LIFE-CYCLE VALUATION OF DIFFERENT UNIVERSITY MAJORS. CASE STUDY OF CHILE

Bernardo Lara, Patricio Meller and Gonzalo Valdés

SUMMARY

The aim of this paper is to calculate the rate of return and the net present value for several fields of university studies in Chile. The methodology employed involves the use of earnings over the life cycle for individuals after graduation. Our results indicate that there are large differences in the economic return to different majors. However, we find clear incentives for studying and financing all of them. The implication here is that higher education in Chile, at least for now, is an attractive investment and should be encouraged. In addition, the results obtained suggest that students tend to choose a university major based on the net present value and not on the internal rate of return.

Introduction

In higher education it is possible to study a wide variety of university majors. Due to this variety, the major choice might be not simple. Therefore, it is important to have adequate information about them. The goal of this study is to calculate the rate of return and the net present value for several majors, and compare which one seems more aligned with student's preferences. The methodology involves an approximation to the professionals' work life cycle (forty years) for Chilean graduates. The paper considers life-cycle valuation by majors.

In general, Chilean students graduate from a single university major. This is because in the Chilean system of higher education, students enroll in specific majors following rigid programs to graduate. Then, it is important to explore indicators which allow us to rank and understand what university majors are more attractive among high school graduates. In that vein, we will explore the net present value (NPV) and the internal rate of return (IRR) as potential indicators for students' preferences.

Our results indicate that there are differences between university majors, the most profitable being Business Management, Civil Engineering, Industrial Engineering and Medicine. On the other hand, Education and Architecture have the lowest IRR and NPV. In addition, the results suggest that students tend to choose a university major based on the NPV and not on the IRR.

After a review of the existing literature, we discuss some details regarding higher education investment. Then, the econometric methodology employed in the paper is explained and the database used is described. The estimations of income, employment probability and calculations of the NPV and the IRR to different careers follow and the results are discussed. The sensitivity of the results is analyzed and, finally, conclusions are presented.

Literature Review

The relationship between education and income has been widely studied in economics. Becker (1964) notes that education is the principal mean of investing in human capital, since the years of study improve productivity and income. Thus, the estimation of the rate of return to education has been a central theme in the literature.

In general, the literature has considered the estimation of the marginal rate of income return (Mincer, 1974), and the total rate of return for the life cycle (Blackburn and Neumark, 1993, 1995; Psacharopoulos, 1995; Psacharopoulos and Patrinos, 2004; Heckman *et al.*, 2008). The empirical results for the rates of return to higher education are heterogeneous across countries: there are large differences between studies of countries with OECD data (Boarini and Strauss, 2007) and independent studies at the country level (Psacharopoulos and Patrinos, 2004). In particular, for the Latin American context, Psacharopoulos and Patrinos (2004) estimate a rate of return to higher education of ~20%. With regard to Chile, Arellano and Braun (1999), using home-based surveys, found a rate of 21%. However, Sapelli (2005), using a synthetic cohort methodology, estimated a rate of return >40%. For the USA, Ashenfelter and Krueger (1994) and Ashenfelter and Rouse (1998) estimate the marginal returns of education by using variation in education across identical twins and find that the marginal return

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VALORACIÓN DEL CICLO DE VIDA PARA DIFERENTES ÁREAS DE ESTUDIOS UNIVERSITARIOS. ESTUDIO DE CASO EN CHILE

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RESUMEN

El objetivo de este trabajo es calcular la tasa de retorno y el valor presente neto para diferentes áreas de estudios universitarios en Chile. La metodología empleada considera el uso de ingresos en el ciclo de vida para individuos después de la titulación. Los resultados indican que hay grandes diferencias en el retorno económico para las distintas áreas de estudio. Sin embargo, nuestros resultados muestran claros incentivos para estudiar y financiar todas las áreas del conocimiento. Esto implica que la educación universitaria en Chile es una inversión atractiva y debería ser promovida. Además, los resultados sugieren que los estudiantes tienden a elegir una carrera universitaria basados en el valor presente neto y no en la tasa interna de retorno.

IMPORTÂNCIA DO CICLO DE VIDA EM DIFERENTES ÁREAS DO ENSINO SUPERIOR. ESTUDO DE CASO NO CHILE

Bernardo Lara, Patricio Meller e Gonzalo Valdés

RESUMO

O objetivo de este trabalho é calcular a taxa de retorno e valor presente líquido em diferentes áreas do ensino superior no Chile. A metodologia considera o uso das receitas no ciclo de vida para indivíduos após a formatura. Os resultados indicam que existem grandes diferenças de retorno econômico para as várias áreas de estudo. No entanto, nossos resultados mostram claros incentivos para estudar e financiar todas as áreas do conhecimento. Isto quer dizer que o ensino superior no Chile é um investimento atraente e deve ser promovido. Além disso, os resultados sugerem que os estudantes tendem a escolher um curso universitário com base no valor presente liquido e não na taxa interna de retorno.

would be at least 9%. In a different approach, Palacios-Huerta (2003) emphasizes the role that risk may play in education investment, risk that Saks and Shore (2005) show that influences the career decision of students. Meanwhile, Harmon *et al.* (2003) discuss the methodological difficulties of estimating marginal returns to education, but still find robust evidence that education provides positive returns. In any case, the most typical approach has been to estimate the rate of return to higher education as a whole, without differentiating much between the different fields of study.

Systematic changes in production processes and the constant shocks in a globalized world affect the demand for certain types of professions and human capital. Hence, not all investments in human capital are economically equivalent. In today's world, in which innovative capacity is important, it is expected that majors that foster this capacity, may generate greater return. For this reason, a second area of the literature on higher education has focused on estimating the rates of income return and their evolution in different fields of study. However, the lack of data has meant that estimations for marginal rates of return according to field of study have been limited to specific years, restricting the possibility of considering rates during the whole life cycle.

In general, the results for the USA have indicated that the areas of Engineering and Business are those that offer the best profitability (Rumberger, 1984; Berger, 1988a, b; James *et al*., 1989; Rumberger and Thomas, 1993; Thomas, 2000). In contrast, areas linked to the Social Sciences have shown lower rates of return. Outside the USA, Finnie and Frenette (2003) obtained similar results for the Canadian labor market. Chia and Miller (2008) studied the incomes of Australian graduates; their estimations indicated that careers linked to Dentistry, Health, Information Technology and Music earned more, while Architecture, Psychology and other Sciences earned less, compared to Science graduates. However, these studies are focused on marginal rates of return for starting salaries or specific years after graduation. Meanwhile, Meller *et al.* (2011) show differences in the wage gender gap across different degrees, making the point that gender discrimination would be different across fields.

However, the differences in returns across fields have been subject of new research. In particular, Altonji *et al.* (2016) provide an overview of the challenges that heterogeneous returns imply. However, these challenges have been partially solved by getting estimates to the returns of the field-of-choice using a regression discontinuity design based on the administrative rules of higher education enrollment. For example, Hastings *et al.* (2013) show that Chilean students have higher wages if they barely get in in their first-choice career. An obvious problem of that approach is that the alternative to the first-choice career is a mix of the different options that students have. Therefore, Kirkeboen *et al.* (2016) estimate the returns of a field, using strategic proof measures of the preferences of individuals, with respect to the next-best alternative. Their returns also indicate heterogeneous returns to different fields of study. Nevertheless, the results of the mentioned papers do not allow comparing the rates of returns to different fields with respect to other social projects that might be in place. That is exactly the objective of this article; obtain the total rate of return and net present value of different fields.

About Decisions: Observables and Marginal Returns

In order to understand the investment decisions made by a young person regarding a higher education major, we have to take into account four characteristics that differ from a financial investment (Becker, 1964; Palacios-Huerta, 2003): 1- *Indivisibility*: It is impossible to graduate as half lawyer or a quarter engineer. 2- *Irreversibility*: Since the costs of human capital investment are sunk. 3- *Intrasferability*: Human capital resides in the individual; therefore, it cannot be liquidated. 4- *Single decision*: Most individuals, at least in the Chilean case, will only get one university degree during their lives. This final characteristic means that the net present value (NPV) becomes a more important indicator than the internal rate of return (IRR) in career choice, since NPV is the most relevant criterion in case only one investment can be made (Hirshleifer, 1970).

The process how a student makes his decision to get involved in higher education has been treated in the literature, mostly, as a rate of return issue. The literature has been developed mostly based on the Mincer equation model (Mincer, 1974; Heckman *et al.*, 2006). However, there is also a literature from the point of view of the NPV (Psacharopoulos, 1995; Psacharopoulos and Patrinos, 2004). Nevertheless, that literature has not performed an analysis by major. This means that there are no studies comparing IRR and NPV at the major level.

In the Chilean system of higher education each university major has a fixed number of enrollments per cohort. Then, the cut-off test score to get enrolled is endogenous. According to this reasoning, the majors that have bigger rate of return should have higher cut-off test scores. However, our results show that higher cut-offs are associated to higher NPV. We could also argue that there might be different preferences (vocation) for different areas as Sciences, Arts or Medicine. Then, in a field of knowledge, for example Health, we should expect cut-offs ordered by their respective rates of return. Our results also show that higher cut-offs, within a field of knowledge, are associated to higher NPVs.

We should note that there are many unobservable aspects that characterize a university major in the labor market. These aspects could act as main points when students make their decisions. For instance, students may have preferences for flexible jobs or any specific characteristic that could be associated to a specific university major and act as a main influence for their decision. All of these factors (unobservables) can make it very difficult to analyze the problem of major choice. Since we are considering NPV by major, we need to assume that we are using a homogeneous pool, which has a common valuation for the unobservable components. Then, students' choice is characterized by the present value of the net income flow discounted by their own intertemporal discount rate, and not by the value of the intertemporal discount rate that equalizes costs and benefits. Finally, it is worth to highlight that the very fact that we are looking to estimate total rate of returns and NPV of the different program introduces the need to extrapolate income that might not have even taken place yet. Therefore, we need simplifying assumptions about the behavior of future income.

Methodology

Econometric estimation

In the analysis of the relationship between income and education, we need to consider that not all people are employed, so observed income will typically follow the process $\tilde{y}_i = E_i \cdot y_i$, where $\tilde{y}_i$: observed income; E_i: dummy that indicates that the individual is employed; and y_i: corresponding salary, not observed if $E_i = 0$.

Therefore, in our estimation strategy we will use two distinct models, one for individuals that are participating in the labor market, and another for the probability of being employed. The objective is to capture the effects that schooling may have on both components, since it should increase both salary and employability of the individuals.

The typical analysis in the estimation of the return of education focuses on wage modelling, excluding individuals that are unemployed. In other words, it examines the determining factors of wages for those professionals that are employed. In general, standard models consider a similar return for different university majors. The most popular model is that proposed by Mincer (1974): $\ln y = \alpha + r_s s + \beta_0 X + \varepsilon$ with y: income received by the individual, α: constant, r_s: marginal (mean) effect on income of one more year of university education, s: individuals' years of schooling, X: control variables, and ε: idiosyncratic error.

In this way, it is possible to obtain the marginal return associated with the number of years of education. The most typically used control variables are experience, age, and sex. As a proxy for experience, the difference between the age of the individual and the age at graduation is generally used. Nonetheless, the data we use corresponds to the observed income for the same cohort of individuals in a given year after graduation. Hence, this proxy would be the same for all the individuals in the same cohort. Therefore, our only control of this type is a dummy variable for gender.

In addition, it is necessary to consider the innate abilities of the individuals since this can create a relative bias as the most able tend to have higher levels of schooling and to choose more profitable majors. Hence, a variable that controls for the ability of the individuals is required. This variable can be measured using the university entrance point score.

Finally, another source of endogeneity is linked to the students' socioeconomic background and social network. Students with a relatively poorer socioeconomic origin tend to have relatively fewer opportunities to finance their higher education in the Chilean system, since it is mostly privately financed (OECD, 2009). Moreover, the level of household income can be correlated with non-observable variables such as discount factors and opportunity costs. For this reason, it is desirable to have a proxy for socioeconomic background. In the Chilean educational system, for Primary and High Schools, there are elite private schools attended by students from a higher socioeconomic status. The percentage of students from these schools at each university can represent the students' level of social connections.

The main objective of this article is to estimate the return for different majors. So, we consider the following econometric specification:

$$\ln y = \alpha + \sum_p r_p d_p + \beta_0 X + \gamma \ln \vartheta + \delta_n z + \varepsilon$$

where ϑ: point score of the individual in the university entrance examination, z: percentage of students at the university that come from private (elite) high schools, and d_p: dummy indicator of a graduate from major p.

Then, the estimated coefficients allow us to project, from the mean of the variables in our samples, the income obtained in each major. From these projections, part of the trajectory (10 years) of the life cycle of the graduates from each field of study can be constructed.

The previous estimation focuses only on those professionals who are employed in each period, and therefore it does not include possible effects of schooling on employability. In order to model this employability, we will use a logistic model with the same control variables used in the estimation of education returns. This is equivalent to modelling the probability of employment as:

$$P(E=1) = \frac{e^{\alpha + \sum_p r_p d_p + \beta_0 X + \gamma \ln \vartheta + \delta_n Z + \varepsilon}}{1 + e^{\alpha + \sum_p r_p d_p + \beta_0 X + \gamma \ln \vartheta + \delta_n Z + \varepsilon}} = \Lambda\left(\alpha + \sum_p r_p d_p + \beta_0 X + \gamma \ln \vartheta + \delta_n Z + \varepsilon\right)$$

NPV and IRR estimation

The values for projected income and expected probabilities of employment provide a base from which to tackle the problem of calculating the return to different university majors during the life cycle. Two indicators are traditionally used for this purpose (Psacharopoulos and Patrinos, 2004): the first is the internal return rate (IRR) to education providing the return to the human capital investment. It also shows which majors are the most profitable to finance from the private or public point of view. The second indicator is the net present value (NPV). This indicator corresponds to the value added generated by the investment in higher education. The estimation of the NPV, which is the addition and subtraction of the current values of the benefits and costs of a major, indicates the net monetary gain that an individual may obtain by choosing a given field of study.

The estimation of educational returns has been examined frequently in the literature (Psacharopoulos and Patrinos, 2004). Ideally, a researcher would like to have a database that would allow him or her to study the whole life cycle of the individuals. In this context, and assuming a retirement age of 65, one could estimate the NPV, at 18 years of age as:

$$NPV_{18} = \sum_{t=L+1}^{47} \frac{(I_u)_t}{(1+r)^t} - \sum_{t=1}^{47} \frac{(I_s)_t}{(1+r)^t} - \sum_{t=1}^{L} \frac{(C_u)_t}{(1+r)^t}$$

where L: major's duration in years, r: discount rate, I_u: expected income obtained by a university graduate, I_s: income obtained by a high school graduate, and C_u: annual fee for the respective university major. Meanwhile, the IRR represents the discount rate (r) where the NPV of the investment in education is equal to zero.

The main problem in this calculation is the lack of data. A typical database for the life cycle is the USA National Longitudinal Study of the High School Class of 1972 from the National Center for Education Statistics, which covers up to 56 years of the same cohort. However, these databases do not have the necessary segregation by major. Moreover, the information about income is based on self-reporting.

Psacharopoulos (1995) has proposed a method to be used when only some points of the life cycle are known, called the 'short-cut method'. This method can provide us with a proxy for return to each field of study from cross sectional data. The method assumes that for all t $I_t = \bar{I}$, with $\bar{I}$ being the income observed at some point in time. In other words, the income is assumed constant for the entire life cycle. When the income used ($\bar{I}$) corresponds to one of the first years after graduation, and the method considers a flat income profile throughout the life cycle, then NPV and IRR are underestimated.

Hence, the advantage of this article is that it considers the observed income for a period of 10 years and uses estimations of *effective incomes* in order to construct this period of the life cycle. We use the observed behavior of those 10 years to extrapolate the income path to the rest of the life cycle.

In order to construct the life cycle income profile for each major, three components are required:

Estimated income: This is the average income estimated during the period of the life cycle that is observed, i.e. the first ten years. In order to construct this initial income, linear regressions of the wages will be projected, using the mean observed for the whole sample as values for the explanatory variables. A similar procedure is used for employability, using the estimates of the logistic regression. Once the wage and the employment probabilities have been projected, the product of these variables is equivalent to the expected income each year. We are assuming that unemployment provides no income, which might not be the case with the presence of unemployment insurance.

Projected life cycle income: Given that we only observe the first ten years, it is necessary to extrapolate the rest of the income path life cycle. To do so, we first estimate a linear model of the mean income $y = \alpha + \beta x$, with x being the year, for the initial period of the life cycle (ten years). Then, in order to extrapolate, we estimate a Mincer type of quadratic model $y = \alpha_1 + \beta x_1 + \delta x_1^2$ with x_1=0 at the age 18+L+10 and α_1 *e*qual to income at the same age. Two conditions are imposed on this model. The first is that the income derivative with respect to age must have the same value at point 18+L+10 for both the linear estimation and the quadratic one. The second is that the income derivative with respect to age must be equal to zero at the peak age of income. Estimations for the life cycle for Chile carried out by Granados (2004) indicate that maximum income level is reached between 50 and 60 years of age for highly qualified workers. Then we can estimate the last quadratic coefficient as $\delta = -\beta / 2\left(x_{Peak} - (Age + L + 10)\right)$.

High school graduates: In order to construct the income profile for high school graduates, we used the upper quartile of income of the respective cohort in the *Encuesta de Caracterización Socioeconómica Nacional* (CASEN) surveys for years 1990, 1992, 1994, 1998, 2000, 2003 and 2006 (http://observatorio.ministeriodesarrollosocial.gob.cl/casen/casen_obj.php). For the rest of the life cycle, a similar methodology is applied as that for the life cycle of university major graduates.

Using these elements, an approximation of the income profile life cycle can be constructed for high school graduates and university graduates of different fields of study.

Data characteristics

The database used in this paper is *Futuro Laboral* (www.mifuturo.cl). This database contains raw data from Chilean university graduates across different majors for the year 1995. The sample represents ~90% of the university graduates. Various institutions participated in order to gather data for the sample, including Chilean universities and the Ministry of Education. In addition, there is also confidential information regarding the real gross income declared to the Chilean internal revenue service (SII). This enabled us to follow the income trajectory of professionals from the time of their graduation through a period of ten years (actual income and not self-reported).

We divide the annual income by twelve to obtain a monthly income. It should be noted that there is no data available regarding the number of hours worked per year. Hence, the average monthly income could represent people that work a different number of hours per month or a different number of months per year.

The information includes sex and age of each individual. The sample used only includes professionals who got their degree before they were 35 years old. In addition, we use data containing the average time that it takes to complete each major and its corresponding tuition fee. Other information used includes the point score obtained by the individuals in the academic admission aptitude test (www.uchile.cl/DEMRE). Finally, information regarding the percentage of students from private schools for each university has also been used.

The university majors under study have been selected so that they have a significant number of observations and represent different areas of knowledge.

The opportunity cost for studying a university major is considered to be what would have happened if a young person would have decided to start working right after high school. In order to have an idea about the wages of the 'equivalent' graduates from high school, we use income data from the CASEN surveys.

Table I shows the basic descriptive statistics of the *Futuro Laboral* data by fields of study. It is important to note that universities recruit their students based on the university academic entrance test (PAA). Certain majors are more demanded than others, that is the reason why their required entry point scores are higher. Medicine, Dentistry and Civil Engineering have the highest entry scores. Some majors are highly feminized,

TABLE I
DESCRIPTIVE CHARACTERISTICS PER UNIVERSITY CAREER, 1997

Observables 1997	Dummy woman	University Entrance Test Score	Student Private Schools	Employed (2nd year)	Wage[a] (2nd year)	Observations
	(Mean)	(Mean)	(Mean)	(Mean)	(Mean)	
Agronomy	0.28	675.38	0.33	0.90	1661.16	273
Architecture	0.30	691.08	0.35	0.95	1930.11	164
Civil Construction Engineering	0.16	642.96	0.27	0.92	1896.64	224
Accounting	0.50	603.09	0.20	0.93	1539.08	530
Law	0.30	697.30	0.49	0.91	2132.68	210
Nursing	0.87	632.27	0.28	0.95	1293.78	269
Civil Engineering	0.08	700.71	0.41	0.96	2832.94	197
Industrial Engineering	0.19	699.53	0.34	0.97	2743.48	418
Business Management	0.39	681.03	0.42	0.93	2453.24	876
Medicine	0.35	742.59	0.32	0.96	2347.61	434
Dentistry	0.50	713.92	0.27	0.97	1607.59	183
Elementary School Teaching	0.85	567.28	0.28	0.75	597.93	149
Journalism	0.69	668.57	0.47	0.88	1251.45	213
Psychology	0.74	699.05	0.43	0.91	1355.35	290
Total	0.43	674.38	0.35	0.93	1968.88	4430

a: The exchange rate for June 2008 was $493.61 chilean pesos per US$.
Source: *Futuro Laboral* (www.mifuturo.cl), basic data.

especially Nursing and Primary Education. The information in Table I shows considerable differences in income among majors. The majors with the highest incomes are Law, Medicine, Business Management, Industrial Engineering and Civil Engineering.

Results:

Net present value and total rate of return

A main objective of this article is to calculate the NPV and rates of return to the investment in higher education for each selected major. For this purpose, we need to construct the income life cycle for different majors. Given that we observe 10 years of the individuals' life cycle, we will proceed to estimate the expected real income for this period. In order to do so, we will employ the two previously specified econometric models: the income model and the employability logistic model. The regressions are based on real wages, so the NPV and the rate of return are in real terms.

In the case of the income model, a robust method of estimating the regressions has been used; this method gives less weight to the extreme observations. The results are shown in Table II. As can be seen, individual ability and the percentage of students from private schools significantly affect income. It is also worth noting that the regressions indicate that, on average, female professionals receive salaries that are 30% less than those of male professionals.

On the basis of the previous econometric regressions, we can estimate average income for individuals in different majors. For this purpose, we use the sample mean of the variables in the regressions shown in Table II. Thus, we can predict the income received by the average representative individual in each of the majors.

Table III shows the projected income that an average individual would get from different majors. Once again, it can be seen that Civil Engineering, Industrial Engineering, Business Management, Medicine and Law are the majors with the highest income. Elementary School Teaching, on the other hand, has the lowest income level.

Another important feature is the employability for different fields of study. The odd-ratios for the logistic regression provide the probability of employment. Then, with a similar procedure as the one described to project income, it is possible to project the probabilities of employment for the different

TABLE II
DETERMINING FACTORS FOR THE MONTHLY SALARIES OF PROFESSIONALS FOR EACH CAREER – ROBUST REGRESSION*

	Year 2	Year 4	Year 6	Year 8	Year 10
	Coeff. ±SD**	Coeff. ±SD	Coeff. ±SD	Coeff. ±SD	Coeff. ±SD
Female dummy	-0.25 ±0.02	-0.29 ±0.02	-0.32 ±0.02	-0.32 ±0.02	-0.33 ±0.02
Ln_PAA (entry point score)	0.61 ±0.12	0.41 ±0.12	0.44 ±0.13	0.61 ±0.14	0.83 ±0.14
% private school students	0.43 ±0.04	0.45 ±0.04	0.58 ±0.05	0.52 ±0.05	0.51 ±0.05
Agronomy	0.64 ±0.06	0.77 ±0.06	0.69 ±0.06	0.59 ±0.07	0.63 ±0.07
Architecture	0.71 ±0.07	0.60 ±0.07	0.50 ±0.07	0.47 ±0.07	0.43 ±0.07
Civil Construction	0.77 ±0.06	0.65 ±0.06	0.64 ±0.06	0.48 ±0.07	0.57 ±0.07
Accounting	0.67 ±0.06	0.70 ±0.05	0.68 ±0.05	0.61 ±0.05	0.63 ±0.05
Law	0.76 ±0.07	0.92 ±0.06	0.94 ±0.07	0.90 ±0.07	0.91 ±0.07
Nursing	0.62 ±0.06	0.61 ±0.06	0.50 ±0.06	0.38 ±0.06	0.40 ±0.06
Civil Engineering	1.06 ±0.07	1.06 ±0.07	0.99 ±0.07	0.91 ±0.07	0.94 ±0.07
Industrial Engineering	1.00 ±0.06	1.05 ±0.05	1.01 ±0.06	0.93 ±0.06	1.01 ±0.06
Business Management	1.03 ±0.06	1.15 ±0.06	1.15 ±0.06	1.05 ±0.06	1.07 ±0.06
Medicine	0.90 ±0.07	1.06 ±0.06	0.95 ±0.06	0.92 ±0.07	1.02 ±0.07
Dentistry	0.58 ±0.07	0.73 ±0.07	0.72 ±0.07	0.67 ±0.07	0.69 ±0.07
Journalism	0.39 ±0.07	0.43 ±0.06	0.36 ±0.07	0.39 ±0.07	0.44 ±0.07
Psychology	0.40 ±0.06	0.52 ±0.06	0.46 ±0.06	0.30 ±0.07	0.40 ±0.07
Constant	8.93 ±0.79	10.33 ±0.79	10.30 ±0.83	9.34 ±0.87	8.07 ±0.86
N	4118	4174	4168	4139	4218

* Dependent variable: monthly salary logarithm.
** All the obtained coefficients were significat ($p<0.01$).
Note: A similar level of significance is obtained for the other years.

TABLE III
MEDIAN MONTHLY INCOME FOR SELECTED YEARS AFTER GRADUATION PER CAREER (US$[a])

University career	Year 2	Year 4	Year 6	Year 8	Year 10
Agronomy	1,594	2,037	2,237	2,393	2,757
Architecture	1,719	1,707	1,840	2,114	2,267
Civil Construction	1,825	1,806	2,116	2,143	2,593
Accounting	1,646	1,888	2,216	2,437	2,751
Law	1,797	2,368	2,851	3,250	3,648
Nursing	1,569	1,724	1,845	1,942	2,186
Civil Engineering	2,421	2,722	3,025	3,301	3,757
Industrial Engineering	2,353	2,977	3,536	3,772	4,302
Business Management	2,299	2,680	3,070	3,359	4,038
Medicine	2,069	2,723	2,907	3,323	4,073
Dentistry	1,507	1,951	2,288	2,592	2,931
Journalism	1,242	1,448	1,600	1,957	2,269
Psychology	1,254	1,587	1,768	1,779	2,196
Elementary School Teaching	842	941	1,119	1,323	1,468

a: The exchange rate for June 2008 was $493.61 Chilean pesos per US$.

majors using the mean values for observed variables.

Now, with these income and employability estimations, we estimate the NPV and IRR using the methodology explained above. Figure 1 shows the results of income projection for Medicine (a major with high remuneration), Journalism (a major with medium remuneration) and High School Education. As can be seen, there is considerable heterogeneity with regard not only to the income level but also to the form of the income path profile. A key assumption of the Mincer model estimation procedure is that income path profiles are parallel (see Heckman *et al*., 2008).

The IRR and NPV can now be calculated for different university majors with respect to a high school graduate. Table IV shows the results of the NPV and IRR for selected fields of study when the income peak is assumed to be at the 55 years of age (other income peaks are used in the Sensitivity Analysis section). As can be seen, Business Management, Civil Engineering, Industrial Engineering and Medicine are, once again, the majors that have the highest total returns, while Elementary School Teaching and Architecture have the lowest. However, an important feature is that the IRR and NPV are positive, showing that there are clear benefits in obtaining a university degree. In other words, investment in higher education, in Chile, is attractive and should be encouraged.

These results show an IRR that is in the range of 21%, similar to the estimations for Latin America made by Psacharopoulos and Patrinos (2004) and the estimation for Chile performed by Arellano and Braun (1999).

Discussion

In brief, all majors have an IRR >15.9% and NPV in the range between US$148,000 and US$493,000. Clearly there is heterogeneity in the results for different majors. The IRR estimations indicate that majors linked with engineering (Civil Engineering and Industrial Engineering), health (Medicine and Nursing), and administration and business (Business Management and Accounting) have high returns. On the other hand, majors linked with social sciences (Journalism and Psychology), Architecture, Agronomy and Elementary School Teaching are the least profitable fields of study. This is in line with the findings reported for marginal returns to income in the international literature for other countries (Rumberger and Thomas, 1993; Finnie and Frenette, 2003; Birch *et al.,* 2009).

The elite majors (Engineering, Medicine and Law) obtain particularly high IRRs and NPVs. In Chile, Nursing and Accounting are fields of study not normally considered of high status, however, they show a high level of IRR and NPV. Consequently, these majors would be a relatively profitable option for students that do not have the required test score for an elite major.

It is remarkable that the IRR of Medicine (21.91%) is lower than the IRR of Nursing (25.19%). Although both majors are from the same field of knowledge, the former, in Chile, has much higher status. According to the discussion above regardin decisions, upper entry point scores reflect higher demand for such majors. While Medicine has a higher entry score, of around 740 (out of 800), Nursing is a little over 630 points. Another interesting comparison is the following: Accounting has a markedly higher IRR than Law (27.17% as compared to 20.94%), yet the point score required for the latter is much higher.

Then, given that Medicine and Law are majors with lower IRRs than those for Nursing and Accounting, why is there greater demand for admission into Medicine and Law? Evidently the IRR indicator does not adequately explain students' choice of majors.

Now we turn to the NPV results. All majors have a positive NPV. When we consider the ranking implied by NPVs, the counter intuitive relationship between Medicine *vs* Nursing and Law *vs* Accounting, observed when ranking majors by IRRs, is now reversed. That is, student's preferences are aligned with NPV ranking. Moreover, there is a considerable gap between Medicine and Law in relation to Nursing and Accounting, which is consistent with the difference in required entry point scores and the status observed in reality. Similarly, majors considered to be elite (Business Management,

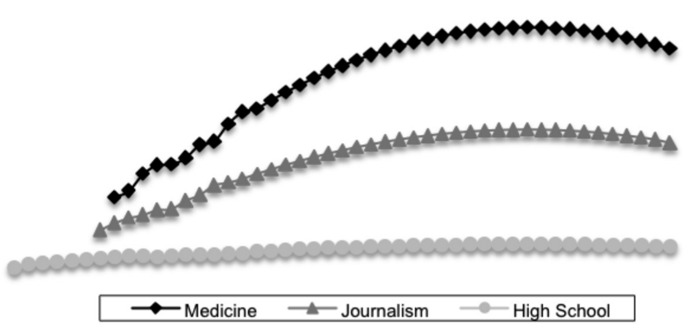

Figure 1. Profile of the expected income for Medicine, Journalism and High School Education

TABLE IV
INTERNAL RATE OF RETURN AND NET PRESENT VALUE[a] FOR DIFFERENT UNIVERSITY CAREERS

University careers	Peak income at 55 years	
	IRR	NPV (r=5%)
Business Management	29.72%	$493,677
Industrial Engineering	25.14%	$491,692
Medicine	21.91%	$480,542
Law	20.94%	$408,422
Civil Engineering	25.46%	$401,751
Dentistry	19.88%	$350,007
Accounting	27.17%	$317,587
Agronomy	19.09%	$263,398
Nursing	25.19%	$238,480
Civil Construction	21.24%	$224,693
Journalism	18.43%	$223,645
Psychology	17.28%	$197,024
Architecture	15.88%	$171,782
Elementary School Teaching	19.91%	$148,338

a: The exchange rate for June 2008 was $493.61 Chilean pesos per US$.

Industrial Engineering, Civil Engineering, Medicine and Law) have NPVs that are markedly higher than other majors. This all suggests that students choose majors based on the NPV rather than the IRR, which contradicts the traditional focus found in the literature on human capital investment.

To illustrate the choice implications of the IRR and the NPV, let us assume a young person interested in the area of health with sufficient aptitude (entry test score) to study either Nursing or Medicine. In order to choose between the two, the student would consider the income he or she believes would be received during his/her professional life. There are two possibilities: choose a less expensive major, with a shorter duration, but without a particularly high-income profile (Nursing), or a longer duration major, more expensive, but with a much higher income profile (Medicine). Conventional economic theory indicates that individuals discount future flows (using their corresponding discount rate), choosing the major that leads to a greater total income value. In other words, they choose the major that leads to the greater NPV.

A different story can be told from the banking sector that provides loans to finance higher education. Our results show that private provision of loans to finance higher education, regardless the major, are completely justified. The banking logic to finance a major is different from the logic used by the students. While students focus on the NPV, banks that provide educational loans only consider the IRR. One implication of this is that, for banks, it may be more profitable to provide two loans to two Accounting students than one loan to a Law student.

Nonetheless, and despite the heterogeneity between majors, it is evident that private banking, there being a rate of return >15% in all majors, has the incentives to provide loans for all majors.

This paper is silent regarding the implication of an educational system that relies on the private provision of funding for higher education. In fact, nowadays a great debate is taking place in Chile about the role played by the government in the educational system (Primary, Secondary, and Higher Education). In particular, the Chilean congress is currently working on a bill that provides universal public funding to higher education. Our results indicate that there are incentives for the government to finance higher education, because such public burden can be financed through taxes.

In short, we found that in Chile it is still profitable, at least for now, to study any university major instead of entering to the labour market right after high school graduation.

Sensitivity analysis

One of the elements used in the previous section to estimate the life cycle is the age at which income reaches its peak. A sensitivity analysis of the results can be conducted using distinct values for the year at which income reaches its peak. The effect of the sensitivity analysis on IRR and NPV is very small. In fact, whether the peak is assumed at 50 or 60 years old, only results in a variation of 0.2% for the IRR and less than 12% for the NPV. This implies that even a change of 10 years, at the age in which income peaks, does not generate significant changes in the estimations. This is due to the fact that distant income values are greatly reduced by the intertemporal discount factor.

Psacharopoulos (1995) suggested that when there are no databases such as ours, a point in the income profile could be used to construct a flat income profile for the length of the life cycle ('short-cut' method). In order to consider the consequences of this procedure, we estimated the IRR and NPV using the short-cut method, on the basis of the observed income two years after graduation. Our results show that the short-cut method tends to underestimate both the IRR and the NPV. For most majors, this method underestimates the returns by at least 3 percentage points and in some cases, up to 16 percentage points of the IRR. For the case of Elementary School Teaching the short-cut method implies a very low IRR.

Similarly, the NPV is also considerably underestimated by the short-cut method. For the vast majority of majors, the NPV would be underestimated by over 50%. Using the short-cut method, fields of study such as Journalism and Psychology have NPVs that are a third of the value computed when richer information with regard to the income profile is used. Moreover, in the case of Elementary School Teaching, the short-cut method generates a negative NPV. A better database allows to see that Elementary School Teaching effectively has a positive NPV of over US $140,000.

Another variable that strongly affects the results is the number of years of study required to complete a university major. Theoretically, most university studies in Chile have a duration of five years. Nonetheless, it is common for students to take more time to graduate. Hence, in our estimation we have considered the average time that a student takes to complete a major, rather than the time stated in the study plan (i.e. the effective duration *vs* the theoretical duration). This assumption is important because an increase in the major's effective duration means that the income for the near future has to be postponed and fees rise.

The results show that both indicators, IRR and NPV, are overestimated when using the theoretical duration. This overestimation depends on the difference between the effective and the theoretical duration. For most fields of study, the NPV is overestimated on average by more than US$40,000 and the IRR by more than 6% (Table V).

Furthermore, the results highlight the crucial influence of majors' duration on the returns obtained from higher education. Greater barriers to a student´s graduation mean fewer benefits to be obtained from higher education. The obstacles to graduation are costs that students end up paying; consequently, universities should provide efficient teaching, enabling students to develop their human capital in a reasonable timeframe and accelerating the graduation process.

Conclusions

One of the main results is that the NPV is a more ade-

TABLE V
EFFECTIVE *vs* THEORETICAL DURATION: IRR AND NPV[a]

University degree	Effective duration		Theoretical duration	
	IRR	NPV (r=5%)	IRR	NPV (r=5%)
Business Management	29.72%	$493,677	35.77%	$534,340
Industrial Engineering	25.14%	$491,692	31.48%	$561,816
Medicine	21.91%	$480,542	22.98%	$495,571
Law	20.94%	$408,422	33.47%	$548,669
Civil Engineering	25.46%	$401,751	32.30%	$459,788
Dentistry	19.88%	$350,007	20.17%	$353,541
Accounting	27.17%	$317,587	39.19%	$380,197
Agronomy	19.09%	$263,398	28.98%	$345,414
Nursing	25.19%	$238,480	28.31%	$251,964
Civil Construction	21.24%	$224,693	33.64%	$292,002
Journalism	18.43%	$223,645	22.04%	$255,225
Psychology	17.28%	$197,024	23.75%	$245,926
Architecture	15.88%	$171,782	20.53%	$210,566
Elementary School Teaching	19.91%	$148,338	19.92%	$148,420

a: The exchange rate for June 2008 was $493.61 Chilean pesos per US$.

quate indicator than the IRR of which majors are more attractive among high school graduates. This is natural given that, in general, only a single university major is studied in a lifetime under the Chilean system of higher education. Thus, students will enter the major with the highest possible NPV that their entrance points will allow. It would therefore seem that future research on human capital should perhaps focus mainly on the NPV rather than on the IRR.

Another important finding of this article is that most (Chilean) university majors have a return >15%, so there are clear incentives for banks to provide financing for higher education. These high rates of return are related to the fact that university graduates have two advantages over high school graduates: higher wages and higher probability of employment. Thus, higher education in Chile, at least for now, is an attractive investment and should be encouraged.

The considerable heterogeneity of the returns, both with regard to the NPV and the IRR for the different majors, indicates that it is not correct to suppose that there is a representative major for higher education. The returns on human capital are heterogeneous. These findings suggest that it is important to investigate the mechanisms that generate the returns differences for different types of human capital.

In developed countries the higher majors' return can be attributed to the emphasis placed on innovation in the process of wealth creation. Given that our findings are in line with the analysis of return in developed countries, it can be inferred that in developing countries, innovation is also a factor that could produce greater returns for majors associated with it.

REFERENCES

Altonji JG, Arcidiacono P, Maurel A (2016) The analysis of field choice in college and graduate school: Determinants and wage effects. In *Handbook of the Economics of Education*. Vol 5. pp. 305-396.

Arellano SM, Braun LM (1999) Rentabilidad de la educación formal en Chile. *Cuad. Econ. 36*: 685-724.

Ashenfelter O, Krueger A (1994) Estimates of the economic return to schooling from a new sample of twins. *Am. Econ. Rev. 85*: 1157-1173.

Ashenfelter O, Rouse C (1998) Income, schooling, and ability: Evidence from a new sample of identical twins. *Quart. J. Econ. 113*: 253-284.

Becker GS (1964) *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. National Bureau of Economic Research. Boston, MA, USA.

Berger MC (1988a) Predicted future earnings and choice of college major. *ILR Rev. 41*: 418-429.

Berger MC (1988b) Cohort size effects on earnings: Differences by college major. *Econ. Educ. Rev. 7*: 375-383.

Birch ER, Li I, Miller PW (2009) The influences of institution attended and field of study on graduates' starting salaries. *Aust. Econ. Rev. 42*: 42-63.

Blackburn ML, Neumark D (1993) Omitted-ability bias and the increase in the return to schooling. *J. Labor Econ. 11*: 521-544.

Blackburn ML, Neumark D (1995) Are OLS estimates of the return to schooling biased downward? Another look. *Rev. Econ. Stat. 77*: 217-230.

Boarini R, Strauss H (2007) *The Private Internal Rates of Return to Tertiary Education: New Estimates for 21 OECD Countries*. Working Paper Nº 591. Economics Department. OECD. Paris, France.

Chia G, Miller PW (2008) Tertiary performance, field of study and graduate starting salaries. *Aust. Econ. Rev. 41*: 15-31.

Finnie R, Frenette M (2003) Earning differences by major field of study: evidence from three cohorts of recent Canadian graduates. *Econ. Educ. Rev. 22*: 179-192.

Granados P (2004) Función de ingresos de los hogares chilenos: ciclo de vida y persistencia de shocks. *Econ. Chil. 7*: 51-89.

Harmon C, Oosterbeek H, Walker I (2003) The returns to education: Microeconomics. *J. Econ. Surv. 17*: 115-156.

Hastings JS, Neilson CA, Zimmerman SD (2013) *Are some Degrees Worth more than others? Evidence from College Admission Cutoffs in Chile*. National Bureau of Economic Research. Nº 19241. 50 pp.

Heckman JJ, Lochner LJ, Todd PE (2006) Earnings functions, rates of return and treatment effects: The Mincer equation and beyond. In *Handbook of the Economics of Education*. Vol. 1. pp. 307-458.

Heckman JJ, Lochner LJ, Todd PE (2008) Earnings functions and rates of return. *J. Human Capital 2*: 1-31.

Hirshleifer J (1970) *Investment, Interest, and Capital*. Prentice-Hall. Englewood Cliffs, NJ, USA. 243 pp.

James E, Alsalam N, Conaty JC, To DL (1989) College quality and future earnings: where should you send your child to college? *Am. Econ. Rev. 79*: 247-252.

Kirkeboen LJ, Leuven E, Mogstad M (2016) Field of study, earnings, and self-selection. *Quart. J. Econ. 131*: 1057-1111.

Mincer J (1974) *Schooling, Experience, and Earnings*. Human Behavior & Social Institutions Nº 2. National Bureau of Economic Research. 152 pp.

Meller P, Valdés G, Lara B (2011) Female discrimination at the professional level in Chile. *Interciencia 36*: 823-830.

OECD (2009) *La Educación Superior en Chile*. Reviews of National Policies for Education. Organisation for Economic Cooperation and Development and World Bank. 290 pp.

Palacios-Huerta I (2003). An empirical analysis of the risk properties of human capital returns. *Am. Econ. Rev. 93*: 948-964.

Psacharopoulos G (1995) The Profitability of Investment in Education: Concepts and Methods. *World Bank Working Paper, Washington, D.C.*

Psacharopoulos G, Patrinos HA (2004) Returns to investment in education: a further update. *Educ. Econ. 12*: 111-134.

Rumberger RW (1984) The changing economic benefits of college graduates. *Econ. Educ. Rev. 3*: 3-11.

Rumberger RW, Thomas SL (1993) The economic returns to college major, quality and performance: A multilevel analysis of recent graduates. *Econ. Educ. Rev. 12*: 1-19.

Saks RE, Shore SH (2005) Risk and career choice. *Adv. Econ. Res. Policy 5*: 1-43.

Sapelli C (2005) *Returns to Schooling and Income Distribution by Cohort in Chile: An Analysis Based on Synthetic Panel Data*. Pontificia Universidad Católica de Chile. Santiago, Chile.

Thomas SL (2000) Deferred costs and economic returns to college major, quality, and performance. *Res. Higher Educ. 41*: 281-313.