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Efficiency and equity effects of subsidies to higher education

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We compare the efficiency and equity effects of three financing systems for higher education: the traditional tax-subsidy system, where education subsidies are financed from general taxation; loan schemes; and a graduate tax. We find that efficiency and equity targets cannot be simultaneously achieved by the traditional tax-subsidy system, and that both loan schemes and a graduate tax fare better. When education outcomes are uncertain, the graduate tax is to be preferred to a pure loan scheme because of the greater insurance provided by the former and because it tends to be preferable to an income contingent loan system.

1. Introduction

Most industrial countries subsidise, to a greater or lesser extent, non-compulsory education, and in particular higher education. One of the justifications for this policy are capital market imperfections which prevent agents from borrowing against future human capital income. Subsidies to higher education are therefore intended to provide equality of chances to all agents, no matter what their family wealth is. Traditionally, these subsidies have been financed from general tax revenue, just like any other education cost borne by the government. There is, however, an important difference between subsidies to higher education and expenditures on compulsory education: while all individuals benefit from the latter, only those who choose to continue their studies enjoy the reduction in the private cost of higher, non-compulsory education. If the average tax payer has a lower lifetime income than the average university graduate (where lifetime income is defined as the discounted sum of all future labour earnings minus labour taxes and private education cost), a subsidy to higher education financed from general taxation implies reverse lifetime redistribution, i.e. redistribution from the poor to the rich.[1] Does this finding imply that subsidies should be abolished and all higher education should be privately financed, thus avoiding reverse resdistribu-

[1] Reverse redistribution is regularly found in empirical studies. Cf. Peltzman (1973), Radner and Miller (1970), and Bishop (1977) for the US, Tussing (1978) for Ireland, Hope and Miller (1988) for Australia, and Grüske (1994) and Holtzmann (1994) for Germany. Creedy (1995, ch. 2.3) provides an overview.

tion, or should subsidies be increased in order to increase the number of individuals from low-income families who have access to education?

The first objective of this paper is to assess the traditionally used tax-subsidy system and understand the impact of different degress of subsidisation on both efficiency and equity.[2] As it turns out, asking whether one needs more or less subsidy is the wrong question as this system performs poorly whatever the policy objective. The paper's second objective is therefore to compare the traditional system with three alternatives: a pure loan scheme, a loan scheme with income-contingent repayments, and a graduate tax system. Three policy targets are used to evaluate these financing systems: Pareto efficiency; *ex ante* equality of opportunity, which means that the decision whether to invest in higher education is independent of parental wealth; and *ex post* equality of lifetime incomes.

A pure loan scheme is a public loan with mortgage-type repayments: each individual pays back exactly the amount she has borrowed plus interest. A system of income-contingent loans (currently in place in Australia, New Zealand, and, since October 1998, the UK; cf. Barr and Crawford, 1998) makes repayments conditional on whether the income of the student exceeds a pre-specified level and computes repayments as a percentage of her weekly or monthly earnings. From our analytical perspective, the main feature is that the maximum amount to be paid back by high-earning graduates is the loan plus interests, while low-earning graduates do not fully pay back their education cost and are subsidised by tax-payers. A graduate tax system, as defined and advocated here, consists of a public subsidy to education, which also makes repayments contingent on income but where repayments by high-earners exceed the cost of their education. The difference between repayments and cost is used to subsidise low-earning graduates who pay an amount smaller than the subsidy received. Under a graduate-tax system, general tax revenue is therefore not used to subsidise education.

The traditional tax-subsidy system cannot avoid a trade-off between the above policy targets: while a subsidy can be set to induce the efficient level of human capital investment, it generates reverse redistribution; increasing the subsidy equates the lifetime incomes of all workers, but implies an excessively high stock of human capital and thereby efficiency losses; a further increase in the subsidy ensures equality of chances but exacerbates the efficiency losses. The graduate tax system avoids the efficiency-equity trade-off of the traditional subsidisation system, provides (partial) insurance when the outcome of the education process is uncertain, and outperforms a pure loan scheme, the standard solution to capital market imperfections usually proposed in public discussions. An income contingent loan scheme tends to have the same efficiency effects as a graduate tax system, provided the subsidy of the latter is high enough, but has less desirable distributional effects as it implies reverse redistribution.

[2] We only briefly discuss implications of external effects of higher education at the end of Section 4.4 as they are not essential for our arguments. This does not deny their possible existence. Creedy (1995) examines the implications of externalities and provides an overview of the empirical evidence.

The presence of reverse distribution when subsidies to higher education are financed by general taxation has been noted by Fernández and Rogerson (1995). They focus on political economy aspects, and address the question of whether poorer individuals will be excluded from education when the subsidy rate is chosen by majority voting. The main drawback of their analysis for our purposes is that, in their framework, it is optimal for all agents to study. Hence, if the government could choose the subsidy rate, it would always be possible to make it high enough for all individuals to be able to invest in education. The entire labour force would become skilled, reverse redistribution would be avoided, and the outcome would be both efficient and equitable.[3]

Johnson (1984) analyses the distributional effects of subsidies received only by those attending higher education. He argues that reverse redistribution caused by a traditional tax-subsidy system may not be a problem, as individuals of lower ability—who remain unskilled—benefit from the tax-subsidy due to the presence of complementarities between skilled and unskilled labour. They may in fact want a higher tax-subsidy rate than those who study.

Creedy (1995) examines higher-education financing when there are externalities in the production process. In particular, he analyses the general equilibrium implications of the government budget constraint and how majority voting affects education policy. He further provides an in-depth introduction to both the theoretical and empirical literature. Both Creedy and Johnson abstract, however, from capital market imperfections and the risk associated with education investments.[4]

The next section of this paper describes the economy and presents the benchmark case of perfect capital markets. Section 3 examines the traditional tax-subsidy system and assesses the efficiency and equity properties of different subsidy rates. It shows that this system implies reverse distribution and a trade-off between the various policy goals. Section 4 introduces uncertainty in the education process. It then compares the effects of a pure loan scheme with those of a graduate tax. The graduate tax system increases both efficiency and equity, as compared to the pure loan scheme, due to its insurance properties. A comparison of the graduate tax with income-contingent loans and a discussion of the optimal degree of insurance follow. Section 5 discusses the robustness of our results with respect to the introduction of heterogeneity in individual ability, and the final section concludes.

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[3] Other studies in the literature on education and distribution have mainly concentrated on the impact of public funding of education in models where all agents receive a transfer or subsidy (see, for example, Glomm and Ravikumar, 1992; Saint-Paul and Verdier, 1993; or Perotti, 1993). Thus, government intervention always benefits the less well off dynasties. This is not, however, an appropriate description of the way in which higher education is usually financed.

[4] Government's decisions on how to optimally provide education when individuals differ in their 'ability to learn' has been studied by Hare and Ulph (1979). Hare and Ulph (1982) study an optimal tax problem under imperfect capital markets in a model similar to Loury (1981). Their model is much more general than ours is but also much harder to analyse. Due to this complexity, they do not analyse the insurance property of certain subsidies to education as we do.

2. The model

2.1 Description of the economy

Consider an economy with a population of constant size N. All individuals live for three periods and are identical in all respects except for the financial support they receive from their parents.[5] We will term this financial support 'inheritance' and denote it by n. Its frequency distribution is given by $f(n)$. In the first period of their life, all children of a given cohort complete compulsory education. At the start of the second period, they choose whether to start working immediately or invest in higher education. If they decided not to study, they work as unskilled workers for two periods. If they enrol in higher education, they study for one period and work as skilled workers afterwards. All consumption takes place in the last period of life.[6] As we focus on steady states, time subscripts will be omitted.

The fixed cost of education is given by E. We assume that borrowing in order to finance the education cost is not possible, as human capital is not a satisfactory collateral for private lenders. Hence, in the absence of government intervention, an individual can only invest in education if her inherited wealth is large enough to cover the education cost, i.e. if $n \geq E$.

The economy produces a unique consumption good Y whose production technology requires two types of labour, skilled or human capital, denoted H, and unskilled, L.

$$Y = F(H, L) \tag{1}$$

First and cross derivatives are positive, second derivatives are negative and both inputs are essential, $F(0, L) = F(H, 0) = 0$. There is perfect competition in goods and factor markets, hence factors are paid their marginal products, denoted by $w_H(H, L)$ and $w_L(H, L)$. The aggregate labour force is given by N, where $L + H = N$.

The only role for the government is to subsidise education and raise the necessary revenue through taxation, while maintaining a balanced budget. We will examine several financing systems and hence specify the choice of taxes and the government budget constraint below.

2.2 The benchmark case of perfect capital markets

We take as a benchmark a situation in which capital markets are perfect. All agents can borrow and there is no need for government intervention. The lifetime income of an individual who decides not to study is the present value of receiving the unskilled wage for two periods, $W_L = (1 + R)w_L(H, L)$, where R is the exogenous

[5] This assumption greatly simplifies the analysis. As we discuss in Section 5, our main arguments would not change if we allowed for differences in abilities to learn.

[6] This assumption allows to study present values of lifetime income rather than discounted utility streams. In Section 4, it simplifies the analysis of risky investment. In neither case does it affect any of the qualitative results of the paper.

discount rate. The lifetime income of an agent who invests in education is equal to the discounted skilled wage minus the education cost, $W_H = -E + Rw_H(H, L)$.

The two lifetime income schedules are represented as a function of the number of educated agents in Fig. 1. The W_L schedule is increasing in H while the W_H schedule is decreasing, since the skilled (unskilled) wage is lower (higher) the greater the supply of educated workers is. Agents invest in education as long as the lifetime income of a skilled worker exceeds that of an unskilled worker. The point of intersection between the W_L and the W_H schedules then defines the equilibrium number of educated workers, for which the lifetime incomes are equalized. The number of individuals who would choose to invest in education if borrowing were possible, H^*, is therefore defined by the expression

$$(1 + R)w_L(H^*, N - H^*) = -E + Rw_H(H^*, N - H^*) \quad (2)$$

Since the skilled wage is strictly decreasing in the number of educated workers and the unskilled wage strictly increasing, and as both human capital and labour are essential for production, it is not efficient that all workers work as skilled or unskilled, hence $0 < H^* < N$, and H^* is unique. As in the present setup there are no market failures, we call H^* the efficient level of human capital, and the factor allocation captured by eq. (2) will be our point of reference.

Under perfect capital markets the three policy targets mentioned in the introduction are attained. There is efficiency, as agents' decisions result in the stock of skilled labour that maximises output and thereby social welfare; there is equality of lifetime income; and there is equality of chances, since all agents have access to education, no matter what their parental wealth is.

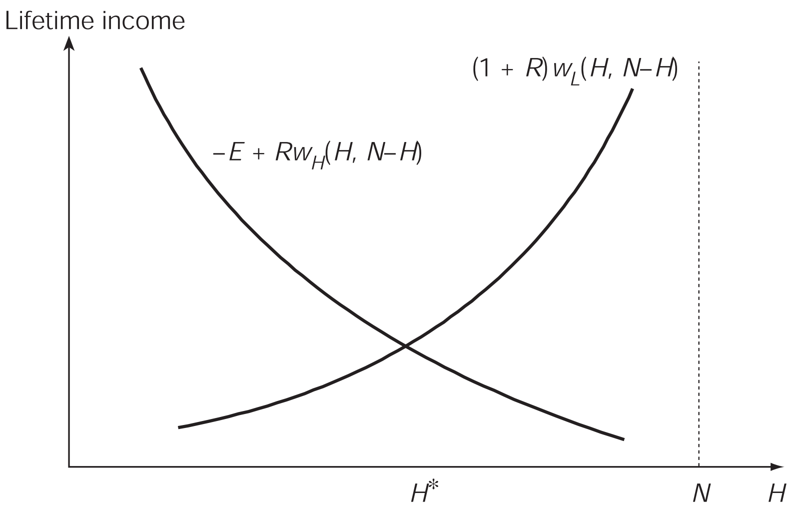

Fig. 1. The equilibrium level of human capital when borrowing is possible

3. The working of traditionally used financing schemes

3.1 The traditional tax-subsidy system

Consider the traditionally used system, where T is a lump-sum tax levied on all agents in the first period of their lives and sE the subsidy received by those who study.[7] The government chooses the subsidy rate and then sets the lump-sum tax so as to maintain a balanced budget. The required level of taxation is therefore equal to total subsidies, sEH, divided by the number of taxpayers, N

$$T = \frac{sEH}{N} \tag{3}$$

Those who do not study pay a tax and receive no subsidy. Those who study pay the same tax and receive a subsidy. This implies a net transfer to those who study, as $sE - T$ is always positive simply because there are more individuals paying the tax than receiving the subsidy.[8]

Define $\underline{n}(s)$ as the minimum level of inheritance required in order to be able to afford education. In the absence of borrowing, an individual's inheritance must be large enough to cover the subsidised education cost plus the tax, that is, $\underline{n}(s) = (1 - s)E + T$. Substituting for the tax rate we have

$$\underline{n}(s) = E\left(1 - s\frac{N - H}{N}\right) \tag{4}$$

Clearly, the higher the subsidy rate, the smaller the cost faced by the agent, and the lower the level of inheritance required in order to be able to study. The number of individuals who can afford to study is greater the higher the subsidy is.

Suppose that under the subsidy rate s the capital market constraint is still binding for some households, so that the lifetime income of university graduates exceeds the lifetime income of workers. This means that more individuals want to study than can afford to do so. Then the number of students this period (i.e. skilled workers next period) is equal to the number of agents that can afford education. That is, H is equal to the number of agents who inherited wealth is greater than $\underline{n}(s)$,

$$H = \sum_{n \geq \underline{n}(s)} f(n) \tag{5}$$

Equations (4) and (5) jointly determine the number of skilled individuals, H, and the threshold inheritance level required for studying, $\underline{n}$, as a function of the policy parameter s and the distribution of inheritances.

[7] Other tax systems could be easily modelled. Studies on tax incidence show that the most reasonable assumption would be a tax proportional to income. Our results would not change if the subsidies were financed by a proportional tax on income or wealth, nor if the tax burden were shifted from the first to the second period of life. In either case there would still be reverse redistribution, as agents with low lifetime incomes would pay a tax used to subsidise the education of those with higher lifetime income.

[8] Inserting the tax rate into the total amount received, $sE - T$, gives a net transfer of $sE(N - H)/N$ which is positive since $N > H$.

3.2 Subsidising the efficient level of human capital

Suppose that the aim of the government is to maximise the net output of a given generation, i.e. to induce the efficient level of human capital, H^*, as defined by eq. (2). Let the distribution of inheritance be such that this level of human capital is not attained in the absence of intervention. The subsidy rate can then be set such that there are exactly H^* individuals with inheritance $n \geq (1-s^*)E + T$, i.e. exactly H^* agents can afford the cost of education.

Figure 2 examines graphically the effect of a subsidy rate s^* on the incomes of the two types of workers. The thin lines represent lifetime income schedules in the absence of a subsidy as in Fig. 1, and $H_0 < H^*$ is the number of agents that could afford education in this case. At H_0, lifetime income is higher for a skilled worker and lower for an unskilled worker than under perfect capital markets. This simply reflects scarcities. Under the tax-subsidy system, the lifetime income of an unskilled worker is the wage received in the two periods minus the lump-sum tax, $W_L = (1+R)w_L(H, N-H) - T^*$. Hence, the introduction of the tax represents a downward shift of the W_L-schedule. The lifetime income of educated workers is now $W_H = -(1-s^*)E - T^* + Rw_H(H, N-H)$. Since the reduction in the education cost due to the subsidy is greater than the tax paid, the lifetime income of those who study increases, for a given H, and the W_H-schedule shifts upwards. Because s^* has been chosen so that only H^* individuals can afford education, the new equilibrium occurs at $H = H^*$.[9]

The efficient subsidy has two distributional consequences. First, all individuals are paying a tax that is distributed only among those with higher income, implying that there is a transfer of resources from poor to rich individuals. This is what we call reverse redistribution. Second, the introduction of a subsidy s^* leads to a situation in which those who study enjoy a larger income than those who do not. The efficient subsidy does not remove inequality. This can be seen in Fig. 2, where the distance between the two schedules, indicated by the double-headed arrow, represents the difference in the lifetime incomes of the two types of agents. It amounts to s^*E. [10]

An efficient subsidy not only fails to equalise life-time incomes, it also fails to provide *ex ante* equality of chances. The somewhat less rich can now afford education, but the possibility to study still starts with the richest person and counts downwards. As a result, poorer people are still systematically excluded.

3.3 Subsidising the equitable level of human capital

Assume now that the government wants to implement a policy that guarantees equality of lifetime income. We term the required stock of human capital the

[9] The intersection of two thick lines determines the equilibrium human capital stock if there were a subsidy s^* and capital markets were perfect. It would, of course, imply over-education.

[10] The difference between the lifetime incomes of the two types of workers is given by $W_H(s^*) - W_L(s^*) = -(1-s^*)E + Rw_H(s^*) - (1+R)w_L(s^*)$. As the efficient subsidy implies wages that satisfy (2), we can substitute for these wages and obtain $W_H(s^*) - W_L(s^*) = s^*E > 0$.

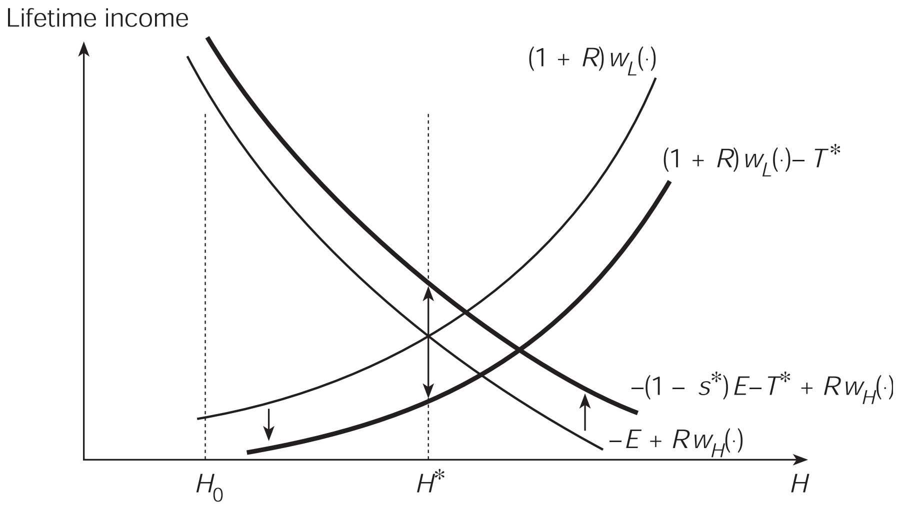

Fig. 2. The efficient subsidy rate

equitable stock, denoted $\hat{H}$. The equitable subsidy rate, $\hat{s}$, and its corresponding tax, are defined by

$$(1+R)w_L(\hat{H}, N-\hat{H}) - \hat{T} = -(1-\hat{s})E - \hat{T} + Rw_H(\hat{H}, N-\hat{H}) \tag{6}$$

together with eqs (4) and (5).

Is the equitable level of human capital greater or smaller than the efficient one? We know from our previous discussion that when H^* individuals invest in education the lifetime income of skilled workers is greater than that of the unskilled. In order to reduce the wages of the former an increase in the subsidy rate, $\hat{s} > s^*$, is necessary. A higher subsidy increases the number of individuals who can afford education and hence the supply of educated labour, thus reducing the skilled wage and increasing the unskilled wage. The level of human capital that equalises the net lifetime wages of the two types of workers is therefore greater than the efficiency level, $\hat{H} > H^*$.[11] This is depicted in Fig. 3.

The increase in the number of educated workers implies that their marginal product is lower than the social cost of education E plus the foregone wage. Consequently, the equitable stock of human capital is inefficient as 'too many' people become skilled and the aggregate output of a generation is lower than if some of the workers that study had remained unskilled.

The traditional tax-subsidy system is therefore characterised by an equity efficiency trade-off. An efficient subsidy implies inequality in lifetime incomes, an equitable subsidy induces an excessively large number of skilled workers. This over-education implies a loss in output.

[11] In order to compare $\hat{H}$ and H^*, subtract the efficiency condition (2) from (6) to get $(1+R)[\hat{w}_L - w_L^*] = \hat{s}E + R[\hat{w}_H - w_H^*]$. This equation is satisfied if $(1+R)[\hat{w}_L - w_L^*] > R[\hat{w}_H - w_H^*]$. As a higher s increases H which implies a higher w_L and a lower w_H, this can only occur if $\hat{H} > H^*$.

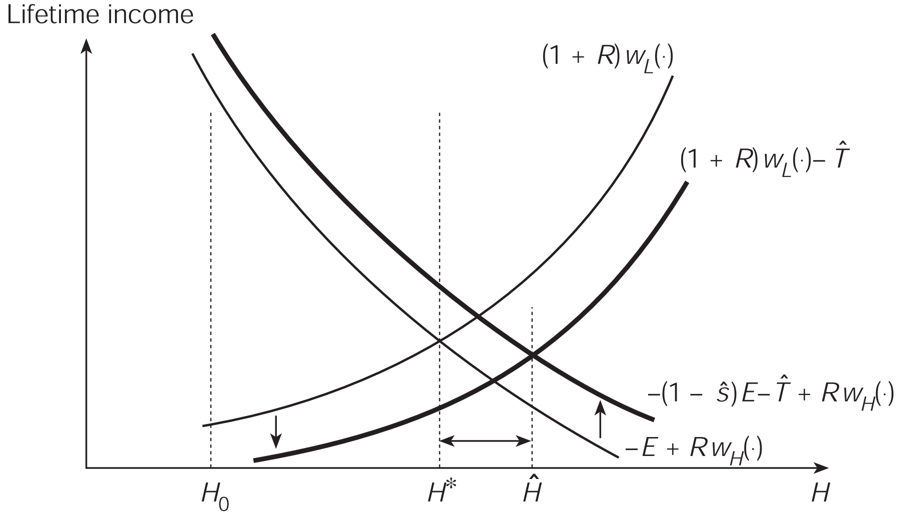

Fig. 3. The equitable subsidy rate

Despite the equality of lifetime income (though there is still a transfer from those with lower to those with higher bequests), there would be no equality of opportunity, as those with a very low level of inheritance would still not be able to afford education. The only way of providing universal access to education would be to fully subsidise education, which would further increase inefficiency.

3.4 Individual mobility

Our analysis of distributional effects has, so far, studied the effects on the lifetime income of labour groups, i.e. skilled and unskilled workers. We also wish to know if a particular individual is better or worse off under the subsidy than in its absence. The answer to this question depends not only on whether she can afford education under the subsidy, but also on whether or not she can study without, or with less, government support.

The introduction of a tax-subsidy scheme has three effects. First, there is a tax effect, as those who do not study have to pay a net tax which subsidises students. Second, there is a cost-reduction effect, since those who engage in education pay less than they did in the absence of the subsidy, even after their tax payments are taken into account. Third, there is a wage effect because the increase in the number of skilled workers results in a higher unskilled wage and a lower skilled wage than before the subsidy was introduced.

Consider first the effect of an efficient subsidy. Middle-income individuals could not afford education in the absence of intervention, but are wealthy enough to study under a partial subsidy. They are always better off under the subsidy, as at H^* the net lifetime wage of a worker that studies is greater than it would have been had there been no subsidy and had she not studied (see Fig. 2). In other words, they benefit from a positive transfer and enjoy a higher wage. The richest individuals, who could afford education in the absence of the subsidy, may be better or worse off. On the one hand, the skilled wage has fallen; on the other, the cost of education that they face is reduced by the subsidy. Either effect could in principle dominate. Similarly, the effect on the lifetime incomes of low-income agents, who remain unskilled, is ambiguous. The tax reduces their net lifetime income, but the fall in the number of unskilled workers increases their wages. If this second effect dominates, unskilled workers may be better off under the tax-subsidy system than in its absence, despite the presence of reverse redistribution.

Under an equitable subsidy, the level of output is less than the economy's potential output. If the subsidy required to achieve equality of lifetime incomes is very large, possibly because the distribution of inheritances is very skewed, the misallocation of labour could be so large that output is lower than it was without the subsidy. It could then be that even the middle-income group experiences a reduction in income, and that the loss of output due to an excessive supply of human capital hurts all agents.

Two implications of our discussion for the political economy of education subsidies are worth mentioning here.[12] First, the traditional tax-subsidy system is particularly attracative for the middle-income group, as it is the group that benefits most. This would help explain the political support that such a policy has received from the middle class in the post-war period. Second, it could be that subsidising education reduces the income of those who could previously afford education, and increases that of those who remain unskilled. It may, therefore, be the case that those who do not study prefer a higher subsidy rate than those who could study in the absence of subsidies.[13]

4. A graduate tax system versus loan schemes under uncertainty

As the previous discussion has shown, a tax system that implies reverse distribution cannot satisfy several optimality conditions at one time. This raises the question of whether there is a better mechanism for financing higher education. A straightforward solution, which removes the constraints imposed by imperfect capital markets without generating reverse redistribution, is to abolish all subsidies to education and introduce a government loan scheme. Education would be entirely privately financed, and capital market imperfections would be overcome by loans provided by the state. Individuals who enrol in higher education can take up a loan and repay it once they start working. In our highly stylised economy, all individuals would then have identical lifetime incomes, the allocation of resources would be

[12] See Fernandex and Rogerson (1995) for a detailed analysis of the political economy of higher-education subsidies.

[13] Johnson (1984) obtained a similar result in a model where individuals differ in abilities but capital markets are perfect.

efficient (since private education cost equal social education cost), and any agent would have the opportunity of attaining higher education.

This solution, however, neglects one important aspect which we have so far not taken into account: the uncertainty related to investments in human capital. Higher education is a risky investment and a student might not be employed as a skilled worker once the education process is completed. The probability of succeeding in education depends both on individual choices, such as how much effort to exert, and on aspects over which the individual has no control, such as ability or the requirements of the courses undertaken. Individuals are unlikely to have full information about the latter aspects before they start studying. Hence, from the student's perspective, there is a risk associated with investment in education. In what follows we consider the simplest form of uncertainty by assuming that the probability of becoming skilled is given and exogenous to any action of the individual. This does not mean that individual effort does not play any role (we will briefly discuss effort choices in Section 4.5), but that an important component of educational success is not under the control of the individual.

Uncertainty affects investment decisions when individuals are risk-averse. In order to solve the associated problems at least to some extent,[14] we propose the use of a graduate tax. In this section, we first derive the social optimum as our benchmark case and study the properties of a pure loan scheme, a policy which, it is often argued, neutralises the effects of capital market imperfections. We then show that a graduate tax system performs better than a pure loan scheme. The differences between an income-contingent loan scheme, currently at work in several countries, and a graduate tax system are then worked out. It is argued that a graduate tax system would represent an improvement over income-contingent loans, provided the subsidy rate under a graduate tax system is sufficiently large.[15]

4.1 The social optimum

Suppose that students have to take an exam at the end of their education that they either pass or fail. If they pass it, they work as skilled workers. If they do not pass it, they work as unskilled workers in the last period of their lives. An agent who invests in education passes the exam with probability $p \in (0, 1)$ and fails with probability $(1 - p)$. For simplicity of exposition, let the wages of skilled and unskilled workers be constant. Preferences of individuals are characterised by decreasing absolute risk aversion and their utility function is denoted by $U(\cdot)$. Let H be the number of students, so that pH is the numer of skilled workers in the next period. Assume further that the expected return to eduction net of the education cost is higher than the discounted wages from working as an unskilled worker for two periods

[14] Eaton and Rosen (1980) study extensively the effect of labour income taxation on human capital accumulation both when human capital accumulation is certain and uncertain. See also Kanbur (1981).

[15] Without using the expression 'graduate tax', Friedman (1962, ch. 6, p.105) argued in favour of such a scheme.

$$-E + R[pw_H + (1-p)w_L] > (1+R)w_L \tag{7}$$

It is hence socially optimal to educate the entire cohort, so that H^* is equal to N.

4.2 Risk-aversion and the pure loan scheme

Under a pure loan scheme, any individual who studies pays the full education cost, E, irrespective of whether or not she succeeds in education. A worker who does not invest in education has a net lifetime income of $n + (1+R)w_L$; an individual who invests in education and succeeds has a net lifetime income of $n - E + Rw_H$; while one who invests but fails and works as unskilled labour in the second period has $n - E + Rw_L$. We define the function $G(n, 0)$ as the difference between the expected utility of investing in education and not investing when there are no subsidies to education. Under a pure loan scheme

$$G(n,0) \equiv (1-p)U(n - E + Rw_L) + pU(n - E + Rw_H) - U(n + (1+R)w_L) \tag{8}$$

Figure 4 depicts the function $G(n, 0)$. Since $U(\cdot)$ exhibits decreasing absolute risk aversion, $G(n, 0)$ is strictly increasing in inheritance.[16] Richer individuals have higher expected utility from studying than poorer individuals, and will therefore be more likely to chose higher education. The intuition for this is as follows. When an agent chooses to study, the variance of her lifetime income depends on her inheritance. If her inherited wealth is large, the wage represents a small proportion of her total income, and hence the effect of whether she receives the skilled or the unskilled wage is small. In the case of an individual with little inherited wealth, lifetime income is very sensitive to whether she succeeds or fails. As a result, the greater an agent's inheritance level, the more she is insured against wage uncertainty and the smaller the difference between the expected utility from studying and from not studying. Differences in inherited wealth levels thus imply different attitudes towards risk. Richer individuals are more willing to undertake risky investments, and consequently more willing to undertake higher education, than poorer ones.

Define $\underline{n}^l$ as the inheritance of the individual who is indifferent between investing in education and not investing, where this threshold level is given by $G(\underline{n}^l, 0) = 0$. All individuals with inheritance above this threshold level will invest in human capital, while individuals with a lower inheritance level are better off, in expectation, when working for two periods. The total number of students is therefore given by the number of agents with inherited wealth above this level

$$H^l = \sum_{n \geq \underline{n}^l} f(n) \tag{9}$$

As long as the threshold level is positive, which will happen if agents are sufficiently risk-averse, the resulting number of students will be smaller than the optimal one, $H^l < H^* = N$. Hence, when there is uncertainty and risk-aversion, the

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[16] Following Varian (1992, p.178–80) it is possible to show that under small risk and with decreasing absolute risk aversion, $dG(n,0)/dn = (1-p)U'(n - E + Rw_L) + pU'(n - E + Rw_H) - U'(n + (1+R)w_L) > 0$.

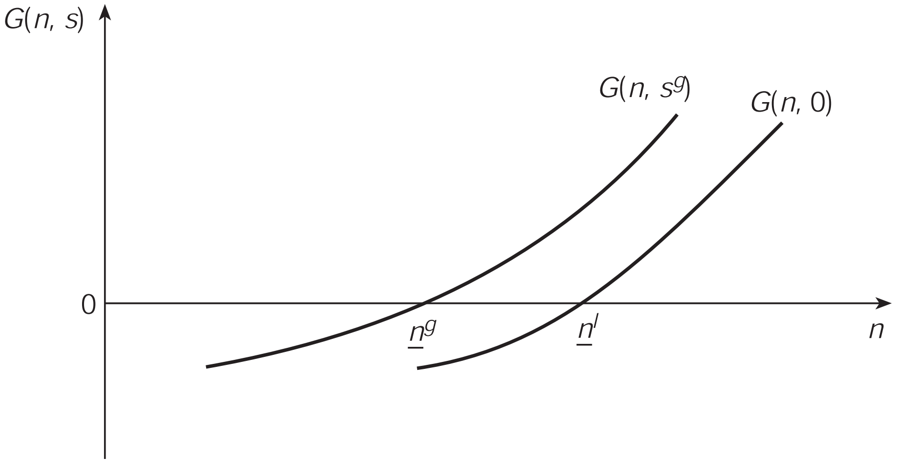

Fig. 4. Inheritance and the decision to invest in education

provision of loans does not result in an efficient allocation. A loan scheme is neither equitable, as there are *ex post* differences between the wages of educated and non-educated workers. From (7), the lifetime income of a skilled worker is greater than that of an individual who never studied, which in turn is greater than that of a student who did not succeed, $-E + Rw_H > (1 + R)w_L > -E + Rw_L$. Finally, there is no equality of opportunity. Although all agents have access to funds, the differences in inheritance levels imply different attitudes towards risk, and consequently only those wealthy enough choose to study.

4.3 Risk-aversion and the graduate tax

A graduate tax system, as defined here, has two components. First, there is a public loan scheme, so that any individual can obtain a loan that has to be fully paid back. In addition to making loans available, the state pre-finances part of the education cost through public debt. The total debt, generated by the subsidies is then repaid by levying a tax on those who have successfully finished university. Those who do not obtain a skilled job after they complete their education do not to pay the graduate tax. Unsuccessful students, hence, receive a net subsidy, while successful students have to pay back not only their own education cost but also the subsidy received by those who fail.

The government subsidises a fraction s of the cost of education EH and finances the subsidy by borrowing. In the next period, it levies a tax on those who have become skilled. Total tax revenue is given by TpH, the lump sum paid by each successful student, T, times the number of successful students, pH. The government's budget constraint has to balance total subsidies with tax income, where the latter is discounted as it is levied one period after the subsidies are paid, $sEH = RTpH$.

Each agent who invests in education and becomes skilled pays education cost of $(1-s)E+RT$ over her lifetime. Substituting for the lump-sum tax from the government budget constraint, this payment can be expressed as $(1+s(1-p)/p)E$ which is clearly greater than E. Those who go to university and fail pay only a fraction of education cost, $(1-s)E$. Compared to the pure loan scheme, education costs rise for successful students and fall for unsuccessful ones. The variance of the lifetime income of an individual who decides to study is lower, which is an insurance property of the graduate tax. It results from the implicit transfer from successful students to unsuccessful ones.

Under the graduate tax system, the diffrerence between the expected utility of investing in education and not investing becomes

$$G(n,s) \equiv (1-p)U(n-(1-s)E+Rw_L) + pU\left(n - E\frac{1-p}{p}sE + Rw_H\right) - U(n+(1+R)w_L) \quad (10)$$

which is now also a function of the subsidy. When $s=0$, we are back to the pure loan scheme represented by eq. (8). For any given level of inherited wealth, a higher subsidy implies a smaller difference in the *ex post* returns from failing and from succeeding. Since the expected return to investing in education, $n-E+R[(1-p)w_L+pw_H]$, is the same for all values of the subsidy, the only effect of increasing the subsidy rate is to reduce the variance of income. A higher subsidy rate therefore reduces risk and increases expected utility for any given level of inherited wealth. An increase in s thus shifts upwards the $G(n,s)$ function, as shown in Fig. 4. Given a subsidy rate $s^g>0$, all individuals with wealth such that $G(n,s^g)>0$ invest in education, while those for whom $G(n,s^g)<0$ do not.

Denoting the inheritance of the individual who is just indifferent between studying and working by $\underline{n}^g$, the number of agents who study is given by the number of individuals who have inherited wealth above this threshold

$$H^g = \sum_{n \geq \underline{n}^g} f(n) \quad (11)$$

Since the expected utility from studying, $G(n,s)$, increases with the subsidy, the indifference level $\underline{n}^g$ lies to the left of $\underline{n}^l$. A greater subsidy rate increases the number of students and therefore the number of skilled individuals. Despite these efficiency gains, however, the socially optimal level of investment $H^*=N$ will not be attained as long as $\underline{n}^g>0$.[17]

[17] It is well known that labour supply decisions are also influenced by taxation. In a world of certainty, taxes on labour income have an ambiguous effect on labour supplies due to the counterbalance between the income and the substitution effects. Here, we ignore such labour supply considerations. There are two reasons for this. First, empirical studies show that labour supplies are generally very inelastic (cf. the references in Eaton and Rosen, 1980). Second, the increase in human capital investment induced by the tax on labour income is reinforced when the labour supply is endogenous and agents have constant absolute risk aversion (see Eaton and Rosen, 1980, Proposition 1). It follows from this proposition that the same holds for decreasing absolute risk aversion. Including these aspects would therefore strengthen the case for a graduate tax.

The graduate tax also has two desirable equity implications: it does not imply reverse redistribution, and it reduces the differences between the *ex post* lifetime incomes of the three types of workers as compared to a pure loan scheme. The net lifetime income of the poorest group (unsuccessful students) goes up, the net lifetime of the richest group (successful students) goes down and the net lifetime income of the middle group remains unchanged. The distribution of net lifetime income is compressed. There remain, nevertheless, differences between agents as far as their willingness to undertake risk is concerned. Because parental wealth provides insurance in the event of successful studies, young agents from wealthy dynasties are more likely to study than those from poorer families. The graduate tax, by providing some degree of insurance, weakens this effect but does not eliminate it. Equality of opportunity is still not attained.

4.4 Income contingent loans

A policy recently introduced by several countries in order to finance higher education is a system of income-contingent loans. An income contingent loan consists in a loan the student receives from the state such that: (i) repayment only takes place in the event that her income after the period of education exceeds a pre-specified level, (ii) annual repayments do not constitute more than a certain proportion of her income[18] and (iii) repayment ceases once the loan plus interest has been repaid.

All individuals who want to study borrow an amount E. Borrowing less would not be rational, given the insurance provided by the income contingent loan. In terms of the present model where only two income levels are possible, only those who succeed and pass their exam have to repay this amount in full. However, a lump-sum tax is levied on all individuals in order to raise the revenue needed to cover the education cost of unsuccessful students, which amount to $(1-p)HE$. Total revenue in present values terms is RTN, as the tax is paid by all individuals. Since we have assumed that the government has a balanced budget, the present value of the tax rate is simply $RT = (1-p)HE/N < E$. It is less than the cost of education E as $(1-p)H < N$. The expected gain from investing in education, by analogy to (8) and (10), now reads

$$G(n,0) = (1-p)U(n - RT + Rw_L) + pU(n - RT - E + Rw_H) - U(n - RT + (1+R)w_L)$$

The expected net lifetime income from studying is given by $n - (1-p)RT - pE + R[(1-p)w_L + pw_H]$ which, as $RT < E$, is higher than the expected net lifetime income under the graduate tax system. This reflects the fact that students are subsidised by those who decide not to study. This subsidy also makes it less attractive not to study, as lifetime income from working two periods as an unskilled

[18] In Australia repayment takes place if a person's average weekly income exceeds the average weekly income of the entire population. The repayment rate lies between 3% and 5% of taxable income (Harding, 1995; Chapman, 1997).

is reduced by RT compared to the graduate tax system. These effects tend to make the contingent-loans scheme more efficient.

The difference in lifetime income between successful and unscuccessful students under the income-contingent loan scheme is given by $R[w_H - w_L] - [N - (1-p)H]N^{-1}E$. Under the graduate tax system, this difference amounts to $R[w_H - w_L] - sp^{-1}E$. The spread under the income-contingent loan system is therefore higher than under the graduate tax if $s > p[N - (1-p)H]N^{-1}$, i.e. if s is sufficiently close to unity or the higher the number of students H. A higher spread under an income contingent loan, however, tends to make this loan system less efficient as compared to a graduate tax system. Overall, neither system dominates the other one on efficiency grounds.

The higher expected return to education of the income contingent loan system is at the cost of those who do not study. They are worse off than under the pure loan scheme and under the graduate tax system as they have to pay taxes RT. Successful students earn as much as under the pure loan scheme and more than under the graduate tax system. Unsuccessful students earn more than under the pure loan scheme (as they do not have to pay the entire education cost E but only RT) and more or less than under the graduate tax system. They earn less if $RT > (1-s)E \Leftrightarrow s > [N - (1-p)H]N^{-1}$ which holds if the subsidy s to education under the graduate tax system is sufficiently close to one. In this case, the distribution of lifetime income would widen.

The graduate tax system therefore tends to outperform a contingent loan system as well. Provided that the subsidy is sufficiently close to one, it is the more efficient system. Independently of the level of the subsidy, it is more egalitarian as it avoids reverse redistribution.

The present paper did not study externalities. If low-skill workers benefit from high-skill workers, e.g. through a positive growth externality, some subsidies from low-skilled to high-skilled workers are appropriate. (Increases in productivity as implied by a production function such as (1) are reflected in wages and do not constitute an externality.) In this case, the implicit subsidy in the income-contingent loan system might internalise this externality which would make it superior to a graduate tax system. If such an externality existed, however, the first-best instrument would be an explicit subsidy as each market failure should have its own instrument.

4.5 How large should the subsidy be?

The question now arises how large should the subsidy rate under a graduate tax system be. Should it be less than unity, cover the entire education cost, or even lie above unity? In an environment with idiosyncratic risk, Pareto optimality requires full insurance, which means identical utility levels in all states of the world. As with all insurance mechanisms, however, a graduate tax implies a potential moral hazard problem. To the extent that the probability of the various states of the world depend on individual behaviour, agents might not provide the socially optimal level of effort when they are fully insured. When effort is costly, an agent whose income will be the same whatever her effort, has no incentive to exert any effort.

Applied to the question in hand, the subsidy should not be so large that the lifetime income after successfully completing education is the same as the lifetime income after leaving university without having obtained a degree. The net lifetime income of a successful student is $W_S = -E - sE[1-p]/p + Rw_H$, while that of an unsuccessful student is given by $W_F = -(1-s]E + Rw_L$. Under full insurance, the two would be the same and the full insurance subsidy, s_f (which can be greater than one, implying that there are net transfers to those who fail) would be given by the expression

$$s_f \frac{E}{p} = R[w_H - w_L] \quad (12)$$

The certain lifetime income of both groups is then equal to the expected lifetime income of someone who decides to study, $W_S = W_F = -E + R[pw_H + (1-p)w_L]$.

One would wish to obtain an estimate of the full insurance subsidy. If it is sufficiently greater than unity, one could safely recommend free access to higher education ($s = 1$) without running the risk of moral hazard problems. In order to obtain such an estimate, it would be necessary to predict the wage profiles of successful students and students who failed and sum up discounted wages to obtain lifetime income. With an estimate of the probability of failure and data on the cost of education, one would be able to compute s_f. While this does not appear to present major problems (despite difficulties related to estimating returns to education, to wage regressions in general or to predicting wage profiles and to choosing appropriate interest rates for discounting), taking the effect of disutility from effort while studying into account appears more challenging. Providing an estimate of the full insurance subsidy is therefore left for future work.[19]

5. Heterogeneous individuals

This section briefly discusses whether our results are robust to allowing for *ex ante* individual heterogeneity in ability. An individual might know what her ability is before the education decision is made or only afterwards. *Ex post* heterogeneity is already present in our analysis. In Section 4 we examined the effects of uncertainty about the outcome of the education process on education decisions. A possible interpretation of this uncertainty is that individuals differ in their ability to learn, and that this ability is only observable after agents have invested in education: those with high learning abilities succeed, those with low ones fail.

[19] We did compute a rough estimate without taking the effort effect into consideration in an earlier version of this paper. The full insurance subsidy lay at around $s_f = 3.5$.

In practice, an agents' ability is partly known and partly unknown *ex ante*. Suppose, following Torvik (1993),[20] that agents differ in their ability to learn and that this is known to them before they engage in higher education. Let a_i denote an individual's learning ability, i.e. the number of efficiency units she accumulates if she is educated. Unskilled workers are assumed to supply one efficiency unit. The ability to learn is distributed according to the density function $g(a)$, and it is assumed to be independently distributed from bequests.

Under perfect capital markets and in the absence of uncertainty, an individual chooses to study if—just as above—her lifetime income were greater when she studies than when she does not. The lifetime income of an individual who studies is given by $a_i R w_H(A, N-H) - E$, where $w_H(A, N-H)$ is the wage per unit of human capital and $A = \sum_{i=0}^{H} a_i$ is the aggregate number of units of human capital. In equilibrium, those with highest ability choose to study while those with lowest ability do not. The equilibrium number of skilled workers H^* is determined by an equation similar to (2)

$$(1+R)w_L(A^*, N-H^*) = -E + Ra_i w_H(A^*, N-H^*) \tag{13}$$

where $A^* = \sum_{i=0}^{H^*} a_i$ is the equilibrium aggregate stock of human capital. Note that when individuals differ in their ability, their lifetime incomes will not be the same even if capital markets are perfect. The incomes of unskilled workers are equal to that of the last individual who chooses to study (whose ability we denote by a^*), while all those who are more able will have a higher income.

If capital markets are imperfect, only those individuals whose bequest is greater than the cost of education can study. Consider now the traditional system, a subsidy financed from general taxation. In order to induce efficiency, the government has to use two policy instruments. First, education must be fully subsidised in order to ensure that all high-ability agents can afford education. Second, as education is now costless (corresponding to $E = 0$ in eq. (13)), a minimum ability requirement must be set at a^* since the individual who is indifferent to studying or not now has an ability below the optimal threshold a^*. Such a system would, as before, have two undesirable distributional consequences: the income of unskilled workers is less than that of the less-able skilled individual because of the transfer from unskilled to skilled agents,[21] and it implies reverse redistribution, as low-ability individuals finance the education of high-ability individuals who have a higher income.

The only way to reduce income differences between the skilled and the unskilled would be to lower the ability threshold required to study. This would increase the stock of human capital, thus reducing the skilled wage per unit of human capital and increasing that of the unskilled. However, it would also result in a misalloca-

[20] Torvik (1993) examines the education decisions of individuals who differ in their ability to learn and in their bequests when the interest rate for borrowing differs from the interest rate for saving. He considers only the case in which education is privately financed, and examines the effect of the capital market imperfection on the allocation of talent.

[21] It is straightforward to check this by using eq. (13).

tion of labour as there is an excessive number of educated workers. Hence, the trade-off between efficiency and equity that we identified in Section 3 is still present when individuals differ in their ability to learn.

Once we allow for uncertainty and risk-aversion, the effect of heterogenous *ex ante* abilities is to create a trade-off between ability and inherited wealth. The function $G(\cdot)$ would now depend not only on the individual's wealth but also on her ability level. The greater the *ex ante* ability, the higher the expected utility from studying, and hence the greater the difference between investing in education and not investing becomes. In terms of Fig. 4, there would be a different $G(\cdot)$ function for each ability level and a different threshold level of wealth $\underline{n}(a_i)$. Because high-ability individuals have a higher expected return from education, the higher the individual's ability, the lower the threshold level of wealth. The results derived in Section 4 about the different financing systems are unaffected by the introduction of *ex ante* heterogeneity. The only difference is that now high ability will partly offset the insurance effect of family wealth.[22]

6. Conclusions

The motivation for this paper is the fact that the tax-subsidy system traditionally used to finance higher education is characterised by reverse redistribution. The education of future high-income earners is partly subsidised by taxes levied on low-income workers. Given that government intervention is needed due to the difficulty of obtaining private loans to finance higher education, we have asked what forms of intervention can avoid reverse redistribution.

We have first examined the traditional tax-subsidy system and asked whether changes in the subsidy rate can help overcome reverse redistribution. There are three possible policy targets that governments may wish to attain: efficiency, equality of lifetime incomes, and equality of opportunity. We found that the traditional system cannot simultaneously achieve all these targets. Since both labour and human capital are essential for production, it is not optimal to educate all workers. There is therefore a trade-off between efficiency and equity: a subsidy rate that allows the optimal number of workers to study results in a greater lifetime income for the skilled than for the unskilled; a higher subsidy rate increases the number of students and equalises lifetime incomes, but the labour force is overeducated and this leads to a loss of potential output.

Three alternative systems have been analysed: a pure loan scheme provided by the government, a graduate tax, and an income-contingent loan system. These systems are identical when the outcome of the education process is certain. When there is uncertainty, the systems differ in the way in which education costs have to be repaid. Whereas under a pure loan scheme a student pays in full her education cost, a graduate tax system makes the payment of education

[22] It would be very interesting to study these effects in more detail than we could do in this paragraph.

costs contingent on whether or not the individual succeeds in education. Students who do not obtain a skilled job do not have to pay education costs. Students who end up working as skilled workers pay both their own education costs and an amount used to cover the subisidies to those who have failed. The graduate tax increases the payoff to an agent who studies and fails, and decreases the payoff to one who succeeds, thus reducing the risk associated with education investment without changing its expected payoff. Such a system provides partial insurance. Hence, if agents are risk-averse, insurance induces more individuals with low wealth to invest in education, thus increasing efficiency.

An income-contingent loan system, such as currently in place in Australia, New Zealand, and the UK, is similar to a graduate tax system and therefore is characterised by most of its advantages over the traditional system. In particular, both systems provide insurance and therefore result in a more efficient number of students. As maximum repayment per student under the income-contingent loan system is limited to the loan plus interest, some general tax income is still needed to subsidise unsuccessful students. In contrast to a graduate tax system, this again implies reverse redistribution. As an income-contingent loan system is not necessarily more efficient, a graduate tax system can be advocated as an improvement of systems currently in place.

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