

Capital-Market Failure, Adverse Selection, and Equity Financing of Higher Education

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We apply theories of capital-market failure to analyze optimal financing of risky higher education. In the market solution, students can only finance their education through debt. There is underinvestment in human capital because some students with socially profitable investments in human capital will not invest in education, due to adverse-selection problems in debt markets and because insurance markets for human-capital-related risk are absent. Legal limitations on the use of human capital in financial contracts cause this underinvestment; without them, private markets would optimally finance these risky investments through equity rather than debt and supply income insurance. The government, however, can circumvent this problem and implement equity and insurance contracts through the tax system by using a graduate tax. This paper shows that public equity financing of education coupled to provision of some income insurance is the optimal way to finance education when private markets fail due to adverse selection. We show that education subsidies to restore market inefficiencies are suboptimal.

Keywords: human capital, capital-market imperfections, credit rationing, financing risky investment, optimal education financing, graduate taxes, education subsidies.

JEL classification: H 21, H 24, H 52, H 81, I 22, I 28, J 24

Investment in professional training will not necessarily be pushed to the margin because earning power is seldom explicitly treated as an asset to be capitalized and sold to others by the issuance of “stock”. [...] If individuals sold “stock” in themselves, i.e., obligated themselves to pay a fixed proportion of future earnings, investors could “diversify” their holdings and balance capital appreciations against capital losses.

Friedman and Kuznets (1945, p. 90)

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1. Introduction

In most countries of the world, higher education is heavily subsidized by the government. Apart from merit motives and the presumed presence of externalities of education¹, the main argument in favor of these subsidies is that the government should guarantee accessibility of higher education. Capital markets can fail to deliver a sufficient supply of funds to graduates to finance their education, and students are generally averse to investing in risky education while incurring debt.² Failures of capital and insurance hamper access especially for students from lower socioeconomic backgrounds. Education subsidies indeed avoid financial market failures by reducing the need for students to borrow and thereby reducing the risks of debt-financed investments in education. The question that remains to be answered is, however, whether education subsidies are the most efficient means to guarantee access to higher education.

Economists have often advocated more efficient forms of education financing, such as income-contingent loans or graduate taxes. The idea is that both capital- and insurance-market failures will be directly addressed by providing the funds to study and by (partially) insuring students' income risks without using education subsidies; see Nerlove (1972, 1975), Barr (1991, 1993), Chapman (1997), van Wijnbergen (1997), Oosterbeek (1998), and García-Peñalosa and Wälde (2000). Friedman and Kuznets (1945) and Friedman (1962) argue that graduates should be allowed to issue equity to finance their investments in human capital.

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 solutions proposed. García-Peñalosa and Wälde (2000) do not pay attention to the underlying microeconomic causes of market failures. In essence, they do not clarify why financing (insurance) of human-capital

- 1 Positive externalities may indeed justify at least some education subsidies. Although Moretti (2004) finds empirical evidence favoring external effects of education, others are more skeptical; see for example Heckman and Klenow (1997), Acemoglu and Angrist (2000), and Krueger and Lindahl (2002), amongst others.
- 2 The importance of capital-market failures is still a matter of empirical controversy. Some argue that capital markets are highly imperfect in view of 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 (2001), and Carneiro and Heckman (2002) argue that credit constraints are not really important empirically. Plug and Vijverberg (2005), 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.

investment (risks) is not possible in that income risks are idiosyncratic and moral-hazard problems are absent. In principle, there would be no barrier for financial institutions to provide loans or insurance. Their reduced-form representation may therefore be hiding the fundamental reasons why the market fails. Our contribution is to show that government intervention can in fact circumvent adverse selection in financial markets under certain circumstances. If, however, income risks are uninsurable due to a moral-hazard problem, the government is likely to be confronted with the same problems as the market – as we argue below. In that case, it is not clear why government intervention really can improve upon social welfare. In our view, any discussion of optimal education financing is therefore incomplete if the underlying causes of the market failure that gives rise to government intervention to begin with are not explicitly incorporated in the analysis.

Some might argue that moral-hazard effects explain the absence of properly working capital markets for financing education and the absence of insurance for human-capital risks.³ Students and graduates may not exert enough effort to study and work after graduation. As banks and insurance companies are not able to monitor students' and graduates' efforts, they are afraid that students will hit and run when they apply for a loan, or that students will become lethargic during and after graduation because they are insured against failure outcomes. Although moral hazard is certainly an issue to be taken into consideration in the design of public intervention, we also think that moral hazard is not the main problem explaining the capital-market failures blocking efficient financing mechanisms for private education, for two reasons.

First, and most importantly, moral-hazard effects would result in lower average returns on human-capital investment, since the profitable investments cross-subsidize the unprofitable investments in those circumstances.⁴ This seems to be unlikely, because the returns to (in particular) higher education are very high and, for example, easily approach the returns to equity.⁵ There is a so-called human-capital equity premium puzzle (Judd, 2002). Standard rates of return on education still appear to be substantially higher than risk-adjusted rates of return on alternative investments with similar risk properties. As Judd (2002) also shows, adding moral hazard (less idiosyncratic risk, more endogenous risk) would make the human-capital eq-

3 See for example De Meza (2000) for this line of reasoning in the context of small firms, and Judd (2002) in the context of insuring human-capital risks.

4 Bernanke and Gertler (1990) and Hoff and Lyon (1995) modify De Meza and Webb (1987, 1990) by including additional costs for investors to verify their type. These costs may result in underinvestment by some investors who have socially desirable projects, but these models all display overinvestment at the aggregate level.

5 See for example Card (1999) and Harmon et al. (2003).

uity premium puzzle even more puzzling, because high returns to education can be justified even less as a compensation for idiosyncratic income risk. Palacios-Huerta (2003) shows empirically that frictions in financial markets, illiquidity and irreversibility, and other factors may explain the high return to human-capital investments. We therefore think that moral hazard is not the dominant information problem in the market, as that seems inconsistent with these empirical findings. Second, moral hazard in financial markets will encourage the poorer students to overinvest in education at the expense of the richer ones, since the latter will lose more in the case of default. Hence, moral hazard cannot explain the well-documented overrepresentation of the well-to-do in higher education.

In this paper we argue that adverse selection in educational debt markets, in combination with the inability of private parties to write equity and insurance contracts covering returns on human capital, explains why and how governments should intervene in the financing of higher education. Adverse selection in debt markets leads to underinvestment because some students with socially profitable investments will not invest or will not get credit (credit rationing). Banks may not increase the interest rate to meet excess demand for credit because this results in large shifts in the overall riskiness of students applying for a loan because the low-risk students drop out of the credit market; see, e.g., Stiglitz and Weiss (1981), Mankiw (1986), and Hellman and Stiglitz (2000).⁶ Risk-averse individuals further require a risk premium on their investments. Hence, if these income risks cannot be insured, underinvestment is exacerbated; cf. Eaton and Rosen (1980). We show that an equity participation model as proposed by Friedman and Kuznets (1945), Friedman (1962), and García-Peñalosa and Wälde (2000) is indeed the optimal way of financing higher education in the presence of adverse selection in capital markets and the absence of insurance markets to insure human-capital risks. In practice, this solution boils down to a graduate tax for the financing of higher education. Our analysis builds on the credit-rationing literature pioneered by Stiglitz and Weiss (1981).

We also contribute to the literature on adverse selection in credit markets and credit rationing by allowing for risk-averse students. Stiglitz and Weiss (1981), Mankiw (1986), De Meza and Webb (1987), and others have generally analyzed risk-neutral investors. However, risk aversion of students is a real-life phenomenon, and we show that the introduction of risk aversion has nontrivial consequences. Credit rationing is less likely to occur, and may

6 Asymmetric information may also play a role in the insurance market. Individual earning capacities and abilities are generally well known before income insurance contracts can be written, so that adverse selection occurs, the good risks separate themselves from the bad risks, and the market for insurance contracts may break down; cf. Rothschild and Stiglitz (1976) and Sinn (1995).

even disappear when students are sufficiently risk-averse. The intuition is that high-risk students also require a large risk premium on their investments. When banks increase interest rates, positive-selection effects may become dominant over adverse-selection effects if high-risk students drop out of the credit market first because they require a larger risk premium on their investments.⁷

Furthermore, we show that debt financing of higher education is not optimal and that students would prefer equity financing were it available. However, legal problems prevent the execution of both equity and insurance contracts by the private sector in the case of education financing. In practice equity contracts for human capital are barely observed. We encountered only three exceptions. Until recently, MyRichUncle provided equity-type contracts to students for the financing of higher education in the U.S. But they stopped this and switched to standard debt contracts for reasons that remain unclear to us.⁸ Also, CareerConcept in Germany and Lumni in Latin America have just started providing equity-type contracts for higher-education financing; see also Popescu (2005).

The reason for this limited use of equity is that the use of human capital as collateral or claiming its proceeds as dividends is largely impossible, for a number of reasons. First, in general, contract enforceability of private equity contracts is problematic because legal frameworks are not yet adapted to protecting the rights of investors who provide the funds for the investment. Since human-capital contracts are not legally acknowledged as securities, trade in claims on human capital is legally obstructed. Second, slavery and indentured labor are outlawed in civil societies, which gives rise to legal constraints on financial contracts. It is not generally possible to sell claims on future incomes. For example, some states in the U.S. do not allow this (Palacios, 2002). Further, bankruptcy laws do not generally feature provisions for graduates who declare themselves bankrupt to avoid dividend payments to financiers, whereas bankruptcy laws do cover provisions for debt contracts (Palacios, 2002).

These legal limitations effectively preclude financial contracts that are contingent upon the returns of human-capital investment. Therefore, only debt financing is provided in markets, credit is rationed, and underinvestment prevails – also due to risk aversion. 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–Weiss (1981) model. Loosely speaking, a bank offering a debt contract only attracts the high-risk students, while an equity contract attracts only the low-risk students (i.e., investors with low-risk

7 De Meza (2000, p. F21) also speculates that this may occur, but does not show it formally.

8 MyRichUncle does not provide us with any details on this.

projects). Therefore, only equity contracts are offered. However, with risk-averse students 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 and not equity contracts would be the equilibrium contracts, because debt contracts then attract the low-risk students. We show that this does not happen and an equity contract is always preferred to a debt contract, no matter how risky the students 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 students. As a consequence, the underinvestment problem is mitigated. Students with low-risk investments will now invest in higher education, whereas they would underinvest with debt financing. And more students with risky education enroll, because they are better protected against failure outcomes.

Government intervention in financing education is warranted, because only the government can currently implement equity contracts at reasonable cost. This is not to say that private contracts are ruled out or impossible in principle. However, given the legal limitations, private contracts are currently prohibitively costly to execute. Attempting to eliminate legal limitations to facilitate trade in equity-type contracts requires far-reaching changes in the legal system that are also very costly. Furthermore, the government can monitor and enforce claims on all returns from human capital through the tax system, as it already does through the regular income tax. As Stiglitz (1989, 1994) has argued, a distinguishing feature of the government in comparison with the market is that the government has the power of compulsion and therefore the power to tax. This makes enforcement of equity-type contracts possible at low marginal cost, since the tax system is in place anyhow. Private parties will waste more resources on screening, tracking, and enforcing contracts. Equity participation by the government comes down to allowing students to finance education in exchange for a claim on part of the students' future incomes through a tax on the returns of the investment, i.e., a graduate tax. Also, we show that introducing a graduate tax is in general not sufficient to attain the optimal level of investment in human capital, since risk aversion of graduates implies that they still underinvest. Although both equity and debt financing feature income insurance, not all income risks are eliminated, so that some underinvestment due to risk aversion remains. Therefore, additional income insurance is welfare-improving. The government may restore social efficiency by reducing income risks through a higher graduate tax.

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 very large education subsidies (on educational costs or interest costs), because education subsidies do not insure income risks. An equity participation scheme

will be far more effective in giving the high-risk students incentives to invest in human capital, because of the associated income insurance. An unfortunate by-product of subsidized higher education is that it also implies reverse redistribution. The costs of subsidies fall on the average taxpayer, whereas the benefits accrue to the most talented, and hence generally better paid. Additionally, a disproportionate number of graduates belong to the wealthiest families. Equity financing of education avoids this perverse redistribution of incomes, since in principle no subsidies are needed.

We present some calculations on the likely 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 in government outlays could be achieved with only modest graduate tax rates.

Finally, we discuss the implications of moral hazard for implementation of equity financing of higher education in practice. As it appears, moral hazard makes some combination of debt and equity financing optimal. Debt instruments feature less insurance and may therefore give better incentives. The government may thus want to introduce some form of income-contingent loan scheme, which combines elements of a graduate tax with an ordinary study loan. Furthermore, the government should monitor and track students and deny funding to nonperforming students so as keep moral hazard under control.

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 financing of education is analyzed in section 3. In section 4 we discuss suboptimal ways of financing education. Section 5 presents some calculations of a graduate-tax system using Dutch data. In section 6 we discuss the consequences of moral hazard for our results, and section 7 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 . Here K can be thought of as tuition costs and forgone earnings. The return to the investment in human capital is random. We only consider two-outcome projects, and we denote the re-

turn under the successful outcome by R_i^s , and the return if the investment in human capital fails by R_i^f . We assume without loss of generality that $R_i^f = R^f$ for all i . Expected returns are the same for all graduates:

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

where p_i in $[0,1]$ is the probability of success for graduate i . We say that graduate i is riskier than graduate j if $p_i < p_j$.^{9,10}

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

We make the following important *nonslavery* assumption: Private financial contracts between students and financial institutions cannot be made contingent upon the returns R_i of the investment in human capital. Only debt financing 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.

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

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

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 : $\lim_{\pi \rightarrow 0} U'(\pi_i) = \infty$, $\lim_{\pi \rightarrow \infty} U'(\pi_i) = 0$. Graduates are willing to invest in risky education financed with debt as long as

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

where ρ is the safe real return on nonhuman investments (savings).

Expected utility is either monotonically increasing in p_i , or nonmonotonic – first increasing, then reaching a maximum, and finally decreasing

9 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 increasing p_i because the returns are bimodally distributed. However, with mean returns restricted to be equal across all i , it is easily shown that the variance decreases with increasing p_i .

10 There is no systematic macroeconomic risk, and all risks are idiosyncratic. In the empirical application below we argue why this is a reasonable benchmark in the case of higher education.

in p_i . To see this, differentiate (3) while substituting (1):

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

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

We can sketch the graph of $EU(p_i)$; see figures 1 and 2 below. We know that $EU(0) = 0$, and $EU(1) = U(R - (1+r)B) > 0$. The graph of $EU(p_i)$ either always increases monotonically, or first increases and then decreases

Figure 1
Investment Decision with Debt Financing and with High and Low Risk Aversion ($R^f = 0.5, R = 3, W = 0.6, B = 1, \rho = 0, r = 0.5$)

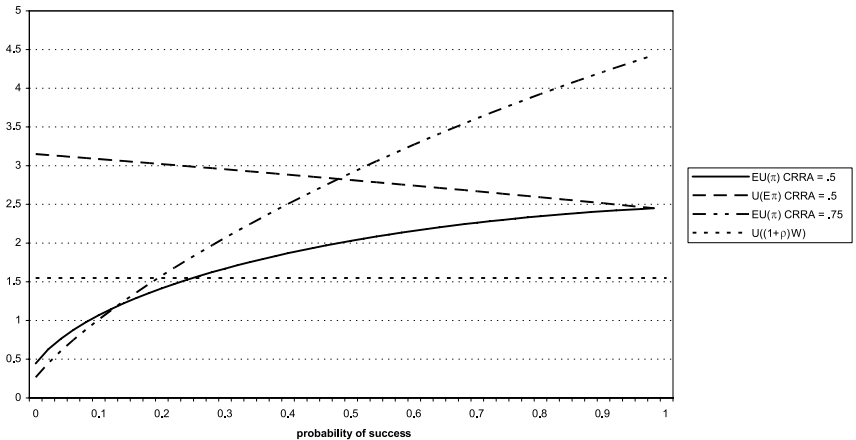
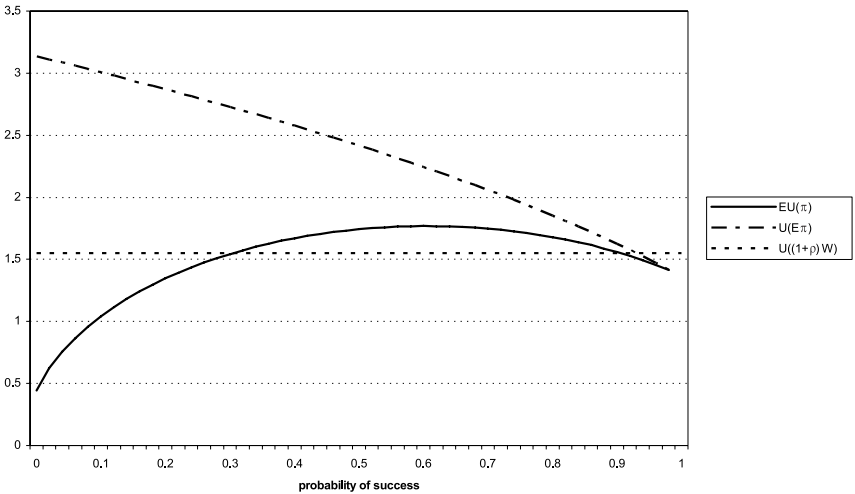


Figure 2

Investment Decision with Debt Financing and with Low Risk Aversion and High Interest Rates ($R^f = 0.5$, $R = 3$, $W = 0.6$, $B = 1$, $\rho = 0$, $r = 1.5$)



to reach $EU(1)$. The shape of $EU(p_i)$ can be understood most easily by also plotting $U(E\pi_i)$, which denotes the utility from the certainty equivalent and corresponds to the case where there is perfect income insurance. This line also corresponds to the case of Stiglitz and Weiss (1981) with risk-neutral investors. 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 allows the high-risk graduates to shift the downside risks to banks.

However, if graduates are risk-averse, the 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 if risk aversion is small, if 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 decreas-

ing p_i , whereas the utility benefit of having limited liability only increases linearly.

For example, if utility features constant relative risk aversion (CRRA) (if $EU(\pi_i) = p_i [R_i^s - (1+r)B]^{1-\theta}/(1-\theta)$), 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) decreases the slope of the EU line. We have plotted the case in 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.

Risk aversion may have important consequences for the equilibrium of the model. For the marginal graduate, i.e., the graduate who is indifferent between investing in education and putting money in the bank, (3) 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 the sign of the derivative in equation (4) is positive. This follows from totally differentiating $p_m U((R - R^f)/p_m - ((1+r)B - R^f)) = U((1+\rho)W)$:

$$\frac{dp_m}{dr} = \frac{p_m U'(\cdot) B}{U(\cdot) - U'(\cdot)(R_m^s - R^f)} \tag{5}$$

Consequently, $dp_m/dr > 0$ when (5) > 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 banks 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 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. Here \underline{p} corresponds to the marginal graduate with the lowest probability of success who is willing to invest, where $d\underline{p}/dr > 0$; and 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. As in Stiglitz and Weiss (1981), 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 $f(p_i)$. Alternatively, one may say that the banks have classified all graduates in groups with different mean returns to their education. In practice, this results in banks charging different interest rates to students in different disciplines with different mean returns to their education.

Banks obtain funds at a 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

$$\Pi = (1+r)B \int_{\underline{p}}^{p^*} p_i f(p_i) dp_i + R^f \int_{\underline{p}}^{p^*} (1-p_i) f(p_i) dp_i - (1+\rho)B. \quad (6)$$

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

2.3. Equilibrium

In equilibrium, banks offer debt contracts such that no equilibrium contract makes negative expected profits and there is no other debt contract allowing the bank to make nonnegative 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 that excess demand, 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:

$$\frac{d\Pi}{dr} = B \int_0^{p_m} p_i f(p_i) dp_i + [(1+r)Bp_m + R^f(1-p_m)]f(p_m) \frac{dp_m}{dr}. \quad (7)$$

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 factor 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 holds for 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 risktaking 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 cease to be an equilibrium. If risk aversion is large, interest rates remain sufficiently low, or R^f is sufficiently high, then $dp_i/dr > 0$, and therefore also $p_i = p_m$.

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, namely, investors for whom $p_i U((R - R^f)/p_i - ((1 + r')B - R^f)) > U((1 + \rho)W)$. 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 $dp_i/dr > 0$. ■

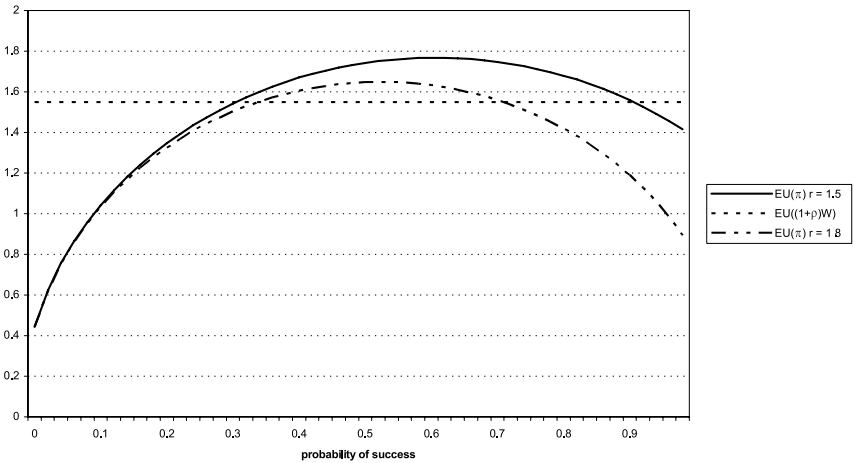
The last proposition contrasts with Stiglitz and Weiss (1981). The credit-rationing equilibrium is apparently not robust to the introduction of risk-averse investors.

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 $[0,1]$, then a credit-rationing equilibrium may still occur. Graduates with $p_i < \underline{p}$ or $p_i > p^*$ do not invest. See figure 3.

Clearly, increasing the interest rate has both a positive and a negative (adverse) selection effect: the positive one because the probability of the

Figure 3

Investment Decision with Debt Financing. Effects of Increasing Interest Rates ($R^f = 0.5, R = 3, W = 0.6, B = 1, \rho = 0$)



graduate with the lowest probability of success (\underline{p}) increases, and the negative one because the probability of success of the graduate with the highest probability of success (p^*) decreases. This can also be seen by differentiating the bank's profit function:

$$\begin{aligned} \frac{d\Pi}{dr} = & B \int_{\underline{p}}^{p^*} p_i f(p_i) dp_i + [(1+r)Bp_m + R^f(1-p_m)]f(p_m) \frac{dp^*}{dr} \\ & - [(1+r)B\underline{p} + R^f(1-\underline{p})]f(\underline{p}) \frac{d\underline{p}}{dr}. \end{aligned} \tag{8}$$

The first term is the standard term expressing the 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 ($dp^*/dr < 0$), and the third term measures the positive 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-risk ones 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, namely, investors for whom $p_i U((R - R^f)/p_i - ((1 + r')B - R^f)) > U((1 + \rho)W)$. 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 take losses. Therefore, if r is increased above the equilibrium rate, then banks get more revenues from successful graduates, and some low-risk graduates may drop out of the market, since $\underline{dp}/dr > 0$. At the same time, there are also fewer low-risk graduates that apply for credit, since p^* falls. Therefore, whether $d\Pi/dr < 0$ or $d\Pi/dr > 0$ 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, then $d\Pi/dr = 0$, 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 an investment in human capital larger than the costs of that investment indeed invest in human capital, i.e.,

$$p_i R_i^s + (1 - p_i)R^f \geq (1 + \rho)K \quad \forall i. \tag{9}$$

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

Proposition 4 (Underinvestment) Underinvestment 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

$$(1 + \rho)W \int_{\underline{p}}^{p^*} f(p_i) dp_i < \int_{\underline{p}}^{p^*} p_i R_i^s f(p_i) dp_i - (1 + r)B \int_{\underline{p}}^{p^*} p_i f(p_i) dp_i. \tag{10}$$

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 $p_i R_i^s + (1 - p_i)R^f > (1 + \rho)K$, and underinvestment in human capital results.

If graduates are risk-neutral, the same derivation holds, except for the fact that we integrate from 0 to p_m rather than from p to p^* , since $p_m = p^*$ and $\underline{p} = 0$ for risk-neutral investors. The information problem results in dropout of the good-risk graduates, for whom investments in human capital

are socially efficient. Therefore, there is underinvestment in equilibrium as a result of asymmetric information *and* of the risk aversion of graduates. ■

3. Optimal Education Policy

Debt contracts are obviously unlikely to be 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–Weiss model. We show below that equity financing of investments is also optimal when graduates are risk-averse. The reason is not trivial and is importantly different from that in 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 due to various legal limitations. Although financiers may observe returns to investments in human capital through, for example, pay checks, they cannot include the return of the investment in human capital in a financial contract, since banks currently lack the ability to enforce the contract, as legal systems do not acknowledge trade in claims on human capital even though private parties are willing to engage in exchange. As a result, only debt contracts are used by private parties, since these are independent of the returns to human-capital investments. 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* 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 through the income tax see also Stiglitz (1989, 1994). By being able to tax incomes, the government already has an effective claim on (part of the return on) all human-capital stocks in society. Therefore, by incorporating the funding in the tax system, the government is able to circumvent the various legal barriers to writing of equity and insurance contracts that private parties face.¹¹

3.1. Equity Financing of Education

We assume for the moment that the government finances education only through equity and graduates do not take up a debt contract at the same time. We establish later that they will indeed never choose to do so, making this a valid assumption. We show later that equity financing is always preferred

¹¹ 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).

over debt financing, so that graduates never want to have a combination of debt and equity.

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, i.e., a graduate tax. A graduate who finances his/her education by issuing an equity stake to the government has expected utility

$$EU(\pi_i) = p_i U((1-t)R_i^s) + (1-p_i)U((1-t)R^f). \quad (11)$$

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 for 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 were 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 $p_i = p_o$:

$$(1-t)[p_o R_o^s + (1-p_o)R^f] = p_o [R_o^s - (1+r)B]. \quad (12)$$

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 (11) is independent of p_i . However, the right-hand side is decreasing in p_i . The government knows therefore that graduates obtaining debt financing have lower probabilities of success than the graduate who is indifferent, i.e., $p_i < p_o$. Similarly, graduates obtaining equity financing 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:

$$t[p_o R_o^s + (1-p_o)R^f] = p_o(1+r)B + (1-p_o)R^f, \quad (13)$$

where the left-hand side gives expected profits from equity and the right-hand side gives expected profits from debt contracts. Although expected profits on equity-financed investments in human capital for the indifferent marginal graduate are equal to expected profits on debt-financed invest-

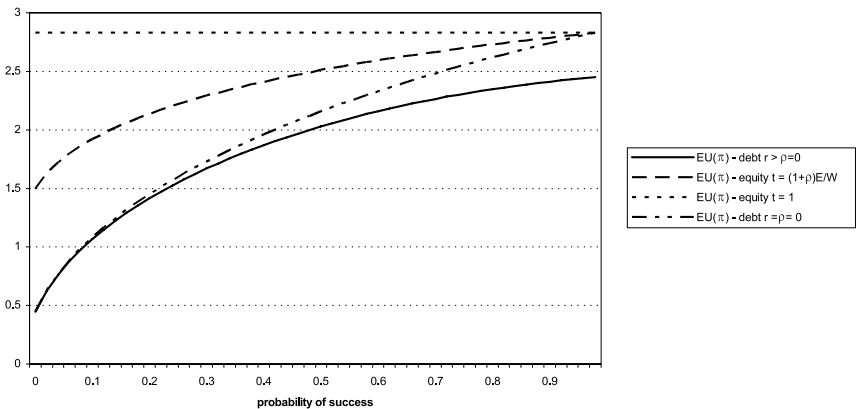
ments, all debt-financed investments in human capital taken together are worse than the equity-financed investments, at least from the government’s point of view. This is so because the first type of contracts only attract the worst risks and will consequently make losses. Therefore, in the optimal solution all investments will be equity-financed. ■

With risk-averse graduates and $dp_o/dr > 0$ one might expect exactly the opposite outcome. Using similar arguments to those 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 however not the case. 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 the 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., $r > \rho$. The expected utility for debt financing then always lies below the expected utility for equity financing. The intuition is that debt financing implies an

Figure 4
Investment Decision with Debt or Equity Financing ($R^f = 0.5$, $R = 3$, $W = 0.6$, $\rho = 0$)



insurance premium that is 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 increasing probability of success than does the variance of equity-financed projects ($\sigma^e \equiv [p_i(1 - p_i)]^{1/2}(1 - t)(R_i^s - R^f)$):

$$\frac{d(\sigma_i^d / \sigma_i^e)}{dp_i} = \frac{((1 + r)B - R^f)}{[(1 - t)(R_i^s - R^f)]^2} \frac{dR_i^s}{dp_i} < 0. \tag{14}$$

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

Since $EU_{\text{equity}} \geq EU_{\text{debt}}$ 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. Consequently, when students are offered combinations of debt and equity, they still prefer 100% equity funding.

Proposition 6 (*Optimal education financing*) 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 than debt-financed investments, but the latter feature limited liability. However, since if $dp_i / dr > 0$ for all i the negative risk-aversion effect always dominates the positive limited-liability effect on investments and thereby on expected utility, equity-financed projects are 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 the 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 than if they choose debt-financed contracts. With $dp_i / dr < 0$ for all i , equity contracts are preferred. The corollary of proposition 5 for 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

All investments would be carried out by means of equity financing if students were risk-neutral. Credit rationing would disappear, as no project would be financed through debt. Social optimality would be obtained as a result (De Meza and Webb, 1987). However, even with equity financing, there remains underinvestment in human capital if graduates are risk-averse. Although both debt and equity contracts also provide income insurance, not all income risks are eliminated. Therefore, the marginal graduate requires a risk premium on the investments in human capital as a compensation for risk.

Proposition 7 (*Underinvestment 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 the utility from nonhuman investments: $EU(\pi_i) = p_i U((1-t)R_i^s) + (1-p_i)U((1-t)R^f) \geq U((1+\rho)W)$. We can derive that $U(p_i(1-t)R_i^s + (1-p_i)(1-t)R^f) > p_i U((1-t)R_i^s) + (1-p_i)U((1-t)R^f) \geq U((1+\rho)W)$, from Jensen's inequality. Consequently, $p_i(1-t)R_i^s + (1-p_i)(1-t)R^f > (1+\rho)W$. Combining this with the government budget constraint, we have $R > (1+\rho)K$, which is exactly the condition for social suboptimality of investments in human capital, i.e., the social returns on investments in human capital are larger than social costs. ■

Not surprisingly, this also contrasts with De Meza and Webb (1987), due to the risk aversion of the investors. With risk-neutral investors, they find that equity financing yields the socially optimal level of investment.¹²

3.3. Optimal Insurance

Given that there is underinvestment in human capital due to risk aversion, some income insurance is optimal. Eaton and Rosen (1980), Varian (1980), and Sinn (1995), among others, 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 setup the government can provide graduates with income insurance, by increasing the graduate tax and rebating the revenues through

¹² De Meza (2000, p. F21) hints at a similar result when investors are risk-averse.

a higher level of equity (E). This enhances the social efficiency of investments in human capital. Not only is the capital-market imperfection remedied 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 be eliminated and the government take 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 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., $p_i R_i^s + (1 - p_i)R^f = (1 + \rho)K$ for all i . If $t < 1$ (and $E < R$), it can be 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 underinvestment 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). We discuss the issue of moral hazard in more detail in section 6.

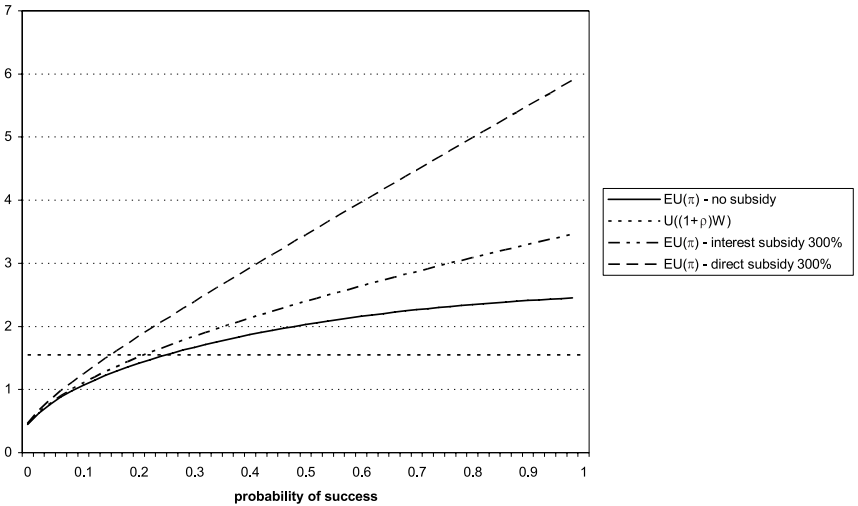
4. Suboptimal Education Policy

Direct subsidies to education are far more widely used to guarantee access to higher education than equity participation schemes. Such education subsidies are often defended by pointing out the existence of capital and insurance market failures that hamper accessibility of education, especially for students with poor backgrounds. 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 have plotted the effects of an interest-rate subsidy on expected utility for the graduate. Interest subsidies shift the expected-utility line counterclockwise 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

Figure 5

Investment Decision with Debt Financing and Education Subsidies
 ($R^f = 0.5, R = 3, W = 0.6, \rho = 0, r = 0.5$)



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.

Education subsidies should be increased to infinity in order to induce the graduate with the lowest probability of success to invest in human capital. This is due to our assumption of constant mean returns to education.¹³ Therefore, social efficiency where all graduates invest in education can only be attained if education subsidies are infinite. Although one may regard this result as a special case, the intuition is nevertheless straightforward. Education subsidies are an imperfect substitute for lacking income insurance, and the more so for individuals with extremely risky incomes. Consequently, when risks in incomes becomes unbounded (by assumption), education subsidies should become infinitely large to induce these individuals to invest in human capital as well.

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 grad-

¹³ This can be established by taking the limit of expected utility under debt financing as $p_i \rightarrow 0$: $\lim_{p_i \rightarrow 0} U(\alpha/p_i - \beta)/g(p_i)$, where $\alpha \equiv R - R^f, \beta \equiv (1+r)B - R^f$, and $g(p_i) \equiv 1/p_i$. Since the ratio is indeterminate, we apply L'Hôpital's rule to find $\lim_{p_i \rightarrow 0} = -\alpha U'(\alpha/p_i - \beta) = 0$, since $\lim_{p_i \rightarrow 0} U'(\cdot) = 0$.

uates only face $(1 - s_k)K$ as costs, the expected utility for all graduates 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 compared to equity participation schemes. This is not a special feature of our model, but a more general property of equity participation schemes. The fundamental reason is that education subsidies are not very effective in reducing income risks. This can be shown graphically as well. An equity participation scheme rotates the expected-utility line clockwise, whereas education subsidies rotate it counterclockwise; cf. figures 4 and 5. An equity participation scheme is therefore by definition more suited to induce the high-risk graduates to invest than are education subsidies.

Generally, very large subsidies are costly. For example, financing subsidies from tax revenues will cause deadweight losses. Due to the distortionary costs of revenue raising, the use of education subsidies is restricted. Consequently, if very large education subsidies are ruled out for practical purposes, it is impossible to achieve the socially desirable level of investment in human capital with education subsidies as long as graduates are risk-averse.

Proposition 9 (*Inefficient education policy*) Education subsidies are at most a second-best means to mitigate underinvestment due to imperfect capital and insurance markets.

The last proposition contrasts with Mankiw (1986) and De Meza and Webb (1987). These authors argued that in general social efficiency can be restored in imperfect capital markets with debt contracts by letting the government employ finite (interest) subsidies on education loans. We have shown that education subsidies are a very indirect means to restore efficiency in investments in human capital and should optimally be nontrivially large, which we rule out for practical reasons.

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. They are explained in more detail in a background working paper (Jacobs, 2002). Also, a complete description of data sources can be found there.

We assume a subsidy s financed from general government revenues remains. For various subsidy levels s we make alternative calculations, viz.,

when $s = 2,119$ euro, $s = 4,237$ euro, and $s = 6,355$ euro.¹⁴ These subsidy levels correspond to increasing private contributions of respectively 75%, 50%, and 25% of current direct expenditures.¹⁵ In the current Dutch system, the private contribution on the part of students is only 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 irrespective of socio-economic characteristics.

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

We correct the estimated lifetime earnings for labor-supply effects. We make adjustments for hours worked and (growth in) participation rates. We assume that each graduate enters the labor market directly after graduation and remains there 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, between subjects, between men and women, and within these groups. Economics, law, and technical education yield higher earnings for both men and women. Then follow agricultural, science, health, and behavioral subjects. Cultural, language, and art studies are at the bottom. 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 duration 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

¹⁴ Externalities, public goods, and fiscal distortions in the accumulation of human capital may also justify at least some subsidy element.

¹⁵ Our definition of total expenditures on education ignores the opportunity costs of education.

set the GT rate so that the scheme becomes self-financing, i.e., in terms of expected discounted value, students will pay out just enough dividends to finance the government debt including interest. Note that this will also entail redistribution from high-income earners to low-income earners. We take into account the potentially distortionary effect of the GT on lifetime labor supply. We assume that the effective marginal rate without the GT repayment equals 50%. As baseline values we take for men an uncompensated wage elasticity of lifetime labor supply of 0.1, and for women of 0.5. We do not consider the consequences of rebating the savings on government outlays through, e.g., lower taxes. Neither do we take into account income effects that may boost the labor supply of graduates, since they will see their incomes reduced because education subsidies are reduced. 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. That is beyond the scope of this paper. We also ignore moral hazard in study effort and adverse selection in the calculations, 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 twenty-first century; see Van Ewijk and 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, due to macroeconomic shocks. Therefore, the average taxpayer is confronted with uncertainty in revenues from the education financing system. On the other hand, one may argue that there is a negative covariance between tax revenues (or government expenditures) and education. That is, the variability in tax revenues or government expenditures is reduced when people are better educated; see for example Gould et al. (2000). The better-educated typically are 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 1% and 2%.

Table 1 shows the resulting GT rates. We first focus on the baseline case in which no subsidies are given and students have to self-finance their higher education completely. In that case the repayment rate, or GT, equals 5.9%. In table 2 we compare this rate with the repayment rates, i.e., the fractions of lifetime incomes, that graduates would have to pay under a pure loan

Table 1
Graduate Taxes (%)

	Subsidy (in euro)			
	$s = 0$	$s = 2,119$ euro	$s = 4,237$ euro	$s = 6,355$ euro
Baseline	5.9	4.4	2.9	1.4
Government savings (in billion euro)	3.2	2.3	1.4	0.5
Robustness				
$g = 0$ ($r = 0.05$)	9.7	7.2	4.7	2.3
$g = 0.01$ ($r = 0.04$)	7.6	5.7	3.8	1.9
$g = 0.03$ ($r = 0.02$)	4.4	3.4	2.2	1.1
Elasticity high	6.1	4.4	2.9	1.5
Elasticity zero	5.7	4.3	2.9	1.4

system. It is clear that a GT involves a lot of redistribution. The reason is that with a GT 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 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 will 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 modest compared with the decreases – in absolute terms – in tax rates for the subjects that are less financially beneficial. This effect can be attributed mainly to the fact that there are a relatively large number of male students in the high-earning subjects.

The GT is reduced when the government increases subsidies. With a low average subsidy of 2,119 euro the GT equals about 4.4%, with subsidies equal to 50% (4,237 euro) it falls to 2.9%, and with a high subsidy of 75% (6,355 euro) it 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 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 table 1 we have computed the consequences for the GT when the crucial parameters of the simulation model are changed. First,

Table 2
Fractions of Lifetime Incomes Repaid under a Pure Loan System

	University					Higher vocational					
	Quintile	Men	Women	Men	Women	Quintile	Men	Women	Men	Women	
Agriculture	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			Behavioral & social	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 & languages	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
Economics	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						

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

we looked at a 1-percentage-point-lower rate of wage growth. This corresponds to increasing the real interest rate by 1 percentage point or including a macroeconomic risk premium of 1%. Clearly, lower wage growth (higher real interest rates or a macroeconomic risk premium) will have important consequences for the GT: the tax rate has to increase by more than 1 percentage point for every percentage-point reduction in the growth rate of wages. Similarly, a required risk premium of +2% increases the GT to 9.7% in the baseline scenario. This would correspond to an increase in the real interest rate of 2 percentage points or to 2 percentage points lower wage growth.

Interestingly, repayment rates are not very sensitive 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 greater, viz., 0.25 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 the labor supply after graduation is not likely to be a very important factor driving repayment conditions.

6. Moral Hazard, Graduate Taxes, and Income-contingent Loans

So far we have ignored moral hazard. In the introduction we argued that moral hazard is not likely to be the fundamental reason why governments should intervene in the financing of higher education. Nevertheless, we acknowledge that moral hazard is a potentially important issue to be taken into account when discussing equity participation models.

Direct empirical evidence on the importance of moral hazard in education financing is lacking, but indirect empirical evidence suggests that moral hazard is not excessive. First, recent experiments in the Netherlands showed an almost complete lack of response to financial incentives in students' work effort (see Leuven et al., 2003). Second, moral-hazard problems might cause an excessive inflow of students with a low return on education. However, empirical research, for example by Cameron and Heckman (2001), indicates a low price elasticity of enrollment in higher education, which suggests that moral hazard in enrollment decisions is not that important empirically. High-return students are inframarginal and would not leave the system in response to moral-hazard problems. Third, our own calculations show quantitatively that moral-hazard effects in labor supply after graduation are not very large. We therefore conclude that, in our particular setting, allowing for moral hazard is not likely to fundamentally change our results.

Furthermore, the government could limit the adverse consequences of moral hazard in education financing more easily than market parties could, because the government can (and does in many countries) collect information on (for example) study marks and enrollment durations. In addition, the government may set admission criteria for enrollment, tuition rates, and so on. By being able to verify study effort and abilities of students to a certain extent, governments suffer less from moral-hazard problems than financial institutions, which lack this information. Consequently, the informational advantages of the government would only strengthen our main point.

One could fear, however, that a pure equity participation scheme would entail too much insurance and students might not exert enough effort while studying or working after graduation. There is a well-known trade-off between incentives and insurance. One way to provide better incentives is for the government to restrict the amount of income insurance by setting a limit on the repayments of graduates. In particular, the financing scheme would then become a hybrid of debt and equity financing: an income-contingent loan scheme. Students borrow the costs of their education, repay their debts

in income-contingent fashion through a fraction of their incomes, and stop repaying when the present value of repayments hits a certain threshold. This threshold is determined by the amount individuals borrow and the maximum amount of insurance payments to cover the costs from students who are not able to repay. Indeed, underinvestment due to risk aversion may reappear when moral hazard is important and the government reacts by reducing the amount of insurance. On the other hand, moral hazard tends to give excessive incentives to invest in education, so restricting insurance corrects for this.

7. Conclusion

In a pure market equilibrium there will be underinvestment in human capital because of adverse selection in financial markets. We have shown that private markets fail to deliver the optimal level of investment in human capital due to the practical impossibility to write contracts that in effect would collateralize future wage income. Moreover, the effect of this market failure goes beyond its effect on aggregate productivity and economic growth. The incidence of capital-market failure falls most heavily on students 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 as to enable a degree of risk sharing, 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 so as to avoid social underinvestment in education. Such *public equity* financing of education through a graduate tax is optimal and can restore social efficiency to investment in human capital. Education subsidies are at most a second-best instrument to solve the underinvestment problem, because in contrast to equity financing, education subsidies do not provide income insurance. Numerical calculations suggest that in practice a graduate tax 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.

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 taxpayer, who is paying for

the education subsidies, will have a lower lifetime income than the average graduate who has received them. This basic argument applies to all levels of education. But because most countries enforce universal school enrollment at least until children turn 16 or 17, general taxation is probably a more reasonable vehicle for recouping expenditure on primary and secondary schooling. Through universal school enrollment all taxpayers have been recipients of the benefits of public expenditure on primary and secondary schooling. Financing higher education through general tax revenue, on the other hand, has adverse distributional consequences.

In future research we would like to extend our analysis by allowing for moral-hazard effects in financing schemes. Although we do not think that this will alter our basic argument, we expect that in the presence of moral hazard, hybrid combinations of debt and equity, such as income-contingent loans, will be optimal, since debt financing provides less insurance and therefore more incentives.

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