Capital market failure, adverse selection and optimal financing of higher education

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OPTIMAL FINANCING OF EDUCATION WITH CAPITAL AND INSURANCE MARKET IMPERFECTIONS[*]

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Abstract – Investments in human capital are sub-optimally low, because debt markets are imperfect due to adverse selection problems and insurance markets for human capital related risk are absent. Legal limitations on the use of human capital in financial contracts prevent equity financing of education and insurance of income risks associated with the investments. The government, however, can write equity and insurance contracts that are dependent on the returns to the investment in human capital through the tax system. This paper shows that public equity financing of education coupled to income insurance is the optimal way to finance education. Education subsidies to restore market inefficiencies are shown to be sub-optimal.

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JEL-codes: H21, H24, H52, H81, I22, I28, J24

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1 Introduction

Higher education is heavily subsidized by the government in most countries of the world. Apart from paternalistic motives and the presumed presence of externalities of education[1], the main argument in favor of these subsidies is that capital and insurance markets are imperfect. Important legal limitations (non-slavery) restrict the use of human capital as collateral in debt contracts, effectively prohibit equity financing of investments in human capital and make insurance of income risks impossible. Due to failing capital markets, under-investment results if poor individuals (or their parents) cannot obtain the necessary funds to finance socially profitable investments in human capital. Risk averse individuals require a risk premium on their investments If income risks cannot be insured because of market failures, under-investment results, cf. Eaton and Rosen (1980).

Furthermore, asymmetric information between (potential) financiers and investors also leads to under-investment. Under-investment occurs if banks ration credit to investors. An increase in the interest rate to meet excess demand for credit may cause large shifts in the overall riskiness of borrowers due to adverse selection effects (low-risk borrowers drop out of the credit market) or moral hazard effects (investors undertake riskier investments). Some investments in socially profitable projects will therefore not be undertaken due to the resulting credit rationing, see e.g. Stiglitz and Weiss (1981), Mankiw (1986), and Hellman and Stiglitz (2000).[2] Asymmetric information also plays a

[1] Positive externalities of education are hard to detect empirically, see for example Heckman and Klenow (1998), Acemoglu and Angrist (2000), Krueger and Lindahl (2002), amongst others.

[2] De Meza and Webb (1987) on the contrary argue that asymmetric information causes over-investment. This is because banks cannot observe the expected returns of the investments, rather than the risks of the investments.

role in the insurance market. Individual earnings capacities and abilities are generally well known before income insurance contracts can be written so that adverse selection occurs and the 'good risks' separate themselves from the 'bad risks' and the market for insurance contracts may break down, cf. Rothshield and Stiglitz (1976), and Sinn (1995).

An important implication of capital and insurance market imperfections is that investments in human capital are dependent on initial conditions. Poorer individuals cannot afford the optimal levels of education; they suffer more from the imperfect functioning of capital markets because they have to borrow more. If relative risk aversion declines with income, poor graduates also require a larger risk premium on their investments in human capital.

Under-investment in human capital due to capital market failures can potentially have further adverse effects as some recent studies suggest.[3] Capital and insurance market imperfections reduce the intergenerational mobility of human capital if parents do not invest optimally in education of their children (Becker and Tomes, 1979, 1986; Loury, 1981). Output or economic growth is lowered as the stock of human capital is below its potential level (Galor and Zeira, 1993; Perotti, 1993). And the segregation of communities is enhanced, because the poorest people cannot escape poor communities. Local externalities and feedback effects add to the persistence of income inequality and spatial segregation (Bénabou 1996a, 1996b; Durlauf, 1996; Fernández and Rogerson, 1998).

Many countries give substantial subsidies (free education, below cost tuition rates and grants) to students in order to resolve problems due to insurance and capital market failures. One unfortunate by-product of subsidized higher education is however that it implies reverse redistribution. The incidence of the costs is born mostly by the average tax payer, whereas the benefits accrue to the most talented, and hence generally better paid, part of the nation. Additionally, a disproportional number of graduates belong to the most wealthy families. In this paper we question whether education subsidies really tackle the problems associated with failing capital and insurance markets and propose better alternatives.

Economists have often advocated more equitable forms of education finance, e.g. income contingent loans or graduate taxes. The idea is that both capital and insurance market failures are directly addressed, see Nerlove (1972, 1975), Barr (1991, 1993), Chapman (1997), van Wijnbergen (1998), Oosterbeek (1998), and García-Peñalosa and Wälde (2000). Friedman (1962) argues that graduates must be allowed to issue equity to

[3] The importance of capital market failures is still a matter of empirical controversy. Some argue that capital markets are highly imperfect based on the significant and positive association between socioeconomic status and enrollment in (higher) education, see e.g. Haveman and Wolfe (1995). On the other hand, this relation may be due to unobserved characteristics such as parental education and abilities. After instrumenting for this, Shea (2000) finds weak evidence for the unimportance of credit constraints. Cameron and Taber (2000), Cameron and Heckman (20010 and Carneiro and Heckman (2002) argue that credit constraints are not really important empirically. Plug and Vijverberg (2003), on the other hand, find strong evidence for the importance of capital market failures while correcting for unobserved characteristics using adopted children as a natural experiment.

finance their investments in human capital.[4] Except for García-Peñalosa and Wälde (2000), none of these studies has yet applied formal analysis to the problem of optimal financing of education and to the proposed solutions. Although García-Peñalosa and Wälde (2000) analyze the optimal design of education financing, they do not pay attention to the underlying micro-economic causes of market failures, i.e. incomplete financial contracts and asymmetric information in credit and insurance markets.

The purpose of this paper is to show that an equity participation model is indeed the optimal way of financing higher education in the presence of asymmetric information. Our analysis builds on the credit rationing literature pioneered by Stiglitz and Weiss (1981). In the presence of asymmetric information, credit markets are likely to fail when investments are debt financed, and under-investment in human capital results. Furthermore, risk aversion reduces investment in human capital further below the socially optimal level. We contribute in various ways to the existing literature.

First, we contribute to the literature on credit rationing by allowing for risk averse investors. Stiglitz and Weiss (1981), Mankiw (1986) and De Meza and Webb (1987), and others have generally analyzed risk neutral investors. However, risk aversion of investors is a real life issue and we show that the introduction of risk aversion has non-trivial consequences. Credit rationing is less likely to occur, and may even disappear when investors are sufficiently risk averse. The intuition is that high-risk investors also require large risk-premia on their investments. When banks increase interest rates, a positive selection effect occurs because high-risk investors drop out of the credit market first due to higher required risk premia on their investments. This positive selection effect may dominate adverse selection effects arising from limited liability that increase the risk of the marginal investor. Consequently, the Stiglitz-Weiss mechanism whereby increasing interest rates give rise to drop-out's of low-risk investors, is reversed and increasing interest rates results in the drop-out of high-risk investors. Credit rationing cannot occur when the positive selection effects dominate the adverse selection effects.

Second, we show that the optimal contract is not a debt contract but in fact an equity contract in markets where debt is rationed and under-investment due to risk aversion is important. For the case of risk neutral investors Cho (1986) and De Meza and Webb (1987) have shown that equity contracts are indeed optimal in the Stiglitz and Weiss (1981) setup.[5] Loosely speaking, a bank offering a debt contract only attracts the

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[4] Friedman actually made explicit reference to equity: "[...] The device to meet the corresponding problem for other risky investments is equity investment plus limited liability on the part of shareholders. The counterpart for education would be to "buy" a share in an individual's earning prospects; to advance him the funds needed to finance his training on condition that he agree to pay the lender a specified fraction of his future earnings. In this way, a lender would get back more than his initial investment from relatively successful individuals, which would compensate for the failure to recoup his original investment from the unsuccessful." Friedman (1962, p.103).

[5] De Meza and Webb (1990) also analyze a model with risk averse investors. However, they only look at investments that differ in mean returns, and not in the risks of the investments. Consequently, credit rationing does not occur and investment is suboptimally *high*, because high return investments cross subsidize low return

high-risk investors, while an equity contract attracts only the low-risk investors (i.e. investors with low-risk projects). Therefore only equity contracts are offered. However, with risk averse investors, this is less obvious. If the positive selection effect of higher interest rates always dominates the adverse selection effect due to limited liability, one might expect that debt contracts are the equilibrium contracts and not equity contracts, because debt contracts then attract the low-risk investors. We show that this does not occur and an equity contract is always preferred to a debt contract no matter how risky the investors are. The reason is that equity contracts offer more income insurance than debt contracts and avoid distortionary redistributions of incomes from low to high-risk investors.

Third, government intervention in financing education is warranted, because only the government can implement such equity contracts Generally, legal problems prevent the execution of both equity and insurance contracts in the case of education financing. In the absence of slavery financial intermediaries cannot claim (parts of) human capital as dividends. This effectively excludes financial contracts that are contingent upon the returns of human capital investment. The crucial distinction between private parties and the government is that the government can monitor and enforce claims on all returns from human capital through the tax system. Equity participation by the government comes down to allowing students to finance education in exchange for a claim on the students' future incomes through a tax on the returns of the investment, i.e. wage income.

Our results are related to De Meza and Webb (1990) and Hoff and Lyon (1995). De Meza and Webb's (1990) model is very similar to ours (although applied to a different problem) but they assume different mean returns and constant spreads. De Meza and Webb (1990) show the possibility of pooling equilibria – where all investors chose the same amount of equity, debt and insurance – and separating equilibria – where investors with different mean returns chose different packages of debt, equity and insurance. Hoff and Lyon (1995) show that redistributive income taxes are optimal in a model with investment in human capital, imperfections in debt markets due to adverse selection, and where investors only differ in their initial wealth. A progressive income tax reduces agency costs because the probability of failure of the marginal borrower declines. Hoff and Lyon (1995), however, study the case with risk-neutral investors and there is an inefficient high level of investment in human capital in absence of government intervention, as in De Meza and Webb (1987, 1990).

Fourth, we show that introducing equity contracts is not sufficient to attain the optimal level of investment in human capital, since risk aversion of graduates implies that they still under-invest. Although both equity and debt contracts feature insurance elements, they typically do not take away all income risks, so that some under-investment due to risk aversion remains. Therefore, additional income insurance is welfare improving. The government may restore social efficiency by insuring income risks through the income tax.

Fifth, we show that education subsidies are at most second-best instruments to restore social efficiency in investment in human capital. We find that efficiency in investment in human capital can only be restored by giving infinitely large education

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investments. However, investments that differ in their risks (resulting in under-investment) are the more relevant assumption for the subject of this paper.

subsidies (on educational costs or interest costs), so that even the most risk averse student opts for investment in education. Therefore social efficiency cannot be achieved through this instrument because infinite subsidies are impossible due to e.g. deadweight losses associated with financing the subsidies. This contrasts with Mankiw (1986) and De Meza and Webb (1987) who show that finite subsidies on interest rates charged by banks are sufficient to restore social efficiency in investments in human capital.

Finally, we present some calculations on the consequences of introducing a graduate tax in the Netherlands. We show that in a graduate tax system payment uncertainties are significantly reduced compared to a loan system and substantial savings on government outlays could be achieved with only modest tax rates.

The setup of the paper is as follows. In section 2 we present the model and analyze the role of capital market imperfections and risk on decisions to invest in learning. Optimal finance of education is analyzed in section 3. In section 4 we discuss sub-optimal ways of financing education. Section 5 presents some calculations of a graduate tax system using Dutch data. Section 6 concludes.

2 Investment in human capital with capital and insurance market imperfections

2.1 Students

The benchmark model is the simplest possible model with capital and insurance market imperfections. We extend Stiglitz and Weiss (1981) by allowing for risk averse investors. Consider a mass of graduates with index *i*, of unit measure. Each graduate decides whether to enroll in higher education which requires an investment of *K*. *K* can be thought of as tuition costs and foregone earnings. The return to the investment in human capital is random. We only consider two-outcome projects and denote the return under the successful outcome R_i^s, and R_i^f if the investment in human capital fails. We assume without loss of generality that $R_i^f = R^f$ for all i. Expected returns are the same for all graduates:

(1) $$R \equiv R_i = p_i R_i^s + (1 - p_i) R^f = const. \quad \forall i,$$

where p_i in [0,1] is the probability of a success for graduate *i*. We say that graduate *i* is riskier than graduate *j* if $p_i < p_j$.[6]

All graduates have identical initial wealth $W_i = W$ which is assumed insufficient to cover all costs of education: $W < K$. Therefore, additional finance is required.

We make the following important 'non-slavery' assumption. Private financial contracts between students and financial institutions cannot be made contingent upon the returns to the investment in human capital. Only debt finance is therefore allowed, since a debt contract (*r*, *B*) that specifies the principal *B* and interest rate *r* is independent of the returns of the investment. Furthermore, income insurance is impossible since this would also require contracts dependent on the return to human capital.

[6] Generally speaking one cannot say that graduate *i* has higher risk than graduate *j* if $p_i < p_j$ because the variance of returns first increases and then decreases with *p* because the returns are bi-modally distributed. However, with mean returns restricted to be equal across all *i*, it is easily shown that the variance decreases with p_i.

If graduates decide to invest in education they borrow $B = K - W$ at interest rate r. If the investment in education fails, banks receive the failure return R^f. If education is successful, banks receive principal plus interest. We assume that $R_i^s > (1 + r)B > R^f$ always holds. Graduates have limited liability, therefore the return π_i for graduate i is given by:

(2) $$\pi_i \equiv \max[R_i^s - (1+r)B, 0].$$

Graduates are risk averse, with a standard expected utility function $EU(\pi_i)$ with $U(0) = 0$, $U' > 0$, $U'' < 0$, $U''' \geq 0$. We also impose Inada type conditions on U: $\lim_{\pi\to 0} U'(\pi_i) = \infty$, $\lim_{\pi\to\infty} U'(\pi_i) = 0$. Graduates are willing to invest in risky education financed with debt as long as:

(3) $$EU(\pi_i) = p_i U(R_i^s - (1+r)B) \geq U((1+\rho)W)),$$

where ρ is the safe real return on non-human investments (savings).

Expected utility is either monotonically increasing in p_i or non-monotonic; first increasing, then reaching a maximum and finally decreasing in p_i. To see this, differentiate (3) while substituting (1):

(4) $$\frac{dEU(\pi_i)}{dp_i} = U(R_i^s - (1+r)B) - U'(R_i^s - (1+r)B)(R_i^s - R^f) <$$
$$U(R_i^s - (1+r)B) - U'(R_i^s - (1+r)B)(R_i^s - (1+r)B).$$

The last line equals zero for risk neutral investors and is positive for risk averse investors. The sign of (4) is therefore strictly negative for risk neutral investors. The sign of (4) cannot be determined in general however. We know that the second line is always positive for any concave utility function. Therefore, the first line may be either positive or negative, since $R_i^s - R^f > R_i^s - (1 + r)B$. Whether (4) is positive or not depends on the size of $(1 + r)B - R^f$ and marginal utility of income U' (which is lowest for low-risk investors). If borrowing costs are large compared to the returns (small $R_i^s - (1 + r)B$), returns in the bad outcome relatively low (low $R_i^s - R^f$), then (4) may be negative, and vice versa. Therefore, (4) is will be typically negative for low-risk investors with relatively small risk aversion due to relatively safe investments and who have a large marginal utility of income since they have relatively high borrowing costs relative to the returns.

We can sketch the graph of $EU(p_i)$; cf Figures 1 and 2 below. We know that $EU(0) = 0$, and $EU(1) = U(R - (1 + r)B) > 0$. The graph of $EU(p_i)$ is either always monotonically increasing, or first increasing and then decreasing to reach $EU(1)$. The intuition for the shape of $EU(p_i)$ can be understood most easily by also plotting $U(E\pi_i)$, which denotes utility from the certainty equivalent and corresponds to the case where there is perfect income insurance. This line corresponds to the Stiglitz and Weiss (1981) case with risk neutral investors as well. As we move along the horizontal axis from $p_i = 1$ to $p_i = 0$ (from right to left), we know that investments become more risky. If graduates could eliminate income risks so as to obtain the certainty equivalent of income, the utility (of expected income) would increase for graduates with lower p_i. Equation (4) is always negative for risk neutral graduates (U linear), since only the limited liability effect is present.

However, if graduates are risk averse, expected utility is lower than the utility of expected income. Expected utility may initially increase if p_i is lowered due to the positive effect of having limited liability. This limited liability effect is more important when risk aversion is small, incomes in the bad state of nature are lower (R^f lower) or if interest rates are higher so that debt costs are higher ($(1 + r)B$ larger), since then the welfare gain of being able to shift default costs to banks increases. Eventually, however, expected utility must become decreasing if p_i decreases, because risk aversion becomes dominant in lowering expected utility. This is because the “utility cost” of being risk averse increases ‘quadratically’ with lower p_i, whereas the utility benefit of having limited liability only increases ‘linearly’ with decreasing p_i.

For example, if utility features constant relative risk aversion (CRRA), ($EU(\pi_i) = p_i\ (R_i^s - (1 + r)B\ )^{1 - \theta} /(1 - \theta)$), then (4) may be always positive (low interest rate, high return in bad outcome) for risk averse graduates, i.e. when $0 < \theta < 1$, see Figure 1. Stronger risk aversion (higher θ) makes the EU line more negatively sloping. We plotted the case for which the interest rate is higher ($r = 1.5$) in Figure 2. Hence, for high p_i the positive effect of limited liability dominates the negative risk aversion effect on risk taking, so that $EU(\pi_i)$ is first increasing and then decreasing as p_i falls.

Figure 1 - Investment decision with debt financing and with high and low risk aversion (R^f = .5, R = 3, W = .6, B = 1, ρ = 0, r = .5).

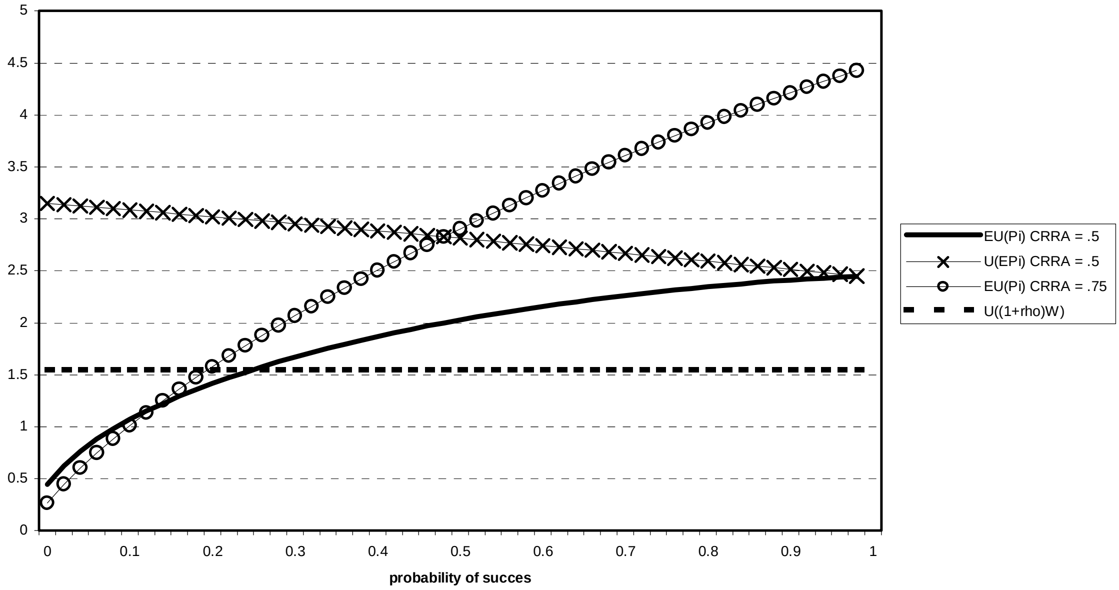
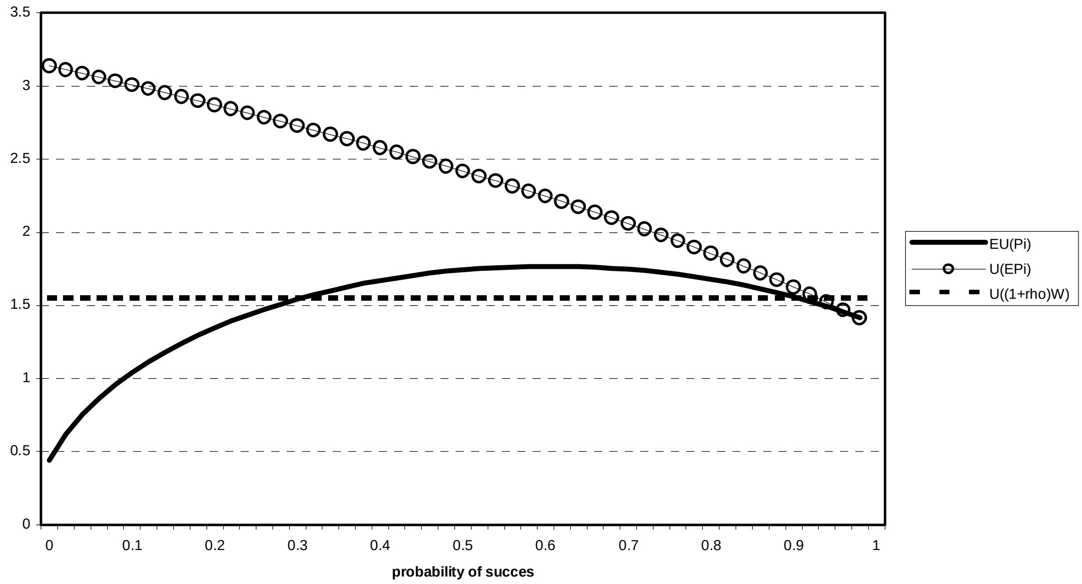


Figure 2 - Investment decision with debt financing and with low risk aversion and high interest rates (R^f = .5, R = 3, W = .6, B = 1, ρ = 0, r = 1.5).



Risk aversion may have important consequences for the equilibrium of the model. For the marginal graduate, i.e. the graduate who is just indifferent between investing in education or putting money in the bank, (4) holds with equality. The success probability at which a student is marginally indifferent between investing and staying out, p_m, may decline or increase if banks increase interest rates depending on whether (4) > 0. This follows from totally differentiating $p_m U((R - R^f)/p_m - (1 + r)B - R^f)) = U((1 + \rho)W)$:

$$(4) \qquad \frac{dp_m}{dr} = \frac{p_m U'(.)B}{U(.) - U'(.)(R_m^s - R^f)}.$$

Consequently, $dp_m/dr > 0$ when (4) > 0 and vice versa. In the limiting case where graduates are risk neutral, $p_m = (R - R^f - (1 + \rho)W)/((1 + r)B - R^f)$, and therefore, $dp_m/dr < 0$ for risk neutral graduates.

If $dp_i/dr < 0$ for all i, high-risk graduates (with low p_i) are willing to pay higher interest rates on loans. This is the source of adverse selection in Stiglitz and Weiss (1981), since banks cannot observe p_i. If bank increase interest rates charged to students, the average risk in the pool of loan applicants increases. However, if $dp_i/dr > 0$ for all i, the high-risk graduates drop out of the credit market first, and increasing the interest rate creates a *positive* selection effect on the loan applicants.

In the intermediate case, dp_i/dr switches sign if risk aversion is small, interest rates are not sufficiently low ($(1 + r)B$ high) or incomes in the bad state of nature are not sufficiently high (R^f low). I.e. when $dp_i/dr > 0$ for for low p_i and $dp_i/dr > 0$ for high p_i. Then, there are in fact two 'marginal graduates' $\underline{p}$ and p^*, because the $EU(\pi_i)$ line cuts the $U((1 + \rho)W)$ line twice on the interval [0,1], see Figure 2. $\underline{p}$ corresponds to the marginal graduate with the lowest probability of success, who is willing to invest, where $d\underline{p}/dr > 0$. p^* corresponds to the marginal graduate with the highest probability of success who is willing to invest, with $dp^*/dr < 0$. Graduates with $p_i < \underline{p}$ or $p_i > p^*$, do not invest.

2.2 Banks

Identical and risk neutral banks offer debt services to graduates so as to maximize expected profits. The credit market is competitive in the sense that there is free entry and exit. Crucial for our exposition is that banks suffer from an information problem. Graduates know the probability of success p_i whereas banks cannot observe p_i. Banks do know the common expected return R to investments in human capital and the distribution of success probabilities denoted $f(p_i)$. One may say that the banks have classified all graduates in groups with different mean returns.

Banks obtain funds at safe real (deposit) rate ρ. For simplicity we assume that the supply of funds to banks is totally elastic at ρ. Expected (average) profits Π for the banks are then given by:

$$(5) \qquad \Pi = (1 + r)B \int_{\underline{p}}^{p^*} p_i f(p_i) dp_i + R^f \int_{\underline{p}}^{p^*} (1 - p_i) f(p_i) dp_i - (1 + \rho)B.$$

In equilibrium, perfect competition between banks drives expected profits down to zero.

2.3 Equilibrium

In equilibrium banks offer debt contract such that no equilibrium contract makes negative expected profits and there is no other debt contract such that this can make non-negative expected profits. From Stiglitz and Weiss (1981), we know that credit may be rationed in equilibrium. The important assumption driving these results is that $dp_m/dr < 0$, which always holds true if graduates are risk neutral. The intuition is that even though there may be an excess demand for credit, banks are not willing to increase the interest rate to choke off excess demand for credit, since the good risk graduates (high p_i) drop out of the market first (adverse selection). The average default risk on loans may increase so much that this causes losses that are larger than the increased revenues from higher interest rates.

The intuition for the credit rationing result can also be derived from differentiation of (5) with respect to the interest rate – note that in this case $\underline{p} = 0$, and $p_m = p^*$, since all high-risk graduates apply for credit:

$$\frac{d\Pi}{dr} = B\int_0^{p_m} p_i f(p_i)dp_i + [(1+r)Bp_m + R^f(1-p_m)]f(p_m)\frac{dp_m}{dr}. \tag{6}$$

The first term measures the increase in repayments of those graduates who do in fact repay their debts. The second term yields the adverse selection effect of increases in the interest rate on the average risk of borrowers. The term in square brackets is positive. Higher interest rates cause the probability of the marginal graduate who repays debts in full to decline if $dp_m/dr < 0$. Maximum profits occur at the interest rate at which (6) is equal to zero.

Proposition 1 (*Stiglitz and Weiss*) A credit rationing equilibrium exists if $dp_m/dr < 0$ for all i, which always for holds risk neutral investors.

Proof – see De Meza and Webb (1987).

However, we have just seen that $dp_m/dr < 0$ does not hold in general. The reason is that debt contracts allow the graduate to take more risks because banks absorb the downside risks. This positive insurance effect on risk-taking may actually be such that probability of success of the marginal graduate increases when banks increase interest rates. This creates a *positive* selection effect and credit rationing may not occur anymore. In case risk aversion is large, interest rates remain sufficiently low, or R^f is sufficiently high, $dp_i/dr > 0$, and therefore also for $p_i = p_m$.

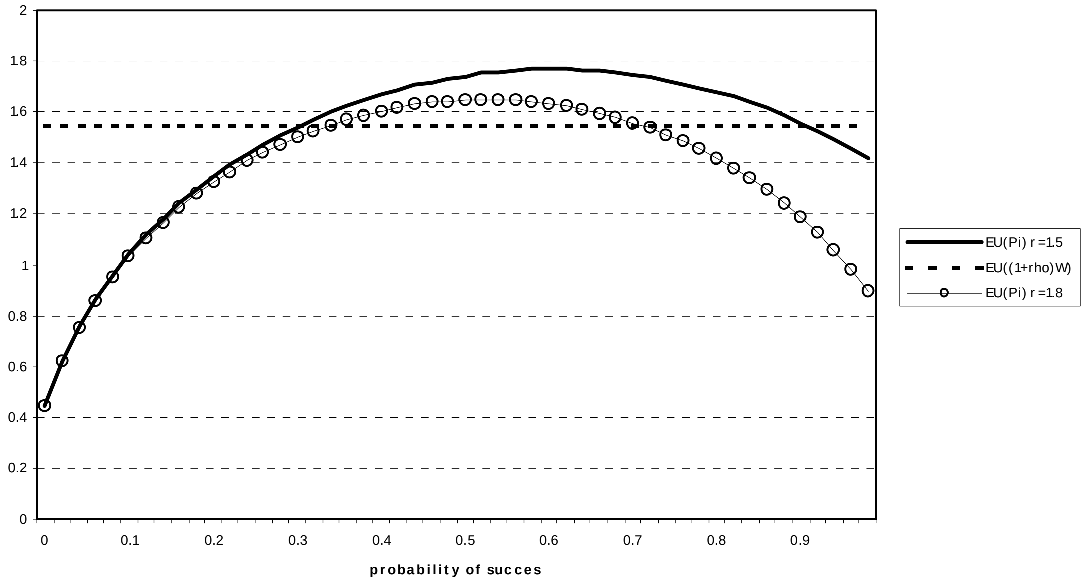
Proposition 2 (*Absence of credit rationing with sufficient risk aversion*) A credit rationing equilibrium cannot exist if $dp_i/dr > 0$ for all i. This may happen if there is sufficiently high risk aversion.

Proof – Suppose that the equilibrium interest rate is r', such that some graduates with socially profitable investments do not get credit, i.e. for investors where $p_iU((R - R^f)/p_i - (1 + r')B - R^f)) > U((1 + \rho)W)$. If this is the case, the bank can increase its initial volume of outstanding loans if it makes a small increase in the interest rate charged. If r' is increased, the probability of success of the marginal graduate increases because $dp_i/dr > 0$; consequently we have from (6) that $d\Pi/dr > 0$. This contradicts the assumption that r' is the equilibrium rate because that assumption implies that $d\Pi/dr = 0$. Therefore a credit rationing equilibrium cannot exist if $dp_i/dr > 0$.

The last proposition contrasts with Stiglitz and Weiss (1981). The credit rationing equilibrium is apparently not robust to the introduction of risk averse investors.

In the intermediate case, if risk aversion is small, interest rates are not sufficiently low ($(1 + r)B$ high) or incomes in the bad state of nature are not sufficiently high (R^f low), and dp_i/dr switches sign on the interval [0,1], a credit rationing equilibrium may still occur. Graduates with $p_i < \underline{p}$ or $p_i > p^*$ do not invest. See Figure 3.

Figure 3 - Investment decision with debt financing. Effects of increasing interest rates (R^f = .5, R = 3, W = .6, B = 1, ρ = 0)



Clearly, increasing the interest rate has both a positive and a negative (adverse) selection effect. Positive because the probability of the graduate with the lowest probability of success $\underline{p}$ increases; and an adverse selection effect, because the probability of success of the graduate with the highest probability of success p^* decreases. This can be seen as well by differentiating the bank's profit function:

$$(7) \qquad \frac{d\Pi}{dr} = B\int_{\underline{p}}^{p^*} p_i f(p_i)dp_i + [(1+r)Bp_m + R^f(1-p_m)]f(p_m)\frac{dp^*}{dr}$$

$$-[(1+r)B\underline{p} + R^f(1-\underline{p})]f(\underline{p})\frac{d\underline{p}}{dr}.$$

The first-term is the standard term denoting increased revenue on all outstanding loans, the second term measures the adverse selection effect occurring because the good risks drop out of the credit market ($dp^*/dr < 0$) , whereas the third term measures the positive selection selection effect because some bad risk graduates also drop out of the market ($d\underline{p}/dr > 0$). There can only be a credit rationing equilibrium if the second effect dominates the first two effects. This depends on the number of good risk graduates dropping out of the market relative to the number of bad risks dropping out of the market.

Proposition 3 (*Existence of a credit rationing equilibrium with sufficiently low risk aversion*) A credit rationing equilibrium exists if there exists a p_s below which $dp_i/dr > 0$ for all $p_i < p_s$, and above which $dp_i/dr < 0$ for all $p_i > p_s$

Proof – Suppose that the equilibrium interest rate is r', such that some graduates with socially profitable investments do not get credit, i.e. for investors where $p_i U((R - R^f)/p_i - ((1 + r')B - R^f)) > U((1 + \rho)W)$. A necessary condition for r' to be an equilibrium interest rate is that $d\Pi/dr = 0$. If banks charge higher interest rates in order to meet excess demand for credit they make losses. Therefore, if r is increased above the equilibrium rate, banks get more revenues from successful graduates, and some low-risk graduates may drop out of the market since $d\underline{p}/dr > 0$, but there are also relatively fewer low-risk graduates that apply for credit since p^* falls. Therefore, $d\Pi/dr$ < = > 0 depends on whether the revenue and positive selection effects are larger or smaller than the adverse selection effect. If at r' the adverse selection effect equals the revenue and positive selection effects, $d\Pi/dr = 0$, and credit is rationed in equilibrium.

2.4 Efficiency of the market equilibrium

We can show that investment in human capital is below its socially optimal level, whether credit is rationed or not. Investment in human capital is socially efficient when graduates with expected 'gross' returns on investment in human capital larger than the costs of that investment indeed invest in human capital, i.e.:

$$(8) \qquad p_i R_i^s + (1 - p_i) R^f \geq (1 + \rho) K, \quad \forall i .$$

Since all projects have the same mean gross return, (8) should hold with equality for all projects.

Proposition 4 (*Under-investment*) Under-investment in human capital results whether credit is rationed or not. The market equilibrium is therefore always socially inefficient.

Proof – For every graduate we have $U((1 + \rho)W) \leq EU(\pi_i) < U(E\pi_i)$, i.e., $p_i(R_i^s - (1 + r)B) > (1 + \rho)W$. Summing over all graduates we have:

$$(9) \qquad (1+\rho)W \int_{\underline{p}}^{p^*} f(p_i)dp_i < \int_{\underline{p}}^{p^*} p_i R_i^s f(p_i)dp_i - (1+r)B \int_{\underline{p}}^{p^*} p_i f(p_i)dp_i .$$

When we add $\int_{\underline{p}}^{p^*}(1 - p_i)R^f f(p_i)dp_i$ to both sides and substitute the zero profit condition for banks, we arrive at: $p_iR_i^s + (1 - p_i)R^f > (1 + \rho)K$. So under-investment in human capital obtains.

If graduates are risk neutral, the same derivation holds, except for the fact that we integrate over $\int_0^{pm}$ rather than $\int_{\underline{p}}^{p^*}$ since $p_m = p^*$ and $\underline{p} = 0$ for risk neutral investors. The information problem results in drop outs of the 'good' risk graduates, for whom investments in human capital are socially efficient. Therefore, there is under-investment in equilibrium on account of asymmetric information *and* risk aversion of graduates.

Proposition 4 contrasts with the De Meza and Webb (1990) who show that there is always over-investment in human capital in the case that there are differences in mean returns, rather than spreads. The latter is the more logical assumption for the problem we are investigating.

3 Optimal education policy

It is not clear whether debt contracts are the optimal type of contracts in the model presented above. For example Cho (1986) and De Meza and Webb (1987) have shown that with risk neutral investors equity financing is optimal in the Stiglitz and Weiss model. We show below that equity financing of investments is also optimal when graduates are risk averse, but the reason is not trivial and importantly different from Cho (1986) and De Meza and Webb (1987).

Private equity and insurance contracts that effectively require collateralization of the returns of human capital investment are impossible to implement for legal reasons. Therefore, only debt contracts can be written by private parties. This is likely to be an important constraint for the financing of investments in human capital. The point of this paper is that the government can in fact buy shares in graduates' earnings prospects because the government can secure claims on human capital. The reason is that the government has the power of compulsion, see also Stiglitz (1989; 1994). Consequently, the government is the only authority that is legally allowed to tax individual members of society. By being able to tax incomes, it has an effective claim on (the return on) all human capital stocks in society. Therefore, the government is actually able to circumvent the barriers to writing of equity and insurance contracts that private parties face.[7]

3.1 Equity financing of education

Suppose that the government buys shares in graduates' human capital. It provides equity $E = K - W$ to all graduates obtaining an education in exchange for a claim on the returns from human capital. We assume that this claim is executed through a proportional tax t on the returns of the investment in human capital. A graduate who finances his/her education by issuing an equity stake to the government has expected utility:

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[7] Further, the tax authorities can do so at relatively low transaction costs; administrative costs were as low as 1% of the total loans repaid in the income contingent loan system in Australia, see Chapman (1997, p. 747).

(10) $EU(\pi_i) = p_i U((1-t)R_i^s) + (1-p_i)U((1-t)R^f)$.

We assume for the moment that if the government finances education, graduates do not issue debt at the same time. We establish later that he/she will indeed never choose to do so, making this a valid assumption.

We first establish the optimality of equity financing when graduates are risk neutral, cf. De Meza and Webb (1987). The intuition is that when banks offer equity contracts, they attract the low-risk investors, because debt contracts would attract the high-risk investors only.

Proposition 5 (*Optimal financing risk neutral investors*) For risk neutral investors the optimal contract to finance education is an equity contract.

Proof – Assume that the government acts as if it was a profit maximizing bank offering both debt and equity contracts. Assume that the marginal graduate is indifferent between debt and equity financing of education. Let his/her probability of success be denoted p_o. We derive the expected returns for the indifferent graduate with $p_i = p_o$:

(11) $(1-t)(p_o R_o^s + (1-p_o)R^f = p_o(R_o^s - (1+r)B)$.

Using (1) yields $p_o \equiv (tR - R^f)/((1 + r)B - R^f)$, so that $\partial p_o/\partial t > 0$, $\partial p_o/\partial r > 0$. Due to the constancy of expected returns, the left-hand-side of (12) is independent from p_i, however, the right-hand-side is decreasing in p_i. The government knows therefore that graduates obtaining debt finance have lower probabilities of success than the graduate who is indifferent, i.e. $p_i < p_o$. Similarly, graduates obtaining equity finance have $p_i > p_o$. Expected profits from equity contracts are always higher than the profits on the indifferent investor whereas expected profits from debt contracts are always lower than on the debt contract offered to the indifferent investor. Therefore, an equilibrium with both debt and equity contracts is impossible.

For the 'indifferent' graduate, expected profits on equity contracts are equal to expected profits on debt contracts:

(12) $t(p_o R_o^s + (1-p_o)R^f = p_o(1+r)B + (1-p_o)R^f$,

where the left hand side gives expected profits from equity and the right hand side gives expected profits from debt contracts. But although expected profits on equity financed investments in human capital for the 'indifferent' marginal graduate are equal to expected profits on debt financed investments, all debt financed investments in human capital taken together are worse than the equity financed investments, at least from the government's p;oint of view. This is so because the first type of contracts only attract the worst risks and will consequently make losses. Therefore, in the optimal solution all investments will be equity financed.

With risk averse graduates and $dp_o/dr > 0$ one might expect exactly the opposite outcome. By similar arguments as above, one could argue that the equilibrium type of contract is a debt contract due to the positive selection effects of offering debt on the margin to the 'indifferent' graduate. This is not the case however. The reason is that there is no graduate indifferent between debt and equity financing; all graduates prefer equity.

In order to illustrate whether graduates would prefer debt or equity to finance their investments in human capital, we plotted expected utility of education financed with both equity and debt in Figure 4. We substituted the government budget constraint for the tax rate and set the interest rate charged to graduates equal to the safe rate ρ. (If no default risks existed, graduates would obtain funds at rate ρ.)

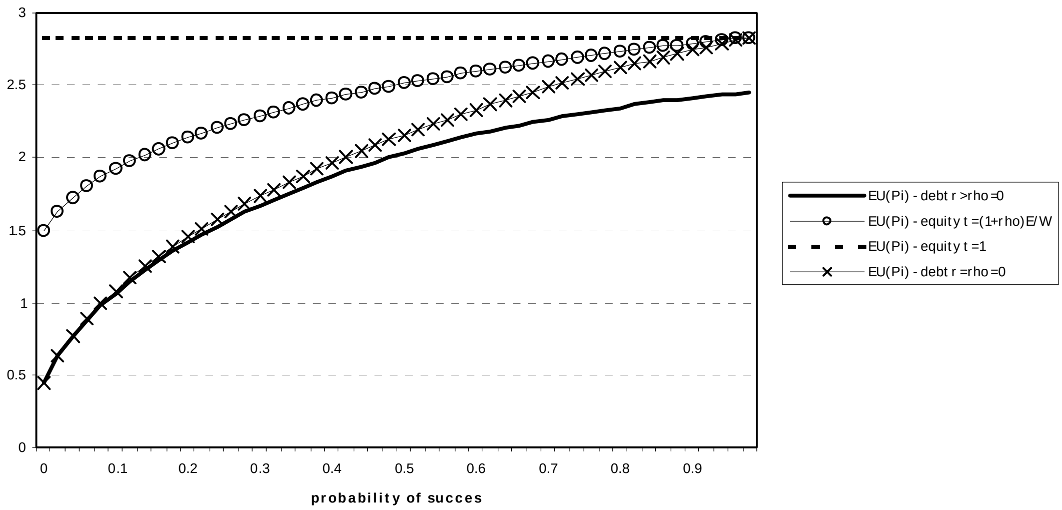
We see that equity financing of education always yields higher expected utility than debt financing. This can be established formally by noting that default risks increase the interest rate above the risk free rate, i.e., $r > \rho$, and then expected utility for debt financing always lies below expected utility with equity financing. The intuition is that debt financing implies 'insurance premia' that are not actuarially fair, since debt financing results in redistribution from low-risk to high-risk graduates. Equity financing of education does not have this property since every graduate has the same expected returns and no distortionary redistribution occurs.

Moreover, the variance of incomes with debt financed contracts ($\sigma^d \equiv (p_i(1 - p_i))^{1/2}(R_i^s - (1 + r)B)$ decreases faster with the probability of success compared to the variance of equity financed projects ($\sigma^e \equiv (p_i(1 - p_i))^{1/2}(1 - t)(R_i^s - R^f)$):

$$\text{(13)} \qquad \frac{d\left(\sigma_i^d / \sigma_i^e\right)}{dp_i} = \frac{((1+r)B - R^f)}{((1-t)(R_i^s - R^f))^2}\frac{dR_i^s}{dp_i} < 0$$

$dR_i^s/dp_i < 0$ follows from (1). Since there is no uncertainty at the safest investment ($\sigma^d_{p=1} = \sigma^e_{p=1} = 0$), we can immediately conclude that at $p_i < 1$ the variance of debt financed investments is higher than for equity financed investments, because (13) < 0. Consequently, the case where mean incomes are constant, i.e., when there is no distortionary redistribution, required risk premia on investments are lower with equity financing compared to debt financing because the variance of income is higher in the latter case.

Figure 4 - Investment decision with debt or equity financing (R^f = .5, R = 3, W = .6, ρ = 0)



Since $EU_{equity} \geq EU_{debt}$ for all i, it is easily established that it is optimal to finance all investments in human capital with equity when graduates are risk averse.

Proposition 6 (*Optimal education finance*) In the optimal solution, all investments in human capital are financed with an equity stake of the government.

Proof – For the case that $dp_i/dr > 0$ for all i , the proof is simple. Equity financed investments have lower variance compared to debt financed investments, but the latter feature limited liability. However, since the negative risk-aversion effect always dominates the positive limited liability effect on investments if $dp_i/dr > 0$ for all i, and thereby on expected utility, equity financed projects are therefore preferred over debt financed projects.

In case dp_i/dr switches sign, the positive limited liability effect dominates the negative risk aversion effect for high p_i and vice versa for low p_i. Let p' denote the probability of success of the graduate for whom $dp_i/dr = 0$. We know from proposition 5 (risk neutral investors) that expected utility for low-risk graduates with $p_i > p'$ (and $dp_i/dr < 0$) is higher if they choose equity contracts that do not redistribute incomes to high-risk graduates rather than debt financed contracts. With $dp_i/dr < 0$ for all i equity contracts are preferred. The corollary of proposition 5 to risk averse agents is straightforward and all agents with $p_i > p'$ prefer equity.

From the first part in this proposition we know that expected utility for high-risk graduates with $p_i < p'$ (and $dp_i/dr > 0$) is higher if they choose equity contracts because the limited liability effect is dominated by the insurance effect, since with $dp_i/dr > 0$ for all i equity contracts are preferred. Consequently, all graduates, both with $p_i > p'$ and $p_i < p'$, prefer equity financing over debt financing.

3.2 Efficiency of equity financing

Even with equity financing, there remains under-investment in human capital since graduates are risk averse. Although both debt and equity contracts also provide income insurance, not all income risks are taken away. Therefore, the marginal graduate requires a risk premium on the investments in human capital as a compensation for risk.

Proposition 7 (*Under-investment with equity financing*) Social efficiency in investment in human capital is not achieved even with equity financing.

Proof – The graduate has expected utility from equity financed investments in human capital at least equal to utility from non-human investments: $EU(\pi_i) = p_iU((1-t)R_i^s) + (1 - p_i)U((1-t)R^f) \geq U((1+\rho)W)$. We can derive that $U(p_i(1-t)R_i^s + (1-p_i)(1-t)R^f) > p_iU((1-t)R_i^s) + (1-p_i)U((1-t)R^f) \geq U((1+\rho)W)$, from Jensen's inequality. Consequently, $p_i(1-t)R_i^s + (1-p_i)(1-t)R^f > (1+\rho)W$. Combine this with the government budget constraint, so that $R > (1+\rho)K$, which is exactly the condition for social sub-optimality of investments in human capital, i.e. the social returns on investments in human capital are larger than social costs.

Again, this contrasts with De Meza and Webb (1987). With risk neutral firms, they find that equity financing yields the socially optimal level of investment.

3.3 Optimal insurance

Given that there is under-investment in human capital due to risk aversion, some form of income insurance is optimal. Eaton and Rosen (1980), Varian (1980), and Sinn (1995), amongst other have shown, that a redistributive income tax is optimal if insurance markets are absent – even if this income tax distorts incentives to invest in human capital (or to supply labor).

In the current set-up the government may provide graduates with some income insurance, by increasing the graduate tax and rebating the revenues through a higher level of equity (E). This enhances the social efficiency of investments in human capital. Not only the capital market imperfection is solved by sufficiently high levels of E, but income risks are insured as well.

Proposition 8 (*Optimal income insurance*) Optimal government intervention requires that all income uncertainty is eliminated and the government takes a 100% equity stake on the returns to human capital, i.e. $t = 1$ and $E = R$.

Proof – The government's budget constraint can be written down as: $tR = (1+\rho)E$. The proportional income tax redistributes income from successful states of nature to unsuccessful states. If $t = 1$ and $E = R$, there is full insurance and no income uncertainty. It is easily verified that in this case social efficiency results, i.e. $p_iR_i^s + (1-p_i)R^f = (1+\rho)K$ for all i. If $t < 1$ (and $E < R$) it is easily shown that $p_i R_i^s + (1 - p_i)\ R^f\ > (1 + \rho)K$ for all i, so that only $t = 1$ yields social optimality.

An equity participation model combined with income insurance solves the under-investment problem associated with imperfect capital and insurance markets. Therefore, the authors mentioned in the introduction were generally correct in their pleas for an income contingent loan system or a graduate tax.

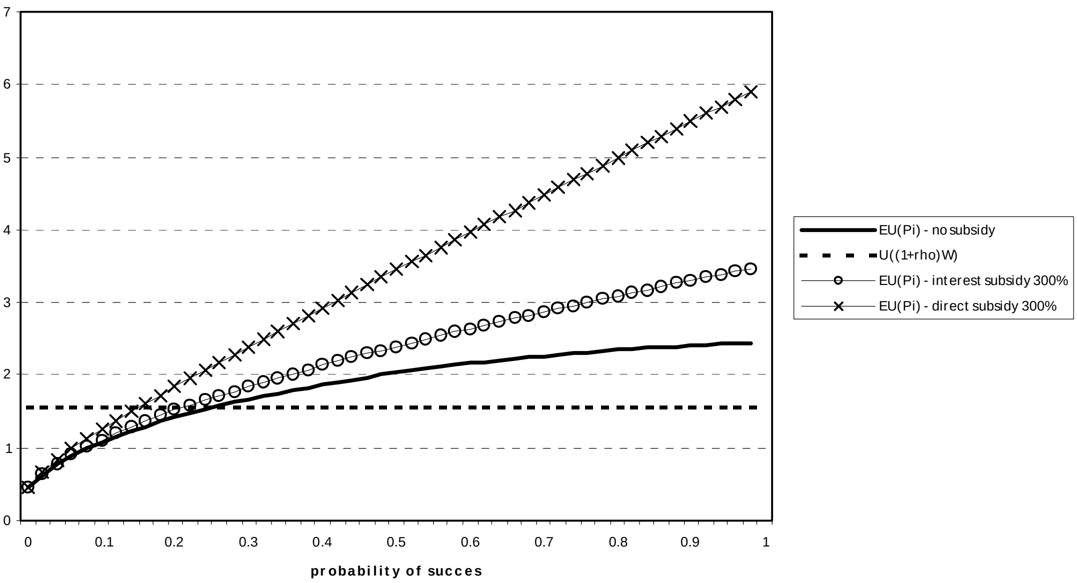
In the current setup, we do not allow for moral hazard effects or other (tax) distortions, so that full insurance can be achieved. In a more general setup, the presence of moral hazard would reduce the optimal insurance cover. There is a trade-off between incentives and risk sharing, see also Eaton and Rosen (1980), Varian (1980), and Sinn (1995).

4 Sub-optimal education policy

Direct subsidies to education are much more widely used than income contingent or equity participation schemes. Such education subsidies are often defended by pointing out the existence of capital and insurance market failures. In this section we analyze whether subsidies can restore social efficiency in the accumulation of human capital in the absence of equity and insurance.

Let s_r denote the subsidy on the interest costs charged by banks, so that graduates only pay $(1 + (1 - s_r)r)B$. In Figure 5 we plotted the effects of an interest rate subsidy on expected utility for the graduate. Interest subsidies shift the expected utility line upwards. This upward shift is large for high p_i graduates and small (approaching zero) for low p_i graduates. As a consequence of the education subsidy, the probability of success corresponding to the marginal graduate who invests in education is lowered. The reason is that interest costs associated with investment in human capital falls, so that investment in human capital becomes more profitable.

Figure 5 - Investment decision with debt financing and education subsidies (R^f = .5, R = 3, W = .6, ρ = 0, r = .5)



Evidently, education subsidies should be increased to infinity in order to induce the graduate with the lowest probability of success to invest in human capital. The reason is that expected utility goes to zero whatever the level of income in the successful state is.[8] Therefore, social efficiency where all graduates invest in education can only be attained if education subsidies are infinite.

A similar story holds for subsidies on the direct costs of education. If the government subsidizes the cost of education K at rate s_k, so that graduates only face $(1 – s_k)K$ as costs, then expected utility for all graduates also increases and the probability of success of the marginal graduate falls, see also Figure 5. Clearly, education subsidies are a very indirect means of restoring efficiency in investments in human capital. The reason is that education subsidies are not very effective in reducing income risks.

Graphically, an equity participation scheme rotates the expected utility line clockwise, whereas education subsidies rotate expected utility counter-clockwise, cf. Figures 4 and 5. An equity participation scheme is therefore more suited to induce the high-risk graduates to invest. This also illustrates the low power of education subsidies to restore efficiency in investments in human capital compared to an equity participation scheme.

Generally, infinite subsidies are not feasible for practical reasons. For example, financing subsidies from tax revenues will generally cause dead weight losses. Due to the distortionary costs of revenue raising, the use of education subsidies is restricted.

[8] This can be established by taking the limit of expected utility under debt financing as $p_i \to 0$: $\lim_{p\to 0} U(\alpha/p_i – \beta)/g(p_i)$, where $\alpha \equiv R – R^f$, $\beta \equiv (1 + r)B – R^f$, and $g(p_i) \equiv 1/p_i$. Since the limit is indeterminate we apply L'Hôpital's rule to find: $\lim_{p\to 0} = –\alpha U'(\alpha/p_i – \beta) = 0$, since $\lim_{p\to 0}U'(.) = 0$.

Consequently, if infinite education subsidies are ruled out, it is impossible to achieve the socially desirable level of investment in human capital if graduates are risk averse.

Proposition 9 (*Inefficient education policy*) Social efficiency in investments in human capital cannot be achieved by means of education subsidies since this requires infinite subsidies.

The last proposition contrasts with Mankiw (1986) and De Meza and Webb (1987). These authors argued that social efficiency in investment can be restored in imperfect capital markets with debt contracts by letting the government employ less than infinite (interest) subsidies on education loans. We have shown that due to risk aversion, the government cannot solve the capital market failure arising from asymmetric information by means of interest subsidies, because only infinitely large subsidies would restore social efficiency in investments in human capital.

5 Equity participation in practice

Suppose that we introduced a graduate tax (GT) for the financing of education. What would be the level of the tax and the degree of income insurance? In this section we present calculations on the introduction of a GT in the Netherlands. Computations are explained in more detail in Jacobs (2002). Also, a complete description of data-sources can be found there.

We assume there remains a subsidy s financed from general Government revenues. For various subsidy levels s we make alternative calculations, i.e. when s = 2,119 euro, s = 4,237 euro, and s = 6,355 euro.[9] These subsidy levels correspond to increasing private contributions of respectively 75%, 50%, and 25% of current direct expenditures. A private contribution percentage of 100% (the GT finances all education expenditure) is not considered if only because moral hazard problems would likely become serious in such an extreme solution. In the current Dutch system, the private contribution on the part of students is 12% of the total outlays on education.

Under a GT all students are treated equally: they all have to pay a constant percentage extra income tax during their whole working lives. Accessibility is guaranteed because all graduates can obtain funds independently from socio-economic characteristics.

We base our computations on estimated age-earnings profiles of graduates with fixed effects for every education type, separately for men, women, higher vocational, and university training. Estimated coefficients are such that familiar age-earnings profiles follow. Under the assumption that the residuals from our estimated wage profiles are log-normally distributed we generate income classes. We use 5 quintiles within each ‘sex’– ‘education type’ – ‘subject’ cell, so that each quintile contains 20% of the students within each cell.

We correct the estimated life-time earnings for labor supply effects. We make adjustments for hours worked and (growth in) participation rates. We assume that each

[9] Externalities, public goods, and fiscal distortions in the accumulation of human capital may also justify at least some subsidy element.

graduate enters the labor market directly after graduation and remains in the labor market until 65 years of age. Real wage growth over the life cycle (*g*) is assumed to be 2% per annum, in line with Dutch historical data.

There is substantial heterogeneity in earnings between various education types, subjects, men and women, and within these groups. Economics, law and technical education have higher earnings for both men and women. Then follow agricultural, science, health and behavioral subjects. Cultural, languages and arts studies are at the bottom end. Men have steeper earnings profiles than women. Men also work more hours and have higher participation rates. Profiles of workers with university education are steeper and less concave than profiles for workers with higher vocational education.

Educational costs are the institutional costs excluding the costs of academic hospitals, scientific research at universities, and arts at higher vocational schools – arts academies, conservatories, acting schools, etc. We assume that students are enrolled 5 years in higher education rather than the nominal length of 4 years. This corresponds to reality.

All (income dependent) grants that are currently given to students will be replaced by an equity stake issued by students to the government. The government finances this through the issuance of government bonds. We set the graduate tax rate such that the scheme becomes self-financing, i.e. in expected discounted value terms students will just repay his or here loans. Note that this will also entail redistribution from high income earners to low income earners. We take into account the potentially distortionary effect of GT on life-time labor supply. We assume that the effective marginal rate without the graduate tax repayment equals 50%. As base-line values we take for men an uncompensated wage elasticity of life-time labor supply of .1 and for women of .5. We do not consider the consequences of rebating the savings on government outlays through e.g. lower taxes. Our computed revenue losses are therefore a very conservative upper bound.

We do not take into account effects of the GT on enrollment and relative wages. It would require a general equilibrium model similar to Heckman et al. (1998) to take these into account which is beyond the scope of this paper. We also ignore moral hazard and adverse selection effects because empirical evidence on these matters is lacking.

Our baseline real interest rate (*r*) equals 3%, at the high end of estimates of the long term real return on Dutch Government paper in the 21st century, see Van Ewijk en Tang (2003). Furthermore, there is the issue of whether one needs to apply a risk-premium on top of the risk-free discount rate. After all through this scheme the government would in effect buy ‘shares’ in graduates’ human capital. Although individual risk will be averaged out, the returns on these shares are not risk-free because of macroeconomic shocks. Therefore, the average tax-payer is confronted with uncertainty in revenues from the education financing system. In this paper we assume that all individual income risks can be diversified (pooled) at the national level. Accordingly there will be no macroeconomic uncertainty so the required risk-premium would be zero. However, in reality the presence of macroeconomic shocks that cannot be diversified at the national level requires a positive risk-premium. On the other hand one may argue that there is a negative covariance between tax revenues (or government expenditures) and education. I.e., the variability in tax revenues or government expenditures is reduced when people become more educated, see for example Gould et al. (2000). The reason is that higher educated are typically less dependent on social benefits, have shorter spells of unemployment, and so on. This implies that a shift in tax revenues from low-skilled workers, towards investments in high skilled workers reduces the average risk of total tax revenues. For our base-case scenario we assume the two effects cancel so we do not use a risk-premium on top of the real interest rate. However we also present robustness calculations using risk premia of respectively 1 and 2%.

Table 1 shows the resulting graduate tax rates. We first focus on the base line case in which no subsidies are given. In that case the repayment rate, or GT, equals 5.9%. We compare this rate with the repayment rates, i.e. the fractions of life-time incomes, that graduates would have to pay under a pure loan system in table 2. It is clear that there is a lot of redistribution involved. The reason is that with a graduate tax all elements in table 2 are equal to 5.9. Thus, there is a very strong compression in repayment obligations. As such our calculations show that income insurance is substantial. There is insurance/redistribution in particular from men to women, from high earning subjects to low earning subjects, and from university to higher vocational education. We can at least conclude that substantial pooling of risk would occur, thus reducing the financial uncertainties involved in choosing a particular type of education. Moreover, on average the absolute increases in the tax rates for the high earning subjects are relatively modest compared with the decreases – in absolute terms – in tax rates for the subjects that are relatively less financially beneficial. This effect can be attributed mainly to the fact that there is a relatively large number of male students in the high earning subjects.

[insert tables 1 and 2 here]

The GT is of course reduced when the government increases subsidies. With a low average subsidy of 2,119 euro the graduate tax equals about 4.4%, with subsidies equal to 50% (4,237 Euro) it falls to 2.9% and with a high subsidy of 6,355 euro the tax rate is only 1.4%. However, government savings on education expenditures also decrease when subsidies are brought in line with current levels, see below. Substantial reductions in gross government outlays can be achieved at only modest tax rates. Net government savings are substantially lower because tax-revenues drop in response to higher marginal taxes. Note however that we do not consider rebating the increased government revenues in the form of lower taxes.

In the rest of the table we have computed the consequences for the GT when the crucial parameters of the simulation model are changed. First, we looked at a 1%-point lower rate of wage growth. This corresponds as well with a higher real interest rate of 1%-point. Clearly, lower wage growth or higher real interest rates will have important consequences for the GT: the tax rate has to increase with more than 1%-point for every %-point reduction in the growth rate of wages. Similarly, a positive value of the required risk premium of 2% increases the graduate tax to 9.7% in the base-line scenario. This would correspond to an increase in the real interest rate of 2% per year.

Interestingly, repayment rates are not very sensitive with respect to labor supply elasticities. We calculated cases in which labor supply effects are absent, i.e., zero for both men and women, and where the elasticity of labor supply is more elastic, that is, .25 for men and unity for women. These are upper bounds that are found in the literature. Very modest increases are found when labor supply elasticities are set at levels that can be considered very high. Based on these figures we may say that moral hazard in labor supply after graduation is potentially not a very important factor that drives repayment conditions.

6 Conclusion

In a pure market equilibrium, there will be underinvestment in human capital because of imperfections in financial markets. We have shown that private markets will fail to deliver the optimal level of investment in human capital due to the impossibility to write contracts that in effect would collateralize future wage income. Moreover, the impact of this market failure goes beyond its impact on aggregate productivity and economic growth. The incidence of capital market failure falls most heavily on children from poor households because they do not have access to parental wealth as a substitute for capital markets. Flawed educational financing thus perpetuates inequality.

The state does not face the same restrictions on enforcement of contracts involving future labor income as private individuals do: it can enforce contracts that involve claims on future labor income through the tax system. Moreover the contracts can be structured in such a way that a degree of risk sharing becomes possible, thereby taking away another barrier to efficient educational financing. In this paper we show that the state can implement contracts that provide liquidity and a degree of risk sharing to such an extent that social under-investment in education disappears. Such “Public equity” financing of education, through a graduate tax or an income contingent loan repayment system is optimal and can restore social efficiency to investment in human capital. Education subsidies however cannot solve the under-investment problem perfectly without an infinite financing burden. Numerical calculations suggest that in practice a public equity participation scheme can substantially reduce net public outlays on education while protecting poor graduates against repayment burdens that are high relative to their income. Such a scheme would also guarantee accessibility because initial wealth (or parental income) plays no role whatsoever.

In this paper we have focused solely on the efficiency properties of the various financing regimes. The analysis of distributional concerns will add additional support for an equity participation model as opposed to straight education subsidies. This is because the average tax payer, who is paying for the education subsidies, will have a lower life time income than the average university graduate who has received them. This is simply the other side of the coin that investment in education has a high rate of return on average. Thus the education subsidies that are generally used to finance higher education are not only inefficient but are also very likely to be inequitable too.

The basic argument applies to all levels of education. Most countries enforce universal school enrollment at least until children turn 16 or 17. Therefore, general taxation is probably the most reasonable vehicle for recouping expenditure on primary and secondary schooling, since through universal school enrollment everybody will be a recipient of the benefits of public expenditure on primary and secondary schooling. However, financing higher education through general tax revenue is generally not the right way to implement an equity participation scheme, because of its adverse distributional consequences.

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Table 1 - Graduate taxes (%)

Subsidy (euro)	*s* = 0	*s* = 2,119	*s* = 4,237	*s* = 6,355
Baseline	5.9	4.4	2.9	1.4
Gross savings (Bln. euro)	3.2	2.3	1.4	0.5
Net savings (Bln. euro)	2.5	1.8	1.2	0.3
g = .01 (r = .04)	7.6	5.7	3.8	1.9
g = .03 (r = .03)	4.4	3.4	2.2	1.1
r = .04	7.6	5.7	3.7	1.9
r = .05	9.7	7.2	4.7	2.3
Elasticity high	6.1	4.4	2.9	1.5
Elasticity zero	5.7	4.3	2.9	1.4

Table 2 - Fractions of life-time incomes repaid under pure loan system

Subject		University		Higher voc.		Subject		University		Higher voc.	
	quintile	men	women	men	women		quintile	men	women	men	women
Agricult.	1	6.4	12.3	8.8	19.7	Law	1	6.0	11.3	9.1	23.9
	2	4.6	8.5	6.3	13.2		2	4.4	7.8	6.5	16
	3	3.7	6.6	5.0	10.0		3	3.5	6.1	5.1	12.2
	4	3.0	5.2	3.9	7.6		4	2.8	4.7	4.1	9.2
	5	2.1	3.6	2.8	5.1		5	2.0	3.3	2.9	6.2
Science	1	8.3	16.2			Beh./ soc.	1	8.6	15.2	10.0	24.3
	2	6.0	11.3				2	6.2	10.6	7.1	16.3
	3	4.8	8.8				3	5.0	8.2	5.6	12.4
	4	3.8	6.8				4	4.0	6.4	4.4	9.4
	5	2.8	4.7				5	2.9	4.5	3.2	6.3
Technical	1	7.2	11.5	7.8	21.1	Arts/lang.	1	9.6	16.0	14.5	30.7
	2	5.2	8.0	5.6	14.2		2	6.9	11.1	10.3	20.6
	3	4.1	6.2	4.4	10.8		3	5.5	8.7	8.2	15.7
	4	3.3	4.8	3.5	8.2		4	4.4	6.7	6.5	11.9
	5	2.4	3.4	2.5	5.5		5	3.2	4.7	4.6	8.0
Medical	1	9.5	18.0	10.0	26.1	Teacher	1			10.3	24.0
	2	6.9	12.5	7.1	17.5		2			7.3	16.1
	3	5.5	9.7	5.6	13.3		3			5.8	12.2
	4	4.4	7.6	4.5	10.1		4			4.6	9.3
	5	3.2	5.3	3.2	6.8		5			3.3	6.2
Econom.	1	5.7	10.4	7.5	19.8						
	2	4.1	7.2	5.4	13.3						
	3	3.3	5.6	4.2	10.1						
	4	2.6	4.4	3.4	7.6						
	5	1.9	3.0	2.4	5.1						

Note: Higher vocational students borrow 8,420 euro per year and university students borrow 8,569 euro per year. This is equal to total educational expenditures per student (in 1997), including tuition fees from students.