

Jacobs, Bas; van Wijnbergen, Sweder J.G.

Working Paper

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

Tinbergen Institute Discussion Paper, No. 05-037/3

Provided in Cooperation with:

Tinbergen Institute, Amsterdam and Rotterdam

Suggested Citation: Jacobs, Bas; van Wijnbergen, Sweder J.G. (2005) : Capital Market Failure, Adverse Selection and Equity Financing of Higher Education, Tinbergen Institute Discussion Paper, No. 05-037/3, Tinbergen Institute, Amsterdam and Rotterdam

This Version is available at:

<http://hdl.handle.net/10419/86622>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



TI 2005-037/3

Tinbergen Institute Discussion Paper

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

Bas Jacobs¹

Sweder J.G. van Wijnbergen²

¹ *European University Institute, University of Amsterdam, and Tinbergen Institute,*

² *University of Amsterdam, Tinbergen Institute, and CEPR.*

Tinbergen Institute

The Tinbergen Institute is the institute for economic research of the Erasmus Universiteit Rotterdam, Universiteit van Amsterdam, and Vrije Universiteit Amsterdam.

Tinbergen Institute Amsterdam

Roetersstraat 31

1018 WB Amsterdam

The Netherlands

Tel.: +31(0)20 551 3500

Fax: +31(0)20 551 3555

Tinbergen Institute Rotterdam

Burg. Oudlaan 50

3062 PA Rotterdam

The Netherlands

Tel.: +31(0)10 408 8900

Fax: +31(0)10 408 9031

Please send questions and/or remarks of non-scientific nature to driessen@tinbergen.nl.

Most TI discussion papers can be downloaded at <http://www.tinbergen.nl>.

CAPITAL MARKET FAILURE, ADVERSE SELECTION AND EQUITY FINANCING OF HIGHER EDUCATION*

Bas Jacobs[‡]

European University Institute, University of Amsterdam,
and Tinbergen Institute (b.jacobs@uva.nl)

Sweder J.G. van Wijnbergen
University of Amsterdam, Tinbergen
Institute and CEPR (svw.heas@planet.nl)

March, 2005

Abstract: 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 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 sub-optimal.

Key words: human capital, capital market imperfections, credit rationing, financing risky investment, optimal education finance, graduate taxes, education subsidies.

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

* Comments by Lans Bovenberg, Amber Davis, Casper van Ewijk, Joeri Gorter, Rick van der Ploeg and seminar participants of the University of Amsterdam, the CPB Netherlands Bureau for Economic Policy Analysis and the CEPR Economics of Education Conference, May 11-12 2001, Bergen, Norway are gratefully acknowledged. Bas Jacobs thanks the NWO Priority Program ‘Scholar’ financed by the Dutch Organization for Sciences for financial support.

[‡] Corresponding author: Department of Economics, University of Amsterdam, Roetersstraat 11, 1018 WB Amsterdam, the Netherlands. Phone: +31 – 20 – 525 5088, Fax: +31 – 20 – 525 4310.

“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)

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 invest in risky education while incurring debt.² Failures of capital and insurance hamper access especially for students from lower socio-economic 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 warrant access to higher education.

Economists have often advocated more efficient forms of education finance 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. And García-Peñalosa and Wälde (2000) do not pay attention to the underlying micro-economic causes of

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 (1998), Acemoglu and Angrist (2000), 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 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 (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.

market failures. But any discussion of optimality is incomplete if the underlying causes of the market failure that gives rise to 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 student's and graduate's efforts, they are afraid that students will hit and run when they apply for a loan, or students might 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 overinvestment in human capital, since the high return investments cross-subsidize the low return investments in those circumstances.⁴ Aggregate overinvestment in human capital is however not a good description of reality, because the returns to in particular higher education are very high and for example easily approach the returns to equity.⁵ We therefore think that underinvestment in education is a more likely possibility, certainly in the absence of government intervention. Consequently, moral hazard is not the dominant information problem in the market. 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 impossibility for private parties to write equity and insurance contracts covering returns on human capital explain why and how governments should intervene in the financing of higher education. Adverse selection in debt markets leads to under-investment 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 under-investment is exacerbated, cf. Eaton and Rosen (1980). We show that an equity

³ See for example De Meza (2000) for this line of reasoning in the context of small firms and Judd (2000) 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 adding additional costs for investors to verify their type. These may result in under-investment of some investors which are socially desirable, but these models all display overinvestment at the aggregate level.

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

⁶ Asymmetric information may also play a 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. Rothschild and Stiglitz (1976), and Sinn (1995).

participation model as proposed by Friedman and Kuznetz (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) and 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 non-trivial consequences. Credit rationing is less likely to occur, and may 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 where it available. However, legal problems prevent the execution of both equity and insurance contracts by the private sector in the case of education financing. The reason for this is that the use of human capital as collateral or claiming its proceeds as dividends is impossible because slavery and indentured labor are outlawed in all civil societies. This effectively precludes financial contracts that are contingent upon the returns of human capital investment. Therefore, only debt finance is provided in markets, credit is rationed, and under-investment 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 and 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 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 are 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 while they would under-invest 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 implement equity contracts. 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, as it already does through the regular income tax. Equity participation by the government comes down

⁷ De Meza (2000, p.F21) also speculates that this may occur but does not refer to work showing this formally.

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 under-invest. Although both equity and debt financing feature income insurance, not all income risks are eliminated, so that some under-investment 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 to give 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 also that it implies reverse redistribution. The incidence of subsidies falls on the average tax payer, whereas the benefits accrue to the most talented, and hence generally better paid. Additionally, a disproportional number of graduates belong to the most wealthy families. Hence, equity financing of education avoids this perverse redistribution of incomes, since in principle no subsidies are needed.

Finally, 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 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. 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 . 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:

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

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 $p_i < p_j$.^{8 9}

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 R_i of 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.

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:

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

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

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

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):

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

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) 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

⁸ 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_i 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 .

⁹ 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.

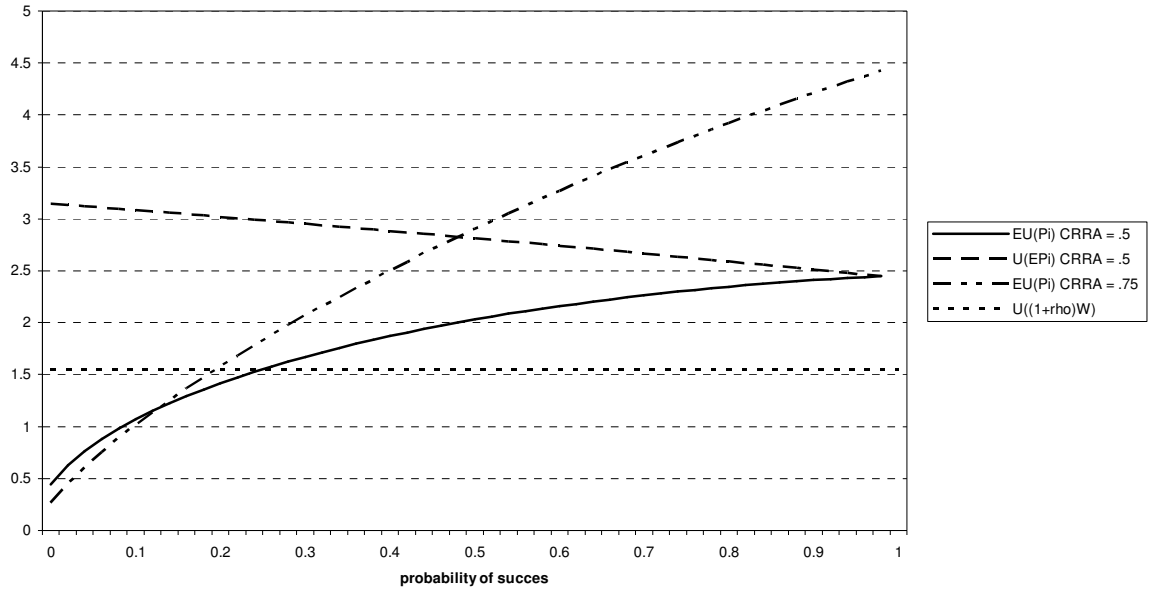
positive or negative, since $R_i^s - R^f > R_i^s - (1 + r)B$. Whether (4) will be positive or not depends on the size of $(1 + r)B - R^f$ and marginal utility of income U' (which is lowest for low-risk investors). If borrowing costs are large compared to the returns (small $R_i^s - (1 + r)B$), returns in the bad outcome relatively low (high $R_i^s - R^f$), 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 $EU(p_i)$ either always increases monotonically, or first increases and then decreases 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 also corresponds to the Stiglitz and Weiss (1981) case 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, 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) decreases the slope of the EU line. We 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.

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

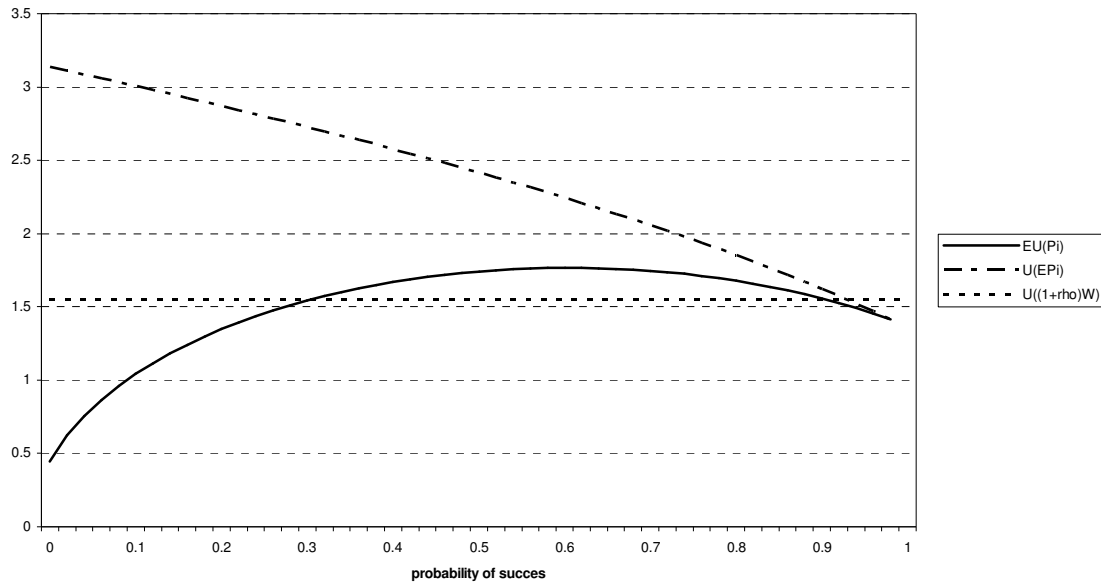


Risk aversion may have important consequences for the equilibrium of the model. For the marginal graduate, i.e. the graduate who is indifferent between investing in education or putting money in the bank, (3) holds with equality. The success probability at which a student is marginally indifferent between investing and staying out, p_m , may decline or increase if banks increase interest rates depending on whether (4) > 0. This follows from totally differentiating $p_m U((R - R^f)/p_m - (1 + r)B - R^f) = U((1 + \rho)W)$:

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

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.

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



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 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 $dp_i/dr > 0$. p^* corresponds to the marginal graduate with the highest probability of success who is willing to invest, with $dp_i/dr < 0$. 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 . While banks do not observe p_i , they 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 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:

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

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:

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

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 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 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 cease to be an equilibrium. 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 $p_i U((R - R^f)/p_i - (1 + r')B - R^f) > U((1 + \rho)W)$. 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 this 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.

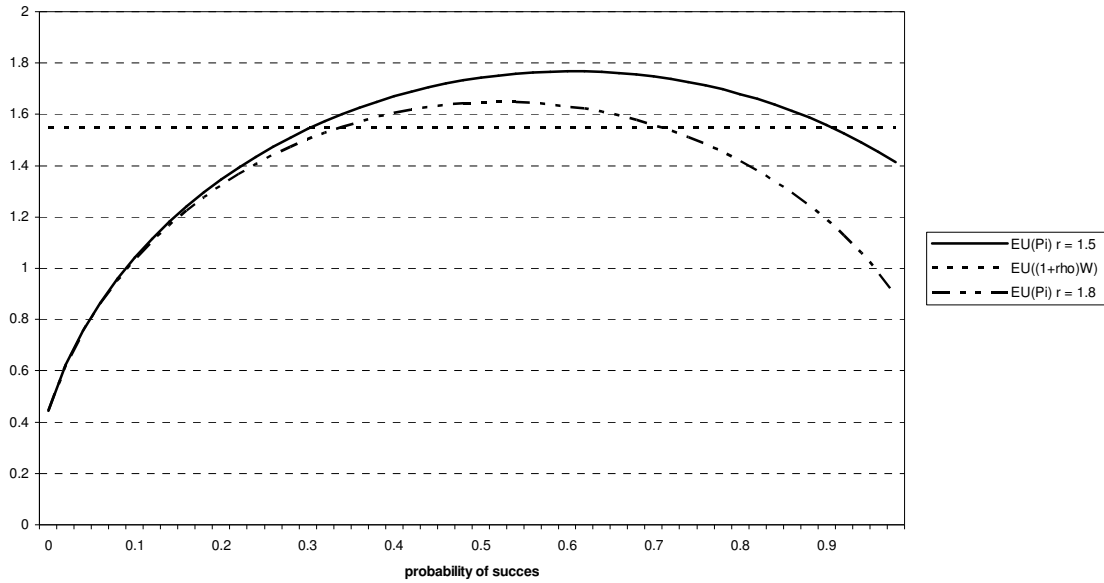
In the intermediate case, if risk aversion is small, interest rates are not sufficiently low ($(1 + r)B$ high) or incomes in the bad state of nature are not sufficiently high (R^f low), and dp_i/dr switches sign on the interval $[0,1]$, a credit rationing equilibrium may still occur. Graduates with $p_i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

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 also be seen by differentiating the bank's profit function:

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

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 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.

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



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 $dp/dr > 0$. At the same time, 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.:

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

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:

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

When we add $\int_{\underline{p}}^{\underline{p}^*} (1 - p_i)R^f f(p_i) dp_i$ 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 under-investment in human capital results.

If graduates are risk neutral, the same derivation holds, except for the fact that we integrate over $\int_0^{p_m}$ rather than $\int_{\underline{p}}^{\underline{p}^*}$ since $p_m = \underline{p}^*$ 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 as a result of asymmetric information *and* due to 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 and Weiss model. We show below that equity financing of investments is also optimal when graduates are risk averse. 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. 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 lack the possibility to enforce the contract in a non-slave state. Therefore, only debt contracts can be written by private parties since these are independent from 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, it is actually able to circumvent the barriers to writing of equity and insurance contracts that private parties face.¹⁰

¹⁰ 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).

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

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

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 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 $p_i = p_o$:

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

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 (11) 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:

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

where the left-hand-side gives expected profits from equity and the right-hand-side gives expected profits from debt contracts. 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

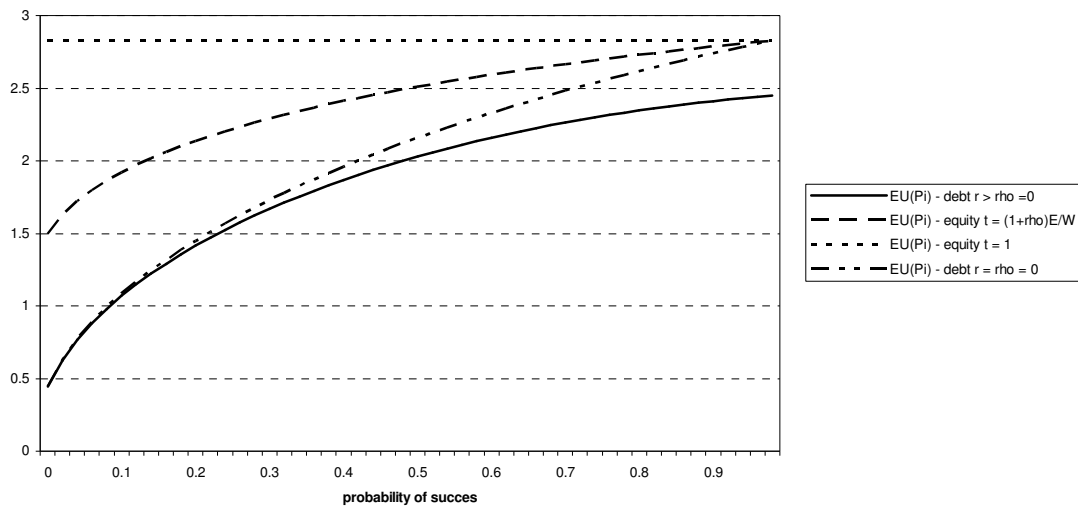
financed investments, at least from the government’s point of view. This is so because the first type of contracts only attract the worst risks and will consequently make losses. Therefore, in the optimal solution all investments will be equity financed.

With risk averse graduates and $dp_o/dr > 0$ one might expect exactly the opposite outcome. Using similar arguments as 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 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. $r > \rho$. Expected utility for debt financing then always lies below expected utility with equity financing. The intuition is that debt financing implies an 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.

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



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 ($\sigma^e \equiv (p_i(1 - p_i))^{1/2}(1 - t)(R_i^s - R^f)$):

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

$dR_i^s/dp_i < 0$ 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 for equity financed investments, because (13) < 0 . Consequently, the case in which mean incomes are constant, i.e. when there is no distortionary redistribution, the required risk premium on investments is lower with equity financing compared to debt financing because the variance of income is higher in the latter case.

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 eliminated. 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: $EU(\pi_i) = p_i U((1-t)R_i^s) + (1-p_i)U((1-t)R^f) \geq U((1+\rho)W)$. 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, $p_i(1-t)R_i^s + (1-p_i)(1-t)R^f > (1+\rho)W$. 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 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 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. $p_i R_i^s + (1-p_i) R^f = (1+\rho)K$ 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 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.

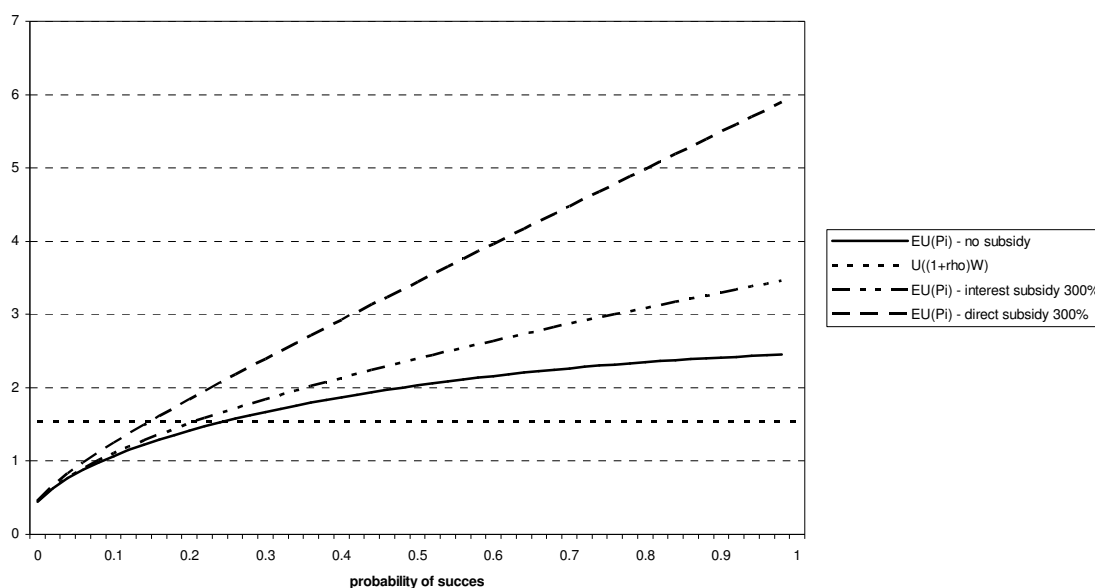
In the current setup, we do not allow for moral hazard effects or other (tax) distortions, so that full insurance can be achieved. In a more general setup, the presence of moral hazard would reduce the optimal insurance cover. There is a trade-off between incentives and risk sharing, see also Eaton and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

4 Sub-optimal education policy

Direct subsidies to education are 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 plotted the effects of an interest rate subsidy on expected utility for the graduate. Interest subsidies shift the expected utility line counter-clockwise 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 ($R^f = .5$, $R = 3$, $W = .6$, $\rho = 0$, $r = .5$)



Education subsidies should be increased to infinity in order to induce the graduate with the lowest probability of success to invest in human capital whose expected utility goes to zero whatever the level of income in the successful state is due to our assumption of constant mean returns to education.¹¹ 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 special case, the intuition is nevertheless straightforward. Education subsidies are an imperfect substitute for

¹¹ 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 limit is indeterminate we apply L'Hôpital's rule to find: $\lim_{p_i \rightarrow 0} = -\alpha U'(\alpha p_i - \beta) = 0$, since $\lim_{p_i \rightarrow 0} U'(\cdot) = 0$.

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 graduates only face $(1 - s_k)K$ as costs, 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 expected utility counter-clockwise, cf. Figures 4 and 5. An equity participation scheme is therefore by definition more suited to induce the high-risk graduates to invest than education subsidies.

Generally, very large subsidies are costly. 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. Consequently, if very large levels of 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 if graduates are risk averse.

Proposition 9 (*Inefficient education policy*) Education subsidies are at most a second-best means to resolve 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 social efficiency in investment can in general 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 non-trivially 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. Computations 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, i.e. when $s = 2,119$ euro, $s = 4,237$ euro, and $s = 6,355$ euro.¹² These subsidy levels correspond to increasing private contributions of respectively 75%, 50%, and 25% of current direct

¹² Externalities, public goods, and fiscal distortions in the accumulation of human capital may also justify at least some subsidy element.

expenditures.¹³ 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, 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 ‘gender’– ‘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 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 pay out enough dividends so as 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 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. Neither do we take into account income effects that may boost 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.

¹³ Our definition of total expenditures on education ignores the opportunity costs of education.

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 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 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 due to macroeconomic shocks. Therefore, the average tax-payer 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. 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 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 – Graduate taxes (%)

	Subsidy (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 (Bln. euro)	3.2	2.3	1.4	0.5
Robustness				
$g = 0$ ($r = .05$)	9.7	7.2	4.7	2.3
$g = .01$ ($r = .04$)	7.6	5.7	3.8	1.9
$g = .03$ ($r = .02$)	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

Table 1 shows the resulting graduate tax rates. We first focus on the base line 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%. 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 a graduate tax involves a lot of redistribution. 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.

The GT is 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 75% (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.

Table 2 – Fractions of life-time 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			Behavior & 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						

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.

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, we looked at a 1%-point lower rate of wage growth. This corresponds also with a higher real interest rate of 1%-point or including a macro-economic risk premium of 1%. Clearly, lower wage growth (higher real interest rates or a macro-economic risk premium) 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 or 2% lower wage growth.

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 driving repayment conditions.

6 Moral hazard, graduate taxes and income contingent loans

So far we ignored moral hazard. In the introduction we argue 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 in student's work-effort to financial incentives (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, by for example Cameron and Heckman (2001), indicates a relatively low price elasticity of enrollment in higher education, which also suggests that moral hazard in enrollment is not that important empirically. High return students are infra-marginal 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 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 who 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 may 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 that the government restricts the amount of income insurance by setting a limit on the repayments of graduates. In particular, the financing scheme would then become a hybrid combination 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 hit 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.

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 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 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 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 under-investment 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 under-investment 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 tax payer, who is paying for the education subsidies, will have a lower life time 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.

References

- Acemoglu, Daron J., and Joshua Angrist (2000). “How Large are the Social Returns to Education? Evidence from Compulsory Schooling Laws”, *NBER Macroeconomics Annual*, 9-59.
- Barr, Nicholas (1991). “Income Contingent Loans: An Idea Who’s Time has Come”, in: G.K. Shaw (1991). *Economics, Culture and Education*. Essays in Honour of Mark Blaug. Aldershot: Edward Elgar Publishing Limited.

- Barr, Nicholas (1993). "Alternative Funding Resources for Higher Education", *Economic Journal*, 103, 718-728.
- Bernanke, Ben, and Mark Gertler (1990), "Financial Fragility and Economic Performance", *Quarterly Journal of Economics*, 105, 87-114.
- Cameron, Stephen, and James J. Heckman (2001), "The Dynamics of Educational Attainment for Black, Hispanic, and White Males", *Journal of Political Economy*, 109, 455-499.
- Card, David (1999), "The Causal Effect of Education on Earnings", in: Ashenfelter, Orley and David Card (eds.), *Handbook of Labor Economics – Vol 3A*, Amsterdam: Elsevier- North Holland.
- Chapman, Bruce (1997). "Conceptual Issues and the Australian Experience with Income Contingent Charges for Higher Education", *Economic Journal*, 107, 738-751.
- Cho, Yoon Je (1986). "Inefficiencies from Financial Liberalization in the Absence of Well-Functioning Equity Markets", *Journal of Money, Credit and Banking*, 18, (2), 191-199.
- Carneiro, Pedro, and James J. Heckman (2002). "The Evidence on Credit Constraints in Post-Secondary Schooling", *Economic Journal*, 112, 705-734.
- Cameron, Stephen, and Christopher Taber (2000). "Borrowing Constraints and the Returns to Schooling", NBER Workingpaper 7761.
- Cameron, Stephen, and James J. Heckman (2001). "The Dynamics of Educational Attainment for Black, Hispanic, and White Males", *Journal of Political Economy*, 109, 455-499.
- De Meza, David (2000), "Overlending?", *Economic Journal*, 112, F17-F31.
- De Meza, David, and David C. Webb (1987). "Too Much Investment: A Problem of Asymmetric Information", *Quarterly Journal of Economics*, 101, 281-292.
- De Meza, David, and David C. Webb (1990). "Risk, Adverse, Selection and Capital Market Failure", *Economic Journal*, 100, 206-214.
- Eaton, Jonathan, and Harvey S. Rosen (1980). "Taxation, Human Capital and Uncertainty", *American Economic Review*, 70, (4), 705-715.
- Ewijk, C. van, and Paul J.G. Tang (2003). "How to Price the Risk of Public Investment?", *De Economist*, 151,3, 317-328.
- Friedman, Milton (1962). *Capitalism and Freedom*, Chicago: Chicago University Press.
- Friedman, Milton, and Simon Kuznets (1945), *Income from Individual Professional Practice*, New York: National Bureau for Economic Research.
- García-Peñalosa, Cecilia, and Klaus Wälde (2000). "Efficiency and Equity Effects of Sub-sidies to Higher Education", *Oxford Economic Papers*, 52, 702-722.
- Gould, Eric D., Omer Moav, and Bruce A. Weinberg, (2000). "Precautionary Demand for Education, Inequality, and Technological Progress", *Journal of Economic Growth*, 6, (4), 285-316.
- Harmon Colm, Hessel Oosterbeek, and Ian Walker (2003), "The Returns to Education: Microeconomics", *Journal of Economic Surveys*, 17, 115-155.
- Haveman, Robert, and Barbara Wolfe (1995). "The Determinants of Children Attainments: A Review of Methods and Findings", *Journal of Economic Literature*, 33, 1829-1878.
- Heckman, James J., and Peter J. Klenow (1998). "Human Capital Policy", in: Boskin, Michael (ed.). *Policies to Promote Human Capital Formation*, Hoover Institution.
- Heckman, James J., Lance Lochner, and Christopher Taber (1998). "Explaining Rising Wage Inequality: Explorations with a Dynamic General Equilibrium Model of Labor Earnings with Heterogeneous Agents", *Review of Economic Dynamics*, 1, 1-58.
- Hellman, Thomas, and Joseph E. Stiglitz (2000), "Credit and Equity Rationing in Markets with Adverse Selection", *European Economic Review*, 44, 281-304.
- Hoff, Karla, and Andrew B. Lyon (1995). "Non-Leaky Buckets: Optimal Redistributive Taxation and Agency Costs", *Journal of Public Economics*, 58, 365-390.
- Jacobs, Bas (2002). "An Investigation of Education Finance Reform. Graduate Taxes and Income Contingent Loans in the Netherlands", CBP Discussion Paper No. 9, CPB Netherlands Bureau for Economic Policy Analysis.
- Judd, Kenneth L. (2002), "Is Education as Good as Gold?", mimeo: Hoover Institution.
- Krueger, Alan B., and Mikael Lindahl (2002). "Education and Growth: Why and for Whom?", *Journal of Economic Literature*, 39, (4), 1101-1136.
- Leuven, Edwin, Hessel Oosterbeek, and Bas van der Klaauw (2003), "The Effect of Financial Awards on Students' Achievement: Evidence from a Randomized Experiment", mimeo: University of Amsterdam.
- Mankiw, N. Gregory (1986). "The Allocation of Credit and Credit Collapse", *Quarterly Journal of Economics*, 100, 455-470.
- Moretti, Enrico (2004), "Estimating the Social Return to Higher Education: Evidence from Longitudinal and Repeated Cross-Sectional Data", *Journal of Econometrics*, 121,175 – 212.

- Nerlove, Marc (1972). "On Tuition and the Costs of Higher Education: Prolegomena to a Conceptual Framework", *Journal of Political Economy*, 80, S178-S218.
- Nerlove, Marc (1975). "Some Problems in the Use of Income contingent Loans for the Finance of Education", *Journal of Political Economy*, 83, (1), 157-183.
- Oosterbeek, Hessel (1998). "An Economic Analysis of Student Financial Aid Schemes", *European Journal of Education*, 33, (1), 21-29.
- Plug, Erik J. S., and Wim Vijverberg (2005). "Does Family Income Matter For Schooling Outcomes? Using Adoption as a Natural Experiment", *Economic Journal*, forthcoming.
- Rothschild, Michael, and Joseph E. Stiglitz (1976). "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information", *Quarterly Journal of Economics*, 90, 629-649.
- Sinn, Hans-Werner (1995). "A Theory of the Welfare State", *Scandinavian Journal of Economics*, 97, 495-526.
- Shea, John (2000). "Does Parents' Money Matter?", *Journal of Public Economics*, 77, 155-184.
- Stiglitz, Joseph E. (1989). "On the Economic Role of the State", in: Heertje, Arnold (ed.) (1989). *The Economic Role of the State*, Oxford: Basil Blackwell, 9-85.
- Stiglitz, Joseph E. (1994). *Whither Socialism?*, Cambridge MA/London: MIT Press.
- Stiglitz, Joseph E., and Andrew Weiss (1981). "Credit rationing in Markets with Imperfect Information", *American Economic Review*, 71, 393-410.
- Stiglitz, Joseph E., and Andrew Weiss (1992). "Asymmetric Information in Credit Markets and its Implications for Macro-Economics", *Oxford Economic Papers*, 44, 694-724.
- Varian, Hal R. (1980). "Redistributive Taxation as Social Insurance", *Journal of Public Economics*, 14, 49-68.
- Wijnbergen, Sweder J. G. van (1998). "Tax Reform, Education and Labor Force Participation", in: Harry P. Huizinga (ed) (1998) *Pre-advice of the Royal Dutch Economics Association 1998: Belastinghervorming in het Fin de Siècle*, Utrecht: Lemma (in Dutch), 43-66.