

Enrollment in higher education, ability and growth

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Abstract

This paper examines the importance of the ability of high-educated individuals for the growth rate. I consider two sources of heterogeneity among individuals: ability and consumption value of education. The latter is assumed to depend on family background and will thus generate different ability thresholds to enroll in higher education for different family background types. If the effect of high-educated individuals on the growth rate depends on their ability, this will affect the willingness of low-educated individuals to contribute to the funding of higher education. Whether state funded subsidies to higher education benefit some of the low-educated individuals or even are Pareto improving is shown to depend on the switchers' ability and hence, their influence on the growth rate.

Keywords: Higher education; Growth

JEL Classification: I22

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1 Introduction

Subsidizing higher education through state funding redistributes resources from low-educated individuals to high-educated individuals. Since the education level is highly correlated with the individuals' earnings in the labor market, this redistribution can also be regarded as going from low-income individuals towards high-income individuals. Yet, higher education is widely subsidized throughout the whole Western world. Since this hardly reflects a public desire to widen the income distribution, more plausible explanations have been advanced.

Johnson (1984) and Dur and Teulings (2003) argue that education subsidies boost the share of educated individuals which, in turn, decreases their wage rate and increases the wage rate of the unskilled individuals, if there is complementarity between skills in the production process. If the wage compression is sufficiently large, unskilled individuals may benefit from contributing to financing the subsidies. Brevia and Iturbe-Ormaetxe (2002) offer another explanation. They argue that education subsidies broaden the future tax base and thus, enable a larger redistribution to unskilled individuals. Creedy and Francois (1990) use an endogenous growth framework and show that if the effect of the number of educated individuals on growth is sufficiently large, unskilled individuals may benefit from an introduction of education subsidies. The reason for this is that this growth externality is assumed to increase the wage rate of everyone.

Based on empirical evidence presented in the next section, this paper further develops the idea of Creedy and Francois (1990) by adding two important dimensions described in the following.

First, the paper acknowledges that the education decision is not only based on pecuniary aspects but also involves a consumption motive, which is "the joy of learning new things, meeting new people, moving to a new city, and participating in campus and student activities, in addition to the increased status in the society that often comes from being a student of

particular fields” (Aalstadsaeter, 2004)¹. Moreover, the consumption value is assumed to be higher for individuals with a high socioeconomic background than for those from less fortunate home environments.

Second, it is assumed that the effect of high-educated individuals on the growth rate depends on their ability. Among the educated individuals, high-ability individuals are assumed to affect the growth rate more than low-ability individuals. This assumption could be compared to the more general case where also low-educated individuals with a high ability affect the growth rate, but at a lower rate than if they had been educated. My way of modeling normalizes low-educated individuals’ effect on the growth rate to zero, since the paper focuses on the role of higher education.

In Creedy and Francois (1990), the different effect on the growth rate of individuals with different abilities is just an uncommented implicit feature of the chosen growth function. The same mechanism also exists in other papers. For example, in Galor and Moav (2000) the contribution to the human capital stock of an individual is determined by her ability and this stock drives the technological progress. Another example is Fershtman et al. (1996). They develop a model where rich low-ability individuals crowd out less wealthy high-ability individuals from growth-enhancing industries, which has a negative effect on the growth rate.²

With the two above assumptions, the model adds a relevant complexity to the decision of subsidizing higher education. The idea is simple. The

¹The consumption value of education was historically considered to be the main motivation for education, before Schultz (1960) and Becker (1964) introduced the human capital theory. In later decades, the common view is that the education decision is probably a combination of pecuniary and nonpecuniary motives; see Aalstadsaeter (2004) for an overview.

²As in these papers, I abstract from the specific mechanism through which high-educated individuals affect the growth rate more than low-educated individuals. It could be the case that more educated people arguably have a larger chance of generating new ideas, the ideas generated are more productivity enhancing, these people learn faster to apply other peoples’ innovations etc; see Bartel and Lichtenberg (1988) and Jamison and Lau (1982) for reviews of these ideas.

heterogeneity of the consumption value of education implies that the ability threshold for enrolling in higher education will be lower for individuals from a high socioeconomic background than for those from a low socioeconomic background. Thus, the individuals of each type that switch to education as a response to the introduction of a subsidy will be of different abilities. According to the second assumption, they will therefore also have different effects on the growth rate. Hence, whether unskilled individuals benefit from contributing to the financing of the education subsidies does not only depend on the *number* of new students the subsidy attracts but also on the switcher's *ability*. I show the condition for when the growth externality is sufficiently large to benefit some of the low-educated individuals and when it is even Pareto improving.

The rest of the paper is organized as follows. In the next section, I present empirical evidence supporting the main assumptions of the paper. In Section 3, a model inspired by Creedy and Francois (1990) and Haupt (2004) is introduced. There is only one time period, which the individuals can use either to work as low-skilled workers or to obtain an education and thereby increase their productivity and thus work as high-skilled workers. The government can tax labor income to finance the education subsidy. The economy's growth rate increases with the share of educated individuals *above a certain ability threshold*³. In Section 4, I assess under which circumstances an education subsidy benefits some of the low-educated individuals and the requirement for it to be Pareto improving. The fifth section concludes and offers some final remarks.

³Ideally, the growth rate should be positively affected by all educated individuals, but more by those with higher ability. However, my way of modelling is simpler and does not affect the main conclusions.

2 Empirical evidence

This section presents empirical evidence on the main assumptions of the paper. The first part presents evidence suggesting that the consumption value of education is higher for individuals from a high socioeconomic background than for those from a low socioeconomic background. The second part presents evidence on the size of the growth externality, and also on the importance of the *composition* as regards the ability of those individuals who choose to enroll in higher education.

2.1 Consumption value of education and family background

Bowles (1972) argues that there is considerable evidence that rich, high status parents place a larger value on the non-pecuniary aspects of work and a lower value on monetary returns than poorer, lower status parents. Osterbeek and Ophem (2000) find support for this view stating that the consumption motive for education is higher for individuals with a high socioeconomic background. Eriksson and Jonsson (1994) find that a considerable part of the enrollment gap for Swedish children from different family backgrounds persists when they control for school grades. All these studies suggest that the consumption motive is indeed higher for individuals from higher socioeconomic backgrounds.

2.2 Higher education and growth

The empirical evidence on the effect of higher education on growth has mainly focused on the *quantity* of higher education. The paper of Creedy and Francois (1990) described above relies on results found by Denison (1984), Schultz (1981), Psacharopoulos (1973) and other papers on the effect of higher education on growth. These studies typically find a significant but relatively

small importance of higher education. Later studies find rather mixed results. Barro and Sala-i-Martin (1995) find that a 0.09 year increase in average male tertiary education raises growth by as much as 0.5 percent. Female tertiary education has no effect on growth, however. This latter result is confirmed in Barro (2001). An interesting result in Gemmell (1996) is that primary and secondary education are especially important for growth in developing countries and that tertiary education is especially important in developed countries. In a review of the empirical literature on education and growth, Gemmell (1997) summarizes that higher education indeed seems to be the most relevant education variable in more developed countries. However, according to him, evidence for higher education remains limited; recent results are more encouraging than what is suggested by earlier studies but the robustness of these results is uncertain.

Much of the focus on the relationship between education and growth, however, has switched from the *quantity* of education to the effect of the *quality* of education on growth. In the following, empirical evidence is presented showing labor-force quality to be highly significant for growth. I also argue that this relation gives support to my assumption that high-educated individuals' effect on the growth rate depends on their ability.

Hanushek and Kimko (2000) construct measures of schooling quality based on student cognitive performance on international mathematics and science tests in elementary and secondary school and use these measures as proxies for labor-force quality. Their results indicate labor-force quality to be strongly related to growth. That result also emerges with different measurements of labor-force quality and different sets of control variables. Moreover, robustness tests show this to be a causal relationship; labor-force quality affects growth rather than vice versa. Similar results are found in Barro (2001). He uses test scores on science, mathematics and reading as proxies for labor-force quality and finds that all these test scores are generally positive and significant for growth, in particular those for science. Another interesting

result in his study is that in specifications with both quantity and quality variables, quantity is still significant for men but the effect of quality is much more important. For example, a one-standard deviation increase in science scores increases the growth rate by 1.0 percent per year. An equally large increase in the school attainment variable, measuring quantity, increases the growth rate by only 0.2 percent per year.

The studies mentioned above use average test scores as proxies for the average labor-force quality. Hence, it is possible that only the *average* labor-force quality is important for growth. Then, it would not be of any importance which individuals in the ability distribution choose to engage in higher education, since high-ability people would affect the growth rate independently of whether they work in occupations demanding higher education. However, this is not a plausible argument. If labor-force quality is important for growth, as is strongly suggested by the evidence, it is arguably of great importance to have high-ability people in the most qualified occupations, where they can make use of the maximum of their potential.

To highlight the analogue with my model, assume there to be one low-ability individual with a high consumption value of education and a high-ability individual with a low consumption value. The low-ability individual chooses to enroll in higher education due to her high consumption value and ends up as an engineer. The high-ability person, on the other hand, chooses not to engage in higher education and ends up working as a carpenter. It is hard to believe that the high-ability individual would materialize growth externalities as a carpenter to the same extent as she would if working as an engineer, where the returns to innovations and new ideas are arguably much higher.

This line of reasoning is supported by the endogenous growth literature, e.g. Romer (1990), where the importance of research and development as the engine of growth is emphasized. Hanushek (2003) also supports the importance of having high-ability individuals engaged in higher education

to foster economic growth. He advances the idea that the large number of foreign high-ability students who enroll in U.S. colleges could be one reason why rather modest U.S. test scores in elementary and secondary education have not yet materialized in low growth rates.

The ability argument enhanced in this paper also bears significant connections to education expansions in the twentieth century. In Sweden, for example, a major school reform was introduced in the 1950s with the very aim of broadening the enrollment in education to also include gifted individuals from less fortunate home environments. Meghir and Palme (2005) find that the reform increased the educational attainment of those with low-skilled parents. Moreover, education also increased significantly *beyond* the compulsory level for this group, which was made possible by improving the financial support for these families. Naturally, it is beyond the bounds of this paper to assess if this human capital boost played any significant role in the strong Swedish growth track in the following decade, but it is indeed a possibility that would be interesting to explore.

3 The Model

Consider an economy where individuals are born and raised by either low-skilled or high-skilled parents. The total population is normalized to one. Let the group of individuals with low-skilled parents be denoted by L and have the share α_L . Those with high-skilled parents are denoted H and have the share α_H . The individuals in each group are uniformly distributed according to ability X_j , $j = H, L$, with support $[\underline{X}, \overline{X}]$ for both groups, where $\overline{X} - \underline{X} = 1$ for computational convenience.

The model only involves one time period. At the beginning of the period, individuals choose whether to enroll in higher education, which is assumed not to be time consuming. After the education decision has been made, all individuals inelastically supply one unit of labor. The individuals' wage rate

depends on their innate ability, but also on the growth rate in the economy and whether they choose to get an education. Education is assumed to increase individual productivity by a factor $k > 0$. In addition, education has a positive growth spillover effect g that is assumed to equally increase everyone's productivity.⁴ In sum, the wage rate is assumed to be $w^l = X(1 + g)$ for individuals choosing not to get an education and $w^h = X(1 + g + k)$ for those choosing to get one, irrespective of the type of individuals.⁵ Note that the notation of the prefixes implies that a capital letter denotes the family background of the individual, and a small letter denotes the type the individual chooses to become.

The education cost is fixed at an amount R . The government subsidizes a share $s \in [0, 1]$ of it, so that the individuals' cost is $R(1 - s)$. The subsidy is financed through a lump-sum tax, t^6 . For simplicity, I impose the restriction that t is considerably smaller than X , so that all individuals can afford the tax. Thus, there is no need to introduce a capital market. Education also brings a consumption value θ_j , where $\theta_H > \theta_L$ and $\theta_H > 0$. θ_j is the imputed value of education, that is, the equivalent income that the individuals are willing to give up in order to get an education if there is no pay-off in the form of an increased wage rate in the labor market⁷.

⁴It might seem strange to include a growth rate in a static model. However, it might be viewed as the discounted value of wage increments due to higher growth. A similar setup is used in Creedy and Francois (1990).

⁵In this setting, g and k are perfect complements. A more general way of modelling would be to let this wage rate be $w^h = X(1 + g)(1 + k)$. However, the setup is chosen for computational convenience and is a very good approximation of the general case as long as g and k are small.

⁶Lump-sum taxes make the computations much easier and analytical solutions can be achieved without changing the main conclusions. Moreover, if the focus is on the conflict between non-educated and educated individuals, as is the case in this paper, it is logical to have lump-sum transfers. With proportional taxes, there is an additional conflict *within* these groups since in this case, high-productivity individuals contribute more to the government's revenues than low-productivity individuals. There is a discussion on this matter in Haupt (2004).

⁷Similar ways of modelling are used in the literature; see, for example, Alstadsaeter et al. (2005) and Haupt (2004). The advantage of my way of modelling is that the utility

The growth rate of the economy g is described in section 3.2. In sum, consumption for an educated j -type is

$$C_j^h = X(1 + k + g) - t + \theta_j - (1 - s)R \quad (3.1)$$

and no education implies consumption

$$C^l = X(1 + g) - t \quad (3.2)$$

Consumption is the only argument in the individuals' utility function

$$U = U(C), \quad U' > 0 \quad (3.3)$$

Assuming interior solutions,⁸ there must exist indifferent individuals such that

$$x_j = \frac{(1 - s)R - \theta_j}{k} \quad (3.4)$$

and since $\theta_H > \theta_L$, it follows that $x_H < x_L$. Since productivity is uniformly

function only depends on one argument, that is consumption.

⁸Throughout the paper, only interior solutions are considered, in order to overcome complex computations of unrealistic corner solutions.

distributed among the individuals, these thresholds relate to the shares of unskilled and skilled individuals within each group. In particular, let the share λ_j indicate the share of skilled individuals within the group, where

$$\lambda_H = \frac{\bar{X}k - (1-s)R + \theta_H}{k} > \frac{\bar{X}k - (1-s)R + \theta_L}{k} = \lambda_L \quad (3.5)$$

Consequently, $1 - \lambda_j$ is the share of unskilled workers in group j .

3.1 The subsidy s

Next, we turn to the government's budget constraint B . Let E be the mass of educated individuals. Assuming that all tax revenues are used to finance the subsidy, it follows that $B = t - sRE = 0$ for the budget constraint to hold.

$$E = \alpha_H \lambda_H + \alpha_L \lambda_L \quad (3.6)$$

and using that $\alpha_L = 1 - \alpha_H$ and rearranging, the budget constraint can now be written

$$B = t - sR \left(\frac{\alpha_H(\theta_H - \theta_L)}{k} + \lambda_L \right) \quad (3.7)$$

As can be seen from equations (3.4-7), there are interdependencies among the tax rate, the subsidy and the enrollment mass E . A higher tax rate enables a

higher subsidy rate. This, in turn, attracts more people to education, which decreases the subsidy per person. Treating the tax rate as exogenous and the subsidy and enrollment mass as endogenous variables, the relationship between the subsidy rate and the tax rate can now be traced. This is done by plugging the expression for λ_L in equation (3.5) into equation (3.7). Then, an equation with t , s and exogenous parameters is obtained. Solving for s yields:

$$s = \frac{1}{2R} \left(\pm \sqrt{\beta^2 + 4tk} - \beta \right) \quad (3.8)$$

where $\beta = \alpha_H(\theta_H - \theta_L) + \bar{X}k + \theta_L - R$, which is proportional to the enrollment mass in laissez-faire. $\beta > 0^9$ and $s = 0$ when $t = 0$. Thus, the negative root is not interesting. Therefore, the equation is:

$$s = \frac{1}{2R} \left(\sqrt{\beta^2 + 4tk} - \beta \right) \quad (3.9)$$

As should be expected, $\frac{ds}{dt} > 0$. Furthermore, $\frac{d^2s}{dt^2} < 0$. This last result is worth commenting. When the tax is increased, the government revenues increase and it can therefore afford higher subsidies which, in turn, will attract more students to enroll in higher education. These subsidies, however, are also increased for those who choose to get an education also *ex ante* the policy change. This means that as the tax increases and the number of educated individuals increases, the additional government revenues must be split among a larger number of individuals; hence the negative sign on the second derivative. This will affect the possibility that unskilled individuals

⁹ $\alpha_H(\theta_H - \theta_L) \geq 0$. Thus, $\beta > 0$ if $\bar{X}k + \theta_L > R$. In laissez-faire, equation (3.4) reads $x_j = \frac{R - \theta_j}{k}$. Since only interior solutions are considered, $x_j \in (\underline{X}, \bar{X}) \Rightarrow \underline{X}k < R - \theta_j < \bar{X}k \Rightarrow \bar{X}k + \theta_L > R$.

may indirectly benefit from subsidies through the growth externality, since increasing subsidies will attract a continuously decreasing number of new students. To see why, note that $\frac{d^2x}{dt^2} = \frac{d^2x}{ds^2} \left(\frac{ds}{dt}\right)^2 + \frac{dx}{ds} \frac{d^2s}{dt^2}$. By inspection of equation (3.4), $\frac{dx}{ds}$ is just a negative constant, which implies that $\frac{d^2x}{ds^2} = 0$. Since $\frac{d^2s}{dt^2} < 0$, the whole expression is positive; that is, as t increases, the decrease in the cutoff values is smaller and smaller.

3.2 The growth rate g

As explained in the introduction, I will assume that all educated individuals do not contribute equally to the growth rate but that the more able individuals contribute more. For simplicity, let there be a threshold ability level \hat{X} such that individuals with $X > \hat{X}$ contribute equally to the growth rate and those with $X < \hat{X}$ do not affect the growth rate at all. g should now be a linear¹⁰ function of the share of individuals above \hat{X} *who are educated*, M . This is crucial. If the effect on growth only depends on innate ability, government policy cannot affect the growth rate. The share of educated individuals above the threshold is given by

$$M = \sum_{j=\{j|x_j>\hat{X}\}} \alpha_j(\bar{X} - x_j) + \sum_{j=\{j|x_j<\hat{X}\}} \alpha_j(\bar{X} - \hat{X}) \quad (3.10)$$

Note that this specification takes into account whether the threshold ability of group j , x_j , is below or above the growth affecting threshold \hat{X} . g can now be written

¹⁰If all individuals who affect the growth rate do this to the same extent, the function must be linear.

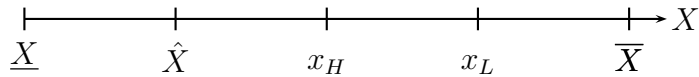
$$g = \phi + \psi M \tag{3.11}$$

where ϕ and ψ are positive constants. ϕ could be viewed as the growth rate without an education externality and ψ as this positive externality from educated individuals. There are three different possibilities of the level of M , depending on how large is \hat{X} relative to x_L and x_H . As could be seen from equation (3.4), a general feature of these three cases is that $x_H < x_L$, since the consumption value is higher for the H -type individuals.

Case 1. $\hat{X} < x_H < x_L$

Call the mass of growth affecting individuals in this case M_1 . Then, M_1 are all the educated individuals from both groups. Therefore, all educated individuals affect the growth rate and so will also students who switch to education as a response to the introduction of subsidies. Hence, there is no leakage in the form of subsidies that target individuals which does not affect the growth rate. The situation can be illustrated with the following figure:

Figure 1: Ability thresholds for case 1



M_1 is all L -individuals with $X_L > x_L$ and the H -individuals with $X_H > x_H$, that is $M_1 = \sum_j \alpha_j (\overline{X} - x_j)$. Plugging (3.9) into (3.4) and rearranging gives x_j as a function of t . Using this in the equation for M_1 gives

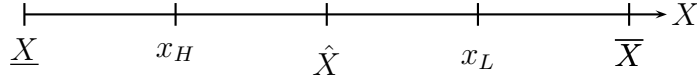
$$M_1 = \bar{X} - \frac{1}{k} \left(R - \alpha_H \theta_H - \alpha_L \theta_L - \frac{1}{2} \left((\beta^2 + 4tk)^{\frac{1}{2}} - \beta \right) \right) \quad (3.12)$$

Equation (3.12) shows that M_1 is decreasing in the education cost and increasing in the consumption values for the two types and the subsidy. This is because all this has a positive effect on the shares of skilled workers of each type, and M_1 is just the total share of skilled workers.

Case 2. $x_H < \hat{X} < x_L$

In this case, M_2 are all educated individuals from group L and the educated H -individuals above \hat{X} , that is $M_2 = \alpha_L(\bar{X} - x_L) + \alpha_H(\bar{X} - \hat{X})$. Subsidies will now lead to a leakage, since the new H -students do not affect the growth rate. The situation can be illustrated with figure 2.

Figure 2: Ability thresholds for case 2



With similar calculations as in the first case, we have

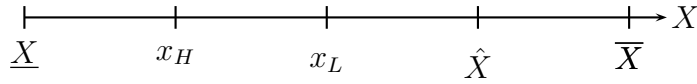
$$M_2 = \bar{X} - \frac{\alpha_L}{k} \left(R - \theta_L - \frac{1}{2} \left((\beta^2 + 4tk)^{\frac{1}{2}} - \beta \right) \right) - \alpha_H \hat{X} \quad (3.13)$$

This expression is similar to that for M_1 in equation (3.12), but the second term is weighted with α_L . Moreover, the last term is new. These differences are due to the fact that not all educated H -individuals have a sufficiently high ability to affect the growth rate.

Case 3. $x_H < x_L < \hat{X}$

In this case, \hat{X} is so high relative to x_H and x_L that M_3 only consists of a part of the educated individuals of both types, see figure 3.

Figure 3: Ability thresholds for case 3



In sum,

$$M_3 = \sum_j \alpha_j (\bar{X} - \hat{X}) = \bar{X} - \hat{X} \quad (3.14)$$

Subsidizing education in this case will only be a leakage of resources, since none of the switching students will affect the growth rate. Obviously, for given x_H , x_L and \hat{X} , it holds that $M_1 > M_2 > M_3$.

4 Welfare

Government intervention will always benefit the high-educated individuals regardless of the magnitude of the growth externality, since they are net

recipients of the tax and subsidy system. Therefore, in this section, I focus on the cases when an education subsidy can benefit none, some or all of the low-educated individuals, respectively. It will benefit some (all) of them if the positive growth effect is larger than the negative tax effect for some (all) of them. Consequently, none of them will benefit from the subsidy if the tax effect outweighs the growth effect for all the low-educated individuals.

Whereas all individuals pay equally large taxes, they benefit to a different extent from an increase in the growth rate. To see this, note that $C = X(1 + g(t)) - t + \theta_j$. The larger the ability X , the higher is the positive effect of the growth externality. Hence, it is not only possible that the increase in the growth rate is sufficiently large to make all low-educated individuals better off; it could also be the case that only a subset of them are made better off. It is also possible that the growth effect is so small that none of the low-educated individuals benefit from the subsidy. The three different possibilities are summarized in Proposition 1.

Proposition 1

1. If $x_L \frac{\partial g}{\partial t} < 1$, that is, when the low-educated individual with the highest ability does not benefit from the subsidy, no low-educated individual will benefit from the subsidy.

2. If $\underline{X} \frac{\partial g}{\partial t} < 1 < x_L \frac{\partial g}{\partial t}$, that is, when the low-educated individuals with the highest ability benefit from the subsidy but the ones with the lowest ability are worse off, there exists $\tilde{X} \in (\underline{X}, x_L)$ such that all low-educated individuals with $X > \tilde{X}$ benefit from the subsidy and all $X < \tilde{X}$ are worse off.

3. If $\underline{X} \frac{\partial g}{\partial t} \geq 1$, that is, when the low-educated individuals with the lowest ability are weakly better off from the subsidy, all low-educated individuals will benefit from the subsidy.

Proof. Follows from the facts that $\frac{dC}{dt} = X \frac{\partial g}{\partial t} - 1$, which is increasing in X , and that $x_H < x_L$. ■

As is clear from Proposition 1, Pareto improvement comes down to making the individuals with the lowest ability better off. Moreover, the higher is $\frac{\partial g}{\partial t}$, the more unskilled individuals benefit from the subsidy. In the following, I will assess the magnitude of this derivative and the condition for Pareto improvement in the different cases of M . Before considering cases 1 and 2, case 3 can be ruled out.

Proposition 2

If $M = M_3$, government intervention cannot be Pareto improving.

Proof. From **Proposition 1**, we know that Pareto improvement implies that $X \frac{\partial g}{\partial t} \geq 1$. However, increasing the mass of educated individuals does not increase g in case 3, that is $\frac{\partial g}{\partial t} = 0$. ■

Note that when computing $\frac{\partial g}{\partial t}$, it is convenient to write equation (3.11) as $g = \phi + \psi M_1(t)$ and $g = \phi + \psi M_2(t)$ using equations (3.12) and (3.13), respectively. Cases 1 and 2 are now assessed one at a time.

Case 1: $M = M_1$

In this case, $\frac{\partial g}{\partial t} = \frac{\partial g}{\partial M_1} \frac{\partial M_1}{\partial t} = \frac{\psi}{(\beta^2 + 4tk)^{\frac{1}{2}}}$. The condition for a Pareto improving subsidy could thus be written

$$\underline{X} \frac{\psi}{(\beta^2 + 4tk)^{\frac{1}{2}}} \geq 1 \tag{4.1}$$

The intuition is clear. The more additional students that increase the growth rate (higher ψ) and the more individuals who are attracted by the subsidy (lower t), the higher is the possibility of the subsidy being Pareto improving. The last result stems from the fact that $\frac{d^2s}{dt^2} < 0$, see section (3.1). The higher the tax rate, the lower is the increase in the subsidy on the margin and hence, the fewer new students are attracted by the increase in the subsidy. There is also another effect reinforcing the result that the requirements for Pareto improvements are best fulfilled when taxes and subsidies are increased from a low level.

Intuitively, this is due to the fact that as the subsidy is increased, more individuals choose to obtain an education, which implies that the "new students" have a lower ability than those previously attracted by the subsidy. This makes the marginal contribution to the growth rate lower as the subsidy increases. In effect, as t increases, the thresholds of the two types move to the left and eventually, case 1 turns into case 2. Keeping increasing taxes and subsidies eventually leads to case 3, where none of the new students have a sufficiently high ability to affect the growth rate.

Case 2: $M = M_2$

In this case, $\frac{\partial g}{\partial t} = \frac{\partial g}{\partial M_2} \frac{\partial M_2}{\partial t} = \frac{\alpha_L \psi}{(\beta^2 + 4tk)^{\frac{1}{2}}}$. The condition for a Pareto improving subsidy could thus be written

$$\frac{X}{(\beta^2 + 4tk)^{\frac{1}{2}}} \frac{\alpha_L \psi}{(\beta^2 + 4tk)^{\frac{1}{2}}} \geq 1 \tag{4.2}$$

and since $\alpha_L \in (0, 1)$, $\frac{X}{(\beta^2 + 4tk)^{\frac{1}{2}}} \frac{\psi}{(\beta^2 + 4tk)^{\frac{1}{2}}} > \frac{X}{(\beta^2 + 4tk)^{\frac{1}{2}}} \frac{\alpha_L \psi}{(\beta^2 + 4tk)^{\frac{1}{2}}}$. This is because in case 2, not only more talented L -individuals with a sufficiently high ability to affect the growth rate are attracted by the subsidy, but also H -individuals with a

lower ability than the growth affecting threshold \hat{X} . Hence, in addition to the intuition for case 1, in this case it holds that the higher is the proportion of L -individuals in the economy, the higher is the possibility of a Pareto improving subsidy.

Next, we turn to the characterization of the social optimum. Define an utilitarian social welfare function SWF , where all variables are expressed as functions of t using equations (3.4), (3.9) and (3.11-14).

$$SWF(t) = \sum_j \left[\int_{\underline{X}}^{x_j(t)} U(X(1 + g(t) - t))f(X)dX \right] + \sum_j \left[\int_{x_j(t)}^{\bar{X}} U(X(1 + k + g(t)) - t + \theta_j - (1 - s(t))R)f(X)dX \right] \quad (4.3)$$

The social optimum tax rate, denoted t^* , is the solution to $\frac{d(SWF(t))}{dt} = 0$. The model is unrealistic in the sense of government taxation not being distortive. This has been assumed to highlight the idea of the paper. Introducing a distortion would change the results in the following way.

First, the conditions for Pareto improvement characterized in equations (4.1-2) would no longer be sufficient, since they only ensure that the positive growth effect outweighs the negative tax effect. With distortive taxation, the growth effect would need to be higher to outweigh both the direct effect of the tax and the distortion effect. Second, the social optimum in the case with non-distortive taxation would be to let the tax rate be so high that all individuals choose higher education. In that way, the growth effect is maximized whereas no redistribution takes place between individuals. The tax that the individual pays is fully recovered by the subsidy to education. With distortive taxation, however, this fictitious redistribution can no longer

take place without a utility loss for the individuals. The social optimum would therefore be one with both low- and high-educated individuals. The exact level of the social optimum tax rate would naturally depend on the utility weight put on each individual - it would be higher (lower) the higher (lower) is the weight put on high-educated individuals.

5 Concluding remarks

The paper has introduced a heterogeneous consumption value of education and an endogenous growth mechanism, where the educated individuals' effect on the growth rate depends on their ability. With this framework, unskilled individuals will be willing to contribute to financing the education of skilled individuals, only if sufficiently able individuals choose to get an education as a response to the introduction of (increase in) the subsidy, and if their effect on the general growth rate is sufficiently large. This is in contrast with earlier literature where it is always assumed that the individuals that choose higher education are those with the highest ability.

Naturally, the model is very stylized and abstracts from several complexities. Nevertheless, it contains mechanisms and components with points of contact to real world educational reforms and policy discussions. For example, the reform conducted in Sweden in the 50's that was discussed in Section 2 may not only have had equality considerations and consequences. Incorporating individuals with unskilled parents into higher education may be a way of ensuring that there are high-ability individuals contributing to the human capital formation in a country. Hence, in an endogenous growth framework, this may also have positive efficiency effects.

As discussed earlier, a crucial assumption in this paper is that of the heterogeneous consumption value of education between individuals of different socioeconomic backgrounds. Naturally, if the consumption value were identical in these different types of backgrounds, the individuals' ability en-

dowment would determine the education decision to a greater extent. Hence, a policy recommendation would be that policy interventions should be addressed at a very early age, before the consumption value of education is formed, in order to narrow the distribution of consumption values. This conclusion is much in line with the proposals in Heckman and Carneiro (2003) and Krueger (2003). On the other hand, if the differences in consumption value persist, non-efficient enrollment to higher education may be mitigated by introducing a subsidy scheme encouraging people from less advanced families to enroll in higher education.

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