (2001) found a similar result using data of the labor market for graduates in the Netherlands.
38. See Appendix (Table A2). We added an interaction term between graduate education and gender to the wage equations. The coefficient of EDUC is now the estimated return to graduate education for men. For women, the coefficient of *EDUC* • FEMALE indicates the reduction on the return to education for women: the return to graduate education would be around 1.5% lower for women. This result did not change using 2SLS.
39. Human resources in the Public Administrations, their personnel classifications, and their structure are something that, in Spain, is mainly pre-determined by administrative legislation of public functions.
40. Ability is positively associated with wages and schooling. More ability leads to higher productivity and therefore higher wages. Also, on average, individuals with more innate ability choose higher levels of education. If returns to

schooling are estimated without accounting for ability, then these returns will be biased upward.

41. There is a substantial literature on ability bias. See, among others, Griliches and Mason (1972), and Blackburn and Neumark (1995).
42. The new variable is called ACADABIL. It is a binary variable that takes the value of 1 if the student completed his universities studies without repetition and with good grades.
43. Blackburn and Neumark (1995) suggested that only non-academic ability is awarded in the labor market. Recently, Donhardt (2004) found that although major, age, and industry were significant factors in predicting postcollege earnings, grade point average did not play a positive role.
44. The variables included are: (i) HUMAN (=1 if the individual studied Philosophy, Geography and History, Languages, or Education); (ii) SCIENCES (=1 if the individual studied Biology, Geology, Mathematics, Physics, or Chemistry); (iii) SURVEY (=1 if the individual studied Quantity Surveying); (iv) ARCHIT (=1 if the individual studied Architecture); (v) NURSING (=1 for nurses); (vi) MEDICINE (=1 for medical doctors); (vii) LAW (=1 for lawyers); and (viii) ECONOM (=1 if the individual studied Economics or Business).
45. Strictly speaking, when the explanatory variable is dichotomous and non-continuous, as is our case for the variables ARCHIT, MEDICINE and LAW, the most correct interpretation is that put forward by Halvorsen and Palmquist (1980, p. 474): "Take the anti-logarithm of the estimated dichotomous coefficient (in base e) and subtract 1." For example, by reinterpreting the estimated coefficient associated to LAW, we would have: $e^{0.2944} - 1 = 0.342$. Therefore, the percentage increase in earnings associated with being a lawyer is 34.2%.
46. Results supported by research carried out in our country (Lassibille and Navarro 1998; Vila and Mora 1998).
47. See Hanushek (1981), Hartog (1985), and Krueger and Summers (1988).
48. See Cooper and Cohn (1997).

Appendix

Table A1. Descriptive statistics

	Mean	Std. deviation[a]
LN_NHWAGE	2.1722	0.4204
EDUC	4.5299	1.6567
HUMAN	0.0560	
SCIENCES	0.0227	
SURVEY	0.0999	
ARCHIT	0.0045	
NURSING	0.3929	
MEDICINE	0.3490	
LAW	0.0431	

Table A1. Continued

	Mean	Std. deviation[a]
ECONOM	0.0318	
EXPER	12.6426	8.8210
ACADABIL	0.4709	
MATCH	0.5193	
UNDERUTI	0.0908	
DEFICIT	0.3899	
PUSECTOR	0.8448	
LARGECO	0.0818	
SMALLCO	0.0734	
SECTOR1	0.0182	
SECTOR2	0.0220	
SECTOR3	0.7229	
SECTOR4	0.1075	
SECTOR5	0.0689	
SECTOR6	0.0553	
SECTOR7	0.0053	
OCCUFA	0.2339	
COST	0.4073	
EDUCMO	5.2157	4.4784
FEMALE	0.4784	
Valid N	1321	

[a]Standard deviation only for quantitative variables.

Table A2. The estimated return to education for men and women[a,b,c,d]

Variable	Basic human capital model			Supply-demand model		
	Coefficient		*t*-ratio	Coefficient		*t*-ratio
Constant	1.5931	**	41.186	1.7424	**	25.283
EDUC	0.0787	**	13.513	0.0727	**	12.283
EDUC • FEMALE	−0.0145	**	−2.966	−0.0150	**	−2.987
EXPER	2.59E−02	**	6.687	2.36E−02	**	6.406
EXPER^2	−3.23E−04	**	−2.748	−2.86E−04	**	−2.544
UNDERUTI				−8.48E−02	**	−1.986
DEFICIT				4.59E−02	**	2.169
MATCH				Reference		
PUSECTOR				7.63E−02		1.300

Table A2. Continued

Variable	Basic human capital model			Supply-demand model		
	Coefficient		t-ratio	Coefficient		t-ratio
LARGECO				8.46E−02		1.171
SMALLCO				Reference		
SECTOR1				−0.2945	**	−3.046
SECTOR2				−0.1164		−0.917
SECTOR3				−0.2120	**	−5.441
SECTOR4				Reference		
SECTOR5				−0.1607		−2.509
SECTOR6				−0.1823	**	−2.614
SECTOR7				−0.1602		−1.947
Adjusted R^2	0.2545			0.2755		
F	113.64	**		36.85	**	
Observations	1321			1321		

[a]OLS estimates.
[b]**Indicates significance at the 5% level.
[c]Results corrected for heteroscedasticity.
[d]Dependent variable is LN_NHWAGE.

Table A3. Academic ability and returns to graduate education[a,b,c,d]

Variable	Model 1			Model 2			Model 3			Model 4		
	Coefficient		*t*-ratio	Coefficient		*t*-ratio	Coefficient		*t*-ratio	Coefficient		*t*-ratio
Constant	1.5671	**	40.027	1.3407	**	15.646	1.6974	**	24.860	1.4771	**	14.131
EDUC	0.0772	**	12.943	0.1296	**	6.871	0.0718	**	11.922	0.1197	**	6.550
EXPER	2.72E−02	**	7.053	2.59E−02	**	6.563	2.51E−02	**	6.841	2.45E−02	**	6.480
EXPER^2	−3.39E−04	**	−2.873	−3.39E−04	**	−2.878	−3.03E−04	**	−2.691	−3.17E−04	**	−2.752
ACADABIL	−1.63E−02		−0.814	−4.65E−03		−0.223	−7.88E−03		−0.391	9.69E−03		0.452
UNDERUTI							−8.13E−02		−1.911	−8.63E−02	**	−2.015
DEFICIT							4.86E−02	**	2.274	9.65E−03		0.383
MATCH							Reference			Reference		
PUSECTOR							8.07E−02		1.364	7.90E−02		1.325
LARGECO							9.08E−02		1.252	9.34E−02		1.283
SMALLCO							Reference			Reference		
SECTOR1							−0.2735	**	−2.849	−0.2389	**	−2.417
SECTOR2							−0.1076		−0.844	−0.1211		−0.943
SECTOR3							−0.2096	**	−5.310	−0.1904	**	−4.635
SECTOR4							Reference			Reference		
SECTOR5							−0.1391	**	−2.159	−0.0437		−0.622
SECTOR6							−0.1717	**	−2.467	−0.1460	**	−2.074
SECTOR7							−0.1408		−1.703	−0.1264		−1.501
Regression	OLS			2SLS			OLS			2SLS		
Hausman test of exogeneity (*t*-values)				(−3.00)	**					(−2.84)	**	
Sargan overidentification test (*p*-values)				(0.1752)						(0.1460)		

Table A3. Continued

Variable	Model 1		Model 2		Model 3		Model 4	
	Coefficient	*t*-ratio	Coefficient	*t*-ratio	Coefficient	*t*-ratio	Coefficient	*t*-ratio
F-test of excluded variables			40.10 **				46.92 **	
Partial R^2 of excluded variables			0.1089				0.1259	
Adjusted R^2	0.2491		0.2072		0.2696		0.2385	
F	110.46 **		87.26 **		35.80 **		30.52 **	
Observations	1321		1321		1321		1321	

[a]**Indicates significance at the 5% level
[b]Results corrected for heteroscedasticity.
[c]Dependent variable is LN_NHWAGE.
[d]Instruments for EDUC (models 2 and 4) are: OCCUFA, COST, EDUCMO, and FEMALE.

Table A4. Higher education and earnings: the impact of degree subject [a,b,c,d]

Variable	Basic human capital model			Supply-demand model		
	Coefficient		*t*-ratio	Coefficient		*t*-ratio
Constant	1.8546	**	21.805	2.0834	**	16.696
HUMAN	9.66E−02		1.004	−8.04E−02		−0.707
SCIENCES	0.1759		1.672	−9.96E−03		−0.083
SURVEY	−2.57E−02		−0.271	−6.56E−02		−0.606
ARCHIT	0.5857	**	4.054	0.4961	**	3.645
NURSING	−9.49E−02		−1.112	−7.31E−02		−0.623
MEDICINE	0.1848	**	2.139	0.1872		1.592
LAW	0.2944	**	2.710	0.2686	**	2.333
ECONOM	Reference			Reference		
EXPER	2.81E−02	**	7.546	2.62E−02	**	7.274
$EXPER^2$	−3.68E−04	**	−3.309	−3.30E−04	**	−3.077
UNDERUTI				−6.71E−02		−1.578
DEFICIT				4.72E−02	**	2.233
MATCH				Reference		
PUSECTOR				3.35E−02		0.553
LARGECO				5.97E−02		0.829
SMALLCO				Reference		
SECTOR1				−0.3493	**	−3.308
SECTOR2				−0.2304		−1.694
SECTOR3				−0.2811	**	−4.085
SECTOR4				Reference		
SECTOR5				−0.2412	**	−2.875
SECTOR6				−0.2913	**	−4.115
SECTOR7				−0.2107	**	−2.065
Adjusted R^2	0.2635			0.2852		
F	53.48	**		28.72	**	
Observations	1321			1321		

[a] OLS estimates.
[b] ** Indicates significance at the 5% level.
[c] Results corrected for heteroscedasticity.
[d] Dependent variable is LN_NHWAGE.

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