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為高等教育籌措資金的選擇 ：人力資本契約在哥倫比亞

Testing Alternatives to Finance Higher Education: Human Capital Contracts in Colombia

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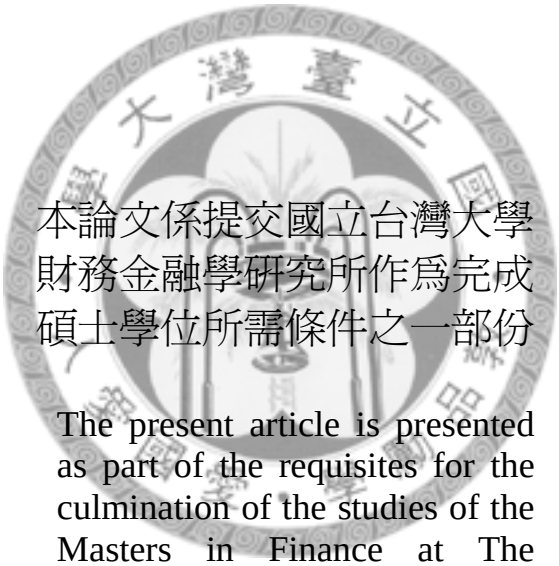

本論文係提交國立台灣大學
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The present article is presented as part of the requisites for the culmination of the studies of the Masters in Finance at The National Taiwan University

研究生：Felipe Lozano

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I assume the responsibility for any mistake in the present article; all of them are my own.

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爲高等教育籌措資金的選擇 ：
人力資本契約在哥倫比亞

民國九十七年九月

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摘要

財務領域的進步提供了改善發展中國家教育管道的新選擇 . 人力資本契約 (Human Capital Contracts) 被視爲暢通高等教育管道的部分解答,本研究即是 評估 HCC 在哥倫比亞實施的獲利能力. 筆者用哥倫比亞教育部教育勞動力觀察局的畢業生就業調查(Following Graduates Survey 2007) 之數據, 套用 Palacios (2004) 的估價模式來進行預估 HCC. 此 FGS 可分析畢業生的特定族群, 提供在學學習領域及父母教育程度的資料,並且納入部分高等教育機構的特色.本研究以傳統最小平方法, 穩健標準誤差, 區間迴歸, 再藉 Mincerian 與 Splines 預測模式得出預估畢業人口未來收入的函數, 研究此數據對 HCC 進行估價.

研究結果顯示在哥倫比亞高等教育的報酬率足以讓 HCC 全額補助給欲進入公立機構的學生. 若用於私立機構, 在所需資訊充足的前提下 HCC 也能提供部分經費. 爲了籌措私立大學計劃的全額資金, HCC 仍需要政府的協助, 以制定利於投資者且吸引學生的契約.

關鍵詞: 投資教育回報酬率,教育籌措資金 , 人力資本契約 (HCC), Mincerian 函數模型, Splines 函數模型, 傳統最小平方法, 穩健標準誤差, 區間迴歸

TESTING ALTERNATIVES TO FINANCE HIGHER EDUCATION: HUMAN CAPITAL CONTRACTS IN COLOMBIA

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ABSTRACT

Advances in the fields of finance offer new alternatives which can lead to an improvement in the access to education in developing countries. Human Capital Contracts (HCC) are introduced as a partial solution to the access to higher education. This article evaluates the viability of implementing HCC in Colombia, replicating an exercise for its valuation as presented by Palacios (2004) with estimations for future income from the Labor Observatory for Education of the Colombian Ministry of Education and its Following Graduates Survey (FGS 2007). The database allows the analysis of the particular group of higher education graduates, providing information about fields of study and parental education attainment and also allows accounting for some characteristics of the Higher Education Institutions. The analysis is made through a Mincerian and Splines model to derive income forecasting equations for the graduated population and then, valuate Human Capital Contracts.

The results show that returns to higher education in Colombia are high enough to give an economic incentive for the implementation of HCC to finance *totally* university programs for students who want to access to public Higher Education Institutions. In the case of private institutions, given the available information, HCC are an alternative to finance *partially* their programs. For total financing of programs at private universities, HCC still requires governmental aid to make the contract both, profitable for investors and attractive for students.

Keywords: Higher Education Returns, Education Financing, Human Capital Contracts, Mincerian Equation, Splines Models, Robust Standard Errors, Interval Regression

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Chapter 1. Introduction

Governments in developing countries have to deal with a tight budget restriction giving room to underinvestment in education. Great efforts and advances have been made in the coverage of basic education, but this is not necessarily the case in Higher Education. In Colombia and in other developing countries as well, individuals with a great potential might be left without entering to the higher education system because they do not have the financial means to access it, and the governments do not have the means to assist this demand either. Then, individuals with no access to education lose the opportunity to develop their full potential and the society losses the gains in productivity and welfare that are derived from education. Instruments linking private investors to those individuals are an important alternative to have in mind, and are the motive of the present article, as they might be able to improve the current situation.

Recently, development on the fields of Finance have allowed the creation of different ways of long term financing and investment, mainly through securitization and the deepening of world financial markets. These changes have brought back the original idea of Friedman (1955), to invest in the equity-like capital of individuals and their potential to generate income. These investments take the form of Human Capital Contracts (HCC), where an individual counts with its future earnings as collateral and source of resources to cover an original investment.

Palacios (2004) makes a clear exposition of the importance of education in development, and introduces the historical process that HCC have gone through, presenting them as a partial solution to the problem of access to education where the resources from private investors can be transferred to students without financial means, in exchange of a percentage of their future income. His book also introduces Human Capital Options as a way of protecting the students of over-payment and investors of students' under-payment. Palacios (2004) uses the results on education returns of Núñez and Sánchez (2000)[1] to valuate a hypothetical HCC to finance superior education to be implemented in Colombia.

In this article, Palacios (2004) analysis is taken one step further, focusing in the returns to education to the specific group of Higher Education Graduates for HCC valuation.

[1]The cited example can be found in Palacios (2004), who develops a model to valuate HCC to finance higher education in the Appendix A and C of his book, the model is presented in this article as well.

Previous studies in Colombia, which focused in this particular group of graduate students, have tried to find determinants of graduate students' income (Forero and Ramírez 2008), but the hereby article aims to look exclusively for the return in Higher Education, and is also the first study that focuses in the valuation of HCC in Colombia. Therefore, this article contributes to the literature of both, Higher Education Financing and Economics of Education.

The present article introduces a simple model of HCC to evaluate the feasibility of the contracts in Colombia from the perspective of the economic incentives for investors and students. It is found that HCCs are able to finance *partially* the higher education programs of professionals in private universities, and *totally* the professional programs at public institutions.

In the present article using data from the Following Graduates Survey 2007 (FGS 2007) database provided by the Labor Observatory of the Colombian Ministry of Education, a Pure Mincerian and a Splines Model are used to estimate the returns to Higher Education, as they have been widely used in previous literature (Internationally: Mincer (1974) for the US, Trostel et Al. (2001) and Psacharoupoulos (1986) for a set of countries; Daniels and Rospabé (2005) for South Africa; Low, et Al. (2004) for Singapore; on the other hand, for Colombia: Núñez and Sánchez (2000); Prada (2006); Guataqui, et Al. (2008)).

This paper does not address critics to the Mincerian or Splines models regarding the functional form; the nonseparability between schooling and work experience, and the inclusion of taxes and tuitions. Some modifications are, however, included, accounting for different socio demographic variables not included in the Classic Mincerian specification.

The article proceeds as follows: Section 2, presents a theoretical framework and reviews the most recent literature and the debates on financing education. In Section 3, an overview of the Higher Education is presented, along with different options students have to finance Higher Education in Colombia. Section 4 presents the data from the FGS 2007 with an introduction of the main variables. Section 5 presents the outcomes of the econometric exercises using OLS, Robust Standard Errors and Interval Regressions for the different model specifications. Section 6 presents Palacios (2004) example to valuate HCC, and the estimation using the outcome of Section 5. Section 7 concludes.

Chapter 2. Theorical Framework and Literature Review

2.1 Economics of Education

Education can be seen as an investment good (Mincer 1958 in Meier 1999, Rebbelo 1991) where individuals accumulate human capital with the aim of improve their skills which, once improved, will receive a higher compensation in the labor market. This is the position of the Human Capital Theory (HCT). Education can also be seen as an investment that generates externalities, as they not only increase the productivity of the student but also the productivity of all factors (Lucas 1988 in Meier 1999), an effect that the worker does not fully appropriate because education has public good characteristics. Above is the claim of the Endogenous Growth Theory (EGT). Lin (2007) analyzes the historical process where technological innovation evolved from *exogenous* shocks that affected positively income, to *endogenous* through research and development made by people at the technological frontier, referring to the highly educated capable of changing technology endowments.

Education can also be seen as a consumption good (Schultz 1961 in Meier 1999): individuals demand it striving for status or recognition. Finally, the screening hypothesis (Spence 1973 in Meier 1999, Palacios, 2004): where education is argued to be a signal of the workers abilities which exist before the education is received. Thus, the latter would not be productivity enhancing for all factors.

Other argument against governmental intervention on the provision of higher education is that there is a "reverse distribution" effect (in Waldi 2007), where all the taxpayers contribute to the subsidies, and returns are only appropriated by graduates from high social backgrounds, highly overrepresented at universities.

Liquidity constraints affect the efficiency of market distribution of education. For the EGT and the HCT solving the liquidity constrains on the students' side will help to escape poverty traps and foster economic growth. Even for the screening hypothesis or the education as consumption hypothesis, liquidity constraints would prevent the optimal level of education to be attained. Linking education with development is important when discussing the extent of the role of public resources in education. In the case of Human Capital Contracts (HCC) where private resources are transferred from savers to students,

there is no debate in the welfare enhancement of their implementation. Even though, it could require some governmental support at the beginning, due to its risky nature.

Exploring further in the market failure of the provision of Higher Education, as it is this kind of education this article is concerned with: structural barriers exist, affecting the potential students, lenders, and the environment where investors and individuals make decisions. These barriers are described by Barr 2001 and Friedman 1955; they compare the long term investment of education and vocational training with a mortgage loan. These barriers are summarized by Palacios 2004 as follows:

Potential Students

-Unknown benefits: It is known with more certainty what to expect from a house.

-Uncertain value: Once bought, the house is not going to stop serving its purpose unless it is destroyed by a calamity.

-Need for constant reinvestment: Higher education become obsolete at a faster pace due to new technology.

-Illiquid Investment: Education cannot be sold off in case of financial distress.

-Cannot be collateralized: Education is an intangible asset not accepted as collateral.

Lenders

-Asymmetric Information: Investors are unaware of the ability of the students. Adverse selection problems may arise.

-Difficult Collection: Enforce payments if compared with a mortgaged loan is harder for student loans

-Uncertain value, illiquid investment and absence of collateral.

Others:

-Externalities: Despite they are not completely accepted (screening hypothesis), their existence would suggest that a greater governmental intervention for granting access would be socially desired.

-Institutional issues: There can be a fear of “greed” determining who and how gets education financed, when decisions are made in an economic basis. This fear might forge institutions, preventing private investors to seek opportunities in education.

HCC have the potential to correct these issues, so they are presented as a potential alternative to finance education.

2.2 Financing Education

Traditionally, societies have financed their higher education with resources from the Government-taxpayer and through direct financing of the individuals. Government offers loans and subsidies to students or to High Education Institutions. Direct financing can be made with savings and wages owned by individuals, their families and relatives; it also can

be made through loans acquired in the private markets, which are often imperfect. Those resources are not enough to meet demand in developing countries.

As mentioned previously, in developing countries, governments face tight budget conditions. Measures which increase supply without increasing the public expenditure should be analyzed. There are two kinds of measures: those that increase efficiency of the resources already available, and those that increase the availability of resources. Competition mechanisms increase efficiency while universities are forced to compete for students, attracting them with improvements on their quality (i.e. vouchers). The availability of resources can be increased by graduate taxes and by involving the private sector into purchases of knowledge profitable in the market (research and student sponsoring).

For students, ideals measures would recover costs without damaging the access. Low income students do not have the resources, their risk aversion is higher –as the returns of education are more uncertain for them and the opportunity cost to go to class is higher- and in most of the cases, they have no access to the financial markets. If students know that they do not need financial resources to show up to classes and if they perceive that the payments after graduation will not be unbearable, the measure will be successful. HCC are a way for private markets to get more involved in filling the government's gap in higher education without marginalizing the low income population (Palacios 2004).

2.3 The History of Human Capital Contracts

After considering the problems which arise when individuals intend to pursue higher education and taking into account the irrevocable liquidity constraints, Friedman writes: "The device adopted to meet the corresponding problem for other risky investments (in other kind of capital) is equity investment plus limited liability on the part of the shareholder. The counterpart of education would be to "buy" a share in an individual's earnings prospects" (Friedman 1955). As stated above, Friedman established the main idea of Human Capital Contracts.

The idea evolved into Income Contingent Loans (ICL), which were first introduced experimentally by some universities in the USA. A cited example was the Yale Tuition Postponement Program launched in 1970. Students' balances were grouped, so default students' balances would be added to the group balance, furthermore, maximum repayment

period was 40 years. The program became burdensome for students who perceived that it was too expensive and long termed. If the experiment could not spread, it drew several issues concerning this kind of contracts, especially about the maximum repayment period affordable and the difficulty for universities to collect the loans (Palacios 2004).

The second wave of ICLs started in Australia with a program called Higher-Education Contribution Scheme Program in 1989. Similar programs have been adopted by other countries (i.e Sweden, Ghana, Chile, New Zealand, and UK). In these programs, Higher Education is still highly subsidized and collection, in some cases, is made by the tributary institutions. The ICL idea veered from the initial idea of Friedman of investing in equity-like instruments to finance higher education.

Given the transformation of the financial markets, with the explosion in the number of mutual funds and the increasing degrees of securitization of different assets; in 1990, Roy Chapman relaunched Friedman's idea. After lobbying for some legal framework, MyRichUncle™ started operations in 2001 as the first institution investing in Friedman's idea (Palacios 2004).

Past experience in the above mentioned experiments, has drawn a path for HCC implementation, and legal issues should be addressed on the particular environment of each country which is beyond the reach of this article. Before evaluating the feasibility of HCC in Colombia, some features of the contract mentioned by Palacios (2004), are presented.

2.3.1 The Contract

The contract has to specify what students and investors expect from each other clearly, following a non-interference principle that can derive in servitude of any kind. A proper separation should be made between investors and students, and should to be guarded by the institutions issuing the contract according to the law.

The contract should mention what would be the percentage of income to commit and its maximum; and it should also mention the longest accepted repayment period. In order to attract investors, the contract should recognize the costs and the risks taken and account for the time value of money. These terms can vary on the timing of the funding, as when graduation comes closer, the carried risk decreases. Still, generic packages can be cheaper from an administration costs point of view.

2.3.2 Additional Features

-Caps on total payments might be used to avoid adverse selection problems. The latter may arise as it is supposed that the best students know the potential of their abilities, they will earn more than the average and then, will not have an incentive to engage in HCC.

-In order to protect students, low income forgiveness provisions can also be taken into account. Both, caps and provisions, distort the interest rate requested by investors as they would try to recover the revenue losses. Wilde (2007) accounts for them in his model.

-Exit conditions should be stipulated as call options on the unpaid balance of the contract, or as immediate payment schemes.

-Adjustment of the repayment period might happen. For example, part-time jobs can be considered a percentage of a defined productive year. Also, when students still want to pursue further education (Specialization, MA, and PhD) requiring retirement from the labor market, a rearrangement of terms should be specified.

2.3.3 Grouping Students and Investors

Investors benefit from students being grouped, as the group income variance would be lower than the variance of each student taken separately. As predicted by the Portfolio Theory (Markowitz 1952), investing in a pool of students will reduce the risk bore by investors and will request a lower interest in return.

Students also benefit from grouping because they would pay cheaper thanks to the diversification and thanks to the fact that the risk of being abused by investors is reduced. Finally, grouping students spreads the administration costs over a wider population.

As second markets grow and deepen, market information produce elements to judge performance of Higher Education Institutions, as well as market demand for particular fields of study and any other derived from the grouping of students and investors.

2.4 Estimating Higher Education Returns

To valuate HCC, an estimation of the graduates' potential future income has to be made. Mincerian equations, as proposed by Mincer 1974, have been widely used. In a Mincerian equation, the variable wage is explained with the scholar level measured in years of education attained, and with the experience and its in quadratic form to account for the convexity of the relation, as below:

$$\log[w_i(s_i, x_i)] = \alpha_0 + \rho_s s_i + \beta_0 x_i + \beta_1 x_i^2 + \varepsilon_i, \qquad (2.1)^2$$

where w stands for the wage of the individual i; s, for the years of education, and x, for the years of experience.

Over the years, some modifications have been made to the original model. One of the modifications tries to account for problems from the linearity of schooling (Splines Models). Linear splines models are used to account for the fact that one year of primary school rendering the same return as a year of doctoral degree stands as a strong assumption.

Another modification is the use of experience as it is a variable hard to measure. In several cases, the potential experience has been used as a proxy, defined as the difference between the age and the years of schooling: $Max[age - s - 6, age - 16, 0]$. This specification makes x a function of s, distorting the interpretation of ρ_s as the growth rate of income due to schooling –Eq. (2.2). The effect of a change in the schooling level would be:

$$\frac{\partial \log w}{\partial s} = \rho_s + \beta_0 \frac{\partial x}{\partial s} + 2\beta_1 \frac{\partial x^2}{\partial s}. \qquad (2.2)$$

Such specification implies that log-earnings experience are parallel across schooling levels, and that log-earnings age profiles diverge with age across schooling levels (Guataqui, et Al. 2008). To avoid these problems the age is used as a proxy for experience without the transformation suggested by Mincer.

In order to break the assumption of unit elasticity of the time worked in relation with the wage, it is included the effective labor supply of the individual (measured as the log of monthly working hours). Other modifications include the addition of socio demographic variables as gender, and the inclusion of the correction of the Sample Selection Bias, proposed by Heckman with household characteristics which can explain the fact that the individual is part of the labor force.

In Colombia, some of the above mentioned specifications have been tested recently by Núñez and Sánchez (2000), with OLS techniques for the period 1976-1998. They estimate a Mincerian equation and a modified version including linear splines for: primary school, finished primary, secondary, finished secondary, university, finished university and more. For the returns to education in their Mincerian exercise, it is found a decrease from

[2] In the present article, log, refers to the natural logarithm

12% to 9% from the period of 1976-1981 to 1982-1992. After, the return increases up to 11% in 1998. In their splines, model the rate to higher education is 22% in total.

Prada (2006), using OLS and Quantile Regression techniques, also estimates a Mincerian model separated from one with splines for data from 1985 to 2000. Prada (2006) finds that the returns to education present a cyclical behavior and that returns are heterogeneous depending on the income groups analyzed. Higher Education returns are found from -2.5% up to 46.8%, depending on the economic cycle and the income group, with lower income groups having a higher variance.

By focusing only on Higher Education and using an earlier release of the database used in this article, Forero and Ramírez (2008), proved the relationship between income and different determinants, including: gender, age, parental education attainment, residence region, fields of study, occupation areas, labor contract terms, Public or Private employment, Higher Education Institution (HEI) region and its accreditation by the Ministry of Education –the last variable was not included in the last release, then is not included in the present analysis–. Using OLS, Ordered Probit and Interval Regression estimates, the article finds out that living in Bogota, being male, the parental education and obtaining a title from private or accredited universities, all have a positive impact on the wage of the graduates from Colombian universities. The fields of study and occupation areas also determine students' income.

For other countries, one of the most updated estimations is the one in Daniels and Rospabé (2005), which uses a Generalized Tobit Model for Interval Regression that accounts for heteroscedasticity, to estimate a modified Mincerian earning function. Waldi (2007) uses panel data to establish differences among levels of education and gender; he also includes fields of study and other socio demographic criteria using a cubic form of the Mincerian equation. Waldi (2007) aims to valuate the feasibility of HCC in Germany. He found that in Germany, HCC are able to finance partially undergraduate programs.

In the present article, OLS, Robust Standard Errors and Interval Regression are used to estimate the returns to education in the group of the higher education graduates. Two models are presented which intend to incorporate past literature evolution using modified versions of the Mincerian equation to get a forecast tool of students' future income. These models will be discussed with more amplitude in Section 5.

Chapter 3. Higher Education in Colombia

According to the document presented by Ayala (2006), the economic crisis of the end of the 90's, the worst since 1929, has affected severely the situation of the higher education in Colombia. Net Coverage (population between 18-24 years that attend to HEIs) increased from 12.25% in 1993, to 16.5% in 2003; but the lag is still noticeable when compared with the Latin American region or with other countries. It was only in 2003 that Colombia reached the Gross Coverage (total of population who attends to HEI) which Latin America had reached in 1997 (25.7%); and this number remains far below the level of the OECD countries (54% in 2003) and of the East Asian countries (Net Coverage at 24% in 2000). If education is regarded as a path to escape poverty traps, there are not real efforts to address the issue: in Colombia, the net coverage in the lowest quintile of income is 17%, while it is 40.5% in the highest quintile; therefore, income differentials are perpetuated.

Desertion remains a strong problem as it reaches levels of 60%. Ayala (2006) observes two main reasons: poor preparation during High School years and the acute economical crisis which forced students to enter prematurely into the labor force. Another aspect of the problem stands in the unused supply. During the 80's, 21.4% of the capacity of HEIs was not used; during the 90's, it increased to 42.6%, and up to 60% in more recent years. The accepted/subscribed ratio in public universities has been between 10% and 20%, leaving out of the system 80% of the aspirants.

Private universities have increased their tuition fees more than proportionately to cover for their fixed costs among fewer students. These costs were also increased by the processes of accreditation now requested by the Ministry of Education. Public universities receive, from the central government, resources which do not recognize the increased number of the students enrolled: enrolment jumped 3.5 times since 1995 in public HEIs, up to 750,000 students in 2007. Furthermore, previous legislation has failed to come with the promised resources; for example, regional entities have failed to make the transfers agreed by law. Have also been suspended other tax reductions which benefited to private institutions donating funds for universities or research institutions. However, Public HEIs still show an increase of their own resources from 14% during the 90's, and up to 20% because of the incentives created by the lack of resources. The average tuition fee cost is

COP359,000 (USD188) in 2004 for new students of public universities. For the private ones, the tuition fees were in average COP2,719,000 (USD1426).

The Icetex was the first institution established in the world to offer educative credit, it has been operating since 1952 (Cardenas 2003) and is one of the main sources for funding Higher Education Colombian students have. Icetex' credits, including those financed with third parties resources, represented 11.46% of the total inscriptions in HEIs in 2003. But their resources are short to meet the demand. In her article, Cardenas (2003) presents other sources of funding that students can find: consumption credits, credit cards and postdated checks, which are all omitted here because they are too expensive. She also presents the educative credit lines from different financial institutions in her article (Table 3.1).

Table 3.1 Different Credit Lines to Finance Education

Entity	Credit Line	Financing Period	Interest rate (a.e)	Credit Subject and other requirements
Bancafe - Davivienda	-Traditional	6, 12 months		
	-Credi U	60% is financed during the study period (6,12 months) and the remaining balanced is defered up to 5 years	DTF+13% 23.14%	Father and son - no codebtor required
Banco de Bogota	-Short Term	6, 12 months	DTF+8%	Son, if he/she has reached majority, parents otherwise - always codebtor required
	-Long Term	50% is financed during the study period (6, 12 months) and the remaining balanced is defered up to 5 years	DTF+12% 22.2%	
Banco de Credito	-Credito Universitario	6,36 months	+/- 25%	Student. Father or Mother guarantee the credit
Bancolombia	-Crediestudio	6,36 months	27%	Son, if he/she has reached majority, parents otherwise - always codebtor required
Santander	-Universia	6,12 months and 36 for postgraduate stud	27%	Parents
Sudameris	-Educa T	6 months	25%	postdated cheqs required

(a.e.) Annual Effective

*DTF stands for the average interest rate offered to the 90 days CDT. It is the benchmark interest rate in Colombia currently 9.9%

Source: Cardenas 2003 and Portafolio Sept 3, 2008. How much is the quota for an educative credit of COP3 mll (USD1500). Available at www.portfolio.com.co

From the conditions offered by different banks, the definition of long term seems too short for the requirements of higher education investment. The longest term is 5 years after period of study (6-12 months), and still 60% of the credit has to be paid during the period of study. Low income students are marginalized from the educative credits offered by the private sector in Colombia.

HCC are an alternative to finance higher education in Colombia with resources of the private sector. The expertise from the banking industry gives a reason to include them among the possible candidates to take the initiative to offer HCC, or to count with their advice in a government lead proposal.

Chapter 4. Data Introduction and Description

This article uses the most updated data on the performance of graduate students' income; this data was collected by the Labor Observatory for Education in the Following Graduates Survey 2007 (FGS 2007). The FGS 2007 collects data from a population who received its diplomas during the period 2000-2007. This data allows to evaluate HCC according to some characteristics of the students (residence, age, working hours, parental education attainment) and characteristics of the Higher Education Institutions (HEIs) where they received their diplomas (Location and private/public character).

The data includes 24,959 observations from which 19,781 are income declaring. The present section introduces data used in the econometric analysis.

4.1 Income of the Graduates

Figure 4.1 shows the frequency distribution of graduates' income for the total sample and for different occupational positions. Are excluded the observations declaring Familiar worker without remuneration as their occupational position, because their histogram shows a different pattern and, also, because students applying for HCC are expected at least to engage in either, the labor or the goods and services markets. Thus, the analysis counts with 19714 observations.

Seven monthly income intervals are presented in the FGS 2007[3]:

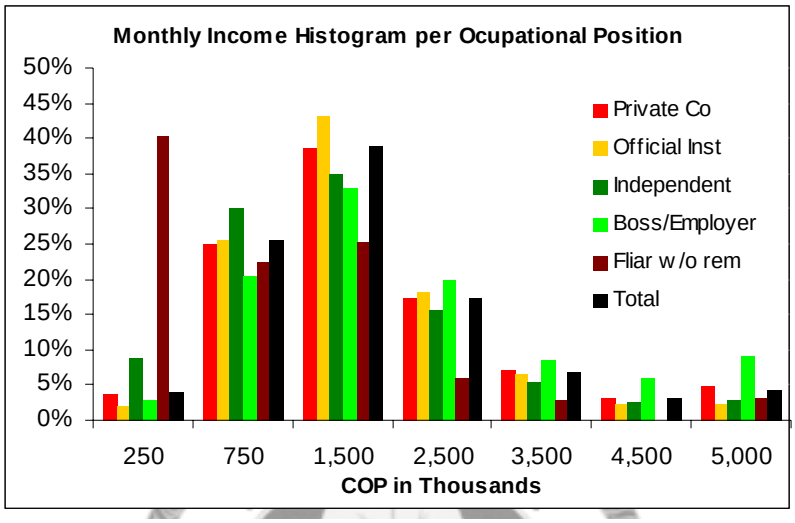
1. Lower than COP500 thousands (th) (USD263),
2. Between COP500th and COP1 million (mll) (USD263-525),
3. Between COP1mll and COP2mll (USD525-1,050),
4. Between COP2mll and COP3mll (USD1,050-1,575),
5. Between COP3mll and COP4mll (USD1,575-2,100),
6. Between COP4mll and COP5mll (USD2,100-2,625)
7. Above COP5mll (USD3,150).

Colombian graduates are more concentrated in the monthly income interval between COP1mll and COP2mll (USD525-1,050) with 39% of the total. 85% of the population is included in the intervals below COP3mll (USD1575). When compared by occupational position, Private Companies have more observations in high income groups (over COP3mll) than Official Institutions do. The same pattern is present when Independent workers are

[3] For USD conversion a rate of COP1907/USD is used in the data introduction. Market Representative Rate (TRM) August 29, 2008. (available in http://www.portafolio.com.co/) . (COP=Colombian Peso)

compared with the Boss/Employer group; however, the latter in the highest income group has more than twice the percentage of any other occupational position.

Figure 4.1 Income Histogram



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

In the gender structure, male graduates account for 55.1% while female graduates account for 44.9%. Male graduates are located in higher income intervals, and female observations are in majority in the first 3 intervals below COP2mll (USD1050) with 63.64%, 63.31% and 57.7% of the sub sample in the first, second and third interval, respectively. Female presence in the higher income groups falls under male dominance with 49.26% (COP2-3mll), 42.92% (COP3-4mll), 40.93% (COP4-5mll) and 28.54% (Over COP5mll).

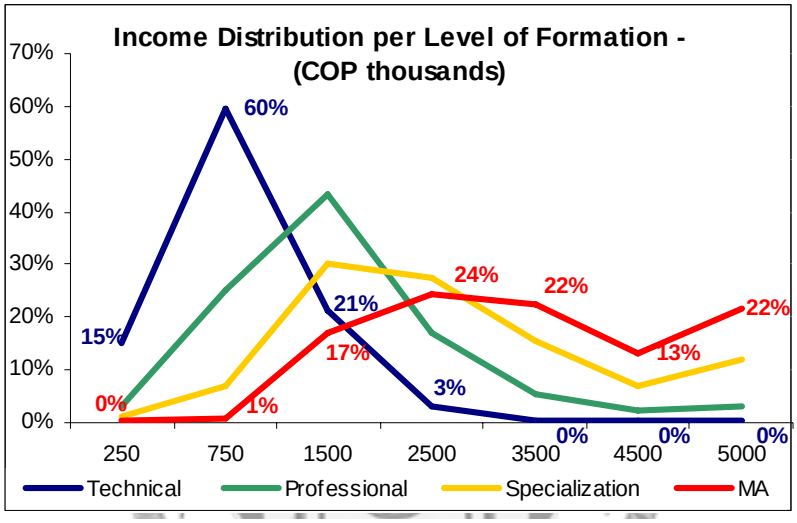
4.2 Level of Formation

The structure of the graduate population per level of formation in the sub sample is as follows: 74.93% of the graduates have finished their professional studies in formal universities, while 9.31% have obtained their diplomas from Technical and Technological institutions. The remaining 15% has pursued degrees higher than the professional level: Specialization (13%), MA (2.42%) and PhD (0.03%).

Trying to find a relationship between the level of formation and the distribution of income, it appears that the population of higher levels of formation is concentrated in higher income groups. Figure 4.2 shows the relative frequency lines for the different levels of formation. The graph includes values for Technical and Technological (T&T) and MA

levels. There are almost no observations for the T&T level on the higher income groups, and there are no observations for the MA level in the lower income groups. For doctoral studies, the histogram does not count with enough degrees of freedom, as there are only 6 observations in the whole sample, and 5 in the sub sample of the analysis. However, all the PhD observations in the sub sample are located in the intervals with incomes of COP3mll (USD1575) per month or higher.

Figure 4.2 Income and Level of Formation



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

Education attainment is still influenced by the gender: the lower the level of formation, the higher the female concentration. For T&T and professional level, female observations account for 55.1% and 56.3+% respectively; while in the MA level there are only 41.9%, and from the 5 observations with PhD degrees, only one is a woman.

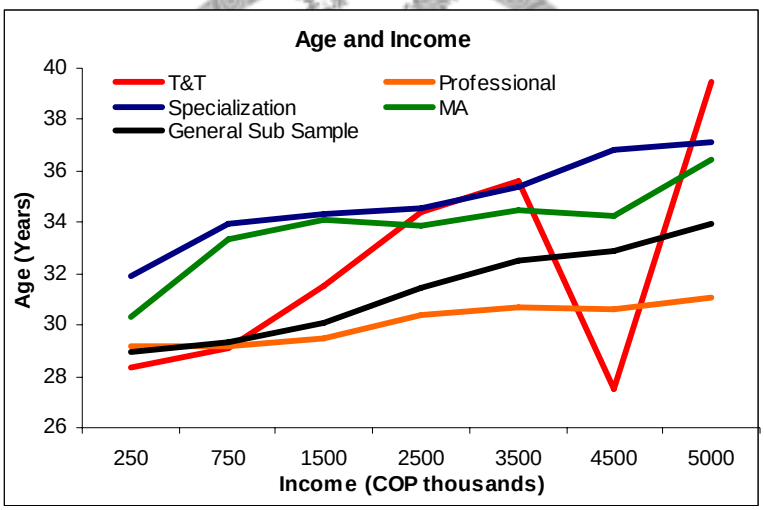
The database does not count with background variables rather than income. The differentiation among variables concerning initial and final income would help proving the causality of education. In the present article, it is assumed that education causes the final income after a certain level of higher education has been attained.

The level of formation is transformed into the Mincerian variable for years of education in one of the econometric models developed in the next section; then, the value would be 14 Years for T&T level, 16 for Professionals, 17Y for Specializations, 18Y for MAs and 22Y for PhDs.

4.3 Age Structure

The mean of the graduate's age is 30 years being centered in the group of 25-30 years (58.45%); less than 10% of the sub sample has attained higher education with less than 25 years; between 30 and 40 years of age, there are 25.89% of the observations, and over 40 only 6.72%. Each level of formation implies different times spent at school, but as people pursue higher education at different times of their lives, depending on the development of their carriers and their budget constraints, the means of age for different levels of formation are not increasing on the level of education attained. Thus, T&T average is 29.7 years of age, while the average of the professional level is 29.67, and while the Specialization level average is 35 years, the MA's one is 34.6 years.

Figure 4.3 Age and Income per Level of Formation



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

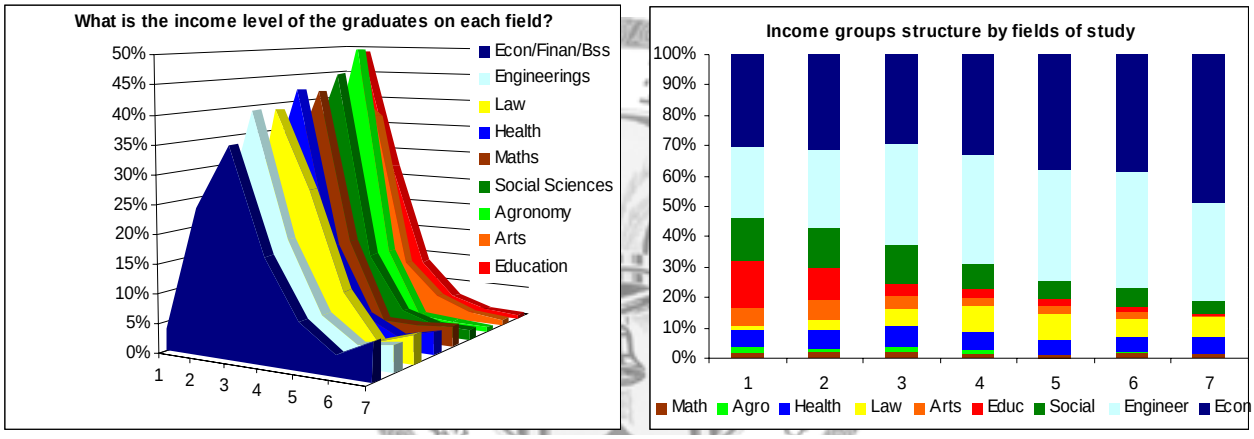
Male graduates are in average 2 years older than female ones (31 vs 29 years old), and they are older in all the sub samples of level of formation but for the PhD one, where the only female is 37 years old and the average age of the 4 males is 37 years old as well.

As age is a proxy for experience, it should have a relationship with income, and, in fact, the mean of the age increases along with the income intervals. Figure 4.3, presents the evolution of the mean of age with the income group for each level of formation. Again, PhD observations are removed, due to lack of degrees of freedom. Most of the lines have upward slopes, but the behavior of the T&T level is remarkable: the age average is only 27 years in the income group with COP4-5mll. These observations are noticeable outliers as there are

only four T&T observations in that interval, which account for 0.22% of the T&T total observations, and for other four observations in the interval with income higher than COP5mll. It is hard to make comparisons between the different levels given the different weights on the income groups and the times required to attain a particular degree. However, for the Specialization and MA the required time is small and the age average is close, so from the graph, it can be thought that for a given age the MA level has a higher income than the Specialization group.

4.4 What do graduates study?

Figure 4.4 and 4.5 Income and Field of Study: Histogram and Income Groups Structure



Note: Income intervals are represented with ordinal numbers, where 1stands for the interval of income below COP250,000, and 7 for the interval of income over COP5,000,000
Source: FGS 2007-Labour Observatory for Education and Author's Calculations

Another way to look at the distribution of income is to analyze its relation with the fields of studies. The FGS 2007 presents data for 55 different basic nucleus of study; in the present article, they are grouped in 9 fields: Agronomy, Veterinary and related; Arts; Education; Health Sciences; Law; other Social Sciences; Economics, Finance, Business and related; Architecture and Engineering; Mathematics, Natural Sciences and related. Appendix A.1 presents how classifications were made from the FGS 2007 database for the current analysis. Figure 4.4 presents the income histograms of the different fields of study. Figure 4.5, shows the field of study structure within each income level. Both graphs present income intervals organized in ordinal numbers, where 1 stands for income under COP500th monthly; and 7, for income above COP5mll.

It seems like there is an embedded decision about future income when students choose their field of study. 69% of the students chose to study Econ/Finance, Engineering

or Law, which are the fields showing higher means and a greater concentration in the higher income intervals. In the same way, less than 10% of the population chose Math or Education, which have the lower means and a stronger concentration in the lower income intervals. The less 'popular' fields are Math and Agronomy, respectively 1.9% and 1.3% of the sub sample.

This structure is similar to the data from the Ministry of Education: Agronomy, Math and Arts remain the less studied careers with 8% as the average of total subscribed in HEIs population during 2002-2007. Accordingly, the students from Economics, Engineering or Social Sciences including Law, have accounted for 72%, in average, of the total population.

Studying Economics or Engineering does not assure the final outcome for income. These two areas represent more than half of the graduates regardless of the income group. However, the higher the income group, the higher the concentration in these two fields: in the lowest income group they take 54% of the graduates, but they account for 81% of the observations in the highest income interval. Law students are also more concentrated in the higher income groups: 1.9% in the lowest income group and 6.1% in the highest. From Figure 4.4, it can be seen that these fields have lower peaks in the 3rd income group, allowing denser tails for high income observations.

Higher income groups present more observations of Math's graduates than Agronomy ones. 35% of the lowest income group pursues degrees in fields such as Education, Social Studies different than Law, and Arts. These subjects practically vanish from higher income groups (5.6% of the income group No. 7). Health Sciences observations have a stronger presence in the 3rd and 4th income groups (7-6%). In Figure 4.4, Arts and Education are the only groups with peaks on the 2nd income group (all the rest have it on the 3rd) and with steep slopes, allowing almost no observations in the higher income groups.

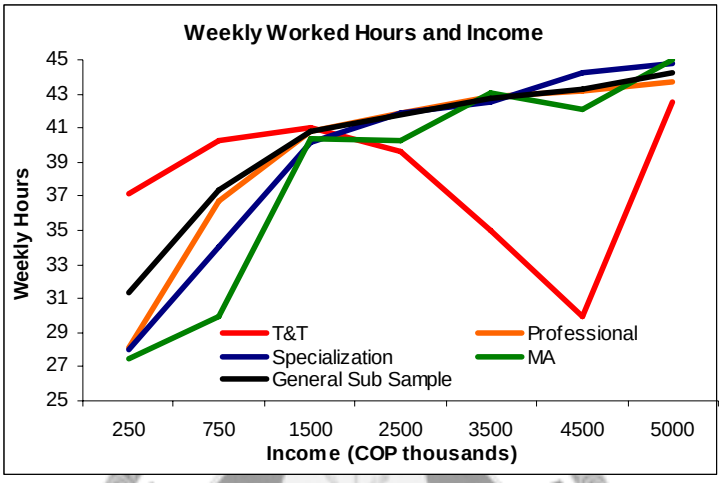
4.5 Worked Hours Monthly

With regard to the hours worked weekly, 49.64% of the graduates declare that their jobs demand between 31 and 48 hours of their time weekly; while other 33.72% are currently being working more than that. Other intervals collected include less than 10h (3.81%), 10-20h (4.68%) and 21-30h (5.36%). The remaining 2.89% gives a NA/NR answer.

The lowest income group, below COP500th (USD263), has the highest concentration among the intervals with less than 30 working hours per week (34.25%). This outcome

might be related with the difficulty to get a formal and permanent job at this level of income. For an income higher than COP3mll (USD1,575), more than 90% of the graduates declare working more than 31hours per week.

Figure 4.6 Worked Hours and Income per Level of Formation



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

The relation between working hours and income is presented for each level of formation in Figure 4.6, using the mean of each interval of working hours and 50 h/week for the highest interval. With the exception of the T&T level, all levels and the sub sample as a whole show a concave curve: for changes in income, the labor supply increases, but less than proportionately each time. In most of the cases, the curve for a given formation level is below the curves of higher formation levels; thus, in order to get the same income, a higher educated individual should work less than others with a lower level of formation. Again, in the high income intervals, the T&T level does not have a uniform behavior; apparently, because it lacks of observations for those intervals. Male graduates work more in average than female graduates, but differences between the averages are not significant as they only account for 1 or 2 hours per week, depending on the level of formation.

4.6 Where do they live?

Most of the graduates live in Bogota (36.47%), but the concentration of graduates in the capital varies with the level of income. For lower income intervals, Bogota accounts for close to the 30%, while for the higher intervals it stands for almost the half. Apart from Bogota, 7 regional variables are set according to the political and regional division of

Colombia (Appendix A.1): Antioquia and Valle, isolated as departments; an Oriental, an Atlantic, a Central, a Pacific and an Amazon regions are presented as groups of departments; and a final variable for Colombian graduates living abroad.

The worst performing graduates live in the most depressed region of the country: the Pacific one, where 53.25% of the sub sample earns less than COP1mll (USD525) per month. The best performing graduates are living abroad: 28% of the expatriates have an income higher than COP5mll (USD2,625) per month, and for the expatriates, the three highest income intervals include 60% of the graduates.

While Bogota absorbs most of the higher income intervals, it is less clear that it absorbs the best prepared graduates. Once the variable of level of formation has been transformed into years of education, as mentioned before, Bogotanians have lower means of years of education than their compatriots in Valle, the Oriental Region, the Atlantic, and the Amazon and than those living abroad. However in Bogota, the bulk of the higher education graduates remains with 49.5% of the T&T, 32.8% of the Professionals, 43.5% of the Specialized graduates, and 62.1% of the MAs. It has no observations with PhD, but the whole sample only shows 5.

From a regional perspective, the FGS 2007 does not offer a dynamic approach. But it still confirms the accelerated growth that Bogota has gone through during the last 30 years. Valle and Antioquia, with the second and third largest concentration of wealth and population in Colombia, are behind Bogota in issues of offering graduate students works with competitive wages. The reasons can be explored in the centralism or in the financial strength of the capital, but the analysis is beyond the scope of the present article.

The inclusion of the residence variable comes from the fact that an initial experiment can be tried on the graduates from Bogota: they present more favorable conditions, as it would be shown in the regression analysis.

4.7 Parental Education Attainment

The FGS 2007 database presents 11 different levels of formation for parental education, presented in Table 4.1. Media Technical and Normal Education are not considered as higher education levels in the present article. Previous generations of women did not benefit from the same education levels as men did, in part because of the cultural

reasons present at that time in Colombia. The percentage of fathers in formation levels higher than professional is always greater than the mothers' one. Mothers who have high school education or below, represent 55.3% from the total; while the fathers at the same level of education, represent only 48.51%. Still, it is important to underline the fact that most of the parents come from lower backgrounds of education; it represents a step forward in the intergenerational education attainment. This variable is also the only one that can lead to obtain more information on the income of the household from where the graduate comes from.

Table 4.1 Parental Education Attainment Levels

1 Primary School
2 Basic High School
3 Academic High School
4 Media Technical
5 Normal
6 Professional Technical
7 Technologic
8 Professional
9 Especialization
10 Masters
11 PhD

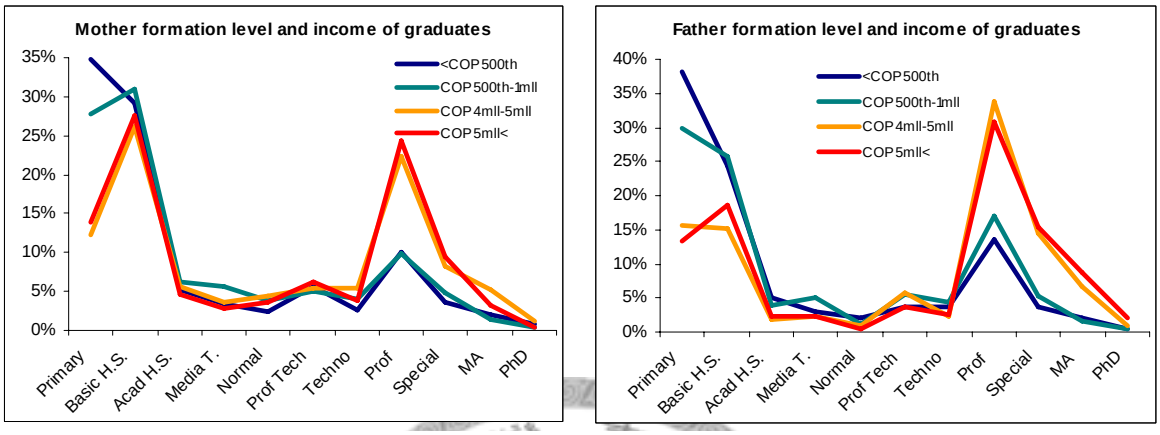
Source: FGS – 2007. Dictionary of Variables

About the level of formation acquired by the descendants, 72% of the fathers of T&T level graduates graduated from Academic High School or below, and 22% obtained higher education degrees as defined in the present article. 46% of the Professional students have fathers with High School or below level, 49% for specialized students and at the MA level, the percentage falls to 40%. In the mothers' case, the percentage who received high school education or less is more concentrated for graduates with lower formation levels: 77%, 56%, 56% and 47% for T&T, Professional, Specialization and MA, respectively.

Parents' education attainment has an effect over the income of the descendants. Parents do not only influence their offspring's decision about the final educational level, but, after graduation, they also can help graduates with contacts and experience in the matching process. Figure 4.7 and 4.8 present the distribution of the parental education for the two lowest and for the two highest income intervals. In both graphs, the percentage of students in higher incomes (orange and red lines) is more concentrated towards higher education

level attained by the parents. On the other hand, low income graduates (blue and aquamarine lines) are more concentrated around low levels of education attainment by their parents.

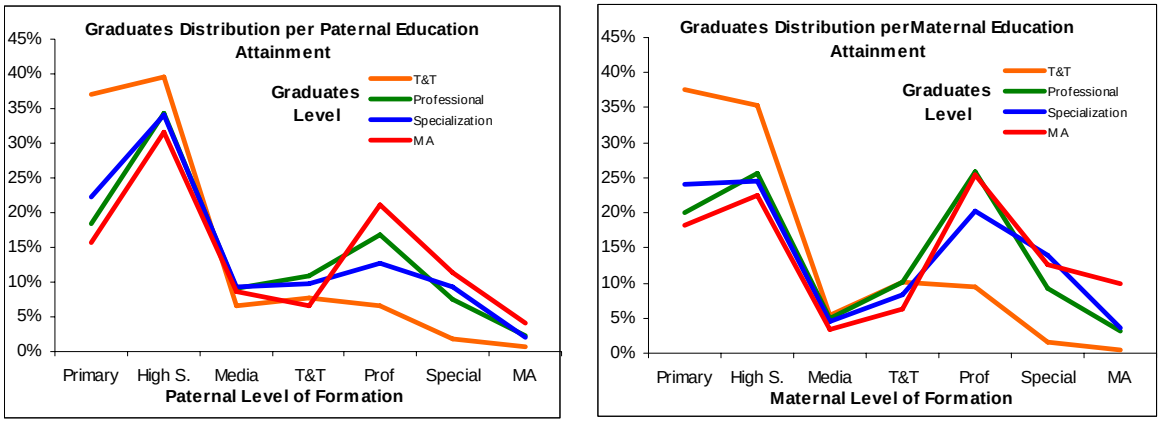
Figure 4.7 and 4.8 Parents Education Attainment and Graduates Income (Mother / Father)



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

Figure 4.9 and 4.10 show the relation between parental education attainment and the graduates' level of formation. Graduates with parents with High School Education or less, account for an important part of each distribution regardless of the graduate level of formation; this means that the incoming generation is in average more educated than the previous one. In addition, the part represented by graduates with parents with low attainment is different within each level of formation: 77% of the graduates from T&T programs have fathers with High School finished or less, while only 3% hold degrees higher than University. On the other hand, MA graduates' fathers with High School or less account for 47%, while 17% hold higher than University degrees.

Figure 4.9 and 4.10 Graduates Distribution per Parental Attainment



Source: FGS 2007-Labour Observatory for Education and Author's Calculations

4.8 Higher Education Institutions Characteristics

According to the Labor Observatory for Education, 25% of the observations come from 4 HEIs[4], an important observation to remember before any drawing of conclusions; data can be bias towards specific differences of these institutions as they are overrepresented. According to the Ministry of Education[5] in 1995 inscribed students in Public HEIs accounted for 33% of the total with 212,000 students, in 2007 they had 55% of the total with 743,000 students, during the period in average 42% of students were registered at public institutions. The FGS (2007) does not capture this trend, and differs from the population distribution.

From the sub sample, 78.7% of the observations declare having graduated from private institutions. For each interval of income and for each level of formation, there are always more observations for private institutions. Nonetheless, the concentration is more accentuated in higher income levels and in superior levels of formation. Thus, 87% of the MA graduates and 94% of the highest income level come from private institutions, while only 64% of the T&T graduates and 63% of the lowest income attend private institutions.

Colombian HEIs are located mainly in Bogota, according to the FGS 2007: 37% of the graduates of the sub sample graduated from HEIs there, this is similar to the data from the Ministry of Education which finds an average of 35% for the period 2005-2007. In the FGS 2007 the lowest participation in the issuance of diplomas is in the Atlantic region, 6%, the Pacific region has 1%, and the Amazon region has only 4 observations. Other regions have a more uniform distribution with Valle (16%), Central (15%), Antioquia (13%) and the Oriental region (12%). There are no observations for Colombians who received their titles abroad. The Central region stands out by being the only region where higher education is mainly provided by the government: 73% of the graduates in the region are from public HEIs. In Bogota, Antioquia, Valle and the Pacific, more than 90% of the individuals surveyed graduated from private institutions. In the present article, Bogota is used as reference for residence and for HEIs location as well.

[4] The universities are: Universidad de los Andes (1.905 Observations), Universidad de Caldas (1.851), Fundacion Universidad de Bogota Jorge Tadeo Lozano (1.539) and Universidad de San Buenaventura (1.038). From the Labor Observatory for Education webpage available at : http://www.graduadoscolombia.edu.co/html/1732/_article-156192.html

[5] Reference about the population subscribed in HEIs can be found in the webpage from the Colombian Ministry of Education at:

4.9 Other Variables in the FGS 2007

As graduates are already in the labor force, then, information about the works they do can be found in the FGS 2007: the economical activity, the kind of contract they have with their employer, and some characteristics of the institution they work for. Although these variables cannot be included in the valuation of HCC, since they are unknown at the time of the arrangement with a new student, still, they give important insights on the final income and about the current demand for workers.

Table 4.2 underlines two economical activities: Mining Exploitation has only 140 graduates who have the highest income mean, as expected. On the other hand, Social Services have the lowest income mean, with 46% of the sub sample. As a sign of scarcity, economical activities with higher profits and lack of professionals try to attract them with better wages.

Graduates from the fields of Education and Health have more than 90% of the jobs related with Social Services activities. For other fields of study, the concentration in this activity is still high –never falls below the 30%-. Graduates who declared being currently working in 'Other Activity' represent 44% of the Arts' graduates and, with the exception of Education and Health, they stand close to the 20% for the other fields. For Mining, 55% of the workers are Engineers and 22% come from economic related fields, but Mining only represents 1.24% of all the Engineers and 0.49% of all the Economists.

Table 4.2 Economical Activities and Graduates

Economical Activity	Obs	% of Total	Income Mean
Agriculture, Fishing, Hunting and Silviculture	358	1,82%	COP 1 785 615
Mining Exploitation	140	0,71%	COP 2 241 071
Manufacturing Industries	1529	7,76%	COP 2 135 710
Electricity, Gas and Water	363	1,84%	COP 2 142 562
Construction	837	4,25%	COP 1 922 043
Retail, Restaurants and Hotels	1009	5,12%	COP 1 827 304
Transport, Storage and Communications	783	3,97%	COP 2 013 091
Financial, Insurance or other services for Companies	1400	7,10%	COP 2 169 821
Communal, Social and Personal Services	9140	46,37%	COP 1 653 146
Other Activity not mentioned previously	4155	21,07%	COP 1 828 418

Source: FGS - 2007 and Author Calculations

In Colombia, there are three different kinds of labor contracts: Undefined Term, Defined Term, and Service Rendering contract. They define the degree of involvement the company does have with the employee, and the perspective of a long or a short term commitment. The cancellation of the Undefined Term contract is the most expensive for the employer and it usually includes more benefits for the worker. The Defined Term contract has a limited term but it includes some benefits as long as the contract is valid. In the other extreme, there is the Service Rendering contract, where the purchase of labor force is accounted as a service acquired by an independent institution; it is mainly used for specific tasks from the worker, but it offers the lowest protection for the latter.

The data on the FGS 2007 shows that within the population linked to a Private Company or a Public Institution, 59% of the graduates have Undefined Term contracts, 27% a Defined Term, and 13% a Service Rendering one. For the highest income level, the percentage of Undefined Term contracts is 86%, while the lowest it accounts merely for 32%. Service Rendering contracts stand for 27% of the lowest income labor contracts and only 4% of the highest income contracts.

Apart from the occupational position mentioned before, the FGS 2007 also gives information concerning the size of the companies where the graduates work. Most of the graduates work in big companies with more than 200 employees (43%), 20% works in companies between 50 and 200 employees and 35% in smaller companies. The relation between the size of the company and the income of the individuals can be seen from the fact that the concentration in smaller companies increases in the lower income intervals: 48% of the graduates in the lowest income interval work for companies numbering only 10 employees or less, and the percentage in such companies for the highest income interval is 9.5%. These variables were included in a regression to find the determinants of income, even though some of these characteristics cannot be incorporated to evaluate HCC.

Chapter 5. Econometric Exercise

The present work intends to forecast the return to education, exclusively for the higher education. As the aim of the article is the valuation of HCC, are excluded the variables presented in the FGS 2007 that cannot be known before a student is about to start his superior studies. The occupational areas, the terms of contract the surveyed graduates have and the characteristics of the companies they work for (size, private or public) are disregarded, because these data may not influence the value of HCC at the moment of their engagement.

In their analysis, Guataqui, et Al. (2008) include only observations from wage earning graduates (Private Companies and Official Institutions), as they compete in the labor market. The present article introduces regression outcomes separately for this group. However, after clearing the problems that may arise with independent entrepreneurs who declare less than earned income, HCC would be offered to individuals regardless of their future occupational position.

Some transformations in other variables should be mentioned as well. For the working hours, the weekly variable is transformed into a monthly one by multiplying the mean of each interval by 30/7. Furthermore, the NA/NR observations for working time are located in the 31-48h interval. It is assumed that there is no lose of generality as this interval concentrates the most number of graduates and as it does not change significantly the relations outlined in the previous section. Parents' educational attainment is kept in the level classification offered in the FGS 2007 with no change into years of schooling.

The present article incorporates the modifications suggested by Heckman et Al. (2008) and Guataqui et Al. (2008). So, modified version of the Mincerian equation is presented along with a modified version of the previous Educative Splines models, with the aim to forecast the returns to higher education to valuate HCC. The correction of the Sample Selection Bias suggested by Heckman is not included as there is no enough information on the household of the graduates. The formulation and outcomes of the models are the subject of the subsections below. The statistical techniques used are OLS, Robust Standard Errors (RSE) and Interval Regression (IR) as it is the case when a limited dependent variable is present.

Robust Standard Errors are used in cases where heteroscedasticity and non-normality of errors are present, having consequences over the standard deviation of the OLS estimates. In the present article, the Consistent Covariance Transformation is used, it estimates the asymptotic covariance matrix adjusted by the degrees of freedom of the regression. This procedure is suggested by the UCLA Statistical Consulting Group 2008, following White (1980). The asymptotic covariance matrix is calculated by:

$$ACOV = (\mathrm{X'X})^{-1}(\mathrm{X'I}(\hat{e}^2)\mathrm{X})(\mathrm{X'X})^{-1}, \qquad (5.1)$$

where $\hat{e}$ is a vector with the OLS estimation of the errors. The new standard errors will be based on the diagonal terms of the asymptotic covariance matrix adjusted by their degree of freedom :

$$\hat{\Omega}(b_{ij})^2_{rob} = \left(\frac{N-k}{N}\right)ACOV. \qquad (5.2)$$

On the other hand, Interval Regression accounts for the uncertain variance of the dependent variable when it is right, left or interval censored. In the FGS 2007, the variable of income has this sort of characteristic, with right, left and interval censoring. For IR, the starting point model differs from the OLS: $\underset{\rho}{y} = \mathrm{X}\underset{\nu}{\beta} + \underset{\rho}{\varepsilon}$. The model to estimate when running an IR model is:

$$\underset{\rho}{y} = \mathrm{X}\underset{\nu}{\beta} + \sigma\underset{\rho}{\varepsilon}, \qquad (5.3)$$

where X is an $N \times k$ matrix including the independent variables, $\underset{\nu}{y}$ is a vector representing the dependent variable responses, and $\underset{\nu}{\varepsilon}$ is a vector of estimated errors with marginal survival distribution function $S(t)$, cumulative distribution function $F(t)$, and probability density function $f(t)$. That is, $S(t) = \Pr(\varepsilon_i > t)$, $F(t) = \Pr(\varepsilon_i \le t)$, and $f(t) = \partial F(t)/\partial t$, where ε_i is a component of the error vector. The log likelihood, *L*, is written as below:

$$L = \sum \log\left(\frac{f(w_i)}{\sigma}\right), \text{ where } w_i = \frac{1}{\sigma}\left(y_i - \underset{\rho}{x'_i}\,\underset{\rho}{\beta}\right). \qquad (5.4)$$

If some of the responses are censored, the log likelihood can be written as:

$$L = \sum \frac{\log(f(w_i))}{\sigma} + \sum \log(S(w_i)) + \sum \log(F(w_i)) + \sum \log(F(w_i) - F(v_i)), \quad (5.5)$$

with the first sum over the uncensored observations, the second sum over the right-censored observations, the third sum over the left-censored observations, the last sum over the interval-censored observations, and $v_i = \frac{1}{\sigma}(z_i - \underset{\rho}{x'_i}\underset{\rho}{\beta})$, where z_i is the lower end of a censoring interval (Maddala 1983). In the FGS 2007, there are no uncensored values and the first sum is not relevant. The estimations of the Eq.(5.5) parameters are obtained through the Newton-Raphson algorithm. In the present article models, all the specifications converged.

5.1 Modified Mincerian

In order to find a return of the higher education as a whole and to look for splines and not parallelism among the higher education levels, two models are used to forecast the income of individuals. Both models include the log of the monthly hours, information about the field of study and socio-demographic variables such as gender, father and mother education attainment and region of residence; they also include available information about the HEI.

First, a Mincerian Model with a transformation from Eq.(2.1) is analyzed, where *s* takes values of 14, 16, 17, 18 and 22, representing T&T, Professional, Specialization, Masters and Doctoral education, respectively; and the above mentioned variables are also included as follows:

$$\begin{aligned}\log y_i = {} & \alpha_0 + \rho_s s_i + \beta_1 Age_i + \beta_2 Age_i^2 + \beta_3 Gender_i + \beta_4 \ln(h\_month_i) + \\ & \beta_5 Ed\_mthr_i + \beta_6 Ed\_fthr_i + \beta_7 HEI\_priv_i + \\ & \sum \theta_a field_{a,i} + \sum \tau_b Rgn\_Rs_{b,i} + \sum \tau_c Rgn\_Grd_{c,i} + \varepsilon_i\end{aligned} \quad (5.6)^*$$

h_month i:	Hours worked monthly by the *i* individual
Ed_mthr i:	Mother's education attainment
Ed_fthr i:	Father's education attainment
HEI_priv i:	Binary variable with value of 1 for private HEIs
Field a,i:	Binary variables for each field of study. Economics/Finance as reference
Rgn_Rs b,i:	Binary variables for each residence region. Bogota as reference
Rgn_Grd c,i:	Binary variables for each graduation regions. Bogota as reference

* $\sigma\varepsilon$, would be the error in the IR case.

Table 5.1 presents estimations for α_0, ρ_s, β_i and θ_a. Table 5.2 presents the outcome for τ_b, τ_c estimations. Significance of the included variables remains the same for the different methods used in the calculations. The direction and significance of the coefficients for the Classic Mincerian variables are as expected in all methods. Gender and the character of the HEI are determinant of the level of income in favor of males and private institutions. Parental education attainment can also influence the income of the graduates, but the education received by the father has a greater effect in the final outcome.

Table 5.1 Modified Mincerian Model. Estimations

Parameter		OLS	RSE	IR
Intercept	α_0	7.0404		6.8128
Std Errors		0.1176	0.1237	0.1221
t/chi2 value		59.8700	56.9125	3115.7
Pr>|t| - Pr>ChiSq		<.0001	0.0000	<.0001
yrs_edu	ρ_s	0.2789		0.2881
		0.0053	0.0054	0.0055
		52.1800	51.7825	2696.97
		<.0001	0.0000	<.0001
age	β_i	0.0715		0.0764
		0.0052	0.0053	0.0053
		13.7800	13.3769	204.35
		<.0001	0.0000	<.0001
age_Sq		-0.00075		-0.0008
		0.0001	0.0001	0.0001
		-10.3900	-9.9987	113.46
		<.0001	0.0000	<.0001
gender		0.1213		0.1394
		0.0081	0.0081	0.0083
		14.9900	14.9918	280.23
		<.0001	0.0000	<.0001
ln(h_month)		0.2173		0.2111
		0.0079	0.0098	0.0082
		27.4200	22.1648	655.37
		<.0001	0.0000	<.0001
ed_mthr		0.0133		0.0140
		0.0016	0.0016	0.0016
		8.3700	8.3208	73.33
		<.0001	0.0000	<.0001
ed_fthr		0.0210		0.0222
		0.0015	0.0015	0.0015
		14.0900	14.0894	211.03
		<.0001	0.0000	<.0001
priv_HEI		0.0543		0.0559
		0.0121	0.0119	0.0125
		4.4900	4.5581	19.91
		<.0001	0.0000	<.0001

Parameter		OLS	RSE	IR
Agronom	θ_a	-0.0750		-0.0884
		0.0354	0.0347	0.0368
		-2.1200	-2.1602	5.76
		0.0342	0.0308	0.0164
Arts		-0.2354		-0.2674
		0.0202	0.0211	0.0209
		-11.6600	-11.1614	163.99
		<.0001	0.0000	<.0001
Educatn		-0.3865		-0.3912
		0.0186	0.0195	0.0193
		-20.7900	-19.7787	408.82
		<.0001	0.0000	<.0001
Law		0.0812		0.0709
		0.0176	0.0173	0.018
		4.6000	4.6887	15.48
		<.0001	0.0000	<.0001
Health		0.0327		0.0295
		0.0173	0.0174	0.0178
		1.9000	1.8816	2.75
		0.0578	**0.0599**	**0.097**
SociSt		-0.1622		-0.1833
		0.0133	0.0133	0.0138
		-12.1600	-12.1671	177.26
		<.0001	0.0000	<.0001
Engineer		0.0564		0.0485
		0.0100	0.0099	0.0102
		5.6600	5.7022	22.37
		<.0001	0.0000	<.0001
Math		-0.0931		-0.1097
		0.0293	0.0301	0.0302
		-3.1800	-3.0961	13.16
		0.0015	0.0020	0.0003

F(OLS) = 354.6	Pr>F	<.0001	Obs 19,714
Adj R Sqr	0.358359		0.3435* u
AdjR Sqr	0.3573		0.3154* l

* The pseudo R Squared used for IR is the Squared Multiple Correlation for the upper (u) and lower (l) value of the income intervals.
P values not significant at the 5% confidence level in red
Source: FGS - 2007. Author Calculations

The elasticity of labor supply is low if compared with estimates found in previous articles (Guataqui, et Al. (2008) find 0.6 for a population including all kinds of education attainment). Furthermore, it should be noted that only graduates who declare income are

being included; there might be a higher elasticity in the threshold at which individuals decide to enter or not into the labor force. One explanation can be that students with higher formation have to work less than individuals with lower formation to achieve the same level of income.

Table 5.2 Modified Mincerian Model. Estimations (Continuation)

Parameter		OLS	RSE	IR
Antioq	τ_b	0.0301		0.0179
Std Errors		0.0257	0.0263	0.0264
t/chi2 value		1.1700	1.1462	0.46
Pr>|t| - Pr>ChiSq		0.2405	0.2517	0.4967
Valle		-0.1870		-0.2057
		0.0225	0.0243	0.023
		-8.3300	-7.6973	80
		<.0001	0.0000	<.0001
Atlant		-0.1611		-0.1591
		0.0276	0.0290	0.0282
		-5.8500	-5.5518	31.78
		<.0001	0.0000	<.0001
Pacific		-0.3305		-0.3466
		0.0446	0.0449	0.0459
		-7.4100	-7.3549	56.95
		<.0001	0.0000	<.0001
Central		-0.2405		-0.2515
		0.0213	0.0217	0.0219
		-11.3000	-11.0988	131.74
		<.0001	0.0000	<.0001
Orient		-0.1855		-0.2067
		0.0169	0.0165	0.0174
		-10.9500	-11.2564	140.88
		<.0001	0.0000	<.0001
Amazon		-0.1158		-0.1373
		0.0413	0.0401	0.0425
		-2.8000	-2.8857	10.43
		0.0051	0.0039	0.0012
Expat		0.4795		0.5822
		0.0232	0.0249	0.0239
		20.7100	19.2526	592.35
		<.0001	0.0000	<.0001

Parameter		OLS	RSE	IR
HEI_Antq	τ_c	-0.0707		-0.0746
		0.0255	0.0267	0.0263
		-2.7700	-2.6450	8.07
		0.0056	0.0082	0.0045
HEI_Vall		0.0418		0.0418
		0.0220	0.0241	0.0225
		1.9000	1.7330	3.46
		0.0572	0.0831	0.0628
HEI_Atla		-0.0826		-0.0961
		0.0282	0.0291	0.0289
		-2.9300	-2.8372	11.06
		0.0034	0.0046	0.0009
HEI_Pacf		-0.1606		-0.1313
		0.0519	0.0528	0.0539
		-3.1000	-3.0435	5.95
		0.0020	0.0023	0.0147
HEI_Cent		-0.0042		-0.0154
		0.0214	0.0215	0.022
		-0.2000	-0.1959	0.49
		0.8438	0.8447	0.4851
HEI_Orie		0.0409		0.0280
		0.0167	0.0160	0.0171
		2.4500	2.5621	2.69
		0.0141	0.0104	0.1013
HEI_Amaz		0.2065		0.1715
		0.2686	0.1750	0.2716
		0.7700	1.1797	0.4
		0.4421	0.2381	0.5277
Root MSE		0.5322		0.5167*

*Scale σ of the IR model. P values not significant at the 5% confidence level in red

Source: FGS - 2007. Author Calculations

A higher rate of growth for income is found with the IR method as per the coefficient of Age, but this rate also falls faster than the OLS estimate, as the coefficient of the square of age is more negative. θ's estimates for OLS seem to be inflated if compared with the IR ones: all of them have a lower value in the IR estimations.

When the outcome for each field of study is compared, the model used shows that Engineers and Lawyers enjoy higher income than Economists with a statistically significant difference. The income of the Health Sciences graduates is not significatively different from the Economists' one, but the difference favors Health Graduates in all models. Graduates from other fields earn less, but the coefficient for graduates of Math and Agronomy fields

(coefficient higher than -0.1) is close to the reference; while it is lower for the graduates from other Social Sciences (-0.16), Arts (-0.23) and Education (-0.38). Comparing with Forero and Ramirez (2008), a similar outcome is found for the lower return fields like Arts or Education, and also for Health, but they find Math and Agronomy not to be significant. In their article, Engineering is not significant and has a negative coefficient. Also, Law is not included as it is part of Social Sciences.

Income is not significatively different in the department of Antioquia with respect to Bogota city, but residence in any other region has a negative effect over the final outcome of income. The Colombians living abroad are an exception to this rule: their income is higher than graduates living in Bogota and the difference is high when it is compared with the negative coefficients in other regions. The highest coefficient for expatriates is found in the IR estimations. HEI's location is not as significant as the residence of the graduates. HEIs located in three of the seven regions defined (Valle, Central and Amazon) have incomes with no significative difference with graduates from Bogota's Institutions. However, this may be misleading, because some regions lack observations; for example, Amazon HEIs only offer 4 observations. The difference with Antioquia, the Pacific and the Atlantic regions is significant, in favor of Bogota's HEIs. Graduated from the Oriental region HEIs seem to have a higher income, but the coefficient of the IR is not significant.

Tests for heteroscedasticity, normality of the errors and multicollinearity of the independent variables were run. The White Test indicates that in the OLS estimations the hypothesis of homoscedasticity can be rejected. Also, according to the Anderson-Darling and the Kolmogorov-Smirnov tests, the hypothesis of normality of the errors can be rejected as well. In order to test for multicollinearity the variance inflation factor was checked for all the variables, and with the exception of Antioquia (VIF=5.003), Age and its square – transformation of the same variable-, all the VIF remained below 5; thus, multicollinearity was discarded. A summary of the statistical tests is presented in Appendix A.2.

As the homoscedasticity and normality assumptions have effects over the consistency of the estimators, the robust standard errors were obtained as an attempt to correct the inconsistency created by the absence of the assumptions. In most of the cases, the standard deviations are greater for each estimator but the significance remains unchanged.

The overall model is significant and the F statistic is shown in Table 5.1 along with the R Squared for OLS and the Squared Multiple Correlation for the lower and upper bounds of the dependent variable for IR. The R Squared found here goes in line with the findings in other studies: Núñez and Sánchez (2000) model find an R Squared around 0.4 and Low, et Al. (2004) for Singapore as well, among the studies which report it. This can be explained by the fact that while analyzing graduates income, several variables describe complicate social interrelations, processes hard to be model by linear or other mathematical relations.

5.2 Splines Model

A splines model is tested where the variable for years of education is omitted. Instead, educative splines are defined for three groups of the levels of formation: a binary variable with values 0 and 1 is used for the T&T level; another variable is included for post-graduate studies with values of 1, 2 and 6 for Specialization, MA and PhD, respectively, as those are years of schooling above the Professional level, the latter is used as the reference as it is the level used to valuate HCC in the next section. Dichotomic vectors are used to evaluate interaction effects with other variables, given that the observation falls in one of the three defined groups for level of formation. Table 5.3 summarizes the definition of the variables included in the splines model. Splines' definitions follow what Guataqui et Al. (2008) did by analyzing all education levels; and in the present article, it is just for the higher education ones.

Table 5.3 Educative Splines. Definition of Variables

Educative Spline per level of formation				Complete degree premium		
Form Level	Sub level	TEC	POS	Level Form.	d_tec	d_pos
Technical		**14**	0	Technical	**1**	0
University		**0**	0	University	**0**	0
Post-Graduate Studies	Specialization	**0**	**1**	Specialization	**0**	**1**
	Masters	**0**	**2**	Masters	**0**	**1**
	PhD	**0**	**6**	PhD	**0**	**1**

Following the above definitions, the Splines model is formulated below:

$$\log y_i = a_0 + \rho_{TC} TEC_i + \rho_{TC} POS_i + \beta_1 Age_i + \beta_2 Age_i^2 + \beta_3 Gender_i + \beta_4 \ln(h\_month_i) + \beta_5 Ed\_mthr_i + \beta_6 Ed\_fthr_i + \beta_7 HEI\_priv_i + \phi_1 Age^2 * \delta_{TC} + \phi_2 Age^2 * \delta_{PS} + \phi_3 Gender_i * \delta_{TC,i} + \phi_4 Gender * \delta_{PS,i} + \sum \tau_b Rgn\_Rs_{b,i} + \sum \tau_c Rgn\_Grd_{c,i} + \varepsilon_i \quad (5.7)^*$$

$\delta_{TC/PS}$: d_tec and d_pos from Table 5.3

$^*\sigma\varepsilon$, would be the error in the IR case.

It is to be noted that there is no interaction between the binary variables for level of formation, $\delta_{TC/PS}$, and the variable of the logarithm of the worked hours or the growth rate of income. Interaction with these variables was tested and the outcomes were counterintuitive and not significant. Interaction was also tested for the different fields of study and the effect seems not to be significant for different levels of formation over the differences at the professional level. The formulation above was chosen after a Forward Selection model was run, as explained in the next sub section. Table 5.4 and 5.5 present the estimates for the Splines model.

In the present model, the value of the intercept captures also the expected return to education for a Professional Graduate. For comparison purposes $\alpha_0 + 16\rho_s$ from the Mincerian model is provided:

- OLS and Robust Regression = 11.5031
- Interval Regression = 11.4224

These values do not seem to far from the intercept estimated in the splines model. Although the intercept is smaller in the IR regression, it seems to be representing the same information as $\alpha_0 + 16\rho_s$ from the Mincerian estimation. Although, both estimations are not comparable per se, the similarity in the estimations highlights the outcome.

In the Splines model, all the socio economic variables are strongly significant as well and the levels of the estimators are close to those found in the Mincerian model. The gender and the character of the institution have an effect over income in favor of males and private institutions. Parental level of formation also affects positively the expected income of the graduates, and the father's level has a higher impact. The logarithm of monthly worked hours also impacts income positively.

Table 5.4 Splines Model. Estimations

Parameter		OLS	RSE	IR
Intercept	α_0+	11.4041		11.2912
Std. Error		0.1015	0.1095	0.1048
t / Chi2 Value		112.3700	104.1363	11603.5
Pr>|t|	ρuni	<.0001	<.0001	<.0001
TEC		-0.0436		-0.0405
		0.0024	0.0025	0.0025
		-18.4300	-17.5347	265.79
	ρ	<.0001	<.0001	<.0001
POS	Tec/ Pos	0.1613		0.1773
		0.0176	0.0155	0.0181
		9.1400	10.4112	95.83
		<.0001	<.0001	<.0001
age		0.0801		0.0863
		0.00534	0.0056	0.0055
		14.99	14.2972	245.98
		<.0001	<.0001	<.0001
age_Sq		-0.00092		-0.001
		0.00008	0.00008	0.0001
		-12.21	-11.4772	160.95
		<.0001	<.0001	<.0001
gender		0.1162		0.1307
		0.0093	0.0094	0.0096
		12.4900	12.3957	186.71
		<.0001	<.0001	<.0001
ln(h_month)	β i	0.2164		0.2096
		0.0079	0.0098	0.0082
		27.3500	22.0668	648.81
		<.0001	<.0001	<.0001
ed_mthr		0.0134		0.0142
		0.0016	0.0016	0.0016
		8.4200	8.3758	75.13
		<.0001	<.0001	<.0001
ed_fthr		0.0207		0.0223
		0.0015	0.0015	0.0015
		13.9400	13.9707	212.05
		<.0001	<.0001	<.0001
priv_HEI		0.056		0.0595
		0.012	0.012	0.0126
		4.580	4.665	22.44
		<.0001	<.0001	<.0001
F(OLS) = 308.3		Pr>F	<.0001	Obs 19,714
Adj R Sqr			0.3609	0.3476* u
AdjR Sqr			0.3595	0.3159* l
Root MSE			0.5322	0.5155**

Parameter		OLS	RSE	IR
dt_age2		0.0000826		0.0001
		0.0000304	0.000033	0
		2.72	2.485822	3.33
		0.0066	0.01293	**0.0679**
dp_age2		0.0001269		0.0001
		0.0000177	0.000017	0
		7.16	7.416521	51.88
		<.0001	<.0001	<.0001
dt_gen	ϕ i	-0.0215		-0.0426
		0.0268	0.0281	0.0281
		-0.800	-0.7645	2.29
		0.4226	**0.4446**	**0.1298**
dp_gen		0.0415		0.0693
		0.0213	0.0202	0.0216
		1.9500	2.0538	10.23
		0.0511	0.040013	0.0014
Agronom		-0.0636		-0.0679
		0.0355	0.0348	0.0369
		-1.7900	-1.8276	3.4
		0.0728	**0.0676**	**0.0654**
Arts		-0.2328		-0.2599
		0.0202	0.0211	0.0209
		-11.5200	-11.0423	154.53
		<.0001	<.0001	<.0001
Educatn		-0.3847		-0.3836
		0.0187	0.0195	0.0194
		-20.5900	-19.7074	390.25
		<.0001	<.0001	<.0001
Law		0.0913		0.086
		0.0177	0.0176	0.0181
		5.1500	5.1911	22.61
	θ_i	<.0001	<.0001	<.0001
Health		0.0353		0.0387
		0.0174	0.0175	0.0179
		2.0300	2.0162	4.68
		0.0424	0.043794	0.0305
SociSt		-0.1575		-0.1711
		0.0136	0.0136	0.014
		-11.6100	-11.6119	149.53
		<.0001	<.0001	<.0001
Engineer		0.0638		0.0612
		0.0101	0.0100	0.0104
		6.3200	6.3744	34.85
		<.0001	<.0001	<.0001
Math		-0.0813		-0.0903
		0.0294	0.0300	0.0303
		-2.7700	-2.7122	8.9
		0.0056	0.0067	0.0028

*'Pseudo R Squared for IR is the Squared Multiple Correlation
**Scale σ of the IR model
P values not significant at the 5% confidence level in red
Source: FGS - 2007. Author Calculations

The residence place has a similar effect as in the Mincerian model, with the department of Antioquia having no significant difference with Bogota and all other regions significant and with a negative effect, with the only exception of the graduates living abroad: their coefficient is strongly positive. The main difference dwells in the speed income growths measured with the coefficients for Age and Age Squared: by using the professional level as reference, the income is expected to increase more rapidly but the rate at which it

increases is expected to stabilize faster than as suggested by the coefficients in the Mincerian model.

Table 5.5 Splines Model. Estimations (Continuation)

Parameter		OLS	RSE	IR
Antioq	τ_b	0.0352		0.0248
Std. Error		0.0256	0.0262	0.0263
t / Chi2 Value		1.3700	1.3448	0.89
Pr>|t|		0.1692	0.1787	0.3456
Valle		-0.1867		-0.2062
		0.0224	0.0242	0.023
		-8.3200	-7.7040	80.68
		<.0001	<.0001	<.0001
Atlant		-0.1558		-0.155
		0.0275	0.0289	0.0282
		-5.66	-5.38838	30.24
		<.0001	<.0001	<.0001
Pacific		-0.3325		-0.3538
		0.0446	0.0450	0.0459
		-7.46	-7.391	59.52
		<.0001	<.0001	<.0001
Central		-0.24016		-0.2527
		0.02126	0.0216	0.0219
		-11.29	-11.1184	133.3
		<.0001	<.0001	<.0001
Orient		-0.1864		-0.2074
		0.0169	0.0164	0.0174
		-11.02	-11.3371	142.33
		<.0001	<.0001	<.0001
Amazon		-0.1158		-0.1351
		0.0412	0.0398	0.0424
		-2.8100	-2.9081	10.14
		0.005	0.0036	0.0014
Expat		0.4844		0.5886
		0.02313	0.024782	0.0239
		20.94	19.54516	607.22
		<.0001	<.0001	<.0001

Parameter		OLS	RSE	IR
HEI_Antq	τ_c	-0.0770		-0.0786
		0.0255	0.0267	0.0262
		-3.0200	-2.8812	8.97
		0.0026	0.0040	0.0027
HEI_Vall		0.0404		0.048
		0.0221	0.0243	0.0226
		1.8300	1.6627	4.51
		0.0677	0.0964	0.0336
HEI_Atla		-0.0898		-0.096
		0.02832	0.029177	0.029
		-3.17	-3.07729	10.97
		0.0015	0.0021	0.0009
HEI_Pacf		-0.1611		-0.1287
		0.052	0.053	0.0538
		-3.110	-3.049	5.73
		0.0019	0.0023	0.0167
HEI_Cent		-0.0057		-0.009
		0.0215	0.0216	0.0221
		-0.2700	-0.2640	0.16
		0.7905	0.7918	0.6854
HEI_Orie		0.0410		0.0353
		0.0168	0.0162	0.0173
		2.4400	2.5347	4.17
		0.0148	0.0113	0.0411
HEI_Amaz		0.1402		0.0923
		0.2683	0.1639	0.2712
		0.5200	0.8554	0.12
		0.6013	0.3923	0.7337

P values not significant at the 5% confidence level in red
Source: FGS - 2007. Author Calculations

As expected, having only finished the T&T level has a negative effect over income if compared with having finished the professional level. But, having finished a post-graduate level has a positive effect instead; and they are both strongly significant. Given the coefficients of the interaction variables, it seems that the speed at which the rate of income decreases is slower at the T&T, and for the post-graduate levels. However, in the T&T level the degree of significance is not strong and even not significant in the case of the IR estimation. Exploring if there is a difference on the gender gap for each level of formation, the difference remains untouched in the T&T level as the interaction coefficient is not significant. In the case of graduates with postgraduate studies, the gap in favor of males seems to be deeper than at the professional level, and the coefficients are significant but not strongly, and they are even insignificant in the OLS regression.

In the OLS estimation, all the variables' VIF remain under 5 but for Age and Age Squared, so multicollinearity is discarded. The assumptions of normality of the errors and of homoscedasticity are rejected again, according to the respective tests; so, robust standard errors are relevant for the splines model as well. The models are overall significant according to the F statistic and its outcome is presented in Table 5.4 along with the R Squared and the Squared Multiple Correlation for the IR.

5.3 Robustness Exercises

A Forward Selection model was used to test the relevance of the included variables. This technique starts with no variables and adds them one by one according to the contribution to the model measured by the increase in R squared. In the case of the Modified Mincerian model, the Forward test takes 30 steps, leaving outside the variable representing HEI Central. On the other hand, according to the F statistic, including HEI Amazon and the residence variable for Antioquia is not significant. The decision of leaving them in the model came from the fact that they are part of greater categorical variables.

For the Splines Model, the interaction effect of the Age with the dichotomic variables for levels of formation proves to be statistically not significant and it is not kept. In the previous sub section the coefficients are already removed and not presented in Eq.(5.2). All other variables are kept and the Forward Selection model is run again, with 35 steps out of 37 variables: the HEI Central and HEI Amazon variables are left outside.

Both models were run only for wage earning observations and for the Independent and the Boss/Employer observations. Those who declare to have an occupational position inside of a Private Company or in Public Institutions compete in the labor market and are subject to its rules (Guataqui, et Al. 2008). Furthermore, income from individuals who are not in the labor market might be determined by other variables different than education, and the Mincerian or Splines Model should not adjust as well.

Estimates of the wage earning observation have higher intercepts and higher growth rate for income (Age coefficient) in both, the Mincerian and the Splines models; some of the standard errors are higher than if all the observations were used. However, the data seems to explain better the wages in this case as the R Squared are higher for both models in all methods. In the next section they were not used, first, as a conservative measure, given that

coefficients for the intercept and income growth are higher, and second, due to the fact that the future occupational position of a student is a piece of information not available when a HCC contract is arranged. If a student has to work as an employee after graduation to apply for HCC, it can be seen as a limit to the student's free will. On the other hand, estimations from the non wage earning observations show different patterns on the effects that the fields of study have if compared with the coefficients presented in this section; moreover, the regressions have a lower R Squared and the degree of significance is lower; thus, the data suggests that the capability of the Mincerian and Splines model to explain the income form independent workers is lower. The estimations for both, wage earning and non wage earning observations are presented in the Appendix A.3.

Forecasts of income at graduation were estimated to be used in the proceeding section with their respective confidence intervals following the outcome of the regressions introduced in this section. A summary of calculations is presented in Appendix A.3. Finally, a regression including the omitted determinants of graduates' income is presented in Appendix A.4 with a brief mention to the relation with the explanatory variable.

Chapter 6. Valuating Human Capital Contracts in Colombia

If the goal of HCC is to link private investors with students, it can be argued that a demonstration of their profitability has to be made before any discussion of the legality, institutional, or implementation issues of HCC. Nevertheless, without this demonstration, the analysis can be used by the government to address the issue of retributive taxes for Public Universities' graduates. Any tax has to be inside of the range that HCC determine, or to provide funding securing the students assistance to college, instead of subsidizing completely the provision of Higher Education. It could be expected that the focus on the group of higher education graduates, increases the feasibility of HCC, if compared with Palacios (2004) example and other studies that focus on the return to education as a whole.

In the present section, Palacios (2004)' Mincerian transformation for the valuation of HCC is presented, followed by a brief review of the macro economical assumptions used by Palacios. Then, the transformation is used to estimate the potential viability of HCC implementation in Colombia, using the forecasts obtained in the previous section.

6.1 Pricing Human Capital Contracts[6]

The value of one HCC is mainly determined by the expected value of the income that the student(s) will generate during the agreed time of the contract, and the percentage of income investors will derive from the operation. Eq.(6.1) establishes the relationship: γ stands for the percentage of the present value of income (*PVI*) committed by the students; $(1-u)$ is the probability of a student to be employed, u being the unemployment rate for the specific groups of graduates with similar characteristics as the students to be grouped; *AC*, accounts for the administrative costs which might be generated by issuance and collection, and *DC*, represents the expected cost of default by any of the group members:

$$HCCV = \gamma \cdot PVI(1-u) - AC - DC. \qquad (6.1)$$

Without any loss of generality, Eq.(6.1) can be parameterized with *AC* and *DC* as percentages of the *PVI* :

$$HCCV = \gamma \cdot PVI\big(1-(u+a+d)\big). \qquad (6.2)$$

[6] The present model can be found in the Appendix A and C of Palacio (2004). Some of the variables have been renamed to match the exercise of the present article.

Students will start repay their obligations after *s* years of schooling and the contract will have a repayment period of *k* years. Using continuous compounding and an *i* interest rate to discount the cash flows, the PVI can be defined as:

$$PVI = \int_{s}^{s+k} Y(t)e^{-it}dt\,. \tag{6.3}$$

Eq.(6.3) can be transformed to include the expected income upon graduation where $Y(t) = Y_s \cdot G(t)$ and $G(t)$ is the income growth function:

$$PVI = Y_s e^{-is} f(i,k,G(t))\,, \tag{6.4}$$

$$\text{where } f(i,k,G(t)) = \int_{0}^{K} G(t)\cdot e^{-it}dt\,.$$

Substituting Eq.(6.4) in Eq.(6.2), the value of HCC will already account with a term for the expected income upon graduation.

$$HCCV = \gamma \cdot Y_s \cdot e^{-is} \cdot f\left(i,k,G(t)\right)\left(1-(u+a+d)\right). \tag{6.5}$$

The profit that an investor receives out of a HCC is given by $\pi = HCCV - C$. Where *C* is the amount financed by the investor. However, in a competitive environment, the profits of the contract would be zero and the risk premium would be included in the competitive interest rate used to price the investments of similar risk. Thus *HCCV = C* and the percentage of income to be committed by the students would be:

$$\gamma = \frac{C \cdot e^{is}}{Y_s f(i,k,G(t))(1-(a+d+u))}\,. \tag{6.6}$$

Eq.(6.6) has an intuitive meaning. If the income at graduation or the potential for income growth are higher, then the percentage of income that should be committed will be lower; similarly, higher costs derived from the operation or harder conditions for graduates to get employed will both create a greater risk which should be compensated by a higher percentage of income to be committed in HCC.

6.1.1 A Mincerian Solution

In order to solve the expression set on Eq.(6.6), the Mincerian equation is used as it offers a solution after the adoption of certain assumptions:

- Administration and default costs are proportionally owed by the student during the repayment period RP.

- Student(s)' income and payments to the investor(s) are continuous
- Income growth is only a function of time
- Unemployment is evenly distributed throughout the RP
- Competitive markets force risk-adjusted profits to zero

Mincer (1974) defines the following variables and parameters:

$$\log Y_t = \log B_0 + \rho_s s + ht - gt^2 \tag{6.7}$$

- B_0 :income without education nor experience
- Y : income after *s* years of schooling and *t* years of experience
- r : rate of income growth per additional year of education
- h : rate of income growth per additional year of experience
- g : factor that decreases income growth

Defining income upon graduation Y_s, Y_t can be written as:

$$Y_t = Y_s \cdot e^{ht-gt^2}, \tag{6.8}$$

$$\text{where } Y_s = B_o e^{rs}, \tag{6.9}$$

and for the Mincerian transformation $G(t) = e^{ht-gt^2}$. (6.10)

Eq.(6.4) can be rewritten incorporating the changes of Eq.(6.8) – (6.10) and transforming the Mincerian model into one that accounts for income growth with Age, instead of potential experience. Finally, it is written resembling the cumulative normal distribution evaluated in *a* and *b* (Algebraic steps can be found in the Appendix A.4):

$$PVI = Y_s \cdot e^{-is} \cdot e^{\frac{(h'-i)^2}{4 \cdot g}} \cdot \sqrt{\frac{\pi}{g}} \cdot \left(N(a) - N(b)\right), \tag{6.11}$$

$$\text{where } a = \sqrt{2 \cdot g} \cdot \left(K - \frac{h'-i}{2 \cdot g} \right), \quad b = \left(-\frac{h'-i}{2 \cdot g} \right) \text{ and } h' = h - 2 \cdot A_{gr} \cdot g$$

Eq. (6.11) and Eq.(6.6) give a solution for the arrangement of HCC, as a γ can be found for a determinate amount to be financed.

6.2 Macro Economical Assumptions over the Parameters

A summary of the assumptions made by Palacios 2004 is presented in Table 6.1, and the update used in this article is presented in Table 6.2. Following Palacios (2004) exercise,

the present article will also set the example in USD. The average 2005-2007 of the foreign exchange is used as an update.

The interest rate to be charged in this sort of investments suggested by Psacharoupoulos (1986) is 8% (Palacios 2004). 10-Years Colombian Government spread over the US Treasuries has decreased to 425 bps[7] making investments in Colombian assets less risky; the assumption of 3% inflation in the US is kept. However, it is worth mentioning that Colombian mortgages work besides a Real Value Unit (UVR for its Spanish initials), a currency used to price long term contracts as mortgages and some Government inflation indexed bonds. When implementation would be discussed, the use of UVR can clear students and investors from risks related to the exchange rate and to the inflation at the same time.

Table 6.1 Assumptions over the Parameters (Palacios 2004)

Parameters			Source
FX Rate	1427,04	Average daily 1998	Banrep (1)
Unemployment	9,10%	Average *u* 1991-2000	Dane (2)
Default	15%	College graduates in the informal sector + 5%	Núñez (2000) (3)
Discount rate	8%	Based in Psacharoupoulos	Psacharoupoulos (1986)
Premium	5%	Country Risk	S&P and Citigroup (4)
Nominal	13%		
Inflation	3%	Inflation Estimates	Palacios (2004)
Risk adjusted real interest rate	10%	Continuous compounding	
Repayment period	10	Years	Assumption
Time to start repayment	5	Career Years (Universitary)	
Administratn Cost	2,0%		Assumption
USD financed yearly	2382,55		Lopez (2001)

(1) Banrep stands for Banco de la República de Colombia. Central Bank
(2) This is a conservative measure as the graduates from higher education levels have lower unemployment rates
(3) Núñez (2000) finds that 90% of the graduates from higher education levels declare income or have Social Security.
(4) Nov 01. Colombian Spread for 10Y Bonds over the US Treasuries was 504 bps

Unemployment and Default rates include some conservative additions in both Palacios' example and the exercise made here. In his example, the unemployment rate is the one provided by the National Statistics Department DANE, for the population with age between 25-55 years, as most of the repayment period is expected to fall within this interval. Unemployment for graduates of higher levels of education is lower; here the average 2001-2007 data for national unemployment will be used from the Household Continuous Survey

[7] Information from http://www.bloomberg.com/markets/rates. Consulted on September 1st .

provided by DANE. Palacios (2004) set the Default rate is based on Núñez (2000) who estimated that 90% of the graduates from HEIs are in the formal sector, either declaring income or making contributions to the Social Security System. Those are income tracking records that can assess the reliability of the graduates' information. As some graduates in the informal sector would pay and some in the formal sector would default, the Default rate is set at 15% as a conservative measure. In the present article the Default rate will be set at the same level.

Table 6.2 Present Assumptions over the Parameters

Parameters			Source
FX Rate	2252,55	Average daily 2001-2007	Banrep (1)
Unemployment	13,00%	Average *u* 2001-2007	Dane (2)
Default	15%	College graduates in the informal sector + 5%	Núñez (2000) (3)
Discount rate	8%	Based in Psacharoupoulos	Psacharoupoulos (1986)
Premium	4,25%	Country Risk	Bloomberg (4)
Nominal	12,25%		
Inflation	3%	Inflation Estimates	Palacios (2004)
Risk adjusted real interest rate	9,25%	Continuous compounding	
Repayment period	10 / 15	Years	
Time to start repayment	5	Career Years (Universitary)	
Administn cost	2,0%		Assumption
USD financed yearly	2397,28		Ayala (2004)

(1) Banco de la República de Colombia. Central Bank. Infornation availble at www.banrep.gov.co
(2) Household Continuous Survey. Consulted Aug 2008. Available at www.dane.gov.co
(3) Núñez (2000) finds that 90% of the graduates from higher education levels declare income or have Social Security.
(4) Sep 08. Colombian Spread for 10Y Bonds over the US Treasuries was 425 bps

The repayment period is set at 10Y for Palacios' example and the amount to be financed comes from López (2001) with COP1,700,000 per semester. This amount represented USD2382.55 yearly using the 1998 average exchange rate. An updated data from Ayala (2006) is used here: the average tuition per semester in private HEIs was COP2.7mlls (USD1198.64 with the updated exchange rate). Discussion over the repayment period should take into account three facts: First, the investor should have an incentive to allocate resources into students' education; second, percentage to be committed by students should not be prohibitive for them (MyRichUncle™ has set a limit of 15%), and third, long repayment periods have already proved to be unsuccessful (Yale's experience). In the present article, repayment periods over 10 to 20 years are considered.

Table 6.3 % of Income to commit in HCC. Palacios 2004 using N&S 2000 estimations

ρ=0.102 C = USD2382,56 Mincerian				
Time left to repayment (5-s)	Men		Women	
	k=10	k=15	k=10	k=15
1	9,11%	7,11%	13,88%	10,83%
2	10,07%	7,85%	15,35%	11,97%
3	11,13%	8,68%	16,96%	13,22%
4	12,30%	9,59%	18,74%	14,61%
5	13,60%	10,60%	20,71%	16,15%
Total Cumulative	56,21%	43,83%	85,65%	66,78%

ρ=0.216 C = USD2382,56 Splines				
Time left to repayment (5-s)	Men		Women	
	k=10	k=15	k=10	k=15
1	1,48%	1,15%	2,25%	1,75%
2	1,63%	1,27%	2,48%	1,94%
3	1,80%	1,41%	2,75%	2,14%
4	1,99%	1,55%	3,03%	2,37%
5	2,20%	1,72%	3,35%	2,61%
Total Cumulative	9,10%	7,10%	13,87%	10,81%

Source: Palacios (2004), Núñez and Sánchez (2000) and Author's calculations

With Palacios' set of parameters and the estimates of returns to education regardless of the levels (ρ_s = 0.102) from Núñez and Sánchez (2000), an outcome measured by Eq.(6.6) and Eq.(6.11) can be derived. A summary of calculations is presented in Table 6.3. If a student wants to finance his tuition in his last year of education, he would be required to commit 9.11% of his future income; while, if he wants to finance his first year, having to wait longer to start the repayment period, he would have to commit 13.6% for a contract with a 10Y repayment period. Under the assumption that conditions do not change from year to year, a male student who wants to finance his whole carrier would have to commit 56% of his future income.

The same exercise can be made with the outcome from Núñez and Sánchez (2000) of their Splines (ρ_s = 0.216), it is also presented in Table 6.3. Once the focus is set on the return to higher education, the outcomes are more attractive for the students and fall inside the 15% of income limit to finance the whole career. Estimations of income at graduation seem to be inflated with an average of USD30,000 yearly, which is far from the average of the FGS 2007 database.

6.3 HCC with data from the FGS 2007

Using the estimates from the econometric models run in the present article and with the parameters assumed in Table 6.2, HCC are still a tool to finance higher education partially at least, if the maximum percentage of income that a student is able to commit is 15% to 20%. Table 6.4 presents the main estimations from HCC valuated for different sets

of income at graduation, with the outcome of the previous Modified Mincerian Model (Interval Regression). Outcomes using the estimations from OLS and the Splines model can be found in Appendix A.5 Depending on the length of the contract and the field under analysis and with the information available, one HCC is capable of financing up to 3 to 4 years of University studies. The field of Law is the best located in the valuation of HCC, because it has the most positive effect over the reference.

Table 6.4 HCC for Private Universities. (γ) % of Income to Commit by Students. (From Mincerian Model – Interval Regression)

Time left to repayment (5-s)	10 Years Repayment Period							
	ECONOMICS		HEALTH SCIENCES		ENGINEERING		LAW	
	Male	Female	Male	Female	Male	Female	Male	Female
1	5.3%	6.0%	5.0%	5.8%	5.0%	5.7%	4.8%	5.5%
2	5.8%	6.6%	5.5%	6.3%	5.4%	6.3%	5.2%	6.0%
3	6.3%	7.3%	6.0%	6.9%	6.0%	6.9%	5.7%	6.6%
4	6.9%	8.0%	6.6%	7.6%	6.5%	7.5%	6.3%	7.3%
5	7.6%	8.8%	7.2%	8.3%	7.2%	8.3%	6.9%	8.0%
Cumulated total	31.9%	36.7%	30.3%	34.9%	30.1%	34.7%	29.0%	33.4%

Time left to repayment (5-s)	15 Years Repayment Period							
	ECONOMICS		HEALTH SCIENCES		ENGINEERING		LAW	
	Male	Female	Male	Female	Male	Female	Male	Female
1	4.0%	4.6%	3.8%	4.4%	3.8%	4.4%	3.6%	4.2%
2	4.4%	5.1%	4.2%	4.8%	4.2%	4.8%	4.0%	4.6%
3	4.8%	5.6%	4.6%	5.3%	4.6%	5.3%	4.4%	5.1%
4	5.3%	6.1%	5.0%	5.8%	5.0%	5.8%	4.8%	5.5%
5	5.8%	6.7%	5.5%	6.4%	5.5%	6.3%	5.3%	6.1%
Cumulated total	24.4%	28.1%	23.2%	26.7%	23.0%	26.5%	22.1%	25.5%

Time left to repayment (5-s)	20 Years Repayment Period							
	ECONOMICS		HEALTH SCIENCES		ENGINEERING		LAW	
	Male	Female	Male	Female	Male	Female	Male	Female
1	3.5%	4.0%	3.3%	3.8%	3.3%	3.8%	3.1%	3.6%
2	3.8%	4.4%	3.6%	4.2%	3.6%	4.1%	3.4%	4.0%
3	4.2%	4.8%	4.0%	4.6%	3.9%	4.5%	3.8%	4.4%
4	4.6%	5.3%	4.3%	5.0%	4.3%	5.0%	4.1%	4.8%
5	5.0%	5.8%	4.8%	5.5%	4.7%	5.4%	4.5%	5.2%
Cumulated total	21.0%	24.1%	20.0%	23.0%	19.8%	22.8%	19.0%	21.9%

Source : FGS - 2007 and Author's Calculations

The findings suggest that should be deepened the ways to estimate the potential income of a University graduate. In average, the income of University graduates is not enough to cover for the risk embedded in HCC and to attract investors without making the contract prohibitive for the students. But including variables which reflect the ability of a student (i.e. his/her high school grades, subjective appreciations), and which are able to

determine the future income after graduation, may lead to the possibility of a more favorable valuation for the students.

The focus on the group of graduates from HEIs, allows to measure part of the increase on income due to the education attainment. But, the increase in the cost of the higher education at the private level makes the investment very risky as the cost is known with certainty, but the return not. It is to be noted that augmenting the level of parental education up to professional, as a proxy for initial income, will improve the conditions for students engaging in HCC, lowering the percentage they have to commit in 200bps in average. But the majority of the population does not fulfill that condition.

Table 6.5 HCC for Public Universities. (γ) % of Income to Commit by Students. (From Mincerian Model – Interval Regression)

Time left to repayment (5-s)	10 Years Repayment Period							
	ECONOMICS		HEALTH SCIENCES		ENGINEERING		LAW	
	Male	Female	Male	Female	Male	Female	Male	Female
1	0.8%	0.9%	0.7%	0.8%	0.7%	0.8%	0.7%	0.8%
2	0.8%	1.0%	0.8%	0.9%	0.8%	0.9%	0.8%	0.9%
3	0.9%	1.0%	0.9%	1.0%	0.9%	1.0%	0.9%	1.0%
4	1.0%	1.1%	1.0%	1.1%	1.0%	1.1%	0.9%	1.1%
5	1.1%	1.3%	1.1%	1.2%	1.1%	1.2%	1.0%	1.2%
Cumulated total	4.7%	5.3%	4.5%	5.1%	4.4%	5.0%	4.3%	4.9%

Time left to repayment (5-s)	15 Years Repayment Period							
	ECONOMICS		HEALTH SCIENCES		ENGINEERING		LAW	
	Male	Female	Male	Female	Male	Female	Male	Female
1	0.6%	0.7%	0.6%	0.6%	0.6%	0.6%	0.5%	0.6%
2	0.7%	0.7%	0.6%	0.7%	0.6%	0.7%	0.6%	0.7%
3	0.7%	0.8%	0.7%	0.8%	0.7%	0.8%	0.7%	0.7%
4	0.8%	0.9%	0.8%	0.9%	0.7%	0.8%	0.7%	0.8%
5	0.9%	1.0%	0.8%	0.9%	0.8%	0.9%	0.8%	0.9%
Cumulated total	3.6%	4.1%	3.5%	3.9%	3.4%	3.8%	3.3%	3.8%

Source : FGS - 2007 and Author's Calculations

On the other hand, tuition in public institutions is 7.5 times lower than in private ones: only COP359,000 is required per semester (USD160). When the capability of HCC is tested to finance public education, the outcome is completely the opposite, and financing the tuitions with private resources, should be attractive for investors, given the expected return. Table 6.5 presents the outcome for HCC with only 10 and 15 years. Less than 5% of the income of the student is required for any of the presented fields.

As education in public institutions is cheap and as the return to education is high enough, more investors might be attracted to support students with very low income and

high opportunity costs, students who otherwise, would have to be looking for a job, probably in the informal sector. The subsidy in the side of the supply allows this possibility. However, it does not reflect the reality of the demand pressure as every year, 80% of the aspirants to public institutions are rejected.

The outcome presented here does not reject the possibility of financial support for students willing to enter into a private university using HCC. Instead, HCC can still be competence-generating and, with some support of the Government, they can be brought into practice. For example, allowing students to commit a maximal amount of their income (i.e. 15%) and the Government, through the Icetex or another institution which fosters higher education, can subsidize the balance left. Such an implementation will ease the pressure over private universities that had to raise their tuition during the last years, while allocating more efficiently the resources spent by the Government in higher education.

6.4 Further Comments about HCC in Colombia

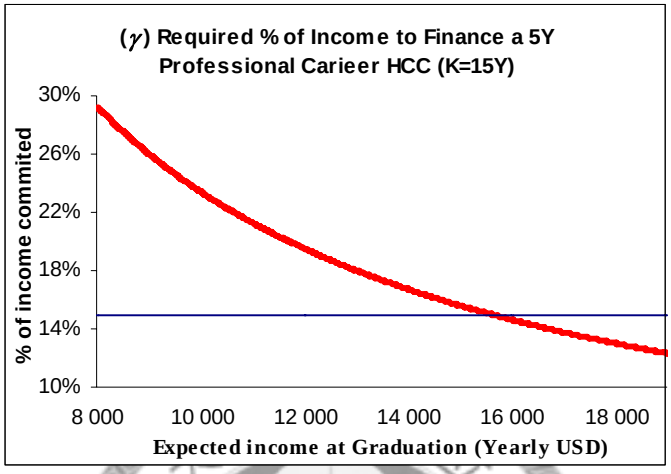
According to the current information, HCC are able to finance partially investments in private institutions and totally in public institutions. However, their use can lead to an increase in the amount of rejected students in comparison with the aspirants (Currently 80%); thus, it would not help in the distribution of private institutions' unused capacity and will add pressure on the demand for the public institutions places, whose supply follow the government's pace.

It has already been mentioned that HCC use might help the government set a retributive tax for graduates from public institutions; also, combined with government subsidies HCC can enhance competition and will redirect resources to private institutions, whose capacity is not being fully used.

Other issues can still be discussed: first, the data base can be improved. More information on what influence graduates income can be derived from future releases of the FGS survey. Plenty of students would be able to be financed by HCC, but the variables used here are not able to identify them. Among the possible examples, could be included more information about the HEI, or a more precise typology of the study fields than the one used in this article.

On the other hand, the present article implemented several conservative measures and, jointly, they might be pushing down HCC valuation. Thus, HCC sensitivity has been checked through the comparative statics analysis on the variables that affect its value.

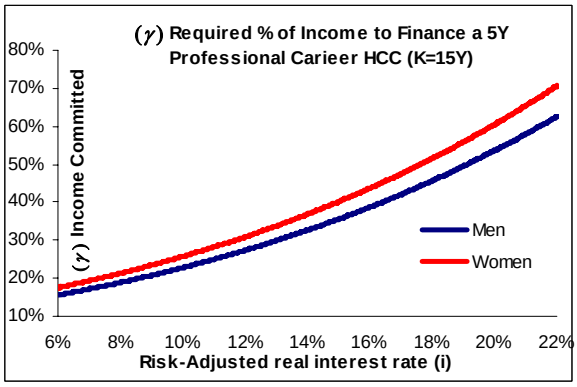
Figure 6.1 (γ) and expected income at graduation

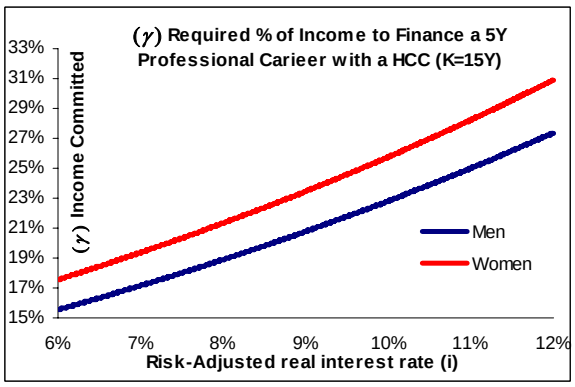


Source: FGS - 2007. Palacios 2004 and Author's calculations

The main driver of value in HCC is the expected income at graduation. Fig. 6.1 presents the relation between (γ) and the expected income at graduation, using OLS Mincerian estimation for h and g (income growth rate and income decreasing speed rate) and having all other parameters constant over the Eq. (6.11) and (6.6). Students with yearly income higher than USD15,500 fall in the acceptable range with 15% or less of their future yearly income to commit in HCC. For comparison purposes, it is worth mentioning that male lawyers (the highest estimation) in average have a yearly income of USD12,000 at graduation (Appendix A.4).

Figure 6.2 and 6.3 (γ) and the Risk Adjusted Real Interest Rate



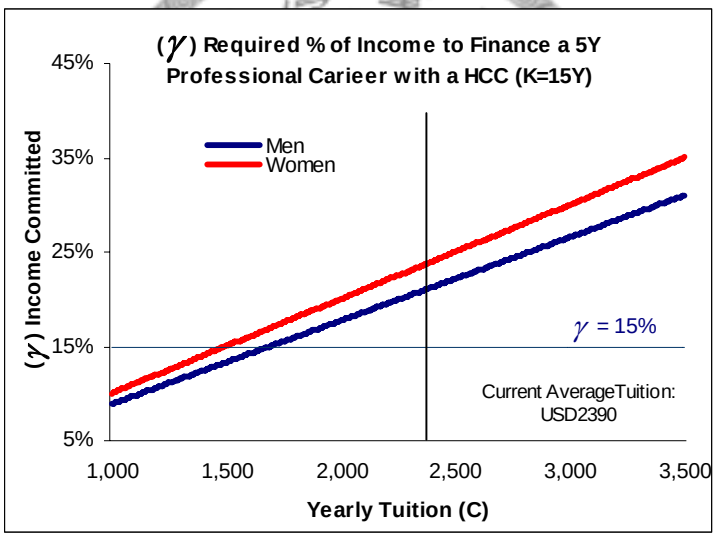


Source: FGS - 2007. Palacios 2004 and Author's calculations

Figure 6.2 and 6.3 illustrate the relation between the risk adjusted interest rate used to discount the cash flows and the percentage of income to be committed in HCC, holding all other variables constant. Measures that help reduce the real interest rate get students closer to HCC. Either in USD or in UVR (Real Value Unit), macro economical control of devaluation/inflation and country risk profile will lead to a better environment for the application of HCC.

Figure 6.4 presents the relation between (γ) and the yearly tuition. A linear relation can be seen in Eq (6.6). Under current conditions, the average tuition in private universities exceeds in almost USD1000 the tuition that would make HCC able to finance these programs without external aid.

Figure 6.4 (γ) and Yearly Tuition (USD)

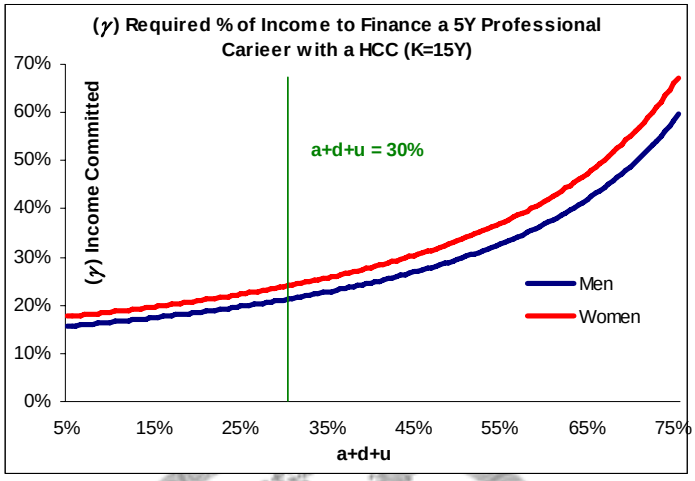


Source: FGS - 2007. Palacios 2004 and Author's calculations

Further easing of the parameters and variables can lead to the viability of HCC. Unemployment, Administration Costs or Default rate also have an effect over HCC valuation as can be inferred by Eq.(6.6). In the present analysis a joint level of 30% has been assumed; although, the unemployment rate is assumed to be constant and the same for the group of graduates from HEIs than for the total population. Accordingly, the default rate has been conservatively assumed to be higher than the proportion of graduates affiliated to the Social Security System. Administration Costs at 2%, following Palacios (2004) are set under the assumption that a critical mass of students is achieved so the fixed costs can be spread

among the students and the total costs are fully covered. Any change on this variables affect the value of HCC as presented in Figure 6.5.

Figure 6.5 (γ) and Administration Costs, Unemployment and Default Rates



Source: FGS - 2007. Palacios 2004 and Author's calculations

The sensitivity analysis shows that HCC implementation needs further adjustments than changes in just one of the variables. But any improvement in measuring education returns, or any effort to improve macro economical stability affecting the above mentioned variables are steps towards HCC implementation.

Chapter 7. Conclusions

The present article followed Palacios' model for Human Capital Contract Valuation to estimate the return to education and to assess the viability of such contracts in Colombia. It is found that financing students at the professional level in private universities can only be done *partially* without any Government help. Other findings suggest that there exist incentives for private investors to support students willing to pursue their studies in public institutions. The latter might not be socially desirable as the current pressure of the demand over the public HEIs is high: the lack of capacity leaves out 80% of the aspirants per year.

HCC still can be used to redirect resources and support students who wish to access to private HEIs with governmental aid. The Government can be a warrantee and subsidize a part of the contract, at least at the beginning of their implementation. This form of subsidy will be efficient as it will increase competence among universities and also because it will avoid rigidities that are present in public institutions.

With regard to the estimation of education returns, the present article used data from the Following Graduates Survey 2007. Focusing in the group of Higher Education Graduates, income forecasts were estimated by two model specifications (Modified Mincerian and Splines Model) and each one, by two econometric alternatives (OLS/RR and IR), according to the previous literature (Mincer 1974; Núñez and Sánchez 2000; Low, et Al. 2004; Daniels and Rospabé 2005; Weldi 2007; Guataqui, et Al. 2008; Forero and Ramírez 2008). As expected, returns to education are greater for higher levels of formation. The income gap among genders seems smaller than in the previous analysis for Colombia, at least at higher education levels. The geographic residence of the graduates affects the outcome of income: it favors the performance of income in the capital or abroad. The field of study also determines the level of income after graduation in favor of students from Law and Engineering over Economics.

There are some issues that earning equations have not been able to solve and that require further study. Among those issues are the relation between income growth and Age/Experience, and the link between current wages in different industries and the expected future income of a student. Furthermore, these issues should be considered dynamically.

It is important to consider the effect of the conservative measures that were taken on the econometric models and in HCC valuation. They might influence downwards the final outcomes. Reconsidering some of the parameters makes HCC implementation closer.

Furthermore, the FGS 2007 is a new database. The fact that there are still only two releases of the survey which overlap each other, does not allow to take into account dynamic effects in the returns to higher education. Future studies will be able to analyze such effects by using the same database.

A further study would be required in the model specification and in the collection of information. It would allow obtaining a better estimation of the students who are to outperform the average and to engage in HCC. At first, new studies could be based on measures of the students' ability (i.e. their high school grades or psychological assessment of their profile), but there are potential series of variables that might influence income after graduation.

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Appendix

A.1 FGS 2007 Reclassification

Table A.1 Fields of Study: Reclassification

CODE	Basic Nucleus of Study	Respective Field
1	Agronomy	Agronomy, Veterinary and related
2	Zoology	
3	Veterinary Medicine	
4	Plastic, Visual Arts and related	Arts
5	Representative Arts	
6	Publicity and related	
7	Design	
8	Music	
70	Other programs associated with Arts	
13	Education	Education
40	Bacteriology	Health Sciences
41	Infirmary	
42	Therapy	
44	Chirurgical Instrumentation	
45	Medicine	
46	Nourishment and Diet	
47	Odontology and Dentistry	
48	Optometry, other Health Science programs	
50	Public Health	
53	Anthropology, Liberal Arts	Social Sciences
55	Bibliothecology, other Social Sciences	
56	Political Science, International Studies	
57	Social Communication, Journalism and related	
58	Sports, Physical Education and Recreation	
61	Military or Police formation	
62	Geography, History	
64	Modern Languages, Literature, Linguistic	
66	Psychology	
68	Philosophy, Theology and related	
69	Sociology, Social Work and related	
59	Law and related	Law and related
9	Business Administration	Economics, Finance and Business Admon
11	Economics	
12	Public Accounting	
18	Architecture and related	Architecture, Urbanism and Engineering
19	Biomedical Engineering and related	
20	Environmental, Sanitary Engineering and related	
21	Administrative Engineering and related	
22	Forestal and Agricultural Engineering	
23	Agro industrial, Nourishment Engineering	
24	Agropecuarian Engineering and related	
25	Civil Engineering and related	
26	Mining, Metallurgic Engineering and related	
27	Systems Engineering and related	
28	Electric Engineering and related	
29	Electronic, Telecommunications Engineering	
30	Industrial Engineering and related	
31	Mechanical Engineering and related	
32	Chemical Engineering and related	
33	Other Engineering	
34	Biology, Microbiology and related	Mathematics and Natural Sciences
35	Physics	
36	Geology and other Natural Sciences programs	
37	Mathematics, Statistics and related	
39	Chemistry and related	

Source: FGS - 2007 Variables Dictionary

Most of the variables used in the current analysis where taken directly from the database offered by the FGS 2007. However, some of the data were reclassified, among them: field of study and regional variables (residence and HEIs location). The variable field of study was reallocated according to the Table A1, following mainly the classifications from Forero and Ramírez 2008. But, in this article, the subject Law was shown apart from the Social Studies field, given that there are significant differences among both groups.

Table A.2 Departments and Regions: Reclassification

Department	Region
BOGOTA D.C.	BOGOTA
ANTIOQUIA	ANTIOQUIA
VALLE DEL CAUCA	VALLE
ATLANTICO	ATLANTICO
BOLIVAR	
CESAR	
CORDOBA	
LA GUAJIRA	
MAGDALENA	
SUCRE	
SAN ANDRES ISLAS	
CAUCA	PACIFIC
CHOCO	
NARI埆	
CALDAS	CENTRAL
HUILA	
QUINDIO	
RISARALDA	
TOLIMA	

Department	Region
BOYACA	ORIENTAL
CUNDINAMARCA	
NORTE DE SANTANDER	
SANTANDER	
ARAUCA	
CASANARE	
CAQUETA	AMAZON
META	
PUTUMAYO	
AMAZONAS	
GUAINIA	
GUAVIARE	
VAUPES	
VICHADA	
In a foreign country	FOREIGN

A.2 Statistical Tests Summary

Heteroscedasticity was checked through the White Test. Given that there is no correlation between the errors and the independent variables the White Test checks the null hypothesis of homoscedasticity. $H_0 : \sigma_i^2 = \sigma^2$ for all $i = 1,2,...,n$[8]. According to the statistical calculation the null hypothesis is rejected for the Modified Mincerian and for the Splines model. To reject the null hypothesis implies that the variance and the linear specification of the model is correct (White 1980).

OLS errors normality was tested through the Kolmogorov Smirnov Test[9], Cramer von Mises Test[10] and the Anderson Darling Test[11]. These tests are based on the empirical

[8] The White Test is equivalent to an auxiliary regression where the squared of the errors is explained by all possible cross products of the regressors. From this auxiliary regression $nR^2_{aux} \sim \chi^2_{K(K-1)/2}$

[9] The KS Test statistic is computed as the maximum vertical distance between the empirical distribution function and the normal distribution.

[10] The CM Test is defined as:

$$W^2 = n\int_{-\infty}^{\infty}\left(F_n(x) - F(x)\right)^2 dF(x) \text{ and calculated from } W^2 = \sum\left(\varepsilon_i - \frac{2i-1}{2n}\right)^2 + \frac{1}{12n}$$

[11] The AD Test is defined as:

$$A^2 = n\int_{-\infty}^{\infty}\frac{\left(F_n(x) - F(x)\right)^2}{\left(F(x)(1-F(x))\right)}dF(x) \text{ and calculated from:}$$

distribution function (EDS) with the null hypothesis of normality of the variable; in this case the errors of the estimations. $H_0 : \varepsilon_i \to iid \sim N(0, \sigma^2)$. The KS Test checks the distance between the EDS and the normal distribution with a linear specification. The CM and the AD tests check the quadratic behavior of the distance between the EDF and the normal distribution.

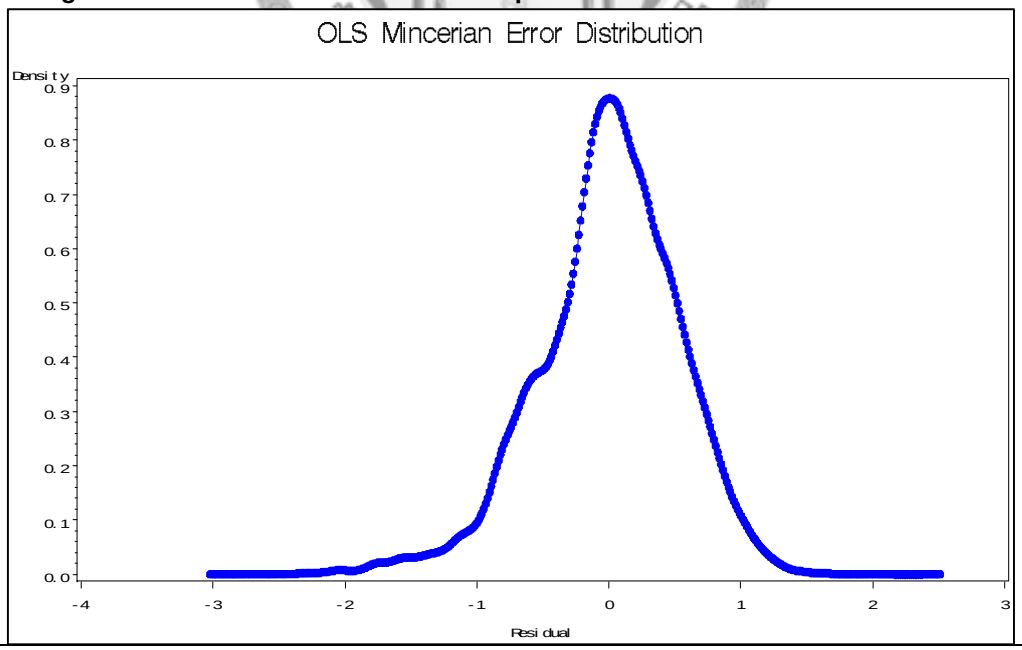
Table A.3 and Table A.4 present the outcomes for the OLS regressions for the Modified Mincerian and for the Splines Model, respectively. According to the tests for all the specifications, the normality of the errors is rejected. Figure A.1 and Figure A.2 also present the empirical density of the residuals from the OLS estimations for both regressions.

Table A.3 OLS Mincerian Model. Error Normality and Homoscedasticity Tests

Error Normality Tests				
Test	**----Statistic----**		**-----p Value------**	
Kolmogorov-Smirnov	D	0.046419	Pr > D	<0.0100
Cramer-von Mises	W-Sq	9.304814	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	54.97441	Pr > A-Sq	<0.0050
Homoscedasticity Test				
White	Chi Sq	726.08	Pr > ChiSq	<0.0001

Source: FGS - 2007. and Author Calculations

Figure A.1 – OLS Mincerian. Errors Empirical Distribution

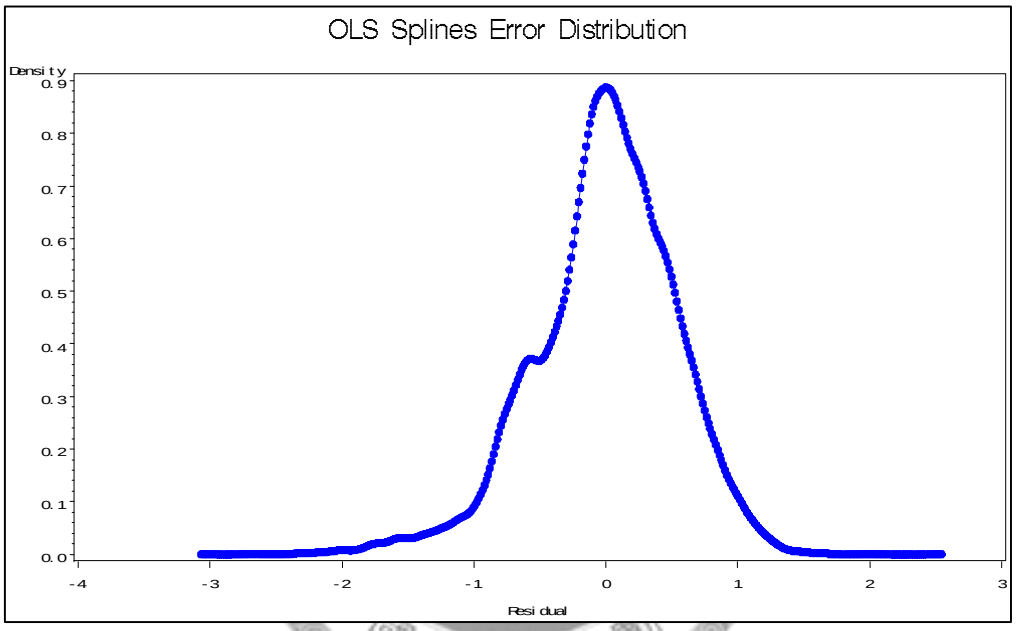


$$A^2 = -n - \frac{1}{n}\sum\left[(2i-1)\log\varepsilon_i + (2n+1-2i)\log(1-\varepsilon_i)\right]$$

Table A.4 OLS Splines Model. Error Normality and Homoscedasticity Tests

Error Normality Tests				
Test	**----Statistic----**		**-----p Value------**	
Kolmogorov-Smirnov	D	0.047264	Pr > D	<0.0100
Cramer-von Mises	W-Sq	9.766852	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	57.08904	Pr > A-Sq	<0.0050
Homoscedasticity Test				
White	Chi Sq	953.49	Pr > ChiSq	<0.0001

Figure A.2 – OLS Splines. Errors Empirical Distribution



Multicollinearity is measured by the Variance Inflation Factor. The VIF for a particular coefficient comes from the regression of the independent variable it represents, on all the other independent variables. Then, the VIF is calculated with the above regression's coefficient of determination[12]. The square root of the VIF states how inflated the variance of the coefficient is, compared with what it would be in the case the variable were uncorrelated with the other independent variables. Although there are no statistic to test the null hypothesis for multicollinearity, there is a thumb rule which defines *VIF > 5* or *10* when exists a high degree of multicollinearity (Kutner, M. et Al. 2004).

[12] $VIF\left(\hat{\beta}_k\right) = \frac{1}{1-R_k^2}$ where R_k^2 comes from the regression: $\vec{x}_k = c + \sum_{j \neq k}^{K} a_j \vec{x}_j + e$, being c a constant and $\vec{x}_k$ a vector with all observations for the k[th] independent variable.

Table A.5 OLS Colinearity Measures. VIF and Tolerance

Mincerian OLS			Splines OLS		
Parameter	Tolerance	VIF	Variable	VIF	Inflation
yrs_edu	0.82489	1.21229	TEC	0.15483	6.4588
			POS	0.22449	4.45456
age	**0.0159**	**62.7788**	age	**0.01496**	**66.83226**
			age_Sq	**0.01462**	**68.40656**
age_Sq	**0.01618**	**61.80033**	dt_age2	0.16972	5.89189
			dp_age2	0.17513	5.71004
			gender	0.6704	1.49165
gender	0.88864	1.12531	dt_gen	0.49983	2.00067
			dp_gen	0.43452	2.3014
ln(h_month)	0.9771	1.0234	ln(h_month)	0.97655	1.02402
ed_madr	0.6276	1.5935	ed_madr	0.6264	1.59641
ed_padr	0.6131	1.6312	ed_padr	0.61089	1.63696
priv_HEI	0.5874	1.7024	priv_HEI	0.58293	1.71546
Agronom	0.8869	1.1276	Agronom	0.88141	1.13455
Arts	0.8644	1.1569	Arts	0.85872	1.16453
Educatn	0.8056	1.2413	Educatn	0.79579	1.25661
Law	0.8681	1.1520	Law	0.85762	1.16602
Health	0.8304	1.2043	Health	0.81546	1.2263
SociSt2	0.8075	1.2383	SociSt2	0.77816	1.28508
Engineer	0.6716	1.4890	Engineer	0.65389	1.52931
Math	0.9122	1.0963	Math	0.90679	1.10279
Antioq	0.2011	4.9736	Antioq	0.20091	4.97725
Valle	0.2226	4.4920	Valle	0.22256	4.49325
Atlant	0.2980	3.3557	Atlant	0.29749	3.3615
Pacific	0.4848	2.0628	Pacific	0.4841	2.0657
Central	0.2997	3.3362	Central	0.29922	3.34202
Orient	0.4916	2.0340	Orient	0.49147	2.03469
Amazon	0.9349	1.0696	Amazon	0.93443	1.07017
Expat	0.8996	1.1116	Expat	0.89835	1.11315
HEI_Antq	0.1993	5.0172	HEI_Antq	0.19873	5.03198
HEI_Vall	0.2188	4.5712	HEI_Vall	0.21581	4.63375
HEI_Atla	0.2958	3.3813	HEI_Atla	0.29262	3.41739
HEI_Pacf	0.4901	2.0405	HEI_Pacf	0.48959	2.04251
HEI_Cent	0.2538	3.9394	HEI_Cent	0.24991	4.00142
HEI_Orie	0.4858	2.0586	HEI_Orie	0.47529	2.10396
HEI_Amaz	0.9850	1.0152	HEI_Amaz	0.98394	1.01632

Source: FGS - 2007. and Author Calculations

For either the Mincerian or the Splines OLS, the VIFs are all under ten with the exception of Age and Age Squared, which are higher. As they are a transformation over the same variable, they are expected to have a high degree of correlation. Considering a threshold of *VIF > 5*, then the department of Antioquia seems to have a high VIF, and in the Splines model, the interaction coefficients seem to be related with the variables they represent; again a transformation among independent variables. VIF and Tolerance (*1/VIF*) are presented in Table A.5.

A.3 Robustness Exercises

A.3.1 Wage and Non Earnings Observations

Table A.6 includes outcome for Mincerian Model Estimations and Table A.7 presents the Splines Model estimations. For the wage earning observations the effects' direction and significance of the variables remain mostly unchanged. Regression Coefficient of Determination is higher than for any of the estimations made with the complete sub sample. Although these regressions fit more accurately the data, the previous sub sample is chosen as a conservative measure given that the coefficients for income growth and the intercept are higher for their estimations in both, the Modified Mincerian and the Splines models. Still, it can be seen the difficulty the models have to fit the data for the non wage earning observations. The direction and significance degree of several variables change when this model is considered. Further development of the data base with the inclusion of more household characteristics, would allow incorporating labor market entrance decisions.

Table A.6 Mincerian Model. Wage vs. Non Wage Earning Observations

Wage Earning Observations						Non Wage Earning Observations					
Obs 17140	OLS		RSE	IR**		Obs 2574	OLS		RSE	IR**	
Parameter	Estimate	Std Error	Rob Std Err	Estimate	Std Error	Parameter	Estimate	Std Error	Rob Std Err	Estimate	Std Error
Intercept	7.0719	0.1223	0.1279	6.8333	0.1277	Intercept	7.1050	0.4028	16.6370	6.8610	0.4087
yrs_edu	0.2788	0.0055	0.0056	0.2877	0.0057	yrs_edu	0.2710	0.0193	14.1556	0.2821	0.0196
age	0.0744	0.0055	0.0056	0.0791	0.0057	age	0.0632	0.0161	3.8603	0.0690	0.0162
age_Sq	-0.0008	0.0001	0.0001	-0.0008	0.0001	age_Sq	-0.0007	0.0002	-2.9688	-0.0007	0.0002
gender	0.1241	0.0084	0.0083	0.1413	0.0087	gender	0.1261	0.0271	4.6616	0.1439	0.0272
ln(h_month)	0.2006	0.0086	0.0104	0.1980	0.0090	ln(h_month)	0.2448	0.0216	9.6313	0.2350	0.0219
ed_madr	0.0135	0.0016	0.0017	0.0141	0.0017	ed_madr	0.1082	0.0429	2.5574	0.0972	0.0432
ed_padr	0.0223	0.0015	0.0015	0.0236	0.0016	ed_padr	0.0118	0.0049	2.3927	0.0127	0.0049
priv_HEI	0.0492	0.0124	0.0123	0.0523	0.0130	priv_HEI	0.0154	0.0052	2.9937	0.0165	0.0052
Agronom	-0.0365*	0.0379	0.0378	-0.0513*	0.0396	Agronom	-0.2485	0.1000	-2.9059	-0.2731	0.1023
Arts	-0.1995	0.0223	0.0224	-0.2381	0.0233	Arts	-0.2914	0.0524	-5.4876	-0.3135	0.0527
Educatn	-0.3759	0.0187	0.0198	-0.3820	0.0196	Educatn	-0.5185	0.0810	-5.6485	-0.4948	0.0833
Law	0.1087	0.0197	0.0184	0.0958	0.0203	Law	0.0261	0.04463*	0.597844*	0.0163	0.0445*
Health	0.0541	0.0178	0.0179	0.0494	0.0184	Health	-0.0777	0.05957*	-1.30641*	-0.0767	0.0598*
SociSt	-0.1455	0.0138	0.0138	-0.1690	0.0144	SociSt	-0.2391	0.0440	-5.4636	-0.2517	0.0442
Engineer	0.0658	0.0102	0.0102	0.0574	0.0106	Engineer	-0.0131	0.03591*	-0.36933*	-0.0175	0.036*
Math	-0.0826	0.0298	0.0316	-0.0964	0.0310	Math	-0.1755	0.10989*	-1.80861*	-0.2178	0.1100
R Sq		0.379411		0.3354 (u)		R Sq		0.2702		0.2351 (u)	
Adj R Sq		0.3783		0.3629 (l)		Adj R Sq		0.2613		0.2460 (l)	
F Value	337.40	Pr > F	<.0001			F Value	30.35	Pr > F	<.0001		

* Not Significant at the 5% confidence level
**Pseudo R Squared for the IR is the Squared Multiple Correlation
Source: FGS - 2007 and Author Calculations

Table A.7. Splines Model. Wage vs. Non Wage Earning Observations

Wage Earning Observations						Non Wage Earning Observations					
Obs 17140	OLS		RSE	IR**		Obs 2574	OLS		RSE	IR**	
Parameter	Estimate	Std Error	Std Err	Estimate	Std Error	Parameter	Estimate	Std Error	Std Err	Estimate	Std Error
Intercept	11.4091	0.1075	0.11519	11.2635	0.1117	Intercept	11.4682	0.3119	0.32320	11.4184	0.3136
age	0.0853	0.0057	0.00587	0.0924	0.0059	age	0.0600	0.0164	0.01672	0.064	0.0164
age_Sq	-0.0010	0.00008	0.000085	-0.0011	0.0001	age_Sq	-0.0006	0.00022	0.000230	-0.0006	0.0002
gender	0.1193	0.0097	0.00970	0.1327	0.01	gender	0.1204	0.0304	0.03004	0.1369	0.0304
ln(h_month)	0.1998	0.0086	0.01040	0.1968	0.009	ln(h_month)	0.2442	0.0216	0.02532	0.2339	0.0219
ed_madr	0.0136	0.0016	0.00166	0.0143	0.0017	ed_madr	0.0156	0.0052	0.00513	0.0168	0.0052
ed_padr	0.0219	0.0015	0.00153	0.0235	0.0016	ed_padr	0.0121	0.0049	0.00492	0.0132	0.0049
priv_HEI	0.0501	0.0124	0.01233	0.0554	0.013	priv_HEI	0.1066	0.0431	0.04265	0.0984	0.0434
dt_age2	0.000116	0.00003	0.00003	0.0001	0.0000	dt_age2	-0.000096	0.00008*	0.00009*	-0.0001	0.0001*
dp_age2	0.000155	0.00002	0.00002	0.0002	0.0000	dp_age2	-0.000061	0.00006*	0.00006*	-0.0001	0.0001*
dt_gen	-0.0249*	0.0275	0.02901	-0.0484*	0.029	dt_gen	-0.0317	0.0957*	0.0967*	-0.0453	0.098*
dp_gen	0.0396*	0.0218	0.02059	0.068	0.0223	dp_gen	0.0478	0.0768*	0.0745*	0.0642	0.0763*
Agronom	-0.0242*	0.0379	0.03783	-0.0298*	0.0396	Agronom	-0.2438	0.1006	0.08618	-0.2587	0.1026
Arts	-0.1975	0.0223	0.02245	-0.2311	0.0232	Arts	-0.2872	0.0528	0.05307	-0.3028	0.053
Educatn	-0.3740	0.0188	0.01983	-0.3738	0.0197	Educatn	-0.5180	0.0812	0.09192	-0.4907	0.0834
Law	0.1204	0.0198	0.01857	0.113	0.0203	Law	0.0249	0.0450*	0.04403	0.0186	0.0448*
Health	0.0567	0.0179	0.01802	0.0593	0.0185	Health	-0.0726	0.0600*	0.05995	-0.0648	0.0601*
SociSt	-0.1407	0.0141	0.01404	-0.1559	0.0146	SociSt2	-0.2351	0.0446	0.04399	-0.2419	0.0447
Engineer	0.0743	0.0103	0.01031	0.0719	0.0107	Engineer	-0.0093	0.0362*	0.03555	-0.0098	0.0362*
Math	-0.0690	0.0299	0.03144	-0.0747	0.031	Math	-0.1700	0.11056*	0.09761	-0.2011	0.1105*
tech	-0.0459	0.0025	0.00254	-0.0422	0.0026	tech	-0.0292	0.0083	0.00884	-0.0275	0.0084
posgrad	0.1387	0.0178	0.01543	0.1494	0.0184	posgrad	0.3234	0.0747	0.07058	0.3896	0.0748
R Sq		0.3828		0.3354 (u)		R Sq		0.2709		0.2352 (u)	
Adj R Sq		0.3815		0.3629 (l)		Adj R Sq		0.2605		0.2399 (l)	
F Value	294.64	Pr > F	<.0001			F Value	26.18	Pr > F	<.0001		

* Not Significant at the 5% confidence level
**Pseudo R Squared for the IR is the Squared Multiple Correlation
Source: FGS - 2007 and Author Calculations

A.4 Forecasting Income at Graduation

For both models, Mincerian and Splines, two different set of forecasts are presented: the first using OLS and RR outcomes, and the latter using IR estimates. The estimation for groups of students to form HCC securities is presented for the Economics and the fields of study that are increase income over the reference, at the professional level for both genders, and both sorts of HEIs. Each group is supposed to include 10 students.

The age at graduation is set at 23 years which is lower than the mean observed in the database. The above is a conservative measure as the regression prizes older graduates. This might be true for highly experienced students, but not necessarily for students who had problems in their academic performance and then delayed graduation.

Furthermore, the parental education level used was the mean of the variable in the sub sample for each parent. Finally, taking into account the mode for working hours (49% in the 31-48h/weekly interval), a level of 160 hours monthly is chosen. Above descriptions account for the hypothetical means of vectors, X_h, from a group of m = 10 students.

For the case of OLS/RSE, to calculate the confidence interval of the mean prediction, given the size of the sub sample, the Central Limit Theorem is summoned to assume that the income mean is normally distributed and the transformed variance covariance matrix from Eq.(5.2), $\hat{\Omega}(b_{ij})^2_{rob}$, is used to calculate confidence intervals

$$\log \hat{\bar{y}}_h \pm t(1-\alpha/2; N-k)\hat{\sigma}_{\bar{y}}, \qquad \text{(A.1)}$$

$$\text{where } \hat{\sigma}^2_{\bar{y}} = MSE\left(\frac{1}{m} + X'_h \hat{\Omega}(bij) X_h\right). \qquad \text{(A.2)}$$

For the IR's, it is assumed that the mean of the income variable is normally distributed as well. The estimation includes a new term σ_{IR} from Eq.(5.3), analogous to the MSE from OLS. Confidence intervals lose a degree of freedom accounting for the estimation of $\hat{\sigma}_{IR}$; in addition, the hypothetical vector of explanatory variables carries an extra zero with the expected value of the error, and the estimated covariance matrix comes from the inverse of the second derivatives of the log likelihood function, L, with respect to the parameters, V, with $(k+1)\times(k+1)$ dimensions (Maddala 1983). Accordingly:

$$\log \hat{\bar{y}}_h \pm t(1-\alpha/2; N-k-1)\hat{\sigma}_{\bar{Y}}, \qquad \text{(A.3)}$$

$$\text{where } \hat{\sigma}^2_{\bar{Y}} = \hat{\sigma}_{IR}\left(\frac{1}{m} + X'_h V X_h\right). \qquad \text{(A.4)}$$

The point estimates, from Eq.(5.6) and Eq.(5.7), for $E(\log \hat{\bar{y}}_h)$ are transformed in their respective value in COP and USD and presented in Table A.5, with the outcome for private universities students, and in Table A.6 with the result for their public counterparts.

Differences between the incomes of the graduates are important considering the effect of the field and the gender. While a male engineer is expected to have an annual income over USD10,000[13], the expected income for a female economist would be below USD8,500 regardless of the method used in the prediction. For reference, is noted that the GDP per

[13] Annual income calculated over 14 working months.

capita in Colombia was USD3,611.47 in 2007 according to the IMF estimations[14].Thus, income for graduates at the professional level in the fields of Economics and Engineers have, in average, from 2.5 to 3.5 times the income of the Colombian GDP per capita. Differences between graduates from Private and Public universities, give an advantage to the former of almost a whole monthly salary per year. However data is presented separately, as in HCC the difference in income will be more than compensated by the difference in tuition.

Table A.8 Expected Monthly Income at Graduation. Private Universities

	Gender	*Method*	Y (COP thds)	95% Conf. Intervals		Y (USD)	95% Conf. Intervals	
Economics, Finance, Accounting and Business Administration	M	Mincer/OLS	1,470.48	1,462.72	1,478.27	771.09	767.03	775.18
	M	Mincer/IR	1,497.91	1,487.27	1,508.63	785.48	779.90	791.10
	M	Splines/OLS	1,353.54	1,352.43	1,354.66	709.77	709.19	710.36
	M	Splines/IR	1,444.91	1,444.54	1,445.28	757.69	757.49	757.88
	F	Mincer/OLS	1,302.45	1,295.58	1,309.35	682.98	679.38	686.60
	F	Mincer/IR	1,300.53	1,291.29	1,309.84	681.98	677.13	686.86
	F	Splines/OLS	1,205.05	1,204.06	1,206.05	631.91	631.39	632.43
	F	Splines/IR	1,267.88	1,267.59	1,268.17	664.86	664.70	665.01
Heatth Sciences	M	Mincer/OLS	1,519.41	1,511.39	1,527.48	796.76	792.55	800.99
	M	Mincer/IR	1,573.77	1,562.58	1,585.04	825.26	819.39	831.17
	M	Splines/OLS	1,402.15	1,400.99	1,403.30	735.26	734.66	735.87
	M	Splines/IR	1,501.92	1,501.41	1,502.44	787.58	787.31	787.85
	F	Mincer/OLS	1,345.79	1,338.69	1,352.93	705.71	701.99	709.46
	F	Mincer/IR	1,366.39	1,356.68	1,376.18	716.51	711.42	721.65
	F	Splines/OLS	1,248.33	1,247.30	1,249.36	654.60	654.06	655.14
	F	Splines/IR	1,317.91	1,317.50	1,318.32	691.09	690.87	691.31
Engineering	M	Mincer/OLS	1,555.76	1,547.56	1,564.01	815.82	811.51	820.14
	M	Mincer/IR	1,586.41	1,575.14	1,597.76	831.89	825.98	837.84
	M	Splines/OLS	1,442.67	1,441.48	1,443.86	756.51	755.89	757.13
	M	Splines/IR	1,536.10	1,535.74	1,536.46	805.51	805.32	805.69
	F	Mincer/OLS	1,377.99	1,370.72	1,385.29	722.59	718.78	726.42
	F	Mincer/IR	1,377.37	1,367.58	1,387.22	722.27	717.14	727.44
	F	Splines/OLS	1,284.40	1,283.35	1,285.46	673.52	672.97	674.07
	F	Splines/IR	1,347.90	1,347.59	1,348.20	706.82	706.65	706.98
Law	M	Mincer/OLS	1,594.91	1,586.49	1,603.37	836.34	831.93	840.78
	M	Mincer/IR	1,648.51	1,636.79	1,660.32	864.45	858.30	870.65
	M	Splines/OLS	1,482.94	1,481.71	1,484.16	777.63	776.99	778.27
	M	Splines/IR	1,574.67	1,574.12	1,575.22	825.73	825.44	826.02
	F	Mincer/OLS	1,412.66	1,405.20	1,420.16	740.78	736.87	744.71
	F	Mincer/IR	1,431.29	1,421.11	1,441.54	750.54	745.21	755.92
	F	Splines/OLS	1,320.25	1,319.16	1,321.34	692.32	691.75	692.89
	F	Splines/IR	1,381.74	1,381.28	1,382.21	724.56	724.32	724.81

Source: FGS - 2007 and Author's Calculations

[14] From the IMF webpage: Query on the World Economic Outlook Database, April 2008. Information available at: http://www.imf.org/external/pubs/ft/weo/2008/

Table A.9 Expected Monthly Income at Graduation. Public Universities

	Gender	*Method*	Y (COP thds)	95% Conf. Intervals		Y (USD)	95% Conf. Intervals	
Economics, Finance, Accounting and Business Administration	M	Mincer/OLS	1,392.78	1,385.43	1,400.17	730.35	726.50	734.23
	M	Mincer/IR	1,421.59	1,411.49	1,431.76	745.46	740.16	750.79
	M	Splines/OLS	1,280.34	1,279.28	1,281.39	671.39	670.84	671.94
	M	Splines/IR	1,361.44	1,361.02	1,361.87	713.92	713.70	714.14
	F	Mincer/OLS	1,233.63	1,227.12	1,240.17	646.90	643.48	650.33
	F	Mincer/IR	1,234.26	1,225.50	1,243.09	647.23	642.63	651.86
	F	Splines/OLS	1,139.88	1,138.94	1,140.82	597.74	597.24	598.23
	F	Splines/IR	1,194.64	1,194.29	1,194.99	626.45	626.27	626.64
Heatth Sciences	M	Mincer/OLS	1,439.13	1,431.53	1,446.77	754.66	750.67	758.67
	M	Mincer/IR	1,493.58	1,482.95	1,504.28	783.21	777.64	788.82
	M	Splines/OLS	1,326.31	1,325.22	1,327.41	695.50	694.92	696.07
	M	Splines/IR	1,415.16	1,414.64	1,415.69	742.09	741.81	742.36
	F	Mincer/OLS	1,274.69	1,267.96	1,281.45	668.42	664.90	671.97
	F	Mincer/IR	1,296.77	1,287.55	1,306.05	680.00	675.17	684.87
	F	Splines/OLS	1,180.81	1,179.84	1,181.79	619.20	618.69	619.71
	F	Splines/IR	1,241.78	1,241.35	1,242.21	651.17	650.94	651.40
Engineering	M	Mincer/OLS	1,473.56	1,465.78	1,481.38	772.71	768.63	776.81
	M	Mincer/IR	1,505.57	1,494.88	1,516.35	789.50	783.89	795.15
	M	Splines/OLS	1,364.64	1,363.52	1,365.77	715.60	715.01	716.19
	M	Splines/IR	1,447.37	1,446.94	1,447.80	758.98	758.75	759.20
	F	Mincer/OLS	1,305.18	1,298.29	1,312.10	684.41	680.80	688.04
	F	Mincer/IR	1,307.18	1,297.90	1,316.53	685.47	680.60	690.37
	F	Splines/OLS	1,214.94	1,213.94	1,215.94	637.09	636.57	637.62
	F	Splines/IR	1,270.04	1,269.66	1,270.41	665.99	665.79	666.18
Law	M	Mincer/OLS	1,510.64	1,502.66	1,518.66	792.15	787.97	796.36
	M	Mincer/IR	1,564.51	1,553.38	1,575.72	820.40	814.57	826.28
	M	Splines/OLS	1,402.73	1,401.58	1,403.89	735.57	734.96	736.18
	M	Splines/IR	1,483.71	1,483.12	1,484.30	778.03	777.72	778.34
	F	Mincer/OLS	1,338.02	1,330.95	1,345.12	701.64	697.93	705.36
	F	Mincer/IR	1,358.35	1,348.69	1,368.08	712.30	707.23	717.40
	F	Splines/OLS	1,248.85	1,247.82	1,249.88	654.88	654.34	655.42
	F	Splines/IR	1,301.93	1,301.43	1,302.43	682.71	682.45	682.97

Source: FGS - 2007 and Author's Calculations

A.5 Deriving a Mincerian Solution

Eq.(6.4), (6.7) and (6.8), link the Mincerian Earnings function -Eq.(6.7)- with the *PIV* of the graduates' lifetime earnings -Eq.(6.4)-. Graduates' *PIV* can be rewritten as:

$$PVI = e^{-is} \cdot Y_s \int_0^K e^{(h-i)t-g\cdot t^2} dt \,. \qquad \text{(A.4)}$$

Some algebraically manipulation will allow to reset the Eq.(A.1) into a known form of the Normal Cumulative Distribution Function (NCDF).

$$PVI = Y_s \cdot e^{-is} \cdot e^{\frac{(h'-i)^2}{4 \cdot g}} \cdot \left[\int_0^K e^{(h'-i)t - g \cdot t^2 - \frac{(h'-i)^2}{4 \cdot g}} dt \right], \qquad \text{(A.5)}^{15}$$

where $h' = h - 2 \cdot A_{gr} \cdot g$ and A_{gr} is age at graduation.

Defining μ and σ for the NCDF

$$\mu = \frac{h'-i}{2 \cdot g} \qquad \text{and} \qquad \sigma = \sqrt{\frac{1}{2 \cdot g}}. \qquad \text{(A.6)}$$

Rearranging arguments, adding 1 as $\frac{\sqrt{2\pi\sigma}}{\sqrt{2\pi\sigma}}$, and substituting Eq.(A.6) into Eq(A.5):

$$PVI = Y_s \cdot e^{-is} \cdot e^{\frac{1}{2} \cdot \left(\frac{\mu}{\sigma}\right)^2} \cdot \sqrt{2 \cdot \pi \cdot \sigma^2} \cdot \left[\frac{1}{\sqrt{2 \cdot \pi \cdot \sigma^2}} \cdot \int_0^K e^{\frac{-(t-\mu)}{2\sigma^2}} dt \right]. \qquad \text{(A.7)}$$

In Eq A.7, the term inside the squared brackets has the form of a NCDF and can be replaced by:

$$PVI = Y_s \cdot e^{-is} \cdot e^{\frac{1}{2} \cdot \left(\frac{\mu}{\sigma}\right)^2} \cdot \sqrt{2 \cdot \pi \cdot \sigma^2} \cdot \left[N\left(\frac{K-\mu}{\sigma}\right) - N\left(\frac{-\mu}{\sigma}\right) \right], \qquad \text{(A.8)}$$

replacing μ and σ defined in Eq.(A.6)

$$PVI = Y_s \cdot e^{-is} \cdot e^{\frac{(h'-i)^2}{4 \cdot g}} \cdot \sqrt{\frac{\pi}{g}} \cdot \left(N(a) - N(b)\right),$$

where $a = \sqrt{2 \cdot g} \cdot \left(K - \frac{h'-i}{2 \cdot g} \right)$ and $b = \left(- \frac{h'-i}{2 \cdot g} \right)$. This is Eq.(6.11).

[15] Transformation comes from a change that makes models looking at the potential experience compatible with those using age as the proxy for determinants of income growth:

$$\ln Y = \ln Y_0 + r \cdot s + h \cdot A - g \cdot A^2$$
$$\ln Y = \ln Y_0 + r \cdot s + h \cdot (A_{gr} + t) - g \cdot (A_{gr} + t)^2$$
$$\ln Y = \ln Y_0 + r \cdot s + h \cdot A_{gr} + h \cdot t - g \cdot A_{gr}^2 - 2 \cdot A_{gr} \cdot g \cdot t - g \cdot t^2$$
$$\ln Y = \ln Y_0 + r \cdot s + h \cdot A_{gr} - g \cdot A_{gr}^2 + (h - 2 \cdot A_{gr} \cdot g) \cdot t + g \cdot t^2$$