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Risk, Resources, and Education: Public Versus Private Financing of Higher Education

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The paper develops a public education scheme that takes aspects of uncertainty in private educational investments explicitly into account. The social merits of public education schemes are related to the lack of markets in which students can insure against educational risks. A case is made for tuition fees that depend on expected returns of investments in education. The consideration of uncertainty provides a neglected link between educational choice, resource endowment, and productivity growth, which may serve to redefine the public role of education financing. [JEL H52, I22, D81]

In virtually all developed countries the government is engaged in higher education. A commonly used argument is that private markets are unable to provide higher education up to an efficient amount. Positive externalities and capital market imperfections figure most prominently in the list of arguments claiming that investments in higher education regulated by private markets are too low.

Positive externalities result if the returns on higher education are not fully priced in private markets. Undoubtedly, university graduates provide the society with valuable services. On the other hand, they earn comparatively high incomes, which may have internalized the economic surplus of university graduates. But, even if some work by university graduates causes external effects beyond the

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respective salary differential, a Pigou-internalization by subsidizing all university students, which is common practice, will hardly be successful.[1]

The imperfect capital markets argument relies on the notion that human capital acquired by education is nontradable. Human capital cannot be lent ahead and thus cannot be used as a security for student loans. This can lead to an inefficiently small demand for higher education by those who are not able to finance a cost-intensive education due to liquidity constraints.[2] Capital market imperfections, however, do not necessarily suggest educational subsidies. Publicly provided student loans should suffice to redress a too-small demand for higher education due to capital market imperfections.[3]

One should bear in mind, though, that individual returns to education are generally *uncertain*. The individual can neither be sure about finishing his education successfully nor about his future returns after a successful examination. In fact, educational returns display a very high variance as many students do not graduate, income differences between graduates are large, and even the risk to become unemployed exists.[4] Publicly provided student loans, which have to be paid back irrespective of educational success, generally do not change the nature of individual educational risk. Yet, the risk an individual faces with an investment in education can be expected to constitute a significant disincentive to invest in education, as individuals are unable to insure against these risks on private markets. Therefore, it can be assumed that risk-averse individuals do not adjust expected marginal returns on educational investments to marginal costs. Instead, they underinvest in education.

What matters for society as a whole are average returns of all university graduates. Society should invest in higher education until average marginal returns of educational investments equal their marginal costs. A publicly provided educational program with a *success-dependent* cost participation of university students may contribute to an individual realization of this rule.

In this paper we develop a public education program that explicitly takes uncertainty of private education into account. The policy objective is charac-

[1]See, for example, Lüdeke (1996) and Heckman and Klenow (1998) for a discussion on positive externalities of higher education. It should be noted that modern growth theory à la Romer (1986) and Lucas (1988) is based on positive externalities from education to endogenize the economy's rate of growth. See Wigger (2001) for internalization policies of such externalities

[2]Most of the literature concerned with the relationship between income distribution and growth assumes some kind of capital market imperfection. See, for example, Galor and Zeira (1993), Perotti (1993), and Barham and others (1995), as well as the surveys by Perotti (1994) and Benabou (1996).

[3]See Lott (1987) for a more in-depth survey of the normative justifications for subsidizing higher education. Trostel (1993, 1996) provides a further efficiency argument for educational subsidies relying on the notion that income taxation distorts the investment decision on education which, in turn, can be corrected by an education subsidy. In contrast to the arguments above, however, this constitutes a second-best argument for subsidizing education. It should be noted that there is an alternative strand of the economics of education literature which emphasizes a public choice perspective of public education financing rather than stressing efficiency arguments. This literature includes Peltzman (1973), Johnson (1984), and Fernandez and Rogerson (1995).

[4]Already Becker (1964, p. 104) has pointed out that educational returns are characterized by a very high coefficient of variation. This observation is supported by more recent studies such as, for instance, Miller and Volker (1993). For a theoretical approach to educational risk see Levhari and Weiss (1974).

terized by a maximization of a tax dividend of public education financing. We first derive a first-best rule of public education financing which implies full insurance against educational risk. We then consider how adverse selection with respect to educational abilities and moral hazard with respect to educational and work effort affect the shape of the educational program. Our model provides a case for *success-dependent* tuition fees as they already exist in some countries.[5]

The consideration of educational risk also gives an interesting insight into the interrelation between individual educational choice, initial resource endowment, and productivity growth. We show that the extent of private educational financing as well as the social surplus of a public funding of education depend on both individual resource endowments and productivity growth. The necessity for a public scheme becomes less compelling when better endowed individuals are increasingly willing to accept educational risks. Productivity growth may also lead to an increase in private educational investments. This effect, however, tends to be much weaker than the impact of an increase in initial endowments.

I. The Basic Framework

This paper considers individuals facing some amount of risk when deciding on the level of educational investment. Such an investment has two possible outcomes: the education undertaken may either be successful or fail, where success and failure are measured in terms of disposable income.[6] Let y^S and y^F be disposable income in case of success and in case of failure, and let π denote the probability that the educational investment fails. This probability can be understood as a measure of the lack of individual talent and purposefulness. Expected utility may then be written as:

$$Eu = \pi u\left(y^F\right) + (1-\pi)u\left(y^S\right).$$

The von Neumann-Morgenstern function $u : \mathbf{R}_+ \rightarrow \mathbf{R}$ is assumed to be twice continuously differentiable. It is assumed that the individuals are risk-averse and anxious to realize positive consumption in any state. This implies $u' > 0$, $u'' < 0$, and $u'(0) = \infty$.

If the educational investment is not successful, individual disposable income is given by:

[5]An example is the Higher Education Contribution Scheme, which was introduced in Australia in 1989. See Chapman (1997) for an economic analysis of this scheme.

[6]The model could easily be extended by considering more than two outcomes of educational investments. This would not, however, affect the main results.

$$y^F = x - e,$$

where e marks the educational investment and x is the labor income of an unskilled individual. Hence, an individual failing in education has less income at its disposal than an individual who has not undertaken an education at all. If education is successful, disposable income is given by:

$$y^S = z(e) - e,$$

where the function $z : \mathbf{R}_+ \rightarrow \mathbf{R}_+$ indicates the return on an educational investment e. It is assumed that $z(0) = x$, $z' > 0$, $z'(0) = \infty$, and $z'' < 0$, implying that marginal returns on education are positive but decreasing.

II. Education Financing

Private Education Financing

If education is financed privately an individual will choose an educational investment e such that expected utility takes on a maximum:

$$\bar{e} = \operatorname{argmax}\left\{\pi u(x-e) + (1-\pi)\, u\big(z(e)-e\big) :\ e \geq 0\right\}.$$

The first-order condition for the ex ante optimal investment $\bar{e}$ may be expressed as:

$$(1-\pi)\, z'(\bar{e}) = 1 + \pi \frac{u'\left(\bar{y}^F\right) - u'\left(\bar{y}^S\right)}{u'\left(\bar{y}^S\right)} > 1,$$

where $\bar{y}^F$ and $\bar{y}^S$ denote disposable income in case of failure and success, respectively, if an educational investment $\bar{e}$ was undertaken. Hence, the individuals do not equate expected marginal returns on education (= $(1 - \pi)\, z'(e)$) and marginal costs (=1), but due to risk considerations, invest a lower amount in education.

Before we can proceed to public education funding, we need a measure for the value individuals assign to privately financed education. It is convenient to employ the concept of the certainty equivalent. The certainty equivalent is that amount of income, $\hat{y}$, which, if received for certain, the individual regards as just as good as

the expected income when it undertakes an educational investment $\bar{e}$. Thus, $\hat{y}$ is implicitly defined by:

$$u(\hat{y}) = \pi u(\bar{y}^F) + (1-\pi)\, u(\bar{y}^S).$$

Obviously, a public education scheme has to offer a utility level of at least $\hat{u} = u(\hat{y})$. Otherwise, individuals will finance the education privately.

Public Education Financing

Suppose that the government encourages individuals by means of a public program to invest more in their education than they would do otherwise. This increases the average return on educational investments if there is a sufficiently large number of individuals who aim at a higher education and whose educational risks are distributed independently. It is sometimes argued that a public program of higher education financing will also be advantageous for that part of the population not participating in higher education, if the additional tax revenues exceed the costs of the scheme. The social (tax) return on higher education is called the *tax dividend* of a public education scheme.[7]

Following the notion of the tax dividend we assume that the policymaker's objective is to maximize the net social return on educational investments, which is defined as the sum of individual returns on educational investments minus the cost of education and minus the disposable incomes of the individuals having undertaken an education. The public program is an educational package that is a triplet consisting of an educational investment e, a disposable income in case of failure y^F, and a disposable income in case of success y^S.

Let the number of individuals being able to participate in higher education be given and normalized to 1. The net social return on educational investments is then given by:

$$T = \pi(x - y^F) + (1-\pi)[z(e) - y^S] - e.$$

In what follows, we first determine the first-best public educational program. Afterward, we consider extensions of the model to analyze how adverse selection with respect to educational abilities and moral hazard with respect to educational and work effort affect the public program.

[7]See, for example, Barr (1993, chap. 13).

First-best program of public education financing

Even in the basic framework the policymaker does not have complete freedom in designing the educational program. Since the individuals can always undertake a privately financed education, the public program must offer individuals at least as much utility as the private alternative. An individual will participate in the public education scheme only if:

$$\pi u\left(y^F\right)+(1-\pi)u\left(y^S\right)\geq \hat{u};$$

that is, if the program offers at least the utility obtained by privately financed education. This constraint ensures voluntary participation in the public program. The optimal public program, denoted by PP I, can then be formulated as:

$$\max_{\left\{e,y^F,y^S\right\}} \quad T=\pi\left(x-y^F\right)+(1-\pi)\left[z(e)-y^S\right]-e,$$

subject to the voluntary participation constraint. The solution to PP I is implicitly determined by:[8]

$$y^F=y^S \text{ and } (1-\pi)z'(e)=1.$$

Thus, the optimal program of education financing is characterized by a full public takeover of all educational risk and by the condition that the marginal expected return of educational investment equals its marginal costs.

Public education financing with different types

So far we have assumed that all individuals are identical. This is not a realistic assumption, however, as individuals normally differ with respect to their educational abilities. Therefore, we extend the model to allow for two types of individuals with differing educational risks.

Let the probabilities of educational failure of type 1 and type 2 individuals be given by π_1 and π_2 and assume that $\pi_1 > \pi_2$, that is, type 1 individuals face a lower chance of success than type 2 individuals. If the government could perfectly observe individual types, it would implement educational packages for each type as determined in the previous section. A reasonable assumption, however, is that individual types are not publicly observable. We assume that the policymaker knows that a proportion q_i of that part of the population, which

[8]See Wigger and von Weizsäcker (1999) for technical details.

is capable of participating in higher education, is of type $i = 1, 2$, with $q_1 + q_2 = 1$, but that he cannot observe each individual's type separately. As a consequence, the first-best program is not feasible. Individuals of type 1 would simply masquerade as individuals of type 2 and choose the educational package intended for individuals of type 2 to achieve a higher utility level. Feasibility of a public financing program requires that no individual finds it worthwhile to choose an educational package designed for individuals of a different type. Standard arguments[9] show that the optimal policy is constrained by the requirement that individuals of type 1 prefer to claim the educational package intended for themselves rather than the one intended for individuals of type 2. More precisely, an optimal program implies:

$$\pi_1 u\left(y_1^F\right) + \left(1-\pi_1\right) u\left(y_1^S\right) = \pi_1 u\left(y_2^F\right) + \left(1-\pi_1\right) u\left(y_2^S\right).$$

On the other hand, whether one or both of the voluntary participation constraints bind is not clear a priori, since individuals of different types would undertake different private educational investments. This implies that either both constraints bind or only the one in which individuals of type 2 prefer to undertake private educational investments binds. Hence, the optimal incentive compatible public scheme, denoted by PP II, may be written as:

$$\max_{\left\{e_i, y_i^F, y_i^S\right\} i=1,2} \quad T = \sum_{i=1,2} q_i \left[\pi_i\left(x_i - y_i^F\right) + \left(1-\pi_i\right)\left[z\left(e_i\right) - y_i^S\right] - e_i\right],$$

subject to the incentive compatibility constraint and a voluntary participation constraint for each type. The optimal educational program in the presence of unobservable types, PP II, satisfies:

$$y_1^F = y_1^S, \quad y_2^F < y_2^S, \text{ and } \left(1-\pi_i\right) z'\left(e_i\right) = 1, \quad i = 1, 2.$$

As in the first-best program, PP II is characterized by an equalization of marginal returns and marginal costs of educational investments for both types. Thus the information of the policymaker on educational types does not affect the optimal level of public educational investments. Furthermore, as in the first-best, the public program should take over the whole educational risk of individuals of type 1. Individuals of type 2, on the other hand, should face some of their educational risk. The intuition behind this result is as follows. Participation in educational risk is less attractive for type 1 than for type 2 individuals. If type 2 individuals face some educational risk this restrains type 1 individuals from masquerading and from choosing the educational package intended for type 2

[9]See, for example, Kreps (1990, chap. 18).

individuals. The net social return on educational investments of PP II is less than that of PP I, even if both participation constraints are binding. If type 2 individuals are given a share in their educational risk, their average disposable income has to exceed their certainty equivalent. Otherwise, due to risk aversion, they would not participate in the public program.

Public education financing and moral hazard

The analysis so far has abstracted from incentive effects of a public takeover of educational risks on individual effort. However, public insurance of educational risks may affect incentives to be successful in two respects. First, it may undermine individual incentives to avoid educational failure. Second, it may give individuals an incentive not to reveal their success in order to reduce their tax liabilities after education. The first instance—ex ante moral hazard—may occur if the government cannot observe individual effort to be successful. The second instance—ex post moral hazard—may occur if the government cannot observe success directly but has to infer it from individual income.

Ex ante moral hazard

In this section we study how these types of moral hazard affect the shape of the public education program. For simplicity we return to the model with only one educational type. We start with ex ante moral hazard. Thus, we assume that the probability of educational success depends on individual effort. Individuals can choose between two effort levels ε_1 and ε_2, with $\varepsilon_1 < \varepsilon_2$. The probability that an individual is not successful is then determined by $\pi_i = \pi(\varepsilon_i)$, i = 1, 2, with $\pi(\varepsilon_1) > \pi(\varepsilon_2)$. Educational effort ε_i is measured in currency units so that disposable income in case of failure and success become $y^F - \varepsilon_i$ and $y^S - \varepsilon_i$. If the government wants to enforce the effort level ε_2 rather than ε_1 (otherwise there would be no moral hazard problem), it has to consider the following incentive compatibility constraint:

$$\pi_2 u\left(y^F - \varepsilon_2\right) + \left(1 - \pi_2\right) u\left(y^S - \varepsilon_2\right) \geq \pi_1 u\left(y^F - \varepsilon_1\right) + \left(1 - \pi_1\right) u\left(y^S - \varepsilon_1\right).$$

The optimal public education program in the presence of ex ante moral hazard, denoted by PP III, then becomes:

$$\max_{\left\{e, y^F, y^S\right\}} \quad T = \pi_2\left(x - y^F\right) + \left(1 - \pi_2\right)\left[z(e) - y^S\right] - e,$$

subject to the incentive compatibility and a voluntary participation constraint. The solution to PP III is characterized by

$$y^F < y^S \text{ and } \left(1-\pi_2\right) z'(e) = 1.$$

Thus, consideration of ex ante moral hazard leads to individual risk participation in the public education program. This is because if the public took over all educational risk, individuals would have no incentive to choose the higher effort level to study towards success. In light of the analysis in the previous section this result implies that individuals of all educational types should bear some of the risk of educational failure. The optimal amount of public education, however, is not affected by ex ante moral hazard. It is still determined by an equalization of marginal returns and costs of educational investments, making the public program superior to its private alternative.

Ex post moral hazard

Consider next ex post moral hazard. Hence, assume that individual gross income does not only depend on educational success but also on work effort. Gross incomes are now assumed to be given by $g^F = xl^F$ and $g^S = z(e)\, l^S$, where l^F and l^S denote work effort in case of failure and success, respectively. Work effort l leads to a disutility measured in currency units by $v(l)$, with $v' > 0$ and $v'' > 0$. If the government can only infer educational success from observed gross income, insurance in the form of redistribution between the successful and the unsuccessful is constrained by the fact that successful individuals can claim to be unsuccessful by choosing a lower level of work effort. The problem of the government then resembles that of designing an optimal income tax scheme. Employing the self-selection method, introduced by Stiglitz (1982) into the optimal taxation literature, a feasible public education program must satisfy:

$$u\left[y^S - v\left(\frac{g^S}{z(e)}\right)\right] \geq u\left[y^F - v\left(\frac{g^F}{z(e)}\right)\right],$$

saying that the successful do not find it worthwhile to claim to be unsuccessful. Thus, the optimal public education program in the presence of ex post moral hazard, denoted as PP IV, may be written as:

$$\max_{\{e, y^F, g^F, y^S, g^S\}} \quad T = \pi\left(g^F - y^F\right) + (1-\pi)\left[g^S - y^S\right] - e,$$

subject to the incentive compatibility and a voluntary participation constraint. The solution to PP IV can be characterized by:[10]

$$y^F < y^S \text{ and } (1-\pi)\, z'(e) l^S > 1.$$

Clearly, PP IV cannot lead to equalization of income between the successful and the unsuccessful as this would not be consistent with incentive compatibility. Furthermore, PP IV does not lead to an equalization of marginal returns and costs of educational investment but implies a *lower* level of educational investment. To get an intuition of this result, assume, for a moment, that the government equalizes marginal costs and returns of educational investment. Then, reduce educational investment by one unit and simultaneously increase net income of the successful in order to satisfy the voluntary participation constraint. Such a policy exerts a negative effect on government revenues which is only of second order. However, it weakens the incentive compatibility constraint which, in turn, permits more insurance and, thus, higher taxes leading to a positive first-order effect on government revenues. Although educational investments are lower than under first-best, they are higher than the ones undertaken privately. This is because PP IV still provides some insurance against educational risk. Furthermore, the net social surplus of PP IV is positive as the policymaker could alternatively imitate private educational financing generating a net social surplus equal to zero.

III. Initial Endowments and Productivity Growth

Hitherto, we have not considered the financial background of the individuals and its potential impact on private educational investments. It is conceivable that a privately undertaken educational investment depends on whether it has to be financed solely out of success-dependent income or whether the individual can fall back on additional financial resources. Furthermore, the absolute amount of disposable income may also affect private educational investments. This is important since, due to productivity growth, incomes of skilled and unskilled individuals have risen continuously during recent decades.

In this section we consider the impact of both initial resource endowments and productivity growth on private educational investment. We start by considering the effect of increasing initial resources. For simplicity we again assume that there is only one type of individual. Let a be an initial endowment. The state-dependent budget constraints are then given by $y^F = a + x - e$ and $y^S = a + z(e) - e$, where y^F

[10]Further results are that the marginal tax rate imposed on the successful should be zero and the one imposed on the unsuccessful should be positive. These results are well known from the optimal taxation literature. For an analysis of insurance and optimal taxation see Varian (1980); for an analysis of public education and optimal taxation see Ulph (1977) and Hare and Ulph (1979).

and y^S now denote disposable resources rather than incomes in case of failure and success, respectively. The privately undertaken amount of educational investments is determined by:

$$\bar{e} = \text{argmax}\left\{\pi\, u(a+x-e)+(1-\pi)\, u\big(a+z(e)-e\big) :\, e \geq 0\right\},$$

providing a function $\bar{e} = \bar{e}(a)$, which describes the relationship between the optimal amount of privately financed educational investments and the initial endowment. It satisfies:

$$\frac{d\bar{e}}{da} \gtreqless 0 \Leftrightarrow A(a+x-\bar{e}) \gtreqless A\big(a+z(\bar{e})-\bar{e}\big),$$

where $A(\cdot)$ is the Arrow-Pratt measure of *absolute* risk aversion. Since $x < z(e)$ for all $e > 0$, the amount of private educational investments is increasing in initial endowment if absolute risk aversion is decreasing. Considering the discussion of the previous section, decreasing absolute risk aversion implies that public education financing is the more important the less individuals can fall back on sufficient initial resources. In view of the standard argument that educational policies should facilitate access to higher education for the poor, this result gains in significance. In fact, it implies that the amount of educational investments undertaken by the poor differs most markedly from the socially optimal level. In this way the result provides a link between the distribution of initial resources and the net social return of public education financing.

When an increase in initial resource endowments a leads to higher private educational investments, one may ask whether a rise in disposable incomes due to productivity growth affects private investments in a similar way. If a is interpreted as an income component depending on productivity, one could conclude that private educational investments go up due to productivity growth, and a public program of education financing would cease to be necessary in the course of time. However, such an interpretation would, among other things, imply that relative educational costs decrease over time. If one observes that educational costs increase over time, such an analogy is less obvious. Suppose that educational costs are governed by the same trend as incomes.[11] The state-dependent budget constraints may then be written as $y^F = \tau \cdot (x - e)$ and $y^S = \tau \cdot (z\,(e) - e)$, where the parameter τ measures productivity at a certain point in time. The optimal amount of privately financed educational investments takes the form:

$$\bar{e} = \text{argmax}\left\{\pi\, u\big(\tau(x-e)\big)+(1-\pi)\, u\Big(\tau\big(z(e)-e\big)\Big) :\, \text{e} \geq 0\right\},$$

[11]This may be the case, for instance, if educational costs are linked to the employment of teachers.

Proceeding in the same way as before we have:

$$\frac{d\bar{e}}{d\tau} \gtrless 0 \Leftrightarrow R\big(\tau(x-\bar{e})\big) \gtrless R\big(\tau\big(z(\bar{e})-\bar{e}\big)\big),$$

where $R(\cdot)$ is the Arrow-Pratt measure of *relative* risk aversion. An increase in productivity leads to higher privately financed educational investments if relative risk aversion is decreasing. The condition for productivity growth leading to higher private educational investments is thus much more restrictive than the condition for increasing resource endowments causing the same effect. Taking the results of the previous section into account, it has to be doubted that productivity growth may lead to privately financed educational investments at the socially optimal level.

IV. Summary and Conclusion

This paper has dealt with private educational investments under risk. It has derived an economic role for the state concerning education financing. In our framework the social merits of public education schemes are related to a nonexistence of markets in which students can insure against educational risks. Hence, a public program of education financing should contain elements of risk insurance. This could be realized, for instance, by success-dependent tuition fees. A complete public takeover of all educational risks cannot, however, be recommended. Individual participation in educational risk should be used to give individuals proper incentives to choose suitable courses of study and to study towards success. Cost-intensive courses should require more individual risk participation. This would ensure that only individuals with adequate educational abilities undertake costly education. Furthermore, individual risk participation induces individuals to make an effort to be successful and to exploit their human capital efficiently after education.

The role of public education financing also depends on the disposability of individual incomes and wealth. If absolute risk aversion is a decreasing function of income, the role of a public scheme becomes less important when educational risks are taken to a socially desirable extent due to a sufficient financial background. In this respect, the frequently used argument that public educational programs serve to facilitate access to higher education for members of low-income groups gains importance. As long as absolute risk aversion decreases, it has to be expected that members of low-income groups will invest less in their education than members of groups with higher incomes, even if they have the same educational abilities.

A general rise in incomes caused by productivity growth may also reduce the public role of education financing, but this would require a distinctly higher income effect on risk aversion. Indeed, the view that economic growth could lead to a stimulation of private demand for education has to be met with caution.

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