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Abstract

Recent criticism from different sides has expressed the view that, with scarce resources, there is little justification for massive public funding of higher education. Central to the debate is the conjecture that colleges and universities use their resources inefficiently and focus insufficiently on their mission to expand students' human potential. Our aim in this paper is to examine the theoretical premises of this conjecture in a small open economy and uncover the conditions under which public investment in higher education is efficient and desirable. We analyze non-stationary equilibria of an OLG economy, characterized by perfect capital mobility, intergenerational transfers and a hierarchical education system. The government uses income tax revenues to finance basic education and support higher education that generates skilled labor. Given this, the following issues are considered: (a) the impact of education and international markets on the equilibrium number of low-skilled and skilled workers in each generation; (b) the economic efficiency of public subsidies to higher education in generating skilled human capital; (c) the endogenous support for a government's educational policies found in a political equilibrium.

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Keywords: hierarchical education, innate ability, capital mobility, education policy, low-skilled workers, skill formation.

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1. Introduction

Higher education is currently being criticized by scholars, politicians, and the popular press who demand that higher education institutions undertake reforms. The claim is that colleges and universities bear the financial costs of very costly bureaucracies and other non-academic activities while in many cases fail to achieve their core mission of increasing the skills and human potential of the individual student (see Hacker and Dreifus, 2010). These demands for value from higher education institutions have been triggered by ever rising tuition fees and shaky economic conditions. This is happening worldwide but is more pronounced in Western countries where governments plan to cut their contributions to higher education (see, e.g., UK, USA, the Netherlands and Israel). Since public resources are generally scarce, choices have to be made and the following questions are often raised: (i) What is the justification for public participation in funding higher education? (ii) For developing countries, should funding of higher education be a priority or, perhaps, should resources be used to upgrade the quality of compulsory schooling? The objective of this paper is to address these tradeoffs formally in an open-economy equilibrium framework.

Nowadays, educational policy can hardly be implemented without incorporating some relevant international aspects, even for decisions that are considered 'domestic' such as compulsory schooling. In most countries, especially for the developed ones, higher education generates a significant part of a country's stock of skilled labor. As a result, it affects the marginal returns to physical capital and channels the limited supply of foreign investments. Despite its importance there are very few studies that capture the way in which international market conditions directly influence governments' allocation of resources and individuals' decision-making regarding the acquisition of additional training and skills.

Balancing the government budget is an important constraint on education policy. This has been expressed by the popular view:

> "*If you want to have a new program, figure out a way to pay for it without raising taxes" US Senate Majority Leader H Reid*[1].

This quote stresses the importance of including both sides of the government balance sheet when the effects of new policies are examined. This issue is also confirmed by studies dealing with the empirics of growth which show that the growth effects of public education spending are generally mixed except when the method of finance is properly accounted for in which case they are clearly positive (see, e.g., Bassanini and Scarpenta, 2001; Blankenau *et al.*, 2007b).

Lastly, another important point is the net social benefits that accrue from public investments in higher education. The social costs of acquiring skills include expenses incurred by society that performs the education and training, necessary expenses by each individual to acquire skills, as well as the foregone income that would have been earned otherwise. Low-skilled workers are important contributors to the government budget since the tax revenues collected from their labor income are used to finance all parts of public education, though they do not directly benefit from these investments (see Garrat and Marshall, 1994; Fernandez and Rogerson, 1995; Gradstein and Justman, 1995; Bevia and Iturbe-Ormaetxe, 2002). The social benefits include higher earnings enjoyed directly by individuals as well as the indirect benefits that the economy derives from the human capital generated via the higher education system. The latter include, for example, a capacity to absorb new production technologies, a higher marginal return to physical capital which gives rise to inflows of foreign physical capital. Given this background, is a government funding policy, like a subsidy to **all individuals** who wish to attend higher education, going to lead to

[1] US Senator H. Reid on *Face the Nation*, CBS News Transcript, Nov 12, 2006.

a net social benefit? Other programs like poverty relief and improved basic education may generate a higher social value than investing in higher education (Johnson, 1984). Our paper studies 'efficient' education policies in small open economies.

Our analysis is carried out in an overlapping-generations model with heterogeneous agents and, starting from some initial conditions, computes and traces non-stationary competitive equilibria. Parents are altruistic in that they care about their offspring and derive utility from his/her lifetime income. Within this setting, the following issues will be analyzed in equilibrium: (*i*) the partition of the set of individuals between low-skilled and skilled workers in each generation; (*ii*) the evolving role of public subsidies to higher education on efficiency and the stock of human capital; (*iii*) the endogenous support for government educational policies generated within a political equilibrium.

Using a general process of hierarchical education and comparing dynamic equilibrium paths period by period, we obtain the following results: (*a*) Under certain conditions some public support in funding higher education will enhance the economy's human capital and growth; (*b*) Under certain conditions, society may be better off when no public funds are allocated to higher education; (*c*) The shape of the distribution of endowments of individuals matters for the allocation of public funds in a political equilibrium. In a society with a majority of low-skilled workers the median voter will oppose any public financing of higher education; (*d*) In equilibrium with a balanced budget, the marginal rate of substitution between expenditure on basic education and expenditure on higher education is larger than unity; (*e*) If an open economy is relatively more endowed with physical capital, then upon free capital mobility, outflows of physical capital will bring about an increase in the unskilled labor force.

Some features of our model have been analyzed before in other hierarchical education frameworks. Particularly, Driskill and Horowitz (2002) study the optimal investment in hierarchical human capital and find that the optimal program exhibits a non-monotonicity in human capital stocks. In Su (2004) the emphasis is on efficiency and income inequality in a hierarchical education system. She also studies the effects on growth of introducing subsidies to higher education (while total education budget assigned to basic and higher education is fixed). Su (2006) studies the endogenous allocation of the public budget when a top class has a dominant political power. Blankenau (2005) finds a critical level of expenditure above which higher education should be subsidized since its impact on growth is positive. Arcalean and Schiopu (2008) study the interaction between public and private spending in a two-stage education system. As in our framework, they observe that increased enrollment in tertiary education does not always imply higher economic growth.

The paper is organized as follows. Section 2 outlines the individual preferences, describes the multistage formation of human capital in an OLG economy and characterizes the non-stationary competitive equilibria. Section 3 studies the partition of the workforce into ’low-skilled’ and ’skilled’ workers and its dependency on education variables and international factor prices. Section 4 analyzes the implications of public funding of higher education for growth and for efficiency. Section 5 introduces a political equilibrium in our model and examines majority voting to allocate education tax revenues. Section 6 contains concluding remarks. The Appendix contains most of the proofs to facilitate the reading.

2. The Economic Framework and Dynamic Equilibrium

Our research strategy in this section is first to specify the lifetime preferences of agents in the economy and derive their optimal behaviour. Optimal decision variables are then aggregated to obtain variables like the economy's human capital and government budget balance. Subsequently, the competitive equilibrium is fully characterized.

Preferences and Hierarchical Education

Consider an overlapping generation economy with a continuum of consumers in each generation, each living for three periods. During the early stage each child is engaged in education/training, but takes no economic decisions. Individuals are economically active during the working period which is followed by the retirement period. At the beginning of the working period, each parent gives birth to one offspring, hence we assume no population growth. Each household is characterized by a family name $\omega \in [0,1]$ where $\Omega = [0,1]$ denotes the set of all families in each generation. We also denote by μ the Lebesgue measure on Ω.

Consider generation *t*, denoted G_t, which consists of all individuals ω born at the outset of date *t*, and let $h_{t+1}(\omega)$ be the human capital of ω at the beginning of the working period. We assume that $h_{t+1}(\omega)$ is achieved by a hierarchical production process of human capital like in Restuccia and Urrutia (2004): it consists of **fundamental** education (assumed to be compulsory) and **higher** education.[2] A child obtains his general skills from the compulsory basic education and acquires eventually specialized skills from higher education. Innate ability of an individual ω, denoted by $\tilde{\theta}_{t+1}(\omega)$, is assumed to be random and drawn (at birth) from a time-independent distribution. Namely, we assume that abilities are independent and identically distributed random variables across

[2] See also Su (2004), Blankenau and Camera (2006).

individuals in each generation and over time.

The human capital of individual ω in G_t, acquired by attending compulsory education, depends on parental inputs as well as school inputs, and it is assumed to be given by the following process:

(1) $$h_{1t+1}(\omega) = \tilde{\theta}_{t+1}(\omega) h_t^{\nu}(\omega) X_t^{\xi}$$

where $h_t(\omega)$ stands for parents' human capital and X_t represents public investment in early-life and compulsory schooling.[3] The above human capital formation process is a representation of the complex interaction between innate ability, family dynamics and public intervention. It stresses the key role played by the individual home environment that is specific to each ω via the individual parental human capital and the public resources invested in public education that are common to all. The elasticities ν and ξ represent the effectiveness of parents' human capital in their efforts towards educating their child, and the efficiency of public education in generating human capital respectively: ν is affected by home education and family background while ξ is affected by the schooling system, teachers, size of classes, facilities, neighborhood, etc.

Enrollment in higher education is costly and, in most countries, requires the payment of a tuition fee at each date *t*, denoted by z_t^* and assumed to satisfy: $z_t^* > 1$. We assume that the government may participate in the cost of higher education, and these subsidies are financed by taxing wage incomes of the working individuals. Denote by g_t the government (or public) allocation to each

[3] Researchers in a number of fields have showed that investments in care and education early in children's lives carry high individual and social rates of returns. The most recent evidence is reviewed in Cunha *et al*. (2006). It is therefore not surprising to see increases in pre-primary enrolments. In a number of OECD countries (The Czech Republic, Germany, New Zealand and Poland) annual expenditures per student are higher on pre-primary education than on primary education (OECD, 2009, Table B1.1a).

student wishing to attain additional skills via the higher education systems. Thus, $z_t(\omega) = z_t = z_t^* - g_t$ is the net payment that each individual pays at date *t* to access higher education.[4] Hence, the cost of higher education is the same for all students of the same generation. For simplicity, we assume that the tuition and public funding are denominated in dollars of the working period of the student (e.g., it can be financed by students loan), and, throughout our analysis, we take the education tax imposed on wage incomes constant at the rate τ.

We assume that acquiring higher education augments each individual's basic skills by some factor $B > 1$. Thus if individual ω invests money z_t^* and time to study in the tertiary education system, then his/her human capital accumulation process increases to the level:

(2) $$h_{t+1}(\omega) = Bh_{1t+1} = B\tilde{\theta}_{t+1}(\omega)h_t^{\nu}(\omega)X_t^{\xi}$$

He/she is then called a **skilled worker**. To simplify our analysis (without restricting the generality) we assume that *B* is time-independent. In contrast, if an agent ω does not enroll in higher education, his/her human capital is determined solely by compulsory schooling education, hence:

(3) $$h_{t+1}(\omega) = h_{1t+1}(\omega) = \tilde{\theta}_{t+1}(\omega)h_t^{\nu}(\omega)X_t^{\xi}$$

We call this agent a **low-skilled worker**. Instead of attending some higher education institute, following the basic education attained, a low-skilled agent works during part of his youth period using basic skills given in (3). We assume that all low-skilled individuals do work during a portion *m* ($0 \le m < 1$) of their youth period. Since they work fully at period $t+1$ as well, the lifetime after-tax

[4]Public funding provides only a share of investments in tertiary education. In 2006 the proportion of private funding of tertiary education ranged between 3.6% in Denmark and 83.9% in Chile (OECD, 2009, Table B3.2b). Different combinations of tuition fees and government subsidies in our model can reproduce the relative importance of private funding observed in the data.

wage income earned by a low-skilled worker ω is:

$$(1-\tau)h_{1t+1}(\omega)\left[mw_t(1+r_{t+1})+w_{t+1}\right]$$

where $(1+r_{t+1})$ is the return to capital at date *t+1*; w_t and w_{t+1} are the wage rates per unit of effective labor at date *t* and *t+1* respectively. In contrast, a skilled worker's after-tax lifetime wage earnings are:

$$(1-\tau)Bh_{1t+1}(\omega)w_{t+1}$$

There is little disagreement about the presence of intergenerational transfers (between parents and their children) in developed and developing countries. These transfers arise from altruistic motives of parents, regarding the well-being of their child, and are expressed in the various forms of investment in education that affect future earnings, and of tangible transfers like *inter vivos* gifts and bequests (see Viaene and Zilcha, 2002; Zilcha, 2003). In our framework, we assume that parents care about the future of their offspring and derive utility directly from the lifetime income of their child.[5] In particular, the lifetime preferences of each $\omega \in G_t$ are represented by the Cobb-Douglas utility function:

(A1) $$U_t(\omega)=\left(c_t^y(\omega)\right)^{\alpha_1}\left(c_t^o(\omega)\right)^{\alpha_2}\left(y_{t+1}(\omega)\right)^{\alpha_3}$$

(4) $$\alpha_1+\alpha_2+\alpha_3\le 1$$

Consumption when young and old is denoted by $c_t^y(\omega)$ and $c_t^o(\omega)$ respectively; $y_{t+1}(\omega)$ is the offspring's lifetime income. Intergenerational transfers that arise from the altruistic motives represented by (A1) take three forms. First, the earning capacity of the younger generation is enhanced by taxes parents pay to finance the education budget, and as a result to enhance their human capital level. Second, parents are

[5]Thus we depart from the dynastic model where the utility functions of all future generations enter this utility function.

willing to contribute to the tuition fees that allow access to higher education. Lastly, under the above preferences, parents are willing to transfer tangible assets directly as well.

Denote by $b_t(\omega)$ the transfer of physical capital by household $\omega \in G_t$ to his/her offspring. Given the return to capital and wages $\{r_t, w_t\}$, lifetime non-wage income of an offspring, whether skilled and low-skilled, is $(1+r_{t+1})b_t(\omega)$. Thus, lifetime income of a **low-skilled** worker (denoted by *l*) is:

(5) $$y^l_{t+1}(\omega) = (1-\tau)h_{t+1}(\omega)\left[mw_t(1+r_{t+1}) + w_{t+1}\right] + (1+r_{t+1})b_t(\omega)$$

If he/she is a **skilled** worker (denoted by *s*) then:

(6) $$y^s_{t+1}(\omega) = (1-\tau)h_{t+1}(\omega)w_{t+1} + (1+r_{t+1})b_t(\omega)$$

Given (2) and (3) it is straightforward to obtain the aggregate (or **mean** as well in our case) human capital H_t that is available to the economy at date *t*. Let A_t denote the subset of individuals in G_t who are **skilled** and let $\sim A_t$ be the complement of A_t, namely the set of low-skilled individuals. Hence:

(7) $$H_t = \int h_t(\omega)d\mu(\omega) + m\int_{\sim A_t} h_{t+1}(\omega)d\mu(\omega)$$

Therefore, government tax revenues are simply $\tau w_t H_t$ where H_t is defined in (7). On the other side of its balance sheet the government faces total education expenditure (in both stages). Denote by $\mu(A_t)$ the measure of skilled individuals who receive some public funding for higher education. Then the government budget constraint at date *t* is:

(8) $$\tau w_t[\int h_t(\omega)d\mu(\omega) + m\int_{\sim A_t} h_{t+1}(\omega)d\mu(\omega)] = X_t + g_t\mu(A_t)$$

We say that an **education policy** $\{(X_t, g_t)\}$ is **feasible** if at each date *t*: (a) given

X_t and g_t, the set of skilled A_t is determined by each individual's 'optimal choice' and (b) condition (8) holds in all periods *t*.

We consider a small open economy that, as of date $t=0$, is integrated into the rest of the world such that physical capital is internationally mobile while labor is kept internationally immobile. As a result, $\{r_t\}$ is equal to the foreign interest rate. Production is carried out by competitive firms that produce a single commodity which is both consumed and used as production input. Physical capital K_t (assumed to fully depreciate) and effective human capital H_t are inputs of a neo-classical production function that satisfies the standard conditions: it exhibits constant returns to scale; it is strictly increasing, concave, continuously differentiable and all inputs are required for production.

Competitive Equilibrium

Given K_0, H_0, education policy $\{(X_t, g_t)\}_{t=0}^{\infty}$, the international prices of capital and labor $\{r_t, w_t\}$, and the tax rate τ, each agent ω at time t with intergenerational transfers $b_{t-1}(\omega)$ chooses the level of *savings* $s_t(\omega)$ and *bequest* $b_t(\omega)$ together with the financial *investment in higher education* $z_t(\omega)$, so as to maximize:

(9) $$\text{Max} \quad U_t(\omega) = \left(c_t^y(\omega)\right)^{\alpha_1} \left(c_t^o(\omega)\right)^{\alpha_2} \left(y_{t+1}(\omega)\right)^{\alpha_3}$$

subject to constraints

(10) $$z_t(\omega) = 0 \quad \text{or} \quad z_t(\omega) = z_t^* - g_t$$

(11) $$c_t^y(\omega) = y_t(\omega) - s_t(\omega) - b_t(\omega) - z_t(\omega) \geq 0$$

(12) $$c_t^o(\omega) = (1 + r_{t+1}) s_t(\omega) \geq 0$$

where $y_t(\omega)$ and $y_{t+1}(\omega)$ are the corresponding incomes given either by (5) or (6), while $h_{t+1}(\omega)$ is defined either by (2) if $z_t(\omega)=0$, or by (3) if $z_t(\omega)=z_t^* - g_t$. Given K_0, H_0, $\{(c_t^y(\omega), c_t^o(\omega), s_t(\omega), b_t(\omega), z_t(\omega)); w_t, r_t\}_{t=0}^{\infty}$ is a **competitive equilibrium** if:

(i) For each date *t*, given factor prices (r_t, w_t) and public education policy $\{(X_t, g_t)\}_{t=0}^{\infty}$, the optimum under conditions (9)-(12) for household ω with bequest $b_{t-1}(\omega)$ is $(c_t^y(\omega), c_t^o(\omega), s_t(\omega), b_t(\omega), z_t(\omega)) \geq 0$.

(ii) Given the aggregate production function, the wage rate of effective labor w_t is determined by the marginal product of (effective) human capital.

(iii) The education policy $\{(X_t, g_t)\}_{t=0}^{\infty}$ is **feasible,** hence the government budget constraint in (8) holds at each date *t*.

After substituting all constraints, first order conditions that lead to the necessary and sufficient conditions for an optimum are (assuming interior solutions):

(13)
$$\frac{c_t^y(\omega)}{y_{t+1}(\omega)} = \frac{\alpha_1}{\alpha_3}\frac{1}{(1+r_{t+1})}$$

(14)
$$\frac{c_t^y(\omega)}{c_t^o(\omega)} = \frac{\alpha_1}{\alpha_2}\frac{1}{(1+r_{t+1})}$$

From (12), (13) and (14):

(15)
$$y_{t+1}(\omega) = \frac{\alpha_3}{\alpha_2}(1+r_{t+1})s_t(\omega)$$

Using (15) and the definitions of income in (5) and (6), we obtain the expression for bequest if the offspring turns out to become low skilled:

(16)
$$b_t(\omega) = \frac{\alpha_3}{\alpha_2}s_t(\omega) - \frac{(1-\tau)\left[mw_t(1+r_{t+1}) + w_{t+1}\right]}{(1+r_{t+1})}h_{t+1}(\omega) \geq 0$$

Likewise for a skilled offspring:

(17) $$b_t(\omega) = \frac{\alpha_3}{\alpha_2} s_t(\omega) - \frac{(1-\tau)w_{t+1}}{(1+r_{t+1})} h_{t+1}(\omega) \geq 0$$

As noted in (16) and (17), we assume that intergenerational transfers are unidirectional and therefore cannot take negative values in equilibrium. Comparing (16) to (17), it is clear that the incidence of *m*, other things equal, decreases the transfer of tangible assets across generations. Also, due to free capital mobility, both intergenerational transfers are affected by international market conditions. The reason is that when altruistic rational parents make forward-looking decisions regarding direct financial transfers and/or investment in attaining skills, they actually compare the return to physical capital with the return to human capital. Thus, in such considerations they take into account the interest rate and the future wage rate respectively.

3. Equilibrium Sets of Skilled and Low-Skilled Workers

The government budget sheet in (8) records the tax contributions made by workers and the public financial support that students in higher education receive while acquiring skills. In (8) both student types are represented by $\sim A_t$ and $\mu(A_t)$ and in order to maintain government budget balance throughout our analysis, it is the important task of this section to determine both sets explicitly.

Reduced-form Lifetime Preferences

From the first order conditions (13) and (14) we obtain $C_t^y(\omega) = (\alpha_1/\alpha_2)\, y_{t+1}(\omega)/(1+r_{t+1})$ and $C_t^0 = (\alpha_2/\alpha_3)\, y_{t+1}(\omega)$. After inserting these expressions into (9) the utility function has the following reduced-form:

(18) $$U_t(\omega) = \Phi\left(\frac{1}{1+r_{t+1}}\right)^{\alpha_1} \left[y_{t+1}(\omega)\right]^{\alpha_1+\alpha_2+\alpha_3}$$

where parameter Φ is a constant independent of time and independent of ω. Therefore (18) is an expression for utility that holds for both skilled and low-skilled offspring. The reduced form utility of parents is now proportional to the lifetime income of their offspring where the term of proportionality is decreasing in the world interest factor at the future date. Thus, if education resources are allocated by a utilitarian social planner that maximizes the current aggregate of individual utilities, it maximizes at the same time next generation's aggregate income. Lastly, whether parents invest in higher education of their child depends very much on their own utility, which entails comparison of future lifetime income of their child.

Table 1: Cross-Country Variation of the Skilled Work Force[a,b]

OECD Countries	*Age Group 25-64 with at least Upper Secondary Education*	*Partner Countries*	*Age Group 25-64 with at least Upper Secondary Education*
Italy	52	*Brazil*	37
Korea	78	*Chile*	50
Mexico	33	*Estonia*	89
Netherlands	73	*Israel*	80
Portugal	27	*Russian Fed*	88
Turkey	29	*Slovenia*	82

Notes: (a) The skilled workforce is approximated by the percentage of the population of age group 25-64 with at least upper secondary education; (b) In percentage, in 2007.
Source: OECD (2009, Table A1.2A, column 1)

Education Decision

Making use of (18), the next result defines the proportion of the population that will receive higher education and become skilled. It sheds some light into the observed cross-country variations in the skill composition of workforces in both developed and developing countries. For example, data in Table 1 show the skill composition of workforces for a subset of OECD countries and for OECD's partner countries. The extent of a skilled workforce is approximated by the share of age group 25-64 with at least upper secondary education. Shares in 2007 vary largely, between 27 percent in Portugal and 89 percent in Estonia.

Define $Z_{t+1}(\omega) = \tilde{\theta}_{t+1}(\omega) h_t(\omega)^{\nu}$ and call it *the initial endowment* of ω. It is the product of both ability and parental human capital and describes the background a young individual inherits prior to any education. The distribution function of $Z_{t+1}(\omega)$ over the continuum of agents has a complex derivation from the underlying variables. On the other hand, it plays an important role in our analysis due to its impact on the decision to attend higher education or not. Given this, the next proposition defines the set of students that will attend higher education:

Proposition 1: *Let A_t denotes the set of individuals who choose to invest in higher education at date t. Then: (a) A_t is nonempty if and only if the following condition holds:*

(19) $$\frac{w_{t+1}}{1+r_{t+1}} \geq \frac{m}{B-1} w_t$$

(b) Assume that condition (19) holds. Define

$$\Lambda_t = \frac{1}{1-\tau}\left[\frac{1}{(B-1)\frac{w_{t+1}}{1+r_{t+1}} - m w_t}\right]\left(\frac{z^* - g_t}{X_t^{\xi}}\right). \text{ Then:}$$

(20) $$A_t = \{\omega \mid Z_{t+1}(\omega) \geq \Lambda_t\}$$

Namely, all individuals with initial endowments above Λ_t become skilled workers.

The proof is included in the Appendix. Λ_t is a threshold that partitions the distribution function of $Z_{t+1}(\omega)$. Under the assumption that (19) holds, all $\omega \in G_{t+1}$ with an initial endowment above Λ_t will invest in higher education and become skilled whereas the other individuals with an initial endowment below Λ_t will not invest and, hence, become unskilled.[6] Conditions (19) and (20) depend on exogenous factor prices and, to stress their importance, let us consider the extreme scenario of **full public funding** of higher education, namely, $\hat{g}_t = z_t^*$ for all *t*. In this case, $z_t = 0$ and from (20) we obtain that all individuals ω invest in higher education given that condition (19) holds at all dates. Thus under full public funding inequality (19) implies that **all young individuals** become skilled, regardless of their initial endowments! Clearly, if the inequality in (19) is reversed **all individuals** will become low-skilled. This is possible when *B* is close to 1, meaning that attending higher education makes a small contribution to the human capital of students. Thus exogenous factor prices play an important role in the formation of types of workers. Since our analysis is relevant when the higher educational system is operative, to guarantee that skilled individuals exist in each generation, we assume:

(A2) *Given the exogenous wages and interest rates, the economy's parameters m and B, condition (19) holds at all dates t , t=0, 1, 2, …..*

Some monotonicity results that can be verified from condition (20) are reported in Table 2 and should be interpreted as follows. Suppose that at date *t* an increase occurs in one of the model parameters of the first row, then the sign of the comparative statics of this change on either Λ_t or A_t is given in each relevant cell.

Table 2: Monotonicity Results for Λ_t and A_t

	$w_{t+1}/(1+r_{t+1})$	w_t	X_t	z_t	g_t	τ	B	m	ξ
Λ_t	-	+	-	+	-	+	-	+	-
A_t	+	-	+	-	+	-	+	-	+

[6]Eicher (1996) models also a partition of the labor force between skilled and unskilled workers but it is individuals who make their own occupation choice based on the respective career paths as skilled or unskilled.

Importantly, the signs of Table 2 give rise to a number of remarks.[7] Proposition 1 deals with individual decision-making with no consideration for notions of equilibrium. Hence, X_t and g_t enter threshold Λ_t directly with no acknowledgement of budget balance. Table 2 reveals also some insights as to how globalization affects the process of skill formation. Upon capital market integration, physical capital flows from the low-return to the high-return country. Once the small open economy removes all capital controls physical capital will flow in if the economy is relatively less endowed in physical capital. As the marginal return decreases to the world interest rate the economy will experience an expansion of its skilled workforce. In contrast if the open economy has initially high levels of capital then capital market integration will bring about an increase in its unskilled workforce. Summarizing:

Corollary 1: *Under the above assumptions, we obtain in equilibrium that: a higher wage-rental ratio* $w_{t+1}/(1+r_{t+1})$ *at date t+1 expands the set of* ***skilled*** *agents at that date, while a lower wage-rental ratio enlarges the set of* ***low-skilled*** *labor.* [8]

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[7]The allocation of individuals at generation t between the groups of skilled and low-skilled workers does not depend on the intensity of altruism α_3 . Likewise, the stock of human capital H_t is independent of the altruism parameter. Thus, in our model the intensity of altruism does not affect growth, as long as $\alpha_3 > 0$. This result is in contrast to the result obtained in dynastic models like that of Armellini and Basu (2009).

[8]There is a long-standing debate in the empirical literature regarding the effects of international markets on wages and the size of the unskilled workforce. Some empirical studies have shown that international trade accounts for the rising income inequality somewhere between 0 and 20 percent. Hence, globalization has been a small contributor to growing wage inequalities in trading nations (see, e.g. Greenaway and Nelson, 2000; Winchester, 2008). Our result in Corollary 1 takes a different approach to the decisions of young individuals whether to acquire skills (beyond the compulsory education) or not and proposes a different explanation to the size of the low-skilled workforce: the decision is made by altruistic rational parents who give significant weight to the ability of their child, the family background and the foregone income due to the time spent acquiring higher education. Given their altruistic preferences, they decide whether to invest in their child's higher education or, perhaps, let him/her start working right after compulsory schooling and, hence, become a low-skilled worker.

Table 3: Estimates of Parameter $m^{a,b}$

OECD Countries	*Ending Age of Compulsory Schooling*	*m*	*Partner Countries*	*Ending Age of Compulsory Schooling*	*m*
Italy	15	0.375	*Brazil*	14	0.417
Korea	14	0.417	*Chile*	18	0.250
Mexico	15	0.375	*Estonia*	15	0.375
Netherlands	18	0.250	*Israel*	15	0.375
Portugal	14	0.417	*Russian Fed*	15	0.375
Turkey	14	0.417	*Slovenia*	14	0.417

Notes: (a) Parameter *m* is computed as the difference between 24 (the average graduation age) and the ending age of compulsory schooling divided by 24 (the number of years in the first generation); (b) In 2006, with no change in 2007.
Source: Authors' own computations and OECD (2009, Table C1.1).

Table 2 identifies other model parameters that affect importantly the set of skilled workers A_t. Among these, parameter *m* stands out since together with w_t it represents lost earnings while studying and captures therefore the opportunity cost of higher education. Table 3 provides estimates of the maximum value of *m* as the difference between the average graduation date and the ending age of compulsory schooling relative to the number of years in a generation. Taking the ending age of compulsory schooling of Table 3 and assuming further that the average graduation age is 24, while the first generation is 24 years long, we obtain estimates of *m* in Table 3. As parameter *m* is inversely related to the ending age of compulsory schooling it is determined largely by institutions. Data reveal large cross-country differences in the opportunity cost of higher education.

Economy's Human Capital

Finally, from the analysis thus far, another important question arises: is it always true that an expansion of the set of skilled workers leads to a higher stock of human capital that is available for production activities? It all depends on the causes of this expansion since variables and parameters of the model have a different status. For example, w_t, m, τ, g_t, X_t interfere directly with the government budget balance while the wage-rental ratio ($w_{t+1} / 1 + r_{t+1}$) and technology parameters (B , ξ) are exogenous to budget balance. The next proposition applies only to the latter predetermined variables and to fix ideas let us make the following assumption linking parameters *B* and *m:*

(A3) *B > 1+m holds.*

Proposition 2: *Under the condition assumed in (A3), output declines at the current date t but expands in **all** subsequent periods $t+k,\ k \geq 1$, in **each** of the following two cases taking place at date t: (a) An unexpected increase in the wage-rental ratio; (b) A technological progress in the education sector (higher B or higher ξ).*

The proof is based on the result of Corollary 1 and on the next lemma.

Lemma 1: *Under the condition assumed in (A3), expanding the set A_t at date t results in a lower H_t but a higher H_{t+k}* for all $k \geq 1$.

It is important to note that *(A3),* the sufficient condition for Proposition 2 and Lemma 1, is empirically verifiable. Parameter *B* has two separate meanings in the model. A first interpretation is that *B* represents the productivity of higher education since it scales up the qualification of students. Alternatively, it represents the education wage gap between a skilled worker with a college degree relative to that of a low-skilled worker with high school and less. Using the information on *m* from Table 2, a testable hypothesis is to verify whether the education wage gap of any country exceeds the country-specific lower bound (1+*m*) and observe whether this condition is more easily satisfied for countries at different stages of economic development.[9]

[9] See Hotchkiss and Shiferaw (2011) and the references therein for measurement and estimation methodologies of the education wage gap.

A puzzling outcome of Lemma 1 is that expanding the set A_t at date t results in a lower H_t. Suppose the cause of the increase in A_t is a technological improvement in primary education (a higher ξ). Some individuals who were planning initially to be low skilled now decide to study longer and therefore leave the ranks of low-skilled workers. The stock of human capital available for production H_t decreases in period t and the economy that observes also an outflow of physical capital faces a decline of output at the current date t as in Proposition 2.

4. The Value of Public Funding of Higher Education

Having described the sets of low- and high-skilled workers, we now turn to the main issue of our study, namely what is the role of a government in enhancing higher education? We shall investigate the conditions under which increasing public funding will enhance the formation of skilled workers and the resulting effects on economic growth and efficiency. This section will begin with the impact of public funding of higher education on the aggregate stock of human capital. We shall analyze the impact at date t first and then focus on the dynamic process and efficiency issues.

Impact Effects

On the expenditure side of its balance sheet the government faces public expenditure in higher education equal to $\mu(A_t)g_t$. Enrollment in higher education is costly and requires a net payment from private sources equal to $\mu(A_t)z_t^* - \mu(A_t)g_t$. Therefore, $(1-g_t/z_t^*)$ represents the **share of private investment** in total expenditure on higher education. A decision by schools to charge a higher tuition fee z_t^* increases this share while a larger public support will decrease it. Data in Table 4 reveal that in tertiary education the proportion of costs funded privately varies widely across our sample of countries. In Chile and Korea for example, public funding represents only a small part of investments in tertiary education. In contrast, approximately 73 percent of expenditure on higher education is public in the Netherlands. These stylized facts show that countries differ in their reliance on the government to fund advanced education.

Table 4: Private Funding of Tertiary Education [a,b,c]

OECD Countries	*Private Funding* $1-g_t/z_t^*$	*Partner Countries*	*Private Funding* $1-g_t/z_t^*$
Italy	27.0	*Brazil*	-
Korea	76.9	*Chile*	83.9
Mexico	32.1	*Estonia*	26.9
Netherlands	26.6	*Israel*	49.9
Portugal	32.3	*Russian Fed*	-
Turkey	-	*Slovenia*	33.1

Notes: (a) Private funding of tertiary education as a percentage of total tertiary expenditure; (b) In 2006; (c) "-" indicates not available.
Source: OECD (2009, Table B3.2b)

It is crucial to be more precise regarding the response of the **threshold parameter** Λ_t (defined in Proposition 1) to public funding, noting that the government budget must be balanced in equilibrium. For that, it is important to obtain the response of $(z_t^* - g_t)/X_t^{\xi}$ to this subsidy. The left-hand side of (8) is simply $\tau w_t H_t$, a useful shorthand expression for government tax revenues. Denote by γ_t, $0 \le \gamma_t \le 1$, the **fraction** of government revenues at date *t* **allocated to compulsory schooling.** Then:

(21) $$X_t = \gamma_t \tau w_t H_t$$

(22) $$g_t \mu(A_t) = (1-\gamma_t)\tau w_t H_t$$

With $\gamma_t = 1$, public funding of higher education is zero ($g_t = 0$) and tertiary education is fully privately financed. With $g_t = z_t^*$, higher education is fully publicly financed. Using the above equations:

(23) $$\frac{(z_t^* - g_t)}{X_t^{\xi}} = \frac{z_t^* - (1-\gamma_t)\tau w_t H_t / \mu(A_t)}{(\tau\gamma_t w_t H_t)^{\xi}}$$

To obtain the effect of higher expenditure in compulsory schooling in equilibrium, we derive from this expression (using some earlier conditions):

(24a) $$\frac{\partial((z_t^* - g_t)/X_t^{\xi})}{\partial\gamma_t} = \frac{\xi}{\gamma_t^{1+\xi}(\tau w_t H_t)^{\xi}}\left\{\frac{1}{\xi\mu(A_t)}X_t - (z_t^* - g_t)\right\} > 0 \Rightarrow X_t / \mu(A_t)(z_t^* - g_t) > \xi$$

Namely, the partial derivative is positive as long as $X_t / \mu(A_t)(z_t^* - g_t) > \xi$. This condition holds generally since (i) per-student public expenditure on compulsory schooling X_t is higher than per-student private expenditure on higher education $(z_t^* - g_t)$, and (ii) $\mu(A_t) < 1$ (less than 0.5 in many economies) and $\xi < 1$. Using these observations, we obtain a positive effect of increasing the funding of compulsory schooling on the threshold parameter Λ_t when the government budget is balanced:

(24b) $$\frac{\delta(\Lambda_t)}{\delta\gamma_t} > 0$$

Vice versa: an increase in public funding of higher education (a decrease in γ_t) leads to a decrease in the threshold level. Given this, we obtain the next results:

Proposition 3: *Assume that $X_t / \mu(A_t) z_t^* > \xi$ holds at some period t. Increasing the public funding of higher education g_t leads in equilibrium to: (i) a larger set of skilled agents at date t+1; (ii) a lower total expenditure on education at date t; (iii)a lower stock of human capital H_t used in production at date t.*

The proof is to be found in the appendix. The above condition requires that the ratio of total expenditure on basic schooling to total spending on higher education is bounded **from below** by $\xi < 1$. The fact that H_t decreases in period *t* corroborates the finding of Proposition 2 and extents the result to a more complex environment. From the proof of Proposition 3 we derive also the next result:

Corollary 2: *In equilibrium with balanced budget the opportunity cost of increasing resources in favour of higher education is larger than unity.*

The reason is that some unskilled workers who previously contributed to tax revenues now become users of higher education subsidies to become skilled.

Dynamic Analysis

Now let us consider the effect of increasing public funding of higher education to enhance the formation of skilled labor (along a feasible education program). Consider the case where the government proposes two policies: either '**no public funding'**, i.e. $g_t = 0$, or the long-run policy $\{\overline{g}_t\}_{t=0}^{\infty}$, which guarantees at **each date t** the **per-student funding** at a positive level $\overline{g}_t$. At date *t*, let the set of families who opt for a 'skilled child' under the 'no funding' policy be defined by:

$$(25) \qquad A_t^0 = \{\omega | Z_{t+1}(\omega) \geq \frac{1}{(1-\tau)(B-1)} \{ \frac{1}{[\frac{w_{t+1}}{1+r_{t+1}} - \frac{m}{B-1} w_t]} \frac{z_t^*}{[\tau w_t H_t]^{\xi}} \} = \Lambda_t^0 \}$$

Let us denote the set of families at period t who opt for a 'skilled child' under the 'per-student public funding $\overline{g}_t$' policy by:

$$(26) \qquad \overline{A}_t = \{\omega | \; Z_{t+1}(\omega) \geq \frac{1}{(1-\tau)(B-1)} \{ \frac{1}{[\frac{w_{t+1}}{1+r_{t+1}} - \frac{m}{(B-1)} w_t]} \frac{z_t^* - \overline{g}_t}{\overline{X}_t^{\xi}} \} = \overline{\Lambda}_t \}$$

Reducing the private cost of higher education will expand the set of skilled labor, namely, we have: $\overline{\Lambda}_t < \Lambda_t^0$. We shall make in the following proposition an assumption regarding the 'sensitivity' of the set of skilled labor to changes in 'initial endowment', namely to variations in the threshold level Λ_t. Let us rewrite the aggregate human capital of **generation *t* +1**:

(27) $$\widehat{H}_{t+1} = \int h_{t+1}(\omega)d\mu(\omega) = X_t^{\xi}[B\int_{A_t} Z_{t+1}(\omega)d\mu(\omega) + \int_{\sim A_t} Z_{t+1}(\omega)d\mu(\omega)]$$

Does a certain level of public funding of higher education enhance the formation of human capital, and hence growth in our economy? The literature has some support for this claim (see, e.g., Bassanini and Scarpenta, 2001; Caucutt and Krishna, 2003; Blankenau, 2005; Arcalean and Schiopu, 2008). We show that in our framework such result depends on certain values for the parameters:

Proposition 4: *Assume that initially there is no government intervention in financing higher education. Introducing public funding of higher education at the levels* $\{\overline{g}_t\}_{t=0}^{\infty}$ *varies the corresponding threshold levels from* $\{\Lambda_t^0\}$ to $\{\overline{\Lambda}_t\}$. D*efine:*

(28) $$\overline{\Lambda}_t = \Lambda_t^0(1-d_t), \quad \textit{for } t=1,2,\ldots$$

If $d_t \le \overline{g}_t / z_t^*$ *holds for all t, then the introduction of such public funding policy increases the stock of human capital at* ***all*** *dates; namely,* $H_t^0 < \overline{H}_t$ *holds for all* $t \ge 1$.

Note that $\overline{g}_t / z_t^*$ is the **share** of the public funding in the total cost of higher education z_t^*. Thus, if the **sensitivity** of the threshold levels to variations in the funding level is not 'too high', hence the resulting expansion of the set of skilled agents A_t is not 'too rapid', we obtain that higher public funding will enhance the creation of human capital. This condition depends basically on the distribution of the initial endowments $Z_0(\omega)$ as well as the 'smoothness' of the human capital distributions in equilibrium and the density function of the random ability. Clearly, public investments in compulsory education over time matter as well. The condition assumed in Proposition 3 compares the per-student investment in compulsory schooling with the average cost of higher education at some given date. In Proposition 4 condition (28) makes an assumption about the elasticity of the **threshold levels** for different levels of public funding.

The Possibility of Inefficiency of Public Funding

Proposition 4 has implications for economic growth. The human capital accumulation resulting from the public funding of higher education is expected to increase domestic marginal returns to physical capital and, hence, generate a foreign inflow of physical capital. The increase in both primary inputs will increase output. But does this outcome justify the diversion of public funds to finance higher education?

The answer depends on cost-benefit consideration: the relevant variable here is the **net value of labor** at the current date, given the openness of this economy. Namely, it is the total additional income generated from this investment: The increase in labor income of generation *t* minus the public expenditure at date *t* on higher education. The reason is that, intergenerational transfers being given at the outset of each period, the working population's only source of income is from labor.

To substantiate the assertion that society as a whole is not always better off when some public funds are used to finance higher education, consider the competitive equilibrium from some initial conditions of this economy and a given feasible education policy $\{(X_t, g_t)\}$. The **net value of labor at date t**, denoted by $W_t(X_t, g_t)$, is defined as:

$$W_t(X_t, g_t) = [mw_t + w_{t+1}] \int_{\sim A_t} \theta_{t+1}(\omega) h_t^{\nu}(\omega) X_t^{\xi} + Bw_{t+1} \int_{A_t} \theta_{t+1}(\omega) h_t^{\nu}(\omega) X_t^{\xi} - g_t \mu(A_t)$$

Given some initial conditions at *t=0*, we say that a feasible education policy $\{(X_t^*, g_t^*)\}$ **dominates** another feasible education policy $\{(X_t, g_t)\}$ if at **any date** ***t***, switching from (X_t, g_t) to (X_t^*, g_t^*) is desirable in the following sense:

(a) $W_t(X_t^*, g_t^*) > W_t(X_t, g_t)$.

(b) At **each** date *k* , *k>t* , if the government has to choose between these two education policies , then (X_k^*, g_k^*) will have a higher net value of labor, i.e., $W_k(X_k^*, g_k^*) > W_k(X_k, g_k)$.

Thus, from the definition we see that the policy $\{(X_t^*, g_t^*)\}$ generates more net aggregate income for each generation, given that each generation compares these two options under the current distribution of human capital at the outset of the period. Let us compare now the **no-public funding** policy, denoted by $\{(X_t^0, g_t^0 = 0)\}$ and the **full-public funding** policy (discussed earlier), denoted by $\{(\hat{X}_t, \hat{g}_t = z_t^*)\}$:

Proposition 5: *Assume that the following two conditions hold:*

(29) $X_t^0 / z_t^* > \xi$ *for all dates t, and*

(30) $B^{1/\xi}[1 - z_t^* / \tau w_t H_t^0] \leq 1$, *for all dates t.*

*Then, the **no-public funding** policy dominates the **full-public funding** policy.*

The proof is to be found in the appendix. Though condition (29) is tighter than what has been assumed in Proposition 4, it remains a mild assumption. Condition (30) requires that *B* should not be 'too large' and/or the per-student cost of higher education is not too 'small' compared to the average per-student public education expenditure. Also, when ξ is close to 1 and *B* is not 'too high' it helps condition (30) to be satisfied. Under these assumptions the cases where the government does not allocate public funds to higher education may be "better" from the point of view of economic efficiency than the fully-funded cases (which we observe in many European countries).

5. Political Equilibrium

So far we assumed that the allocation of the public education funds (hence γ_t) within the educational system is exogenously given. This assumption is questionable since the allocation of government revenues between these two types of education stages is likely to vary with changes in the educational technology of early education vs. college education, market conditions at home and abroad, etc. Moreover, Table 5 that compares the shares of public expenditure on tertiary education (as a percentage of total public expenditure on education) reveals a large diversity between countries: the largest share γ_t is observed for Turkey; Korea and Chile have the smallest shares. Clearly the latter countries rely heavily on private funding to finance higher education.

In economies with heterogeneous agents, the choice of an 'optimal' γ_t can be determined via the outcome of some political process at each date. It is possible to establish a mapping between the set of heterogeneous agents, given their preferences regarding education, and an 'optimal' education policy determined by majority voting. Economies at different stages of development, with a different composition of the labor force between skilled and low-skilled workers, are then expected to reach different political equilibria regarding this educational budget allocation.

Table 5: Public Expenditure on Tertiary Education [a,b]

OECD Countries	$(1-\gamma_t)$	*Partner Countries*	$(1-\gamma_t)$
Italy	16.84	*Brazil*	16.67
Korea	14.67	*Chile*	15.06
Mexico	17.27	*Estonia*	19.44
Netherlands	27.50	*Israel*	16.79
Portugal	19.46	*Russian Fed*	22.14
Turkey	31.03	*Slovenia*	21.71

Notes: (a) As a percentage of total public expenditure on education; (b) In 2007.
Source: Authors' own calculations based on OECD (2009, Table B4.1)

Preferences of Agents

As we have observed earlier in (18), maximization of utility by an agent is equivalent to the maximization of his/her offspring's income. Let us therefore express individual income as a function of γ_t by substituting away x_t and $g_t\mu(A_t)$. Making use of (5), (6), (16) and (17) income of agent ω who has either a low-skilled or a skilled offspring is:

$$y_{t+1}^{l}(\omega)=\left(\frac{\alpha_3}{\alpha_1+\alpha_2+\alpha_3}\right)(1+r_{t+1})\left\{\frac{(1-\tau)(w_{t+1}+mw_t(1+r_{t+1})}{(1+r_{t+1})}\ Z_{t+1}(\omega)\gamma_t^{\xi}\tau^{\xi}w_t^{\xi}H_t^{\xi}+y_t(\omega)\right\}$$

$$y_{t+1}^{s}(\omega)=\left(\frac{\alpha_3}{\alpha_1+\alpha_2+\alpha_3}\right)(1+r_{t+1})\left\{\frac{(1-\tau)w_{t+1}}{(1+r_{t+1})}B\ Z_{t+1}(\omega)\gamma_t^{\xi}\tau^{\xi}w_t^{\xi}H_t^{\xi}+y_t(\omega)-z^{*}+\frac{(1-\gamma_t)}{\mu(A_t)}\tau w_t H_t\right\}$$

Given the parameters at each date t including H_t and $y_t(\omega)$, both expressions for next generation's income are strictly concave function of $\gamma_t\in[0,1]$. This implies that the optimal choice $\gamma_t(\omega)$ of each agent is unique.

Assume now that each individual votes either for **no public funding,** i.e., $g_t=0$, or for **public funding at level** $g_t=\bar{g}_t$. The choice will be determined by comparing the income of his/her offspring under these two policies; namely, given

$Z_{t+1}(\omega)$ we compare $y^l_{t+1}(\omega)$ under $g_t = 0$ to $y^s_{t+1}(\omega)$ under $g_t = \bar{g}_t$. Denote by $\bar{\gamma}_t$ the fraction of the education budget assigned to compulsory schooling when higher education is publicly funded with $g_t = \bar{g}_t$. The condition that determines voting in support of $g_t = \bar{g}_t$ is given by:

$$\frac{(1-\tau)w_{t+1}}{1+r_{t+1}} BZ_{t+1}(\omega)[\tau w_t H_t \bar{\gamma}_t)]^{\xi} - z_t^* + \bar{g}_t + y_t(\omega) \geq$$
$$[\frac{1+r_{t+1}}{1-\tau}]^{-1}[w_{t+1} + mw_t(1+r_{t+1}]Z_{t+1}(\omega)[\tau w_t H_t]^{\xi} + y_t(\omega)$$

Rearranging terms implies:

$$Z_{t+1}(\omega) \geq v_t \,,$$

where

(31)
$$v_t = \frac{(z_t^* - \bar{g}_t)[\tau w_t H_t]^{-\xi}}{(1-\tau)}[(B(\bar{\gamma}_t)^{\xi} - 1)\frac{w_{t+1}}{1+r_{t+1}} - mw_t]^{-1}$$

Like Λ_t in Proposition 1, v_t in (31) is another threshold that partitions the distribution of endowments, namely between those who favour public funding for higher education at level g= $\bar{g}_t$ versus those in favour of the alternative policy $g_t = 0$. Namely, all voters whose endowment is such that $Z_{t+1}(\omega) \geq v_t$ will vote in favour of public funding, all others will vote against.

The threshold v_t is another channel through which international market conditions affect the education system. For example, a higher wage/rental ratio at the next period (resulting from globalization and liberalization of capital markets) implies a larger group of individuals who support $g = \bar{g}_t$ Also partition parameter v_t responds negatively to the changes in the following parameters: (i) In a society endowed with a larger stock of human capital H_t more people support larger public resources be allocated to higher education; (ii) As public education expenditures ($\tau w_t H_t$) increase more individuals support an increase in resources for higher education; (iii) A lower value of *m* or larger value of ξ imply more support for the policy $g = \bar{g}_t$. Again, it is notable that v_t does not depend on the intensity of altruism.

Further insights into the voting behaviour of individuals in generation *t*, which are summarized in the next two claims, can be gained by comparing the position of partition parameters in the distribution of endowments:

Claim 1: $v_t > \bar{\Lambda}_t$.

Claim 2: $\bar{\Lambda}_t < \Lambda_t^0$ holds for all *t*.

The proofs of the two claims are included in the appendix. The following corollaries follow directly from Claim 1 and Claim 2:

Corollary 3: *Some of the agents who voted against instituting public funding for higher education will invest in higher education when public funding is provided.*

Corollary 4: *Some of the households who did not invest in higher education under the no-public funding regime will invest in higher education when public funding is provided.*

Majority Voting

In order to reach a political equilibrium, what matters is to know the relative position of the median voter in the distribution of initial endowments. Let '*M*' denote the median voter and let $Z_{t+1}(M) = \tilde{\theta}_{t+1}(M) h_t(M)^{\nu}$ be his/her initial endowment. Hence:

Proposition 6: *When the allocation of resources invested in public education is determined by a political equilibrium, applying the Median Voter theorem implies that public funding is approved, i.e.,* $g_t = \bar{g}_t$, *if and only if* $Z_{t+1}(M) \geq v_t$. *Thus the shape* *of the* ***distribution of endowments*** *in generation t matters for the determination of the equilibrium.*

We obtain that in a society with a majority of low-skilled workers with low endowments the median voter is in favour of not allocating public resources to college education (Blankenau *et al*., 2007a). This result is clear in a small open economy: parents of generation *t* who are aware that their child is becoming a low-skilled worker will not benefit from supporting public funding for higher education. They perceive public funds assigned for higher education as a net transfer of government resources from them to individuals who shall mostly have high income in the future.[10]

6. Concluding Remarks

Is it always desirable that public funds be used to finance higher education? It is the main question that has been raised by this paper. The answer may depend on the underlying features of the economy, such as cost and productivity of the higher education system and other parameters describing the process of skill formation. In some cases we demonstrate that such public funding will enhance the formation of human capital and thus promote economic growth. We also derive conditions under which public financing of higher education is inefficient. In other words, in some small open economies refraining from using public resources for higher education can 'dominate' the regime in which the government fully funds higher education. Thus, using public funds to send 'low quality' students to college may be inefficient since the government has better alternatives like using these resources to improve the compulsory schooling system (which is benefiting all students).

[10]If, in addition, the conditions of Proposition 5 are met, then the choice of low-skilled voters is desirable as well. In richer economies with a majority of skilled workers the allocation of resources depends on the shape of the distribution of endowments of individuals in that generation. If the condition of Proposition 6 is met, the government allocates public resources to higher education and the predictions of Propositions 3 and 4 are applicable in this context.

The tremendous expansion of globalization in the last three decades has affected small open economies very significantly and its impact on education policy and skill formation is a significant topic. The relevant theoretical literature (see, e.g., De Fraja, 2002, and many others) has studied educational policies mostly within closed economies, while our aim was to promote our understanding of these relationships in small open economies. We explore the role of international capital mobility in affecting education choices as well as governmental decisions related to public funding. Our results may be relevant to certain small open economies but not to others. Some of the conditions we have assumed are related to the productivity of advanced education, the cost of attaining skills, the prices of international factors and the importance of the initial distribution of human capital among countries.

The framework we have applied has several important features, some of which contribute to our results in a significant way. For example, we take into account parental altruism and the opportunity cost of attending higher education. It is not clear to us how robust the results are when we dispose of such assumptions. However, we feel comfortable with such assumptions since they add realism to the analysis. Though we have allocated individuals in this economy to groups of skilled and low-skilled workers we abstained from studying the effects of international factors on income inequality. This important issue should be considered in future research. In a different framework, Viaene and Zilcha (2002) have examined the effect of international factors on income distribution in equilibrium.

7. Appendix

Proof of Proposition 1: Consider the case where the child is skilled. Substitute first order conditions in (11) and solve for $b_t(\omega)$. Making use of (17) we are able to solve for $y^s_{t+1}(\omega)$. Repeat the same steps for the case where the same child is low skilled to derive $y^l_{t+1}(\omega)$. Hence,

$$y^s_{t+1}(\omega) \geq y^l_{t+1}(\omega) \Leftrightarrow U^s_t(\omega) \geq U^l_t(\omega)$$

implies:

$$(1-\tau)B\tilde{\theta}_{t+1}(\omega)h_t(\omega)^{\nu} X_t^{\xi} w_{t+1} - z_t \geq (1-\tau)\tilde{\theta}_{t+1}(\omega)h_t(\omega)^{\nu} X_t^{\xi}[w_{t+1} + (1+r_{t+1})mw_t]$$

Note that this inequality holds only if condition (19) holds. Moreover, it is easy to verify that when (19) holds the set of skilled individuals is given by (20). ■

Proof of Corollary 1**:** Let us rewrite the condition that defines the set of individuals $\omega \in G_{t+1}$ that choose to assume higher education:

$$Z_{t+1}(\omega) = \tilde{\theta}_{t+1}(\omega)h_t(\omega)^{\nu} \geq \frac{1}{1-\tau}\left[\frac{1}{(B-1)\frac{w_{t+1}}{1+r_{t+1}} - mw_t}\right]\frac{z_t}{X_t^{\xi}} = \Lambda_t$$

Assume that in date t we have a higher interest rate $(1+r_{t+1})$; this implies a lower wage-rental ratio $w_{t+1}/(1+r_{t+1})$. As a result, note that condition (19) remains valid, examining the definition of A_t we find that the value of Λ_t increases since the private investment z_t and public investment in compulsory schooling X_t^{ξ} remain unchanged. Hence the set of skilled agents A_t shrinks. Similarly, lowering the rate of interest will lower Λ_t, hence expanding the set of skilled workers A_t. ■

Proof of Lemma 1: Recall the definition of the stock of human capital at date *t*:

$$H_t = \int h_t(\omega)d\mu(\omega) + m\int_{\sim A_t} h_{t+1}(\omega)d\mu(\omega)$$

As A_t increases, the first term in this expression remains unchanged while the second decreases. Hence H_t drops. Consider now later periods:

$$H_{t+1} = \int h_{t+1}(\omega)d\mu(\omega) + m\int_{\sim A_{t+1}} h_{t+2}(\omega)d\mu(\omega)$$

$$H_{t+1} = \int_{A_t} h_{t+1}(\omega)d\mu(\omega) + \int_{\sim A_t} h_{t+1}(\omega)d\mu(\omega) + m\int_{\sim A_{t+1}} h_{t+2}(\omega)d\mu(\omega)$$

There are two effects. First, low-skilled workers join the skilled workforce: A_t increases but $\sim A_t$ decreases by the same number. Second, low-skilled workers induce their child to be low-skilled workers as well but at date $t+1$ because of the endowment condition: $\sim A_{t+1}$ decreases (hence A_{t+1} expands). Consider now two situations and denote the corresponding sets of skilled workers by: A_t^1 and A_t^0 with $\mu(A_t^1) > \mu(A_t^0)$. Since we transfer unskilled workers to skilled ones we obtain that $\int h_{t+1}(\omega)d\mu(\omega)$ increases. On the other hand, since A_{t+1} expands we obtain that $\int h_{t+2}(\omega)d\mu(\omega)$ increases. Let us write:

$$H_{t+1}^0 = \int h_{t+1}^0(\omega)d\mu(\omega) + m\int_{\sim A_{t+1}^0} h_{t+2}^0(\omega)d\mu(\omega)$$

$$H_{t+1}^1 = \int h_{t+1}^1(\omega)d\mu(\omega) + m\int_{\sim A_{t+1}^1} h_{t+2}^1(\omega)d\mu(\omega)$$

Let us denote by Δ_t = [$\sim A_t^1$] / [$\sim A_t^0$], then for any $\omega \in \Delta_{t+1}$ we have by our assumptions: $h_{t+1}^1(\omega) \geq Bh_{t+1}^0(\omega)$, hence

$$\int_{\Delta_{t+1}} h_{t+1}^1(\omega)d\mu(\omega) \geq B\int_{\Delta_{t+1}} h^0{}_{t+1}(\omega)d\mu(\omega) > (1+m)\int_{\Delta_{t+1}} h_{t+1}^0(\omega)d\mu(\omega)$$

This implies that $H_{t+1}^{1} - H_{t+1}^{0} \geq m\int_{\Delta_{t+1}} h_{t+1}^{0}(\omega)d\mu(\omega)$. This process can be continued for all coming dates since we obtained that A_{t+1}^{0} also expands. Thus our claim is proved.■

Proof of Proposition 3**:** For some t assume that g_t increases. Let us rewrite (8) as follows:

$$(8') \qquad \tau w_t[\int h_t(\omega)d\mu(\omega) + mX_t^{\xi}\overline{\theta}\int_{\sim A_t} h_t(\omega)^{\nu}d\mu(\omega)] = X_t + g_t\mu(A_t)$$

since $\widetilde{\theta}_t(\omega)$ are i.i.d. Any increase in g_t decreases parameter γ_t. By (20), as g_t expands, z_t / X_t^{ξ} decreases, which clearly implies a decrease in X_t. Since Λ_t declines we obtain that the set A_t expands. From (8') we see that H_t decreases, hence the RHS $X_t + g_t\mu(A_t)$ must decrease as well even though $g_t\mu(A_t)$ increases. Thus, total expenditures on education decrease. The drop in X_t is larger than the initial increase in g_t: the marginal rate of substitution between X_t and g_t is therefore larger than 1 in absolute value. ■

Proof of Proposition 4**:** Write: $z_t^{*} = z_t^{0}$ and hence, $\overline{z}_t = z_t^{*} - \overline{g}_t$. Thus:

$$\frac{\overline{z}_t}{(\overline{X}_t)^{\xi}} = \frac{z_t^{0}}{(\overline{X}_t)^{\xi}} - \frac{\overline{g}_t}{(\overline{X}_t)^{\xi}} = \frac{z_t^{*}}{(X_t)^{\xi}}(1-d_t)$$

We obtain from this equation,

$$\frac{z_t^{*}}{(X_t)^{\xi}}[(\frac{X_t}{\overline{X}_t})^{\xi} - 1 + d_t] = \frac{\overline{g}_t}{(\overline{X}_t)^{\xi}}$$

which yields:

$$(\frac{X_t}{\overline{X}_t})^{\xi} = \frac{1-d_t}{1-\overline{g}_t / z_t^{*}}$$

Now, let us define $Q(\overline{g}) = B\int_{A_t} h_t^{\nu}(\omega)d\mu(\omega) + \int_{\sim A_t} h_t^{\nu}(\omega)d\mu(\omega)$ and write the expressions for the ratio of generational aggregate human capital:

$$\frac{\overline{H}_{t+1}}{\widehat{H}^0_{t+1}} = (\frac{X_t}{\overline{X}_t})^{\xi} \frac{\overline{\theta}\, Q(\overline{g}_t)}{\overline{\theta}\, Q(0)} = \frac{1-d_t}{1-\overline{g}_t / z_t^*} \frac{Q(\overline{g}_t)}{Q(0)}$$

Since $\overline{\Lambda}_t < \Lambda_t^0$ the set of skilled with the subsidy contains (strictly) the set under 0 subsidy, namely: $A_t \subset \overline{A}_t$, hence $Q(\overline{g}_t) > Q(0)$. Thus, by our assumption, we obtain that $H^0{}_{t+1} < \overline{H}_{t+1}$ for all t. ■

Proof of Proposition 5: Suppose that we switch from zero-public funding to full-public funding at date *t*. Comparing the net labor income in these two cases, the Proposition requires that:

(A1)
$$\begin{aligned} W_t(X_t^0, 0) &= [mw_t + w_{t+1}] \int_{\sim A_t} \theta_{t+1}(\omega) h_t^{\nu}(\omega) X_t^{\xi} + Bw_{t+1} \int_{A_t} \theta_{t+1}(\omega) h_t^{\nu}(\omega) X_t^{\xi} > \\ W_t(\hat{X}_t, z_t^*) &= Bw_{t+1} \int \theta_{t+1}(\omega) h_t^{\nu}(\omega) \hat{X}_t^{\xi} - z_t^* \end{aligned}$$

But the right hand side of (A1) can be rewritten as follows:

$$W_t(\hat{X}_t, z_t^*) = Bw_{t+1} \hat{X}_t^{\xi} \int_{A_t} Z_{t+1}(\omega) + w_{t+1} \hat{X}_t^{\xi} \int_{\sim A_t} Z_{t+1}(\omega)$$

Thus, the inequality in (A1) holds if the following inequality holds:

$$\begin{aligned} & mw_t(1+r_{t+1})(X_t^0)^{\xi} \int_{\sim A_t^0} Z_{t+1}(\omega) + w_{t+1}[(X_t^0)^{\xi} - B\hat{X}_t^{\xi}] \int_{\sim A_t^0} Z_{t+1}(\omega) > \\ & Bw_{t+1}[\hat{X}_t^{\xi} - (X_t^0)^{\xi}] \int_{A_t^0} Z_{t+1}(\omega) - z_t^* \end{aligned}$$

A sufficient condition for this inequality to be satisfied is: $(X_t^0)^{\xi} \geq B\hat{X}_t^{\xi}$. This can be rewritten as: $X_t^0 \geq B^{1/\xi} \hat{X}_t$. Rewritting this inequality:

(A2)
$$\tau w_t H_t^0 \geq B^{1/\xi} [\tau w_t \hat{H}_t - z_t^*]$$

Using Proposition 3 we obtain that by increasing public funding from $g_t^0 = 0$ to $\hat{g}_t = z_t^*$ the period *t* stock of human capital will decline; namely, that $\hat{H}_t < H_t^0$. Now, from (A2) we obtain: $1 \geq B^{1/\xi} [\frac{\hat{H}_t}{H_t^0} - \frac{z_t^*}{\tau w_t H_t^0}]$. Thus, we attain that condition (30) of the Proposition implies condition (A2). Now, in each date $k > t$, given the initial distribution of human capital, a choice between these two public funding regimes requires the same type of comparison as we did for date t. Hence, when the conditions required in this Proposition hold at date *k* we obtain the same outcome. ■

Proof of Claim 1: Let us rewrite the expression for v_t as follows:

(A.3) $$v_t = \frac{(z_t^* - \bar{g}_t)[\bar{\gamma}\tau w_t H_t]^{-\xi}}{(1-\tau)}[(B(\bar{\gamma}_t)^{\xi} - (\bar{\gamma}_t)^{-\xi})\frac{w_{t+1}}{1+r_{t+1}} - (\bar{\gamma}_t)^{-\xi} m w_t]^{-1}$$

From (31) and (A.3) we see easily that $v_t > \bar{\Lambda}_t$ holds if and only if :

$$[(B - (\bar{\gamma}_t)^{-\xi})\frac{w_{t+1}}{1+r_{t+1}} - (\bar{\gamma}_t)^{-\xi} m w_t] < (B-1)\frac{w_{t+1}}{1+r_{t+1}} - m w_t$$

which holds since $(\bar{\gamma}_t)^{-\xi} > 1$. ■

Proof of Claim 2: To prove this claim let us define: $h_t(y) = \frac{z_t^* - y}{(A-y)^{\xi}}$ where the positive constant A is $\tau w_t H_t$. By straightforward calculation we verify that *h'(y)<0* since

$\frac{z^* - y}{A-y} < 1$ *and* $\xi < 1$. Thus: $\frac{z_t^*}{(\tau w_t H_t)^{\xi}} > \frac{z_t^* - \bar{g}_t}{(\tau w_t H_t - \bar{g}_t)^{\xi}} > \frac{z_t^* - \bar{g}_t}{[\tau w_t H_t - \bar{g}_t \mu(\bar{A}_t)]^{\xi}}$ ■

8. References

Arcalean, C. and Schiopu, I. (2008), "Public versus Private Investment and Growth in a Hierarchical Education System," Mimeo, Indiana University Bloomington.

Armellini, M. and Basu P. (2009), "Altruism, Education Subsidy and Growth," manuscript.

Bassanini, S. and Scarpenta, S. (2001), "Does Human Capital Matter for Growth in OECD Countries? Evidence from Pooled Mean-group Estimates," OECD Economics Department, WP # 282, Paris.

Bevia, C. and Iturbe-Ormaetxe, I. (2002), "Redistribution and Subsidies for Higher Education," *Scandinavian Journal of Economics* 104(2), 321-340.

Blankenau, W. F. (2005), "Public Schooling, College Subsidies and Growth," *Journal of Economic Dynamics and Control* 29(3), 487-507.

Blankenau, W. and Camera G. (2006), "A Simple Economic Theory of Skill Accumulation and Schooling Decisions," *Review of Economic Dynamics* 9, 93-115.

Blankenau, W., Cassou, S.P. and Ingram, B. (2007a), "Allocating Government Education Expenditures across K-12 and College Education," *Economic Theory* 31, 85-112.

Blankenau, W., Simpson, N.B. and Tomljanovich, M. (2007b), “Public Education Expenditures, Taxation, and Growth: Linking Data to Theory,” *American Economic Review* 97(2), 393-397.

Caucutt, E. and Krishna, K. (2003), “Higher Education Subsidies and Heterogeneity: A Dynamic Analysis,” *Journal of Economic Dynamics and Control* 27(8), 1459-1502.

Cunha, F., Heckman, J. J., Lochner, L. and Masterov, D.V. (2006), “Interpreting the Evidence on Life Cycle Skill Formation,” in Hanushek, E. and Welch, F. (eds.), *Handbook of the Economics of Education*, Volume I, Chapter 12 (Amsterdam: Elsevier).

Driskill, R. and Horowitz, A. W. (2002), "Investment in Hierarchical Human Capital," *Review of Development Economics* 6 (1), 48-58.

De Fraja, G. (2002), “The Design of Optimal Education Policies,” *Review of Economic Studies* 69, 437-466.

Eicher, T. (1996),”Interaction between Endogenous Human Capital and Technological Change,” *Review of Economic Studies*, 63(1), No. 214, 127-144.

Fernandez, R. and Rogerson, R. (1995),”On the Political Economy of Education Subsidies,” *Review of Economic Studies* 62, 249-262.

Garrat, R. and Marshall, J. (1994), “Public Finance of Private Goods: The Case of College Education,” *Journal of Political Economy* 102, 566-582.

Gradstein, M. and Justman M. (1995), “Competitive Investment in Higher Education: The Need for Policy Coordination,” *Economic Letters* 47, 393-400.

Greenaway, D. and Nelson, D. (2000), “Globalization and Labour Market Adjustment,” *Oxford Review of Economic Policy* 16, 1-11.

Hacker, A. and Dreifus, C. (2010), *Higher Education? : How Colleges are Wasting our Money and Failing our Kids – And what to do about it*. (New York : Times Books).

Hotchkiss, J.L. and Shiferaw, M. (2011), ”Decomposing the Education Wage Gap: Everything but the Kitchen Sink,” *Review of the Federal Reserve Bank of St. Louis* 93(4), 243-271.

Johnson, G.E. (1984), “Subsidies for Higher Education,” *Journal of Labor Economics* 2, 303-318.

OECD (2009), *Education at a Glance* (Paris: OECD).

Restuccia, D. and Urrutia, C. (2004), “Intergenerational Persistence of Earnings: the Role of Early and College Education,” *American Economic Review* 94(5), 1354-1378.

Su, X. (2004), “The Allocation of Public Funds in a Hierarchical Educational System,” *Journal of Economic Dynamics and Control* 28, 2485-2510.

Su, X. (2006), “Endogenous Determination of Public Budget Allocation across Education Stages,” *Journal of Development Economics, 81, 438-456.*

Viaene, J-M and Zilcha, I. (2002), “Capital Markets Integration, Growth and Income Distribution,” *European Economic Review* 46(2), 301-327.

Winchester, N. (2008), “Searching for the Smoking Gun: Did Trade Hurt Unskilled Workers?” *The Economic Record* 84(265), 141-156.

Zilcha, I. (2003), “Intergenerational Transfers, Production and Income Distribution,” *Journal of Public Economics* 87, 489-513.