Capital Markets and Optimal Educational Policy[1]

Marisa Hidalgo-Hidalgo[2] Universidad de Alicante

Iñigo Iturbe-Ormaetxe[3] Universidad de Alicante

June 1, 2006

[1]Financial support from Spanish Ministry of Science and Technology (BEC2001-0535), Instituto Valenciano de Investigaciones Económicas, Generalitat Valenciana (Research Project No. GV01-371) and Fondo Social Europeo is gratefully acknowledged. **Address for correspondence:** María Luisa Hidalgo, Departamento de Fundamentos del Análisis Económico, Universidad de Alicante, Carretera de San Vicente, E-03071, Alicante, Spain. E-mail: marisahh@merlin.fae.ua.es

[2]I appreciate the comments on a previous version of this paper of participants at XXVII Simposio de Análisis Económico, VIIIth Spring Meeting of Young Economists, II Mediterranean Summer School, XVIII ASSET Meeting and 16th Annual EALE Conference. I also acknowledge Tinbergen Institute of Amsterdam for their hospitality.

[3]I thank Peter Hammond and the Department of Economics of Stanford University for their hospitality and acknowledge financial support for my stay from the Secretaría de Estado de Educación y Universidades (Spanish Ministry of Education, Science, and Sports) and from the University of Alicante.

Abstract

This paper analyzes two different educational policies. The first one consists on attaining an optimal division of public budget for education between two different educational levels, compulsory and post-compulsory or college education. The second one is the setting of the tuition fees. The objectives of the government with these policies are efficiency and increasing college excellence and college attendance. We show that if the government wants to increase both excellence and attendance it has to reduce the tuition cost. However, the effect that has a change in the share of public expenditure spent in higher education depends on the quality of capital markets. In some interesting cases, we show that, as the quality of capital markets increases, the government should spend a larger fraction of total expenditure on higher education if it wants to achieve efficiency.

JEL Classification: H52, I28, J24

Keywords: Human Capital, Educational Policy, Educational Levels, Tuition Cost, Capital Markets Imperfections.

1 Introduction

In most countries, public expenditure in education accounts for at least 80% of total expenditure in education.[1] Government intervention takes place at all different stages of education, from kindergarten to college education and on-the-job training. Today is under debate both the size of the overall public intervention and how this intervention should be targeted towards each one of the different education levels.

In most of the OECD countries there has been recently a tendency towards more limited public expenditure in education during the second half of the nineties.[2] Moreover, according to Heckman (2000; p.8):

"Also missing from current policy discussions of education and training policy is any consideration of priorities or recognition of the need to priorize. In an era of tight and limited government budgets, it is impractical to consider increases in investment programs for all persons. The real question is how to use the available funds wisely."

Heckman refers to the need to priorize between young and old, and between skilled and unskilled individuals. In this paper, however, we focus on a different dimension of public intervention which is how to prioritize between different educational levels. The main difference between his analysis and ours is that Heckman proposes different objectives (or population groups) mutually exclusive while the different levels of education, compulsory and post-compulsory education have a strong level of dependence since both are stages of the individuals' process of human capital accumulation.

In policy discussions regarding education, different levels of education are almost always considered separately, in the context of specific programs that affect them. In general, relatively little emphasis is placed on examining the performance of our education system as a whole. In one sense the general lack of attention is not surprising because these topics are frequently taken as entirely separated issues, research by different people. At the same time it is natural to think that there is some relationship between the different levels of education. Roughly speaking, the different levels of education can be divided into two groups: compulsory and post-compulsory (college) education. Of course there is a relationship, since both are pieces of the process of

[1] In particular, the average level for all OECD countries of the relative proportion of public expenditure on educational institutions for all levels of education accounted for 88,4 in 2000. See Education at a Glance 2001 for a more detailed analysis.

[2] For a more detailed analysis see Education at a Glance 2001.

generating productive investment in human capital.

The aim of our paper is to study public intervention in education when the government, taking into account that relationship, has to decide how to split optimally its budget between these two levels of education, and how this optimal split could be affected by the presence of borrowing constraints.

Several works within the Economics of Education have addressed public intervention in education but, most of them, restricted to one level of education in isolation, either compulsory or post-compulsory. For example, Hoxby (1996) and (2000) discusses the possible trade-offs between efficiency and equity in the different financing systems for compulsory education in the US. García-Peñalosa and Wälde (2000) compare the efficiency and equity effects of three different systems for financing higher education. Some exceptions are Lloyd-Ellis (2000), who studies the impacts of alternative allocations of public resources between basic and higher education on enrollments, income distribution and growth, and Blankenau at al (2005) who investigate its output and welfare implications.

Also, many authors have analyzed the relationship between borrowing constraints faced by individuals when investing in education and educational expenditure. There is still some disagreement about the importance of credit constraints in determining schooling outcomes. It has been widely accepted among economists that borrowing constraints and other capital market "imperfections" lead to under-investment in human capital (among others see, e.g., the seminal papers of Becker (1960); Schultz (1961); Friedman (1962); and more recently Kane (1994)).[3] On the other hand, Keane and Wolpin (2001) and Heckman (2000), argue that borrowing constraints cannot have much influence on college attendance decisions, given the existing level of subsidization.

Our model is a standard overlapping generations model similar to Razin and Sadka (1995 and 2002) in which each generation lives for two periods. In the first period of their lives, all individuals attend compulsory education at public schools and are not allowed to work. In the second period, individuals can either work the whole period

[3]There are, mainly, two arguments for this position. First, because education is not a tangible good, it cannot be used as collateral. Second, there is a positive probability of failure, and thus not repaying the loan, as the only possible security for the loan (the expected lifetime income of the individual) is a risky one and has inherent moral hazard associated with it.

as unskilled workers or they can spend some part of the period acquiring additional education at college and working the rest of the period as skilled workers. Individuals differ in two dimensions, income and innate ability to learn. The supply of each type of workers is endogenously determined. There are two types of workers, skilled and unskilled (high and low-education workers), who are imperfect substitutes.[4]

As we are interested in a normative theory, we need to define which are the objectives that the government pursues with its educational policy. This is obviously complicated, since it is clear that the government may have several different (and sometimes conflicting) objectives. At the outset, we assume that the government has three different objectives, and we will explore the effect of different policies in each one of them. These objectives are college excellence, college attendance and efficiency. College excellence is defined as the average level of ability among college students and it is a way of describing the quality of college students. By efficiency we mean that the government will try to maximize total output in the economy. The government has two different instruments to attain these objectives: tuition costs and the distribution of the budget between schools and college.[5]

Regarding the objective of increasing college excellence and college attendance we find that, independently of the quality of capital markets, the government will have to reduce the tuition cost. However, the change in the share of public expenditure on higher education depends on the quality of capital markets. In particular, if the quality of capital markets is low the government can either increase or reduce it, and if the quality of capital markets is high the government should reduce it.

The main results with respect to the objective of efficiency are as follows. We find that although college attendance increases, the impact of the reallocation of public expenditure from compulsory to post-compulsory education on aggregate labour income is, in general, quite ambiguous. On the one hand it reduces the proportion of unskilled workers and lowers their productivity. On the other hand it increases the proportion of skilled workers and may increase theirs productivity levels. However we find that under some reasonable assumptions total labour income is increasing with

[4]The two-skilled model is a convenient simplification, less realistic than a world with a continuum of skills with some level of complementarity.

[5]The standard definition of efficiency is related to the maximization of total output in the economy. See for example Stiglitz (1986) p.99.

tuition cost. We also show that, in some interesting cases, as the level of borrowing constraints in the economy diminishes, the government has to increase the share of investment in higher education in order to attain efficiency.

The paper is organized as follows. In section 2 we describe the economy. In section 3 we consider the objective of maximum college attendance and present a comparative static analysis on it. Section 4 analyzes the objective of efficiency under the policy of splitting the budget between compulsory and post-compulsory education. In section 4 we analyze the objective of efficiency under the policy of setting the tuition cost. Finally, section 5 concludes.

2 Model

2.1 Individuals

Our model is inspired in Razin and Sadka (1995 and 2002).[6] We consider an overlapping generations economy in which each generation lives for two periods. In the first period of their lives, all individuals (children) attend basic education at public schools and are not allowed to work. In the second period, all individuals have one unit of time. They can either dedicate the whole unit to work as unskilled workers or, alternatively, they can spend some fraction of the period acquiring additional education at a college, in which case they become skilled workers for the rest of the period.

Individuals differ in two dimensions, the amount of transfers they receive from their parents, y, and their cost of acquiring college education, a. This cost represents the fraction of the unit of time individuals have in the second period needed to complete college education. So we could think of those individuals with low a as high ability individuals. An individual, by investing a fraction a of her labour time in higher education becomes a skilled worker and works as such a fraction $1 - a$ of her labor time. We assume $0 \leq \underline{y} \leq y \leq \overline{y}$, $0 \leq a \leq 1$, and we denote their respective cumulative distribution functions by $F(y)$ and $G(a)$, and the respective density functions by $f(y)$ and $g(a)$. We assume both characteristics are independently

[6] Razin and Sadka (2002) deal with a different issue: the political-economy design of a social security system. Razin and Sadka (1995) analyze the effects of wage rigidity and investment in physical and human capital on the potential gains from migration.

distributed and both distributions are exogenous and time invariant. For the most part of the paper, we will focus on the case in which a follows a uniform distribution. In addition we assume that the transfers received from the parents can only be used to acquire education during the first part of the second period, whereas wages are used to consume through the rest of this final period.[7] There is no population growth and each cohort has size 1. A new cohort of individuals is born in every period.

We will concentrate on the steady state equilibrium. This allows us to skip all references to time which will simplify notation.

2.2 Educational Sector and the Government Budget

As we said above, there are two levels of education: basic education which is compulsory and college education, which is not. We assume that both levels are operated by the government. However, while compulsory or basic education is totally free for all individuals, this need not be the case for college education. The government can require college students to pay some tuition costs.

In each period the government has a fixed budget to spend on education and has to decide how to split the budget between basic education and college. To simplify matters we normalize the total budget to 1. We denote the shares allocated to basic and higher education by s_b and s_h. The government budget constraint is, therefore:

$$s_b + s_h = 1. \tag{1}$$

As basic schools obtain all their revenue from the public budget, their total revenue is s_b. If we call b per student expenditure we have $b = s_b$, since attendance at this level is compulsory and cohort size is one.

To attend college, we assume that each student has to pay some monetary cost $c \geq 0$. In addition colleges get transfers s_h from the government. Thus, if the proportion of individuals attending college is π, the level of expenditure that each student enjoys is equal to:

[7] Note that we do not consider a complete intergenerational transfer system as, for example, in Maoz and Moav (1999). They distinguish among different transfers received from parents depending on whether they are skilled or unskilled workers. We have chosen this framework to focus the analysis on the role of borrowing constraints on the optimal distribution of public expenditure in education.

$$\frac{s_h}{\pi} + c = h + c, \tag{2}$$

where h denotes the quality of higher education publicly provided. Note that although the government sets the value of c, it does not enter its budget constraint.

The government may have different objectives when deciding the optimal educational policy. In this paper, we will focus on college excellence and attendance levels and the objective of efficiency. In our set-up, efficiency means that the government tries to maximize total output in the economy (see Section 3 below).

2.3 Production of Human Capital

The level of human capital that a given individual has is determined by her education. If an individual has only basic education, which means that she enters the labor market as an unskilled worker, we assume that her human capital q_u is simply per capita educational expenditure at compulsory education, namely b $(= s_b)$. That is, we assume $q_u = b = s_b$. If an individual attends college, she becomes a skilled worker and her level of human capital q_s is per capita expenditure at compulsory education, plus the level of expenditure enjoyed at college. We have:

$$q_s(\pi) = b + h + c = s_b + \frac{s_h}{\pi} + c. \tag{3}$$

We write $q_s(\pi)$ to stress the fact that the human capital that a college graduate has depends negatively on the proportion of college students.

2.4 Production Technology and Labor Demand

Production occurs according to a constant-returns-to-scale technology represented by a production function similar to that of de Gregorio (1996) and Galor and Tsiddon (1997):

$$Y = F(K, L) = Lf(k), \tag{4}$$

where Y is aggregate output, K is aggregate capital, L is aggregate labor measured in efficiency units, and $k \equiv \frac{K}{L}$. The production function $f(k)$ has the standard properties needed to guarantee the existence of an interior solution to the producers' profit maximization problem. Producers operate in a perfectly competitive market. Then,

$$
\begin{aligned}
1 + r &= f'(k) && (5) \\
w &= f(k) - f'(k)k, && (6)
\end{aligned}
$$

where r is the rate of interest and w is the wage per efficiency unit of labor.

We take r as given at the world level $\bar{r}$. This assumption is often called "small open economy" in the literature (see Galor and Tsiddon (1997)). This implies that k is fixed at the level $f'^{-1}(\bar{r}) = \bar{k}$, and thus w is also fixed. We set $w \equiv 1$. Moreover we assume that there are two types of labor, skilled labor S and unskilled labor U. We also assume that the two types of labor are perfect substitutes in efficiency units of labor input.[8]

Each type of worker provides a number of efficiency units of labor per unit of labor time that is simply the per capita stock of human capital that she acquired through the different levels of education that she attended. Firms take into account the number of efficiency units of labor and, thus, the final wage paid by firms to skilled workers is:

$$w_s(\pi) = q_s(\pi), \tag{7}$$

and to unskilled workers:

$$w_u = q_u. \tag{8}$$

Note that we consider only the private returns to education, and we do not include the possible externalities created by human capital investments.[9]

[8] This simple framework that classifies workers into skilled and unskilled groups is commonly used in the literature of Labour Economics. See, for example, Acemoglu (2002).

[9] For example, low skilled workers could benefit from high skilled workers through a positive growth externality. The empirical evidence about human capital externalities is mixed, whereas some works find very large positive externalities (Rauch, J. (1993)), some others suggest that there are no significant external returns (Acemoglu and Angrist (2000)). If such an externality existed, the different policies implemented by the government should internalized it. Creedy (1995) examines the implications of externalities and provides an overview of the empirical evidence.

2.5 Labor Supply

The supply of skilled workers will be made up of those individuals who attended college and the supply of unskilled workers will be made up of those individuals who did not attend college. To derive these supplies, we need to study how individuals choose between college and not college. We assume that individuals maximize their consumption that is equal to lifetime income. If an individual with education cost a goes to college, her income will be $q_s(\pi)(1-a)-c$, since she will get the skilled wage $q_s(\pi)$ times the fraction of the second period that she works as a skilled worker $(1-a)$.[10] If an individual does not go to college, she works the whole period as unskilled worker, and her income will be q_u. Then, an individual with education cost a will attend college, provided that:

$$q_s(\pi)(1-a)-c \geq q_u. \tag{9}$$

This expression determines a cut-off level, $\widehat{a}$, such that only individuals with an education cost below that threshold will become educated. This is the value that satisfies Equation (9) with equality.

However, in order to attend college, a second condition must be satisfied. Individuals must be able to afford c. They have two sources of funding, their income y and a loan that they can get from a bank. We want to allow for imperfections in the capital markets. We model these imperfections in an extremely simple way: Any individual can borrow from a bank an amount γc, with $0 \leq \gamma \leq 1$. The parameter γ captures the "quality" of capital markets. This borrowing constraint, an exogenous feature of the model, is assumed to be the same across all individuals.[11] The two polar cases are $\gamma = 0$, which means complete impossibility of borrowing, and $\gamma = 1$ which means that capital markets are perfect. So, the higher is γ the better the capital markets are.

The condition that has to be satisfied at the beginning of the second period for those individuals who borrow from the bank is $y + \gamma c \geq c$ or:[12]

$$y \geq (1-\gamma)c. \tag{11}$$

[10] For simplicity we assume that individuals do not discount the future.

[11] Lochner and Monge-Naranjo (2002) in contrast, develop a framework with endogenous borrowing constraints. In their model, individuals of heterogeneous abilities or those making different schooling choices will face different borrowing constraints.

[12] At the end of the second period, an additional condition must be satisfied for those individuals

From Equation (11) we define $\widehat{y} = (1-\gamma)c$ as the minimum level of income needed to attend college. Note that, when $\gamma = 1$ or $c = 0$, this constraint is not binding for any individual. The proportion of students who can afford to pay for college will be the proportion of individuals whose income is above $\widehat{y}$, which is exactly $1 - F(\widehat{y})$. To simplify notation we will call $p(c, \gamma) = 1 - F(\widehat{y})$ and in the sequel, we will assume that the government will set a tuition cost c such that $p(c, \gamma) > 0$, which means that at least some individuals will always be able to afford to pay for college.[13]

As ability and income are independent, the proportion of individuals attending college will be the proportion of individuals whose income is above the threshold level $\widehat{y}$, times the proportion of individuals whose cost of acquiring education is below $\widehat{a}$. Then,

$$\pi = G(\widehat{a}) \times p(c, \gamma). \tag{12}$$

It is easy to see that an increase in s_h has always a positive effect on π, since it moves $\widehat{a}$ to the right.[14] We will analyze below how both the quality of capital markets and the tuition cost affect college attendance.

2.6 Equilibrium

For given values of the parameters, a steady state equilibrium is a value π^*, that is, a proportion of individuals attending college, such that when the skilled wage is $q_s(\pi^*)$, the proportion of individuals willing to attend college is exactly π^*.

We solve for an equilibrium in the following way. First, we fix a value of π. We call it $\widehat{\pi}$. Second, we compute the corresponding skilled wage $w_s(\widehat{\pi}) = q_s(\widehat{\pi})$. Using Equation (9), we obtain a cut-off value $\widehat{a}$ which, in turn, using Equation (12) determines the proportion of college students:

$$G(\widehat{a})(\widehat{p}(\gamma, c)) = \widehat{\pi}. \tag{13}$$

who borrowed from the bank:

$$q_s(\pi)(1 - a) \geq \gamma c. \tag{10}$$

This means that their second period income must be high enough to repay the loans. However, it is easy to see that this condition is implied by Condition (9).

[13]This is like saying that, even in the worst case where $\gamma = 0$, the richest individuals can afford college. In particular, this will be the case provided $c < \overline{y}$.

[14]Blankenau et al (2005) obtain a similar result.

If this proportion coincides with the initial value $\widehat{\pi}$, then it will be an equilibrium. To illustrate the equilibrium, suppose for a moment that for some value π^0 we get $q_s(\pi^0)$ such that Equation (14) induces a^0 such that the resulting proportion of college students from Equation (13) is $\pi^1 > \pi^0$. Thus, π^0 is not an equilibrium. That proportion of college students was "too low", which means that human capital per college student $q_s(\pi^0)$ is high and, as a consequence, too many individuals would be willing to attend college.

The next proposition shows that there is always some equilibrium proportion π^*.

Proposition 1 *Take any value of s_h. For all values of the parameters, there is always an equilibrium proportion π^*. Moreover, if $s_h > 0$ (resp. $s_h = 0$) then $\pi^* > 0$ (resp. $\pi^* = 0$).*

Proof. An equilibrium will be a cut-off level of ability a^*, such that:

$$q_s(\pi^*)(1 - a^*) = q_u + c, \tag{14}$$

where $\pi^* = G(a^*)p(c, \gamma)$. We substitute Equation (3) and the government budget constraint (1) into Equation (14) to get:

$$(1 + s_h(\frac{1}{(\pi^*)} - 1) + c)(1 - a^*) = c + 1 - s_h. \tag{15}$$

We simply need to prove that there is some value a^* satisfying this equation. Now the term in the left is a continuously decreasing function of a. When $s_h > 0$ it takes the value $+\infty$ when $a = 0$ and the value 0 when $a = 1$. As the term in the right is a positive constant both terms must cross at some point $a^* > 0$. As we assume $p(c, \gamma) > 0$, we get $\pi^* > 0$. See Figure 1. When $s_h = 0$, the term on the left and the term on the right coincide for $a = 0$, while for $a > 0$ the term on the left is always below the term on the right. This implies $a^* = 0$ and, thus, $\pi^* = 0$. ■

This equilibrium allocation is always Pareto efficient for all values of the parameters since, given the proportion of individuals attending college π^*, each individual in the economy has taken an optimal decision regarding the maximization of her lifetime income. Given π^*, it is not possible to make any individual better off without making some other individual worse off. Then, we have that for any level of investment in higher education s_h, there is a Pareto efficient allocation. Note that throughout the paper we are implicitly assuming that individuals are risk neutral and have identical utility functions that depend on their lifetime income, for skilled and unskilled workers: $V_s(\pi) = q_s(\pi)(1-a) - c$, and $V_u = q_u$. Therefore the equilibrium π^* is the solution to the problem: $Max\ V_s(\pi)\ s.t.\ V_u \geq \overline{V}$.

Next we present a simple example to illustrate the equilibrium of the model.

Example 1 *Suppose $a \sim U[0,1]$. Then, we can write Equation (15) as:*

$$(1 + s_h(\frac{1}{a^* p(c,\gamma)} - 1) + c)(1 - a^*) = c + 1 - s_h. \tag{16}$$

This expression is a quadratic equation whose solution is:

$$a^* = \frac{-s_h + \sqrt{s_h^2 + 4p(c,\gamma)s_h(1 - s_h + c)}}{2p(c,\gamma)(1 - s_h + c)}. \tag{17}$$

We also have $\pi^* = G(a^*)p(c,\gamma) = a^* p(c,\gamma)$.

3 On College Excellence and Attendance

One might think of higher education as positive for the individual and her wellbeing. In addition it is well known the significance of human capital accumulation for economic growth, and as a result there is much policy focus on promoting human capital formation (see, for example, PISA 2003 Report). In addition, by allocating more resources to higher education this may create "trickle-down effects" that can generate growth that is beneficial to all individuals.[15] Thus, it is crucial the extent to which the demand for higher education is affected by the education finance policies prevailing, as for example the level of investment in higher education, or the level of tuition costs.

However, one might also think that it is not the proportion or quantity of college students what really matters but their excellence or quality level.[16] In our model the quality of students is measured by their costs of getting an education. Then, in order to guarantee a high level of quality, we could be interested in preventing individuals

[15] This is a situation in which the poorest gradually benefit as a result of the increasing wealth of the richest. See Lloyd-Ellis (2000).

[16] This is specially true for developed countries with relatively high levels of college graduates. For that case there is no clear evidence regarding a positive relationship between investment in higher education and growth levels.

with high cost from attending college. In our model this could be done by lowering the threshold level a^* or, alternatively, by rising $1 - a^*$.

Suppose that initially, there is a given value of the parameters c and s_h and as a result there is a particular value of college excellence. Thus, we are going to analyze how college excellence might change if we move those parameters c and s_h. We can start by proving a very simple result that states that, for any quality level of capital markets γ, college excellence is a monotonically decreasing function of s_h. This is straightforward from Equation (15). The intuition for this result could be that, an increase in s_h rises the human capital of college students by $(\frac{1}{(\pi^*)} - 1)$ units, while the human capital of non-graduates decreases by one unit, making more attractive the first alternative. The individual who was exactly indifferent between attending college or not, now is strictly better off. However, we can show that it is crucial for the government to take into account the quality of capital markets when deciding the optimal tuition cost in order to pursue excellence. For a fixed level of a^* we can define an iso-excellence curve as the set of all possible combinations (c, s_h) that give rise to that value a^*. We are going to see that the sign of the slope of the iso-excellence curves plays a crucial role in determining the impact of the policies of the government.

The next Proposition shows that the slope of the iso-excellence curves depends on the quality of capital markets γ. We denote by $\widetilde{\gamma}$ a threshold value of quality of capital markets.

Proposition 2 *The slope of the iso-excellence curves depends on the quality of capital markets, γ. If $\gamma \leq (\geq)\widetilde{\gamma}$, the iso-excellence have negative (positive) slope.*

Proof. First note that the space we are considering here is (c, s_h). Thus, the slope of the iso-excellence curves is: $\frac{\partial s_h}{\partial c} = -\frac{\frac{\partial a^*}{\partial c}}{\frac{\partial a^*}{\partial s_h}}$. Since the denominator is always positive, we have that $\frac{\partial s_h}{\partial c} < 0$ if and only if $\frac{\partial a^*}{\partial c} > 0$. We compute now the derivative of $a^*$with respect to c. To obtain an expression for $\frac{\partial a^*}{\partial c}$ we rewrite Equation (15) as:

$$s_h(1 - a^*) = a^*(c + 1 - s_h)[G(a^*)p(c, \gamma)]. \tag{18}$$

From Equation (15) and the Implicit Function Theorem we have that:

$$\frac{\partial a^*}{\partial c} = \frac{G(a^*)a^*[f(\widehat{y})(1-\gamma)(c+1-s_h) - p(c,\gamma)]}{s_h + (c+1-s_h)p(c,\gamma)[a^*g(a^*) + G(a^*)])}. \tag{19}$$

This derivative will be positive if the following condition holds:

$$f(\widehat{y})(1-\gamma)(c+1-s_h) > p(c,\gamma). \tag{20}$$

The term in the left is a continuously decreasing function of γ (provided that the derivative of $f(\widehat{y})$ with respect to $\widehat{y}$ is close to cero). As the term in the right is increasing with γ then, both terms must cross for some γ that we denote by $\widetilde{\gamma}$. Thus it is clear that a^* is increasing (decreasing) with c if $\gamma \leq (\geq)\widetilde{\gamma}$. ■

In Figure 2 we illustrate this result. Thus we have shown that when the quality of capital markets is sufficiently high, an increase in c moves a^* to the left (i.e. it has a positive effect on excellence). The intuition is as follows. As c increases in one unit, everything equal, the cost of acquiring education increases in one unit, whereas the skilled wage increases in $(1-a^*)$ units. The restriction (9) is now binding for a higher proportion of individuals. The individual with ability a^* who was originally exactly indifferent between attending college or not, now is strictly worse off attending college, since an increase in the tuition cost reduces her lifetime income. Thus, an increase in c acts as an ability selection device, where only the most able individuals will be selected to attend college. However, when capital markets are imperfect, there are two additional effects. First, there are more people that cannot afford college. This is reflected in a reduction of the term $(1-F(\widehat{y}))$ which entails a reduction in π^*. But as π^* gets lower, it also happens that the quality of higher education (s_h/π) rises, which has a positive effect on a^* that can offset the first negative effect on a^* that we mentioned above. However as we showed the overall effect on the cut-off level of ability is positive, and thus college excellence diminishes as the government increases the tuition cost.

Finally we are interested in studying whether we can rise excellence while, at the same time, not affecting negatively college attendance, π^*. To study this issue we need first to analyze how college attendance changes with the different combinations of s_h and c. We know from section 2.6 above that an increase in s_h has always a positive effect on π^*. If we focus on the effect of a change in c it turns out that, although the effect of a rise in c on a^* depends on the quality of capital markets, an increase in the tuition cost has always a negative effect on π^*. If we compute the derivative of the equilibrium value of π with respect to c we get:

$$\frac{\partial \pi^*}{\partial c} = -G(a^*)f(\widehat{y})(1-\gamma) + g(a^*)p(c,\gamma)\frac{\partial a^*}{\partial c}. \tag{21}$$

This derivative will be negative if the following condition hold:

$$g(a^*)p(c,\gamma)\frac{\partial a^*}{\partial c} < G(a^*)f(\widehat{y})(1-\gamma). \tag{22}$$

Plugging Equation (19) into Equation (22) and rearranging terms, we get:

$$-a^*p(c,\gamma)^2 g(a^*) < f(\widehat{y})(1-\gamma)\left[s_h + (1-s_h+c)\left(\pi^*\right)\right], \tag{23}$$

which is always true, since the term in the left is negative and the term in the right is positive.

We can define now an "*iso-attendance*" curve as all possible combinations (s_h, c) that give rise to a constant level of college attendance $\overline{\pi}$. From Equation (12) and using the Implicit Function Theorem, we can get an expression for the slopes of the curves:

$$\frac{\partial s_h}{\partial c}\mid_{\pi=\overline{\pi}} = -\frac{\frac{\partial \pi^*}{\partial c}}{\frac{\partial \pi^*}{\partial s_h}}. \tag{24}$$

Since the numerator is negative and the denominator is positive, the "iso-attendance" curves have a positive slope. Moreover, in the space (c, s_h) the iso-attendance curves represent a higher value of the attendance levels as we move to the Northwest.

We can prove that, independently of the quality of the capital markets, if the government wants to increase both college excellence and college attendance it will have to reduce c. However, depending on the quality of the capital markets, the government can either increase or decrease s_h. We show this result in the following proposition:

Proposition 3 *Suppose that starting from a given combination (s_h, c) we want to increase both excellence and college attendance. To do this we have to reduce c, independently of the value of γ. However, the change needed in s_h depends on γ as follows:*

(i) If $\gamma < \widetilde{\gamma}$, the government can either increase or reduce s_h.

(ii) If $\gamma > \widetilde{\gamma}$, the government must reduce s_h.

Proof. Consider Figure 2 where we represent both the iso-excellence and the iso-attendance curves that go through point A. If $\gamma < \widetilde{\gamma}$ the iso-excellence curves have negative slope. To increase both π and $(1-a)$ we can either increase s_h (at the cost of not increasing that much excellence) or reduce it (at the cost of not increasing attendance that much). If $\gamma > \widetilde{\gamma}$ then both curves have positive slope. However, we can prove that the iso-excellence curve is flatter than the iso-attendance curve at any point in the space (s_h, c). To see this, note that if the iso-excellence curve is steeper we could increase both excellence and college attendance by rising both s_h and c. However, this cannot happen. As we move along the iso-attendance curve in this direction, we know that an increase in s_h has always a positive effect on a^* but then $(1 - a^*)$ must decrease, making impossible the case represented in Figure 2.b. Now, if the iso-excellence curve is flatter then the only way of increasing at the same time college excellence and college attendance is by reducing s_h and c. ■

On the one hand we find that, if a large fraction of the population is affected by borrowing constraints, the government should reduce c and either reduce or rise s_h in order to increase both college excellence and attendance. By reducing c the proportion of individuals who can afford college rises. If the government reduces s_h, the level of human capital of college students may decrease and thus, there will be a lower a^*. However, the net effect on college attendance is positive and, due to this reduction in a^*, there will be an increase in college excellence. If we rise s_h we have that the level of human capital of college students may increase (or at least not decrease) and thus, there will be an increase in a^* (or at least the same proportion as initially). Thus, the final effect on college attendance is clearly positive, whereas college excellence may not increase that much.

On the other hand we show that when γ is large, the government should decrease both s_h and c. Note that by reducing c there is an increase in $p(c, \gamma)$. As a result there will be an increase in college attendance. This, together with a reduction in s_h, implies that the level of human capital of college students will decrease and so a^*. Thus, the final effect on both college excellence and attendance is positive. This case is interesting because the situation where γ is large corresponds to what happens in the developed countries.

Finally, for given values of s_h and c, we want to see the effect of an increase in γ on both college excellence and attendance levels. The effect of an increase in γ on college attendance is not obvious since, as $\pi^* = G(a^*)p(c, \gamma)$ it has two opposite effects. First, there is a positive effect on the term $p(c, \gamma)$ which means that there are more individuals whose income satisfies Equation (11). Second, using Equation

(15) we see that there is a negative effect on the term $G(a^*)$, since the cut-off level of ability a^* moves to the left. When more people can afford a college education, public expenditure per college student gets lower, making college education less attractive. However, we can prove that the first effect is always greater than the second one, which means that the overall effect of an increase in γ on π^* is always positive.[17]

Proposition 4 *Suppose that $c > 0$. Then, an increase in γ has always a positive impact on college attendance.*

Proof. See Appendix. ■

It is also interesting the effect of γ on the composition of college students. As γ rises, there is an increase in college excellence, since the cut-off a^* is lower. Thus, there will be less individuals with high education cost attending college. Since, at the same time there is an increase in college attendance, the mean income level of college students will be, at least, lower than before the increase in γ.

4 On Maximizing Total Output

In this section we study how the government sets optimal education policies in order to maximize total output in the economy. From Equation (4) and the assumption of "small open economy" total output is the same than total labor income. We denote by W total labor income. We can decompose W into the sum of the wages of the skilled workers, W_s, and the wages of unskilled workers, W_u, as follows:

$$\begin{aligned} W(s_h, c, \gamma) &= W_s + W_u = \\ &= p(c,\gamma)q_s(\pi^*)\int_0^{a^*}(1-a)dG(a) + (1-\pi^*)q_u. \end{aligned} \tag{25}$$

[17]In the proposition above we assumed $c > 0$. When $c = 0$, a change in γ has no impact at all on attendance. This could be the case when the government subsidizes heavily higher education. While the result is an immediate consequence of the model (see Equations (36) and (38) in the Appendix), it is worth mentioning since it follows the lines of the last empirical works regarding the link between borrowing constraints and individuals' decision of college attendance. See for example Heckman (2000), where he claims that, due to the high level of subsidization of higher education in many Western countries, it seems that few individuals are refrained from attending higher education because of facing borrowing constraints.

All unskilled workers get the same income (q_u), while labor income of skilled workers depends on the cost of acquiring education a. This wage is $q_s(\pi^*)(1-a)$, since $(1-a)$ is the fraction of the second period that she will work. Thus W_s is the product of three elements. First, the term $p(c,\gamma)$ is the proportion of individuals that can afford a college education. Second, the human capital of every college graduate $q_s(\pi^*)$. Third, the term $\int_0^{a^*}(1-a)dG(a)$ represents total labor time of skilled workers.

In order to simplify the analysis and have a more tractable model, we will assume from now on that $a \sim U[0,1]$. Then:

$$W(s_h, c, \gamma) = p(c,\gamma)q_s(\pi^*)a^*\left(1-\frac{a^*}{2}\right) + (1-\pi^*)q_u, \tag{26}$$

where a^* as in Equation (17).

4.1 Some preliminary results

We start by analyzing the effect of c on total labor income. We decompose this effect into two parts: the effect on W_s and the effect on W_u. >From Equation (26) we compute:

$$\frac{\partial W}{\partial c} = \frac{\partial p}{\partial c}q_s a^*\left(1-\frac{a^*}{2}\right) + p(c,\gamma)\left(\frac{\partial q_s}{\partial c}a^*\left(1-\frac{a^*}{2}\right) - q_s(1-a^*)\frac{\partial a^*}{\partial c}\right) - \frac{\partial \pi^*}{\partial c}q_u. \tag{27}$$

The last term in the right-hand side represents the effect on W_u. This effect has a positive sign, since an increase in c entails no change in the human capital of unskilled workers and an increase in their numbers.

The effect on W_s is not that immediate. The first term is negative since there is a lower proportion of individuals who can afford college. The second term is positive as c increases the level of human capital of college students. To see this we use Equation (3) to get:

$$\frac{\partial q_s(\pi^*)}{\partial c} = 1 - \frac{s_h}{(a^*p(c,\gamma))^2}\frac{\partial \pi^*}{\partial c}, \tag{28}$$

and this expression is positive since we know from section above that $\frac{\partial \pi^*}{\partial c} \leq 0$. An increase in the tuition costs has a positive effect on the human capital of college graduates for two reasons. First, it directly increases it since their level of human capital is total expenditure (public plus private) per student. Second, as attendance reduces, per capita public expenditure in college increases and thus, their human capital also increases. Finally, from Equation (19) we know that the sign of the third term, i.e. the total labor time of skilled workers, depends on the quality of capital markets. Therefore, in general we do not know which will be the final effect on total labor income of skilled workers and, as a result, on total labor income of the economy, W. However, in the particular case of perfect capital markets, we can prove that labor income is always increasing in c.

Proposition 5 *Let $a \sim U[0,1]$. Then, under perfect capital markets, total labour income is always increasing with tuition cost.*

Proof. Using Equation (28), we have that now Equation (27) becomes:

$$\frac{\partial W}{\partial c} = \left(1 - \frac{s_h}{(a^*)^2}\frac{\partial a^*}{\partial c}\right) a^* \left(1 - \frac{a^*}{2}\right) + c\frac{\partial a^*}{\partial c}. \tag{29}$$

Rearranging terms:

$$\frac{\partial W}{\partial c} = a^* \left(1 - \frac{a^*}{2}\right) + \frac{\partial a^*}{\partial c}\left(\frac{-s_h - (1 - s_h + c)2a^* + 2c}{2}\right). \tag{30}$$

Using Equation (19) and rearranging again, we have:

$$\frac{\partial W}{\partial c} = a^* \left(1 - \frac{a^* c}{((1 - s_h + c)2a^* + s_h)}\right) > 0. \tag{31}$$

■

This result can be extended to cases where γ is high but lower than 1. We show in Proposition 4 that as c increases there is a tendency towards meritocracy. Only the most able individuals go to college, and from Equation (28) we see that those individuals end up with higher wages. There is also a growing proportion of unskilled workers whose wages do not change. Therefore, as tuition cost increases, total labor income increases too.

4.2 Splitting the Budget Optimally

In this section we analyze how the government should split its expenditure in education between the two educational levels, in order to maximize total labour income. Thus, we want to study the effect on W of a change in s_h, the amount that the government spends in higher education. Again, we decompose the effect of s_h on W into its effects on W_u and W_s.

The first thing to note is that W_u is always decreasing with s_h, since an increase in s_h induces a reduction both in the number of unskilled workers $(1-\pi^*)$ and in their wages.

With regard to W_s, the final effect is not immediate. The first term $p(c,\gamma)$, does not change with s_h, while the third term q_s is an increasing function of s_h, because a^* is an increasing function of s_h.

We have to study the effect of s_h on the second term, q_s. The first thing to note is that when $s_h = 0$, $q_s(\pi^*) = 1 + c$, while when $s_h = 1$, $q_s(\pi^*) = \frac{1}{\pi(s_h=1)} + c$. According to this, the value of s_h that maximizes $q_s(\pi^*)$ is always strictly positive because $\frac{1}{\pi(s_h=1)} > 1$. We denote by $\widetilde{s_h}$ the level of expenditure in higher education that maximizes the human capital of skilled workers. From Equations (4) and (17) it can be checked that $\widetilde{s_h}(c,\gamma) = \frac{c+1}{4p(c,\gamma)-1}$. Since $p(c,\gamma)$ is decreasing with c, $\widetilde{s_h}$ is increasing with c. We denote by c^* the tuition cost such that $p(c^*,\gamma) = 1/4$. We will assume that $c < c^*$ and thus $\widetilde{s_h}(c,\gamma)$ will be strictly positive.[18] In addition, the government will fully spend its budget in higher education, i.e. $\widetilde{s_h} = 1$ if the tuition cost is above c^+, where c^+ is such that $p(c^+,\gamma) = \frac{1}{2} + \frac{c^+}{4}$. It can also be checked that $c^+ < c^*$. If $c < c^+$ then, $\widetilde{s_h} < 1$. In addition it can be checked that is a decreasing function of the quality level of capital markets, γ. The intuition behind this result could be as follows. We know that an increase in γ induces an increase in the proportion of people who can afford college. If the government does not change s_h, the proportion of college students would rise and, as a result, q_s would be lower. Thus, and in order to avoid this last effect, the government reduces s_h since by doing this, it induces a reduction in the proportion of people willing to attend college $G(a^*)$ that can compensate the positive effect of an increase in γ.

We analyze now the value of s_h that maximizes total income of skilled workers, $W_s = p(c,\gamma)q_s(\pi^*)a^*\left(1-\frac{a^*}{2}\right)$. We denote by $\widehat{s_h}$ the value of s_h that maximizes it. It can be checked from the definition of W_s and Equation (17) that $\widehat{s_h} = \frac{2p(c,\gamma)(c+1)}{4p(c,\gamma)-1}$. Since $p(c,\gamma)$ is decreasing with c, it is clear that $\widehat{s_h}$ is increasing with c. The government will fully spend its budget in higher education, i.e. $\widehat{s_h} = 1$ if the tuition cost is above c^{++},

[18] Note that the proportion of people who is not credit constrainted from college attendance is, in most of countries, above 1/4.

where c^{++} is such that $p(c^{++},\gamma) = \frac{1}{2(1-c^{++})}$. It can also be checked that $c^{++} < c^{+}$. If $c < c^{++}$ then, $\widehat{s_h} < 1$. Additionally it can be checked that $\widehat{s_h} > \widetilde{s_h}$.[19]

Finally note that $\widehat{s_h}$ is also a decreasing function of γ:

$$\frac{\partial \widehat{s_h}}{\partial \gamma} = \frac{2(c+1)}{(4p(c,\gamma)-1)^2}\left(-\frac{\partial p}{\partial \gamma}\right) < 0. \tag{32}$$

The reason why the government should reduce s_h in order to maximize W_s as the quality of capital markets increases is related to the fact that $\widetilde{s_h}$ is also decreasing with the quality of capital markets. Note from the definition of W_s that as γ increases, the proportion of skilled workers increases too. But we already know that this has negative effect on their level of human capital. Thus, in order to have a more balanced combination between the proportion of skilled workers and their human capital, the government has to reduce the share of expenditure in higher education.

Now we want to find the value of s_h that maximizes the sum of W_s and W_u, that is, total labor income W. We denote it by s_h^*. Therefore, this value is characterized by the following First Order Condition:

$$\frac{\partial W_s(s_h^*)}{\partial s_h} + \frac{\partial W_u(s_h^*)}{\partial s_h} = 0. \tag{33}$$

The impact of the reallocation of public expenditure from basic to higher education on aggregate labour income is, in general, quite ambiguous. On the one hand it reduces the proportion of unskilled workers and lowers their productivity. On the other hand it increases the proportion of skilled workers and may increase their productivity levels.

As we want to do some exercises on Comparative Statics, we need to assume that the optimum is interior. As W_u is a decreasing function of s_h, this will always be the case provided that $\widehat{s_h} < 1$. Therefore we will assume that the level of tuition cost is below c^{++}. Moreover, from Equation (33) we will have that $s_h^* < \widehat{s_h}$.

[19] From the previous definition of W_s and $\widetilde{s_h}$ and since the total labor time of skilled workers is an strictly increasing function of s_h, we have that:

$$\frac{\partial W_s}{\partial s_h}\,|_{s_h=\widetilde{s_h}} = q_s(\pi^*(\widetilde{s_h}))\frac{\partial(a^*(1-\frac{a^*}{2}))}{\partial s_h}\,|_{s_h=\widetilde{s_h}} > 0$$

4.2.1 The Role of Borrowing Constraints

In this section we study which is the effect of an increase in the quality of capital markets on the optimal value s_h^*. Provided that the solution is interior, we can use the Implicit Function Theorem to see that:

$$\frac{\partial s_h^*}{\partial \gamma} = -\frac{\dfrac{\partial^2 W_s(s_h^*)}{\partial s_h \partial \gamma} + \dfrac{\partial^2 W_u(s_h^*)}{\partial s_h \partial \gamma}}{\dfrac{\partial^2 W_s(s_h^*)}{\partial s_h^2} + \dfrac{\partial^2 W_u(s_h^*)}{\partial s_h^2}}. \tag{34}$$

Provided that total labor income is a concave function of s_h, the sign of $\frac{\partial s_h^*}{\partial \gamma}$ will coincide with the sign of the numerator. However, we find that while the sign of $\frac{\partial^2 W_s(s_h^*)}{\partial s_h \partial \gamma}$ is negative, the sign of $\frac{\partial^2 W_u(s_h^*)}{\partial s_h \partial \gamma}$ is positive making difficult to derive any general conclusion regarding the sign of $\frac{\partial s_h^*}{\partial \gamma}$. What we do is to perform some simulation in order to highlight the sign of $\frac{\partial s_h^*}{\partial \gamma}$ in some interesting cases. In the next table we present the calculation of s_h^* for different combinations of γ and c. The main result we observe in the table is that as γ increases, the optimal value s_h^* increases as well. In a sense, it seems that the positive effect of γ on $\frac{\partial W_u(s_h^*)}{\partial s_h}$ is always stronger than the negative effect on $\frac{\partial W_s(s_h^*)}{\partial s_h}$. Figure 3 illustrates the effect of γ on total labor income as a function of s_h.

Thus, the numerator of Equation (34) is strictly positive and therefore it implies that γ has a positive effect on s_h^*. In the following table we show the results of several simulations of the model regarding s_h^* for different values of the tuition cost c.

$p \setminus c$	.1	.4	.7
.505	.0039	.0385	.0866
.7	.0046	.0549	.1260
.9	.0070	.0726	.1714

(35)

The intuition of the previous result could be as follows. First note that s_h^* is the share level such that the marginal productivity of both labor types, skilled and unskilled coincides. In addition, from the previous table observe that, in general, s_h^* is close to zero, and below s_h^s and s_h^u (see previous examples). It means that, an increase in γ implies an increase in the marginal productivity of skilled labor, and a decrease in the marginal productivity of unskilled labor (it becomes more negative).

Therefore, the government has to increase the share of investment in higher education s_h^*, since it implies a decrease in the marginal productivity of skilled labor and an increase in the marginal productivity of unskilled labor. Figure 3 illustrates the effect of γ on total labor income as a function of s_h.

5 Concluding remarks

In this paper we analyzed public intervention in education when the government, taking into account the relationship between the two main levels of education compulsory and post-compulsory, has to decide how to split optimally its budget between both levels and how this optimal split is affected by the presence of borrowing constraints. We also consider other possible objectives of the government, as the maximization of the proportion of individuals attending college and their excellence level. In addition we analyze the effect of others educational policies, in particular the setting of the tuition cost.

In the previous analysis we have considered two possible criteria that the government may have when undertaking its educational policy, efficiency and maximum college attendance. But we could also consider others criteria, among them, the Rawlsian one.

This criteria implies the maximization of the welfare of the individual with worse situation in the society. Thus, in our model this would imply to spend more on those individuals who will not attend college, and as a result will have lower wages. In spite of doing that, we could also consider another strategy that consists on investing all the resources in the more able individuals. This possibility is completely justified from an economic point of view in order to increase the income of the poor people. Thus, through spending more on the more able and establishing higher taxes to them, we can implement a redistributive policy.[8] However, most people think that higher education is a value, and thus, such a "transfers system" would lead to a mainly ignorant society. In addition, empirically it is not clear that the returns to education of more able students are always higher that the returns of the less able students.[9]

[8] This is the implicit proposal by Herrnstein and Murray (1994) when they establish that "...the elite of the more able will implement an expanding welfare state for the 'lower classes'...".

[9] Ashenfelter and Rouse (1999) estimate the returns to education for different ability groups. As a measure of the ability they propose the AFQT scores (Armed Forces Qualification Test). They find

Our model allows for some extensions. On the one hand we would like to design an optimal educational policy as a combination of both instruments, under a situation of continuously improvement of capital markets. On the other hand, it is also important to consider the role of private education in this context, and which could be the effects on our previous results. In addition to adding realism, incorporating this factor will be helpful for determining the optimal design of the public and private expenditure on education, as well as its effects on the efficiency, equity and college attendance.

It is well known that labor supply decisions are also influenced by taxation. In a world of certainty like ours, the basic result is that the impact of taxation on hours of work is indeterminate because of the conflict between the income and the substitution effects. Empirical studies show that estimated labor supply elasticities are very small (see the references in Eaton and Rosen (1980), Heckman (2000)). In addition, it is easy to see from Equation (9), that the optimal choice of whether attending college or not is independent of any proportional tax rate on income. The intuition behind this result arises from the fact that both investment costs (foregone earnings s_b, and tuition costs c) are tax deductible. If the tuition expenses were not deductible, a tax rate discourages human capital investment ($\hat{a}$ will decrease), because it lowers the returns to investment more than the costs. It is also the result with a progressive tax rate. In this situation, some individuals who decide to invest will switch to a marginal tax rate higher that the initial one at which their foregone earnings (in our model s_b) are deducted. However we have abstracted from the effects on taxation on labor supply decisions in order to focus on the distribution of a given budget for education and the optimal educational policy.

no evidence that the return to schooling differs significantly by the measured ability of the student.

A Appendix

Proof of Proposition 4:

Proof. We compute the derivative of the equilibrium value of π with respect to γ:

$$\frac{\partial \pi^*}{\partial \gamma} = G(a^*)f(\widehat{y})c + g(a^*)(1 - F(\widehat{y}))\frac{\partial a^*}{\partial \gamma}. \tag{36}$$

The first term is positive and stands for the effect due to the relaxation of the borrowing constraints. The second term is negative and it reflects the negative impact on a^*. We need to prove that, when $c > 0$, the first (positive) effect always offsets the second (negative) effect. This means that the following condition must hold:

$$G(a^*)f(\widehat{y})c > -g(a^*)\left[1 - F(\widehat{y})\right]\frac{\partial a^*}{\partial \gamma}. \tag{37}$$

From Equation (15) and using the Implicit Function Theorem we get:

$$\frac{\partial a^*}{\partial \gamma} = \frac{-a^*(1 - s_h + c)G(a^*)f(\widehat{y})c}{s_h + (1 - s_h + c)\left[(1 - F(\widehat{y}))a^*g(a^*) + \pi^*\right]}. \tag{38}$$

Plugging this value into Equation (37) and rearranging terms, we get:

$$1 > \frac{g(a^*)(1 - F(\widehat{y}))a^*(1 - s_h + c)}{s_h + (1 - s_h + c)\left[(1 - F(\widehat{y}))a^*g(a^*) + \pi^*\right]}, \tag{39}$$

which is always true, since the denominator of the term in the right is always greater than the numerator. ■

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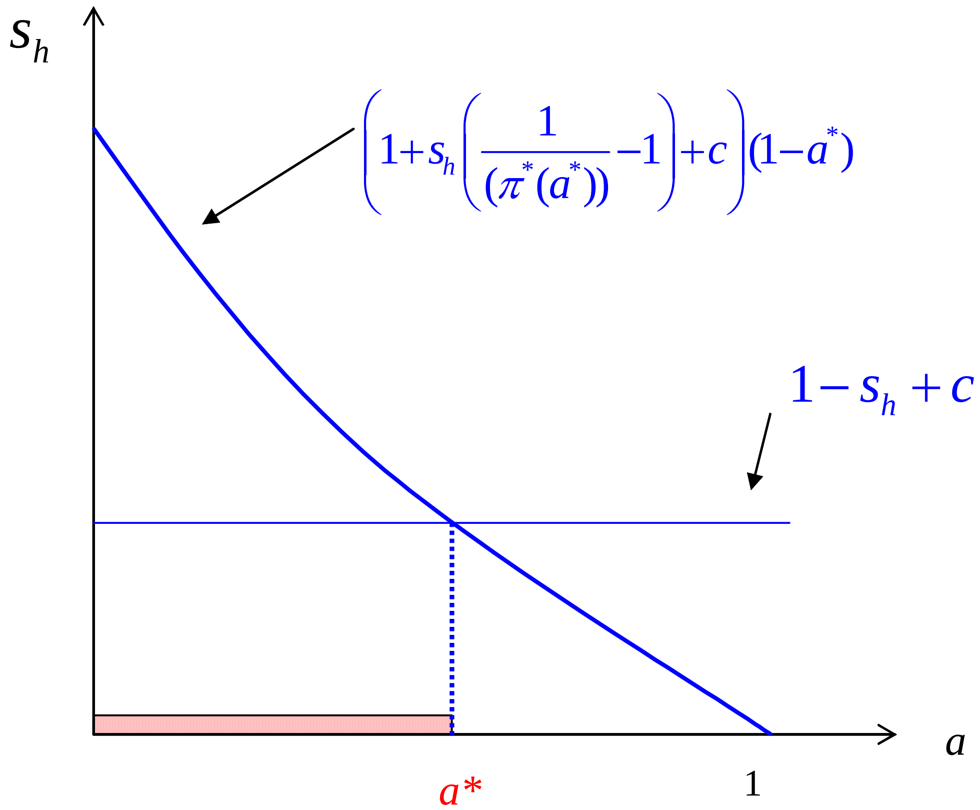

FIGURE 1: EQUILIBRIUM

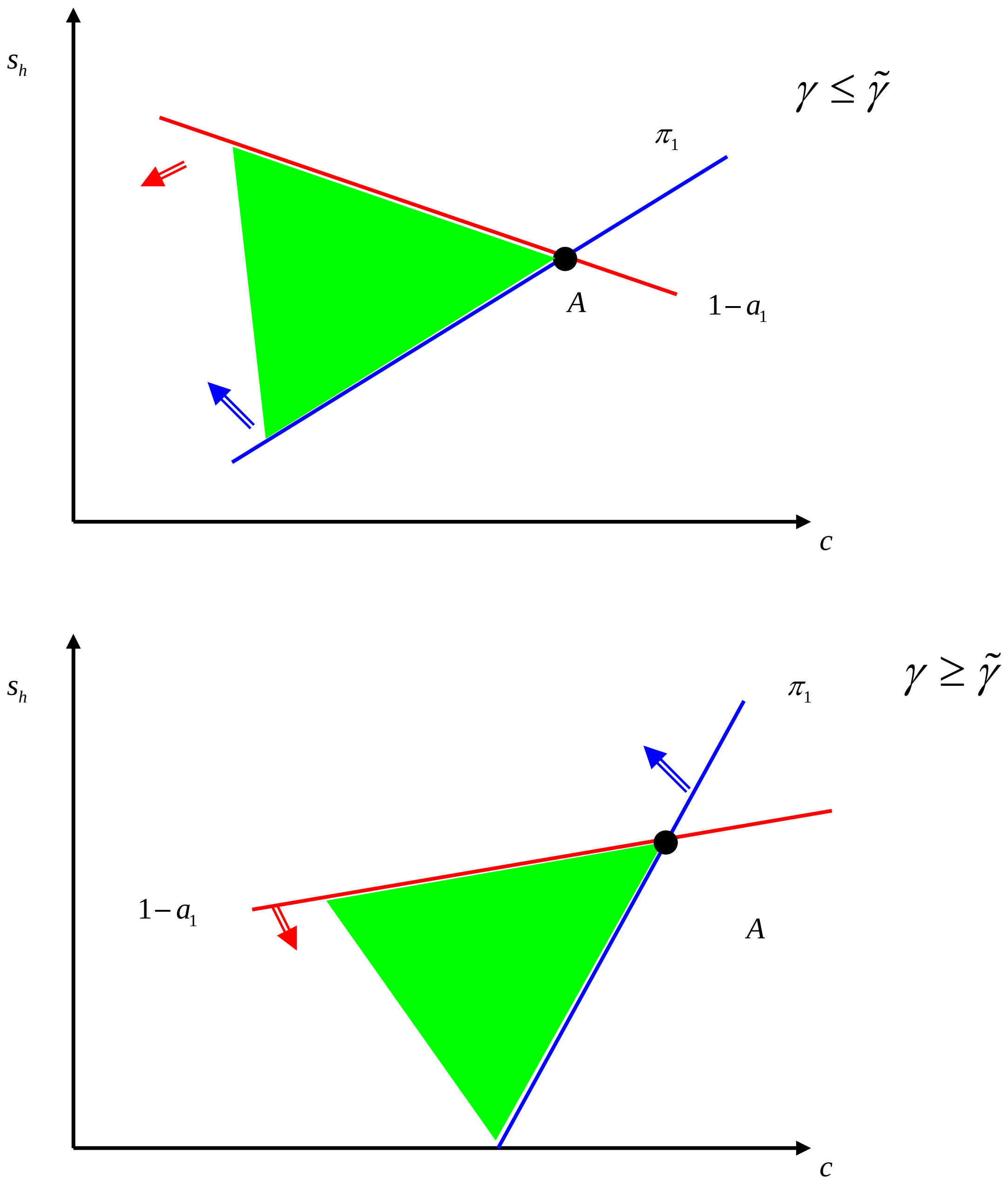

FIGURE 2: COLLEGE EXCELLENCE AND ATTENDANCE

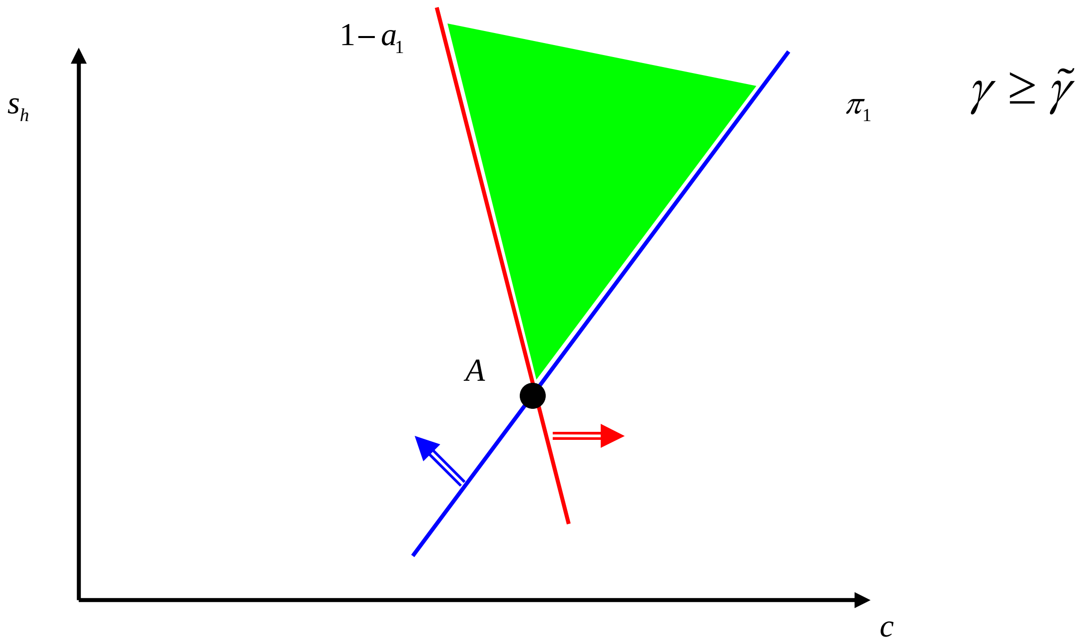

FIGURE 2b: COLLEGE EXCELLENCE AND COLLEGE ATTENDANCE

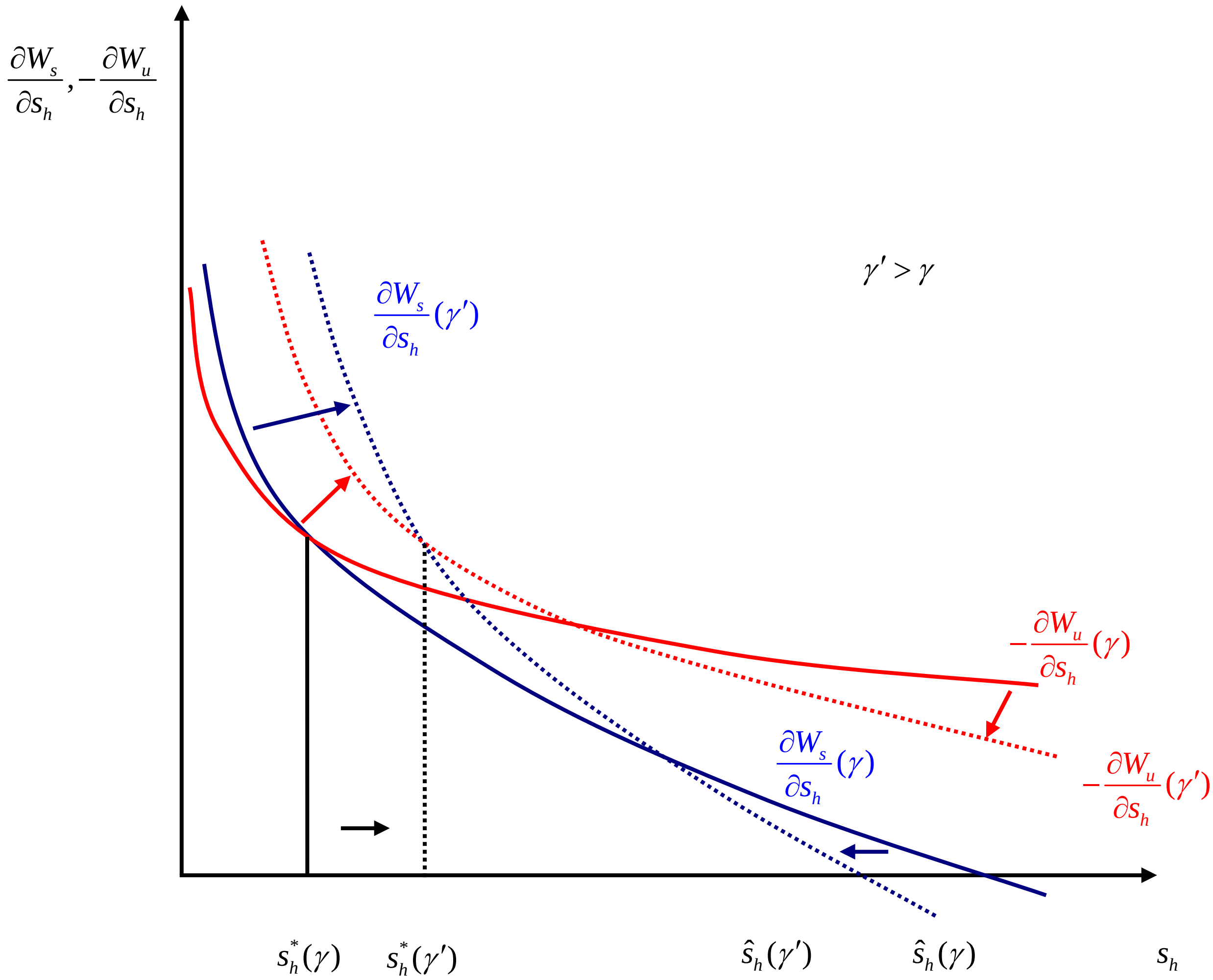

FIGURE 3: EFFECT OF γ ON s_h^*: THE UNIFORM CASE