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Competition in Funding Higher Education

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CESIFO WORKING PAPER NO. 3588
CATEGORY 5: ECONOMICS OF EDUCATION
SEPTEMBER 2011

CESifo *Working Paper No. 3588*

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Abstract

In higher education pure credit market funding leads to underinvestment while income-contingent loans funding tends to produce overinvestment. We analyze whether a market structure in which both funding schemes coexist and compete against each other might restore efficiency of the educational investment process. In the absence of government intervention, we find that funding competition does not rectify the investment inefficiency nor will it improve pooling of individual income risks. However, a policy which allows the two financing schemes to compete and which, at the same time, restricts access to higher education can achieve investment efficiency and improve risk pooling. We find that the equilibrium with funding competition and restricted participation yields the highest level of social welfare.

JEL-Code: D310, H310, I220.

Keywords: higher education, funding competition, human capital formation.

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July 2011

1 Introduction

Higher education financing faces two main problems which may lead to underinvestment in skilled human capital formation. The first problem is due to the peculiarities of human capital which prevent this form of capital from being used as loan collateral. As a consequence, banks are reluctant to provide higher education loans (see, e.g., Galor and Zeira, 1993). The second problem is caused by imperfections in the market for risk bearing. Investment in higher education is risky because students are at least partially ignorant about their abilities and, hence, about the returns on their investments. Yet, financial markets are unlikely to provide adequate pooling or diversification of these risks due to the existence of moral hazard incentives in an agent's acquisition of human capital and in his performance in the labor market.

As a possible response to these market failures the creation of income-contingent loan-repayment programs has been suggested (Friedman, 1962; Nerlove, 1975; Chapman, 2006). Income-contingent loans have the special characteristic that the terms of repayment depend on the borrowers' future incomes: individuals with higher incomes have higher repayment obligations. Such loan contracts not only allow students to pool (part of) their future income risks but can also be used to transfer risks on investment in human capital from borrowers and lenders to third parties. Such student loans arrangements exist in Australia, New Zealand, Chile, Sweden, the UK, and few other countries. Yet, while income-contingent loans may ease credit constraints and improve the risk allocation, they also imply significant cross-subsidization between subgroups of students with different future income prospects which may lead to excessive investment in higher education. In fact, students with poor income prospects are more likely to take out education loans under such a scheme than students with good income prospects and, hence, the human capital formation process is characterized by both adverse selection and overinvestment in education (Eckwert and Zilcha, 2011).

The observation that a financing regime consisting of competitive credit markets tends to produce underinvestment in higher education, while an income-contingent loans-repayment program tends to produce overinvestment, suggests that perhaps a market structure in which both schemes coexist might produce the efficient level of aggregate investment in human capital formation. Moreover, since the market structure with funding competition offers students more options in financing their educational investments, economic welfare may also be higher.

Our paper concentrates upon the implications of funding competition between credit markets and income-contingent education loans regarding human capital formation and economic welfare. We set up a theoretical framework in which individuals live for two periods. In the 'youth' period, agents obtain education and in the 'working' period they generate incomes based on their human capital and skills. At birth, each individual is randomly endowed with some innate ability which becomes fully known only in the working period. Following compulsory schooling in the first part of the youth period, each individual receives a (publicly observed) signal which is correlated to his/her true innate ability. To simplify our analysis we take all agents to be ex ante identical. In particular, we ignore family background when decisions about higher education are made. The decision whether to acquire higher education following the compulsory schooling will be based on the financing options available to the agent and on the information conveyed by the signal. Agents with different signals differ in their posterior distributions of ability and, hence, they have different income prospects.

We consider three financing regimes. Under the first regime, the government guarantees access to *credit markets* for all students who attend higher education. Under the second regime, a Student Loans Institution (SLI) offers *income-contingent loan contracts* to all individuals who are willing to invest in higher education. And under the third regime, which is the main focus of our study, income-contingent education finance coexists with competitive credit markets. We find that credit market funding leads to underinvestment in higher education while income-contingent loans funding leads to overinvestment. Funding competition does not remedy this misallocation of educational investment: we find that under the third regime aggregate investment in higher education is suboptimally high; and the pool of students who participate in the income-contingent loans program is adversely selected which leads to more income inequality and less social welfare.

In the absence of government intervention, funding competition in higher education is plagued by adverse selection in two respects. First, the cross-subsidization within the income-contingent loans program entices students with negative expected net returns on their investments to participate in the program. This misallocation of educational investment raises the financing costs for all participants, because the program is not subsidized by the government and, hence, must break even in equilibrium. Second, the elevated financing costs within the program provide incentives for students with good income prospects to shun the program and turn to the credit market for funding. This effect pushes the financing costs within the program even higher. Thus, in equilibrium, individuals with poor income prospects tend to pay higher financing costs. As a consequence, income inequality rises and social welfare declines.

The fact that funding competition alone does not remedy the misallocation of educational investment suggests a role for government policy, which would *restrict access* to higher education to individuals with non-negative expected net returns on their investments. We find that such policy, if combined with funding competition in higher education, is quite appropriate as it restores efficiency of the educational investment process and, at the same time, mitigates the adverse selection problem within the income-contingent loans program. In particular, under a policy of restricted access, funding competition leads to higher social welfare compared to pure credit market funding. Since a regulation which excludes credit markets from higher education finance is not a feasible policy option, we conclude that funding competition in combination with access restrictions constitute the best regulatory framework for the higher education sector.

2 The Model

We consider a two-period model with a single commodity (capital good) and a continuum of individuals, say, in the interval $[0, 1]$. In the latter part of the first period, following compulsary education, an individual may take out a loan and make a capital investment in higher education in order to acquire additional skills. Thus, the capital investment increases the agent's human capital in the second period when the agent works and earns labor income. Labor income depends on each agent's skills or human capital, which is assumed to be observable. In the second period, each individual consumes his net wealth which is the difference between his labor income and the repayment obligation of the loan.

Diversity within the population is generated by random innate ability, which affects an agent's productivity level. Abilities are assigned to individuals by nature at birth. i.e., at the outset of the first period. At this time, however, individual ability is not observable, and is not even known to the agent himself. Human capital of individual i depends on his random innate ability a^i and on his private investment in higher education, x^i. The investment decision is made at date 0 while random innate ability realizes at date 1.

In order to keep the analytical setup simple, we assume that following his basic education the agent faces a binary investment choice: he may either invest one unit of capital in education, or he may not invest at all. If the individual does not invest, $x^i = 0$, he remains unskilled and attains a basic human capital level $A > 0$ in period 1. If the agent invests, $x^i = 1$, then he becomes a skilled worker. In that case, his human capital in period 2 is $A + \tilde{a}^i$, where ability $\tilde{a}^i$ represents the additonal productivity due to higher education. The random variable $\tilde{a}^i$ assumes values in some interval $\mathcal{A} := [a^1, a^2] \subset \mathbb{R}_{++}$.

We denote by $\mu(a)$ the density of agents with ability a and adopt the normalization $\int_{\mathcal{A}} \mu(a)\,\mathrm{d}a = 1$. From the perspective of an individual in period 0, ability is random as it is the realization of a random variable $\tilde{a}$ with expectation $\bar{a} := E\tilde{a}$ and distribution $\mu(\cdot)$. Yet, there is no aggregate uncertainty in the economy, i.e., the ex post distribution of abilities across the population is exactly μ . Our modeling approach follows the technique suggested in Feldman and Gilles (1985, Proposition 2), where uncertainty exists at the individual level but in the aggregate there is no uncertainty.

Each agent receives a publicly observable signal $y \in Y := [\underline{y}, \bar{y}] \subset \mathbb{R}$ of his ability, a, before he makes the investment decision. The signal might be interpreted as a noisy test result which is correlated with the agent's ability.[1] Real world examples include high school grades and the matriculation examinations used in

[1]We assume that signals and abilities satisfy the strict Monotone Likelihood Ratio Property (MLRP), i.e., the signals are ordered in such a way that $y' > y$ implies that the posterior distribution of ability conditional on y' dominates the posterior distribution of ability conditional on y in the first-degree stochastic dominance (see Milgrom, 1981).

many countries. Since the tests are noisy, individuals with the same ability, a, typically receive different signals. We denote by $\nu_a(y)$ the density according to which signals are distributed across agents with ability a. Each individual uses the signal as a screening device and forms expectations about his unknown ability in a Bayesian way. The signals are distributed across the entire population according to $\nu(y) = \int_{\mathcal{A}} \nu_a(y)\mu(a)\,\mathrm{d}a$. If $\tilde{a}_y$ denotes random ability conditional on the signal y, then average ability of all agents in the signal group y is $\bar{a}_y := E[\tilde{a}_y]$.

The human capital of agent i who has received signal y^i, will be[2]

$$\tilde{h}_{y^i} = \begin{cases} A; & ; \text{ if } \; x^i = 0 \\ A + \tilde{a}_{y^i} & ; \text{ if } \; x^i = 1 \end{cases} . \tag{1}$$

Production is carried out by competitive firms in period 2 according to a constant returns to scale production technology which uses physical capital, K, and human capital, H, as factors of production. Each individual i inelastically supplies l units of labor. The agent's supply of effective labor units is given by lh^i. His labor income in period 2 is wlh^i, where w denotes the wage rate (price of one efficiency unit of labor). To ease notation we adopt the normalization $l = 1$.

Assumption 1 *The aggregate production function $F(K, H)$ is concave, homogeneous of degree 1, and satisfies $F_K > 0$, $F_H > 0$, $F_{KK} < 0$, $F_{HH} < 0$.*

Our economy represents a small country in a world where physical capital is internationally mobile while human capital is immobile. By and large, this specification is in line with the empirial observation that the globalization process has promoted international mobility of physical capital far more than international mobility of labor. International capital mobility in combination with the small country assumption implies that the interest rate, r, is exogenously given. Physical capital fully depreciates in the production process. Hence, marginal productivity of aggregate physical capital equals $R := 1+r$. Given the aggregate stock of human capital, H, the stock of physical capital K adjusts such that

$$F_K(K, H) = R \tag{2}$$

[2]Later we shall extend our analysis to the case where A depends on the average human capital of the older generation, following the type of assumptions used by Lucas (1988).

is satisfied. Equation (2) in combination with Assumption 1 implies that K/H is determined by the gross international rate of interest R. The wage rate which equals the marginal product of effective labor, $w = F_L(K/H, 1)$, is also determined once R is given. Throughout the paper we assume $\bar{a} > R/w$, so that investment in education is profitable for an individual with average ability.

2.1 Funding Structure and Individual Behavior

All individuals are risk-averse expected utility maximizers with vNM-utility function $u(\tilde{c})$, where $\tilde{c}$ denotes random second period consumption.

Assumption 2 *The utility function $u : \mathbb{R}_+ \to \mathbb{R}$ is twice differentiable, strictly increasing and concave, and exhibits relative risk aversion less than or equal to 1, i.e., $-u''(c)c/u'(c) \leq 1,\ \forall c > 0$.*

Consumption is the difference between the agent's labor income and the repayment obligation of his loan. Below we will analyze three different market structures for financing loans: competitive credit market, income-contingent loans market, and a structure with coexistence of competitive credit market and income-contingent loans market. The third structure, which gives individuals a choice between two funding schemes, is the main focus of our analysis.

The equilibria under the various market structures will be evaluated and compared with regard to their social welfare implications. The social planner's welfare index, W, evaluates the distribution of average incomes across the signal groups,

$$W = \int_{\underline{y}}^{\bar{y}} v(\bar{c}_y)\nu(y)\,\mathrm{d}y, \tag{3}$$

where $v : \mathbb{R}_+ \to \mathbb{R}$ is a strictly increasing and concave function, $\bar{c}_y := E[\tilde{c}|y]$, and $(\tilde{c}|y)$ represents random consumption of an individual with signal y.[3] Ceteris paribus, higher average consumption in a signal group raises the index; and higher consumption (= income) dispersion across signal groups decreases the index due to

[3]In our model, all individuals are identical ex ante. Therefore, in equilibrium, agents with the same signal choose identical consumption profiles.

the concavity of v. The concavity of v thus reflects the inequality aversion of the social planner.

The social welfare criterion uses only *observable* data, namely average incomes in the various signal groups. These data are available to the government and can thus be used for evaluating policy choices. Therefore our comparison of funding schemes and policy options will be based on the social welfare criterion (3).

2.1.1 Credit Market

Under this funding structure the government guarantees access to credit markets for all students who attend higher education. Suppose agent i considers to finance his investment via the credit market at the going interest rate r, where $R = 1 + r > 0$. The agent will choose $x^i = 1$, if

$$E\big[u\big(wA + w\tilde{a}_{y^i} - R\big] > u(wA). \tag{4}$$

Otherwise he chooses $x^i = 0$. Due to MLRP (cf. footnote 1) the LHS in (4) is strictly monotone increasing in the signal y^i. Hence there exists a unique cutoff signal $\hat{y}$ such that all individuals with signals larger than or equal to $\hat{y}$ invest in higher education, and individuals with signals lower than $\hat{y}$ do not invest.

The aggregate stock of human capital can then be represented as

$$H = A + \int_{\hat{y}}^{\bar{y}} \bar{a}_y \nu(y) \mathrm{d}y \ . \tag{5}$$

In equilibrium, each agent chooses investment in education according to (4), factor markets clear, and aggregate human capital follows the accumulation equation (5).

Definition 1 *Given the international gross interest rate $R = 1 + r$, an equilibrium with credit funding (CME) consists of a vector $(\hat{y}, w, K, H) \in \mathbb{R}^4_+$, $\hat{y} \in [\underline{y}, \bar{y}]$, such that*

(i) *the cutoff signal, $\hat{y}$, satisfies (4) with equality,*

(ii) *the aggregate stock of human capital, H, satisfies (5),*

(iii) *the wage and physical capital satisfy $w = F_L(K/H, 1)$ and $R = F_K(K/H, 1)$.*

A CME always exists and it is unique: for given $R > 0$, the second equality in (iii) uniquely determines K/H. For given K/H, the first equality in (iii) uniquely determines the wage rate w. (4) then yields the cutoff signal $\hat{y}$ which is independent of H. Finally, aggregate human capital, H, is determined by eq. (5).

In a CME, the economy-wide aggregate investment in education is suboptimally low. To illustrate this fact, we calculate the *efficient* cutoff signal, y_e, which maximizes social welfare. In the social welfare optimum, y_e separates agents who invest in higher education from those who do not invest. y_e maximizes

$$W(y) = \int_{\underline{y}}^{y} v(wA)\nu(y')\,\mathrm{d}y' + \int_{y}^{\bar{y}} v(wA + w\bar{a}_{y'} - R)\nu(y')\,\mathrm{d}y'$$

and, hence, satisfies

$$0 = W'(y_e) = \nu(y_e)[v(wA) - v(wA + w\bar{a}_{y_e} - R)] \iff \bar{a}_{y_e} = R/w. \tag{6}$$

According to (6), in a social optimum investment in education is efficient in the sense that only those signal groups invest in higher education, for which the expected return, $w\bar{a}_y$, exceeds the funding cost R. This investment rule implies that aggregate consumption is maximized.

From $E[wA + w\tilde{a}_{y_e} - R] = wA$ we conclude

$$E[u(wA + w\tilde{a}_{y_e} - R)] < u(wA) \tag{7}$$

due to risk aversion. Combining (4) and (7) yields $\hat{y} > y_e$, i.e., the cutoff signal beyond which agents invest in higher education in a CME is suboptimally high and, hence, investment is suboptimally low.

Proposition 1 *In the CME, aggregate investment in education is suboptimally low.*

2.1.2 Income-Contingent Loans Equilibrium (ICLE)

The inefficiency of educational investment under the credit market regime is due to the fact that the credit market does not allow individuals to share idiosyncratic ability (hence income) risks. To mitigate the problem of underinvestment, the provision of income-contingent education loans through some government agency or private lending institution has been proposed (Friedman, 1962; Chapman, 2006). If properly designed, such loan contracts have the potential to improve risk sharing and reduce underinvestment in the higher education sector (Eckwert and Zilcha, 2010).

Assume that a financial institution (Student Loans Institution, or SLI) offers income-contingent loan contracts to all individuals who are willing to invest in higher education. The payback obligation of a loan is linked to an individual's future (gross) income: agents with higher incomes (i.e. higher abilities) have higher payback obligations. Clearly, such loan contracts provide insurance against uncertain income prospects that are due to random ability realizations. We consider an income-contingent loans (ICL) program that includes all individuals and requires no subsidization from the government. For now, by assumption, the regular credit market cannot be used for funding educational expenditures.[4]

If agent i decides to invest in higher education, he receives a loan of 1 unit in period 0 with repayment obligation $Ra^i/\bar{a}$ in period 1.[5] The net income from this investment in period 1 is

$$a^i \left[w - \frac{R}{\bar{a}} \right]. \tag{8}$$

Note that agent i's *expected* payback, $R\bar{a}_{y^i}/\bar{a}$, is increasing in the signal, i.e., the scheme 'penalizes' agents with high signals.

The ICL-program takes no account of the heterogeneity in ability prospects that is already revealed through the individual signals when investment and borrowing decisions are made. Thus the ICL-program does not just provide insurance, but rather it combines insurance against the unrealized part of ability with cross-subsidization between classes of people in different signal groups. Observe that the SLI makes no profits. It just breaks even as it provides loans that, from an ex ante

[4]This assumption may appear unrealistic as it requires a regulatory regime under which ICLs are mandatory and, hence, credit markets are excluded from higher education finance. In fact, our study considers the ICL-equilibrium mainly as a benchmark for comparison rather than a viable regime for higher education finance. However, in some countries (e.g., Australia) at least part of the tuition fees are collected through mandatory ICLs (Chapman, 2006).

[5]This type of student loan market was studied recently in Eckwert and Zilcha (2011). Such student loan markets exist in Australia, Sweden, the UK and Chile, for example (for more details see Barr and Crawford, 1998; Lleras, 2004).

perspective, share income risks on fair terms across the entire population.

In view of (8), *all* agents invest in higher education since $\bar{a} > R/w$ has been assumed. We conclude that in an equilibrium[6] with ICL-funding (ICLE, for short) the economy-wide aggregate investment in education and, hence, human capital formation, is suboptimally high, because individuals with signals below y_e choose to invest.

2.1.3 Funding Competition Equilibrium (FCE)

We have seen above that credit funding leads to underinvestment in higher education while ICL-funding leads to overinvestment. In this section we analyze whether income-contingent education finance can coexist with competitive credit markets in the absence of government regulation and, if so, how competition between the two financing schemes affects the efficiency properties of the investment allocation in the higher education sector. Suppose that each individual has the option, but not the obligation, to participate in an ICL-program. Within this program, the terms of repayment of an education loan depend on the individual's signal and, hence, on his income in the working period. Let

$$\bar{a}(y') := E[\bar{a}_{\tilde{y}} | \underline{y} \leq \tilde{y} \leq y'] \tag{9}$$

denote average ability of agents in the signal groups between $\underline{y}$ and y'. Consider the following arrangement: if all individuals with signals less than or equal to y' participate in the ICL-program and all other individuals do not participate, then the repayment obligation (for borrowing one unit of capital to finance education) of each participant i is $Ra^i/\bar{a}(y')$.

Note that the ICL-program just breaks even. Also note that within this program risks are shared (in an ex ante sense) across signal groups: individuals with high signals 'subsidize' those with low signals.

The net return to investment in education under the ICL-program is

$$\tilde{a}_y \left(w - \frac{R}{\bar{a}(y')} \right) \tag{10}$$

[6]The equilibrium is defined in analogy to Definition 1.

for all agents in signal group y. Thus, if the net return in (10) is positive for *some* signal group y then it is positive for *all* signal groups. Therefore, if the ICL-program does not break down in equilibrium, i.e., if it attracts at least one customer, then *all* individuals invest in higher education. Some of these individuals, however, may find it optimal to finance their investments via the credit market.

We now investigate which signal groups participate in the ICL-program and which ones choose the credit market. Let

$$\tilde{c}_1(y) = Aw + \tilde{a}_y w - R \tag{11}$$

and

$$\tilde{c}_2(y; y') = Aw + \tilde{a}_y \left(w - \frac{R}{\bar{a}(y')} \right), \tag{12}$$

where (11) describes random consumption of an agent with signal y if he invests via the credit market; and (12) describes random consumption under the ICL-program. Denote by

$$V_1(y) = Eu(\tilde{c}_1(y)); \qquad V_2(y; y') = Eu(\tilde{c}_2(y, y'))$$

the corresponding expected utilities.

Lemma 1 *Suppose y^* satisfies*

$$V_1(y^*) = V_2(y^*; y^*). \tag{13}$$

Then

$$V_1(y) - V_2(y; y^*) \tag{14}$$

is strictly increasing in y.

Proof: See Appendix.

Equation (13) implies that individuals in signal group y^* are indifferent between investing via the ICL-program and investing via the credit market, if all agents in the signal groups $y \leq y^*$ participate in the ICL-program. From Lemma 1 it follows immediately that all agents with signals greater than y^* finance their investments via the credit market and all agents with signals smaller than y^* participate in the ICL-program.

Definition 2 *Given the international gross interest rate* $R = 1 + r$*, an equilibrium with funding competition (FCE, for short) consists of a vector* $(y^*, w, K, H) \in \mathbb{R}_+^4$*,* $y^* \in [\underline{y}, \bar{y}]$*, such that*

(i) *the cutoff signal,* y^**, satisfies* $u(Aw) \leq V_2(y^*, y^*) = V_1(y^*)$*,*[7]

(ii) *the aggregate stock of human capital satisfies* $H = A + E\tilde{a}$*,*

(iii) *the wage and physical capital satisfy* $w = F_L(K/H, 1)$ *and* $R = F_K(K/H, 1)$*.*

In (i), the inequality ensures that the ICL-program does not break down, and the equality implies that the credit market co-exists alongside the ICL-program. Note that, given (12), the inequality $u(Aw) \leq V_2(y^*, y^*)$ implies $w\bar{a}(y^*) \geq R$, i.e., on average investment in education within the ICL-program is profitable. Moreover, the last inequality in combination with (3) and (13) implies $y^* > \hat{y}$. Thus, in the FCE fewer individuals use the credit market than in the CME. The equality in (ii) holds because in this equilibrium all individuals invest in higher education. In fact, according to Lemma 1, all agents with signals lower than y^* join the ICL-program, and all other agents finance their educational investments via the credit market.

If the agents are risk-neutral, then the equality in (i) of Definition 2 is only satisfied for $y^* = \underline{y}$. In that case, no FC-equilibrium exists, because $\underline{y} < y_e$ has been assumed. Thus, a sufficient amount of risk aversion is necessary for this type of equilibrium to exist.[8]

In an FCE, all individuals are (weakly) better off at the interim stage, i.e., after they have received their signals, than in an equilibrium with credit funding. This follows from the observation that expected utility of individuals with signals $y \geq y^*$ stays the same, and expected utility of all other agents increases because

[7] $y^* := \bar{y}$, if $V_2(y, y) > V_1(y)$ for all y.

[8] Let y' be defined by $\bar{a}(y')w = R$ which implies $y' > y_e$. Then a risk sharing equilibrium exists if, as a sufficient condition, individual preferences satisfy the inequalities

$$u(Aw) < Eu(Aw + w\tilde{a}_{y'} - R)$$

$$Eu(Aw + w\tilde{a}_{\bar{y}} - (\tilde{a}_{\bar{y}}/\bar{a})R) > Eu(Aw + w\tilde{a}_{\bar{y}} - R).$$

they *voluntarily* choose to participate in the ICL-program rather than using the credit market.

Nevertheless, even though competition between the financing schemes has some merits, the FC-equilibrium is still inefficient.[9] Inefficiencies are caused by two factors. The first factor consists of an externality, which is caused by the competition between the schemes. The externality is imposed on individuals who participate in the ICL-program: the more agents go to the credit market, the less favorable are the terms of repayment for agents participating in the ICL-program. Due to this externality, the cutoff signal y^* is suboptimally low, i.e., it lies below the socially optimal level.

Proposition 2 *In the FCE, the cutoff signal, y^*, which separates the signal groups that join the ICL-program from the signal groups that use the credit market, is suboptimally low, i.e.,*

$$\frac{\partial W(y^*)}{\partial y^*} > 0.$$

Proof: see appendix.

According to Proposition 2, the externality from funding competition could be mitigated and social welfare could be raised if some individuals who finance their investment through the credit market would join the ICL-program. Yet, in the absence of government intervention these individuals have no incentive to change their financing decisions.

Second, in an FC-equilibrium individuals with very low signals $y < y_e$ invest in higher education because they are subsidized by other agents in the ICL-program. Investments of these individuals are inefficient for the economy as a whole because, on average, the returns to these investments fall short of the investment costs; i.e., $w\bar{a}_y < R$ for $y < y_e$.

Proposition 3 *In the FCE, aggregate investment in education is suboptimally high.*

[9] In particular, the FCE does not dominate the equilibrium with ICL-funding in the Pareto sense. Under funding competition, the ICL-program becomes adversely selected, i.e. $\bar{a}(y^*) < \bar{a}$, which worsens the terms of borrowing for those individuals who participate in the ICL-program.

3 Funding Structure and Social Welfare

Under all funding structures considered so far the investment allocation process is inefficient: in the CME, aggregate investment is suboptimally low while ICLE and FCE both lead to aggregate overinvestment. Moreover, the various funding structures lead to different degrees of income inequality across the signal groups. Both income inequality as well as inefficiencies in the investment process have a negative impact on social welfare. In this section we focus on the combined impact of these two sources of welfare losses, i.e., we investigate how the funding structures compare from the perspective of social welfare.

Even though funding competition gives individuals more financial flexibility than ICL-funding, the latter funding structure leads to higher social welfare.

Proposition 4 *Social welfare is higher in the ICLE than in the FCE.*

Proof: see appendix.

The ICLE and the FCE both exhibit the same degree of investment inefficiency: individuals in signal groups lower than y_e invest in higher education even though in these signal groups the funding cost exceeds the average return to investment. Yet, the FCE has a more unequal income distribution than the ICLE, because the pool of agents who participate in the ICL-program is adversely selected: individuals with high signals and, hence, excellent income prospects don't join the program thereby worsening the terms of loan repayment for agents with lower signals who participate in the program. This mechanism reduces social welfare as it increases the spread between incomes in high signal groups and incomes in low signal groups.

Proposition 5 *Suppose*

$$w\bar{a} - R \geq \int_{\hat{y}}^{\bar{y}} (w\bar{a}_y - R)\nu(y)\, dy, \tag{15}$$

i.e., the aggregate net return to investment in education is higher in the FCE than in the CME. Then social welfare is higher in the FCE than in the CME.

Proof: see appendix.

The investment inefficiency in the FCE (agents with signals less than y_e investing in higher education) and, hence, the term on the LHS in (15) is independent of posterior ability risks and of the individuals' attitudes towards those risks. The investment inefficiency in the CME, by contrast, results from individuals with signals higher than y_e but lower than $\hat{y}$ who refuse to invest in higher education because they shy away from the involved risk. This effect is strengthened by both higher posterior ability risk and higher individual risk aversion. The investment inefficiency in the CME therefore increases and, hence, the term on the RHS in (15) declines with higher posterior ability risk and/or higher individual risk aversion. Thus, Proposition 5 suggests that social welfare is higher in the FCE than in the CME if either individuals are strongly risk-averse or if the screening information is vague such that the posterior ability risks remain high.

Suppose, for instance, that individual preferences exhibit constant absolute risk aversion, $\alpha > 0$, and that the posterior distribution of abilities takes the form $\tilde{a}_y = \bar{a}_y + \tilde{\epsilon}$, where $\tilde{\epsilon}$ is Normally distributed with mean zero and variance σ^2. Here σ^2 measures the posterior ability risk as well as the vagueness, or noisiness, of the screening information. In that case $\bar{a}_{\hat{y}} = \frac{1}{2}w\alpha\sigma^2 + \frac{R}{w}$. Thus, if $\alpha\sigma^2 \to \frac{2}{w^2}(w\bar{a}_{\bar{y}} - R)$ then $\hat{y} \to \bar{y}$ such that the inequality in (15) is satisfied if the product of risk aversion and posterior ability risk is sufficiently high.

Propositions 4 and 5 together imply that under condition (15) the ICLE dominates the CME in terms of social welfare:

Corollary 1 *Suppose condition (15) is satisfied. Then social welfare is higher in the ICLE than in the CME.*

4 Access Restriction to Higher Education

In equilibria with ICL-funding, i.e., in ICLE and FCE, the economy-wide aggregate investment in education is suboptimally high. This overinvestment worsens the terms of loan repayment for individuals who participate in the ICL-program. In the FCE, this problem is intensified as individuals in the highest signal groups turn to the credit market for funding which further reduces the attractiveness of the ICL-program. These sources of inefficiency can possibly be mitigated by a government policy which restricts access to higher education to individuals with signals higher than the efficient threshold level y_e. We now investigate how the equilibria under the various funding schemes compare with regard to social welfare, if such access restriction to higher education is implemented.

4.1 Restricted Participation ICLE (RP/ICLE)

Suppose that the ICL-program is the only accessible means of higher education finance and that the government restricts access to higher education to agents with signals higher than the efficient threshold level y_e. Let

$$\breve{a}(y_e) := E[\bar{a}_{\tilde{y}} | y_e \leq \tilde{y} \leq \bar{y}] \tag{16}$$

denote average ability of agents in signal groups higher than y_e. Under restricted access, the loan repayment obligation of each agent i who participates in the ICL-program is $Ra^i/\breve{a}(y_e)$. The ICL-program just breaks even because all individuals with signals larger than y_e participate in the program. In such *restricted participation* ICLE[10] (RP/ICLE, for short) individuals with signals higher than y_e are better-off than in the ICLE because $\breve{a}(y_e) > \bar{a}$ and, hence, their terms of loan repayment have improved; and individuals with signals lower than y_e are worse-off as they are denied access to the higher education system.

4.2 Restricted Participation FCE (RP/FCE)

Suppose the government restricts access to higher education under a system of funding competition where individuals can choose between participating in the ICL-program and using the credit market. Such restriction not only prevents agents with poor ability prospects from investing, but also makes the pool of agents who participate in the ICL-program less adversely selected. As a consequence, the ICL-program might become more attractive to individuals with higher signals thereby raising the cutoff signal y^* and mitigating the externality from the competition between the two funding schemes. More formally, define

$$\tilde{c}_2(y; y_e, y') := Aw + \tilde{a}_y \left(w - \frac{R}{\bar{a}(y_e, y')} \right); \quad \bar{a}(y_e, y') := E[\bar{a}_{\tilde{y}} | y_e \leq \tilde{y} \leq y']. \tag{17}$$

[10]The equilibrium is defined in analogy to Definition 1.

$\tilde{c}_2(y; y_e, y')$ represents consumption of an individual with signal y who participates in the ICL-program, if the ICL-program attracts all individuals with signals in $[y_e, y']$. Note that $\tilde{c}_2(y; y_e, y') > Aw$ for all $y' > y_e$.

Definition 3 *Given the international gross interest rate $R = 1 + r$ and the government threshold policy y_e, a restricted participation equilibrium with funding competition (RP/FC-equilibrium, for short) consists of a vector $(y^\dagger, w, K, H) \in \mathbb{R}^4_+$, $y^\dagger \in [y_e, \bar{y}]$, such that*

(i) *the cutoff signal, $y^\dagger$, satisfies $Eu(\tilde{c}_2(y^\dagger; y_e, y^\dagger)) = V_1(y^\dagger)$,*[11]

(ii) *the aggregate stock of human capital satisfies $H = A + \int_{y_e}^{\bar{y}} \bar{a}_y \nu(y) dy$,*

(iii) *the wage and physical capital satisfy $w = F_L(K/H, 1)$ and $R = F_K(K/H, 1)$.*

In an RP/FC-equilibrium with government policy y_e, only individuals with signals larger than y_e (are allowed to) invest in higher education, hence aggregate consumption is maximized. An agent with signal y participates in the ICL-program if $y \in [y_e, y^\dagger]$, and he uses the credit market if $y > y^\dagger$.

Observe that $y^\dagger$ is strictly larger than y_e, because $Eu(\tilde{c}_2(y_e, y_e, y_e)) > Eu(\tilde{c}_1(y_e)) = V_1(y_e)$. The inequality holds because $\tilde{c}_1(y_e)$ is a mean preserving spread of $\tilde{c}_2(y_e, y_e, y_e)$.[12] Thus, unlike FC-equilibria, RP/FC-equilibria with operative ICL-programs always exist. Moreover, (17) implies that $\tilde{c}_2(y^\dagger; y_e, y^\dagger) > Aw$, from which we conclude that $y^\dagger > \hat{y}$.

In the RP/FC-equilibrium, all individuals are (weakly) better off at the interim stage, i.e., after they have received their signals, than in the equilibrium with credit funding: expected utility of individuals with signals $y < y_e$ or $y \geq y^\dagger$ is the same in both equilibria; and expected utility of individuals with signals between y_e and $y^\dagger$ is (weakly) higher in the RP/FC-equilibrium because the agents *voluntarily* invest and *voluntarily* participate in the ICLP.

[11] $y^\dagger := \bar{y}$, if $Eu(\tilde{c}_2(y; y_e, y)) > V_1(y)$ for all $y \in [y_e, \bar{y}]$.

[12] Note that $\tilde{c}_1(y_e)$ and $\tilde{c}_2(y_e, y_e, y_e)$ have the same mean and that $\tilde{c}_2(y_e, y_e, y_e) \overset{(<)}{>} \tilde{c}_1(y_e)$ for $\tilde{a}_{y_e} \overset{(>)}{<} \bar{a}_{y_e}$.

4.3 Restricted Participation and Social Welfare

We now compare the RP/ICL-equilibrium and the RP/FC-equilibrium with respect to the social welfare criterion (3). In both equilibria, agents with signals larger than y_e invest in higher education. In the RP/ICLE, all investments are financed via the ICL-program, while in the RP/FCE, individual investments are partly financed via the ICL-program and partly via the credit market. Since the allocation of investments is the same in both equilibria, aggregate consumption is also the same, i.e.,

$$\int_{\underline{y}}^{\bar{y}} \bar{c}_y^{RP/ICLE} \nu(y)\,\mathrm{d}y = \int_{\underline{y}}^{\bar{y}} \bar{c}_y^{RP/FCE} \nu(y)\,\mathrm{d}y. \tag{18}$$

Expected consumption of individuals in signal group y is

$$\bar{c}_y^{RP/ICLE} = \begin{cases} Aw & ; \text{ if } \; y < y_e \\ Aw + \bar{a}_y \left(w - \frac{R}{\breve{a}(y_e)} \right) & ; \text{ if } \; y \geq y_e \end{cases}$$

in the RP/ICLE, and

$$\bar{c}_y^{RP/FCE} = \begin{cases} Aw & ; \text{ if } \; y < y_e \\ Aw + \bar{a}_y \left(w - \frac{R}{\breve{a}(y_e, y^\dagger)} \right) & ; \text{ if } \; y \in [y_e, y^\dagger] \\ Aw + \bar{a}_y w - R & ; \text{ if } \; y > y^\dagger \end{cases} \tag{19}$$

in the RP/FCE. It can easily be verified that

$$\bar{c}_y^{RP/ICLE} \overset{(<)}{\geq} \bar{c}_y^{RP/FCE}, \quad \text{if } \bar{a}_y \overset{(>)}{\leq} \breve{a}(y_e). \tag{20}$$

(18) and (20) imply that $\bar{c}_y^{RP/FCE}$ is a mean-preserving spread of $\bar{c}_y^{RP/ICLE}$ from which we conclude

$$W^{RP/ICLE} = \int_{\underline{y}}^{\bar{y}} v\big(\bar{c}_y^{RP/ICLE}\big)\nu(y)\,\mathrm{d}y > \int_{\underline{y}}^{\bar{y}} v\big(\bar{c}_y^{RP/FCE}\big)\nu(y)\,\mathrm{d}y = W^{RP/FCE}.$$

The RP/ICLE therefore dominates the RP/FCE in welfare terms.

Proposition 6 *Social welfare is higher in the RP/ICLE than in the RP/FCE.*

The welfare comparison in Proposition 5 between the FCE and the CME was ambiguous because both equilibria entail different forms of investment inefficiency: the FCE leads to overinvestment while the CME leads to underinvestment in higher education. As a consequence, the aggregate net return to educational investment in the FCE can be higher or lower than in the CME. Yet, if the government restricts access to higher education, investment efficiency is restored under funding competition and, hence, the RP/FCE dominates the CME in terms of social welfare.[13]

Proposition 7 *Social welfare is higher in the RP/FCE than in the CME.*

Proof: see appendix.

Propositions 6 and 7 together imply

Corollary 2 *Social welfare in higher in the RP/ICLE than in the CME.*

Table 1 summarizes the results of our social welfare comparison across the various funding structures. If access to higher education is not restricted, and if the initial funding structure in the higher education sector consists solely of a competitive credit market, then the creation of an ICL-program which competes against credit market funding may enhance economic welfare (if condition (15) is satisfied). Yet, if the initial funding structure consists solely of an ICL-program, then economic welfare declines if students are given access to a credit market which competes against the ICL-program. Such competition leads to an adversely selected ICL-program from which the welfare losses arise. A policy which restricts access to higher education to signal groups with positive net returns on educational investment eliminates overinvestment under ICL-funding and under funding competition. Yet, given such regulation, funding competition in the higher education sector continues to be of questionable value. Funding competition still leads to an adversely selected ICL-program which results in welfare losses, i.e., $W^{RP/FCE} < W^{RP/ICLE}$. Thus, whether or not the government restricts access to higher education, each

[13]The dominance of the RP/FCE relative to the CME is not limited to the welfare criterion in (3) but holds more generally. In fact, towards the end of subsection 4.2 we noticed that at the interim stage the RP/FCE dominates the CME in the Pareto sense. This implies in particular that ex ante expected utility of each agent is higher in the RP/FCE than in the CME.

equilibrium with funding competition is dominated in social welfare terms by some equilibrium without funding competition.

5 A Generalization

Our analysis so far has proceeded on the assumption that the social value of investment in human capital equals the private return on education; i.e., we have abstracted from possible higher education externalities on productivity growth. While these externalities are difficult to measure they are believed to be significant (Creedy, 1995; Hanushek and Kimko, 2000; Englebrecht, 2003). Our model can be generalized to include higher education externalities by assuming that the basic productivity level A depends on aggregate human capital in the economy, H. In this generalized setting, the human capital of agent i who has received signal y^i is given by (1), where A is replaced with $A(H)$.[14]

Assumption 3 *The basic human capital level of unskilled workers, $A(H)$, is an increasing function of the aggregate human capital, H, and satisfies $0 < A'(H) < 1$, $\forall H > 0$.*

As the externality in Assumption 3 makes investment in higher education socially more valuable, an obvious implication is that underinvestment in the CME becomes more severe while the extent of overinvestment in the ICLE and FCE declines. Apart from this, all results in sections 3 and 4 which compare the levels of social welfare across the various funding structures (see Table 1) remain valid. This claim is easily verified for propositions 4 and 6, because the equilibria compared in each of these propositions exhibit the same stocks of aggregate human capital, H, and, hence, the same individual basic human capital level, $A(H)$. The proofs therefore remain valid with minor notational modification.

As to propositions 5 and 7, observe that social welfare, W, is an increasing function of individual basic human capital, A, in the FCE and in the RP/FCE.

[14] This formulation implies that *all* individuals (skilled and unskilled) benefit from the externality. Some authors argue that the external effect should be confined to agents who invest in higher education: bright students generate positive externalities for other students and for teachers but not for unskilled workers (Gary-Bobo and Trannoy, 2008).

This is true because in both equilibria the set of individuals who invest in higher education is fixed, i.e., independent of A,[15] and therefore an increase in A raises average consumption in each signal group. Now, due to the higher education externality, individual basic human capital in the RP/FCE and (under condition (15)) in the FCE exceed the corresponding level in the CME. Therefore, the social welfare assessments in propositions 5 and 7 remain valid.

Proposition 8 *Modifying the human capital formation function (1) to include education externalities such that $A(H)$ satisfies Assumption 3 does not affect the results obtained in propositions 1-7.*

6 Policy Implications and Conclusion

Our analysis suggests that government intervention in the higher education sector can be helpful in two ways. First, such intervention may mitigate imperfections in the market for risk bearing which prevent risks on investment in higher education from being pooled in diversified portfolios. In particular, pure credit market funding does not allow individuals to pool their idiosyncratic ability risks which results in aggregate underinvestment in higher education. One important task of the government is therefore the organization of additional higher education finance by means of an income-contingent loans program and its implementation. Such program reduces the risks on investments in human capital through pooling, thereby improving the risk allocation in the economy and enhancing accumulation of human capital.

Second, a funding structure for investment in higher education under which an income-contingent loans program competes against credit markets has two considerable drawbacks which call for further government intervention. On the one hand, such funding structure leads to aggegate overinvestment in human capital; on the other hand, the competition between the ICL-program and credit market funding creates an externality which leaves the ICL-program adversely selected thereby worsening the terms of repayment for agents participating in the program. The first drawback can be eliminated, and the second drawback can be mitigated, by a policy

[15] In the FCE *all* individuals invest, and in the RP/FCE those individuals with signals larger than y_e invest. According to (6), y_e is independent of A.

which restricts access to higher education to individuals with sufficiently promising ability prospects. Under such regulation, the installation of an ICL-program which competes against the credit market for higher education loans raises social welfare in the economy. In order to be effective, government intervention must therefore combine the provision of income-contingent education loans with access restrictions to higher education.

The incentive mechanisms involved when funding systems compete in higher education are relevant in other areas of economic policy as well. In many countries, for instance, health insurance is provided by a public insurance agency as well as by private insurance companies. The public insurance agency pools health risks across the entire population of insurees while the private insurance companies pool health risks only across individuals in the same signal group, i.e., with similar health reports. The competition between these insurance schemes gives rise to similar mechanisms of risk pooling and adverse selction as those studied here for the higher education sector.

Appendix

In this Appendix we prove Lemma 1 and propositions 2,4,5,7 in the main text.

Proof of Lemma 1: By MLRP, the term in (14) is strictly increasing in y, if

$$\rho(a) := u(c_1(a)) - u(c_2(a, y^*))$$

is strictly increasing in a, where

$$c_1(a) := Aw + aw - R; \qquad c_2(a, y^*) := Aw + a\left[w - \frac{R}{\bar{a}(y^*)}\right].$$

Differentiating $\rho(\cdot)$ we get

$$\rho'(a) = wu'(c_1(a)) - \left[w - \frac{R}{\bar{a}(y^*)}\right] u'(c_2(a, y^*)).$$

The RHS of the above equality is trivially positive if $c_2(a, y^*) \geq c_1(a)$. Let us therefore consider the case $c_2(a, y^*) < c_1(a)$. The RHS of the last equality can be written as

$$\frac{1}{a}\left[c_1(a)u'(c_1(a)) - c_2(a, y^*)u'(c_2(a, y^*)) + Ru'(c_1(a)) + wA\big(u'(c_2(a, y^*)) - u'(c_1(a))\big)\right].$$

This expression is positive because $c_1(a) > c_2(a, y^*)$ and $cu'(c)$ is increasing in c by Assumption 2. □

Proof of Proposition 2: We need to show that $\partial W(y^*)/\partial y^* > 0$. Define

$$\begin{aligned} c(y, y^*) &:= Aw + \bar{a}_y \left[w - \frac{R}{\bar{a}(y^*)} \right] \\ c(y) &:= Aw + \bar{a}_y - R \end{aligned}$$

By MLRP, $c(y, y^*)$ and $c(y)$ are both strictly increasing in y. Note that

$$\begin{aligned} &\int_{\underline{y}}^{y^*} \left(wA + \bar{a}_y \left[w - \frac{R}{\bar{a}(y^*)} \right] \right) \nu(y)\,\mathrm{d}y + \int_{y^*}^{\bar{y}} [wA + \bar{a}_y w - R] \nu(y)\,\mathrm{d}y \\ &= \int_{\underline{y}}^{\bar{y}} [w(A + \bar{a}_y) - R] \nu(y)\,\mathrm{d}y + \underbrace{\int_{\underline{y}}^{y^*} \left[R - \bar{a}_y \frac{R}{\bar{a}(y^*)} \right] \nu(y)\,\mathrm{d}y}_{=0} \end{aligned}$$

Since the RHS of the above equality is independent of y^*, differentiation with respect to y^* yields

$$\frac{R\bar{a}'(y^*)}{(\bar{a}(y^*))^2} \int_{\underline{y}}^{y^*} \bar{a}_y \nu(y)\,\mathrm{d}y = \nu(y^*)[c(y^*) - c(y^*, y^*)] \tag{21}$$

Now, differentiating

$$W(y^*) = \int_{\underline{y}}^{y^*} v(c(y, y^*)) \nu(y)\,\mathrm{d}y + \int_{y^*}^{\bar{y}} v(c(y)) \nu(y)\,\mathrm{d}y$$

yields

$$\begin{aligned} \frac{\partial W(y^*)}{\partial y^*} &= \left[v\big(c(y^*, y^*) - v\big(c(y^*)\big)\right] \nu(y^*) + \frac{R\bar{a}'(y^*)}{(\bar{a}(y^*))^2} \int_{\underline{y}}^{y^*} v'\big(c(y, y^*)\big) \bar{a}_y \nu(y)\,\mathrm{d}y \\ &> \left[v\big(c(y^*, y^*) - v\big(c(y^*)\big)\right] \nu(y^*) + v'\big(c(y^*, y^*)\big) \frac{R\bar{a}'(y^*)}{(\bar{a}(y^*))^2} \int_{\underline{y}}^{y^*} \bar{a}_y \nu(y)\,\mathrm{d}y \\ &\overset{(21)}{=} \nu(y^*) \big\{ \left[v\big(c(y^*, y^*) - v\big(c(y^*)\big)\right] + v'\big(c(y^*, y^*)\big) \left[c(y^*) - c(y^*, y^*) \right] \big\} \\ &> 0 \end{aligned}$$

The last inequality follows from the concavity of $v(\cdot)$. □

Proof of Proposition 4: Recall that in both equilibria all individuals invest in higher education. Therefore, aggregate consumption is the same in both equilibria, i.e.,

$$E\big[\bar{c}_y^{ICLE}\big] = E\big[\bar{c}_y^{FCE}\big]. \tag{22}$$

Expected consumption of individuals in signal group y is

$$\bar{c}_y^{ICLE} = Aw + \bar{a}_y \left[w - \frac{R}{\bar{a}}\right]$$

in the ICLE, and

$$\bar{c}_y^{FCE} = \begin{cases} wA + \bar{a}_y \left(w - \frac{R}{\bar{a}(y^*)}\right) & ; \text{ if } \quad y < y^* \\ w(A + \bar{a}_y) - R & ; \text{ if } \quad y \geq y^* \end{cases} \tag{23}$$

in the FCE. It is easily verified that

$$\bar{c}_y^{ICLE} \overset{(\leq)}{>} \bar{c}_y^{FCE}, \quad \text{if } \bar{a}_y \overset{(\geq)}{<} \bar{a}. \tag{24}$$

(22) and (24) together imply that $\bar{c}_y^{FCE}$ is a mean-preserving spread of $\bar{c}_y^{ICLE}$ from which we conclude

$$W^{ICLE} = \int_{\underline{y}}^{\bar{y}} v\big(\bar{c}_y^{ICLE}\big)\nu(y)\,\mathrm{d}y > \int_{\underline{y}}^{\bar{y}} v\big(\bar{c}_y^{FCE}\big)\nu(y)\,\mathrm{d}y = W^{FCE}.$$

Thus, the ICLE dominates the FCE in welfare terms. □

Proof of Proposition 5: We prove the proposition by showing that $\bar{c}_{\tilde{y}}^{CME}$ is a mean decreasing spread of $\bar{c}_{\tilde{y}}^{FCE}$. Average consumption in signal group y is

$$\bar{c}_y^{CME} = \begin{cases} wA; & ; \text{ if } \quad y < \hat{y} \\ w(A + \bar{a}_y) - R & ; \text{ if } \quad y \geq \hat{y} \end{cases} \tag{25}$$

in the CME, and given by (23) in the FCE, where $y^* > \hat{y}$. From (23) and (25) it follows immediately that

$$\bar{c}_y^{FCE} \overset{(\leq)}{>} \bar{c}_y^{CME} \iff y \overset{(\geq)}{<} \hat{y}, \tag{26}$$

i.e., consumption is more dispersed across signal groups in the CME than in the FCE. In addition, from (15) we conclude

$$E\big[\bar{c}_{\tilde{y}}^{FCE}\big] - E\big[\bar{c}_{\tilde{y}}^{CME}\big] = (w\bar{a} - R) - \int_{\hat{y}}^{\bar{y}} (w\bar{a}_y - R)\nu(y)\,\mathrm{d}y \geq 0. \tag{27}$$

Thus, aggregate consumption is higher in the FCE than in the CME. (26) and (27) together imply that $\bar{c}_{\tilde{y}}^{CME}$ is a mean decreasing spread of $\bar{c}_{\tilde{y}}^{FCE}$. □

Proof of Proposition 7: We prove the proposition by showing that $\bar{c}_{\tilde{y}}^{CME}$ is a mean-decreasing spread of $\bar{c}_{\tilde{y}}^{RP/FCE}$.

Since in the RP/FCE aggregate consumption is maximized, we conclude

$$E\Big[\bar{c}_{\tilde{y}}^{RP/FCE}\Big] \geq E\Big[\bar{c}_{\tilde{y}}^{CME}\Big]. \tag{28}$$

Average consumption in signal group y is given by (25) in the CME and by (19) in the RP/FCE. Since $\bar{a}_{y^\dagger} > \bar{a}(y_e, y^\dagger)$ and $\bar{c}_y^{RP/FCE}$ is flatter than $\bar{c}_y^{CME}$ for $y \in (\hat{y}, y^\dagger)$, (19) and (25) imply the existence of $\breve{y} \in [\hat{y}, y^\dagger]$ such that

$$\bar{c}_{\tilde{y}}^{RP/FCE} \overset{(\leq)}{(\geq)} \bar{c}_{\tilde{y}}^{CME}, \quad \text{if } y \overset{(\geq)}{\leq} \breve{y}. \tag{29}$$

In view of (28) and (29), $\bar{c}_{\tilde{y}}^{CME}$ is a mean-decreasing spread of $\bar{c}_{\tilde{y}}^{RP/FCE}$. □

Funding strucure / Access policy	Income-contingent loans		Funding competition		Credit market
Unrestr. participation	W^{ICLE}	$>$	W^{FCE}	[under restriction (15)] $>$	W^{CME}
Restr. participation	$W^{RP/ICLE}$	$>$	$W^{RP/FCE}$	$>$	W^{CME}

Table 1

References

Barr, N., Crawford, I.: Funding Higher Education in an Age of Expansion. Education Economics **6(1)**, 45-70 (1998).

Chapman, B.: Income Contingent Loans for Higher Education: International Reforms, in: E. Hanushek and F. Welch (eds.), Handbook of the Economics of Education, Vol 2, North Holland, 1435-1500 (2006).

Creedy, J.: The Economics of Higher Education: An Analysis of Taxes Versus Fees. Hants: Edward Elgar Publishing Ltd. (1995).

Eckwert, B., Zilcha, I.: Improvement in Information and Private Investment in Education. Journal of Economic Dynamics and Control **34(4)**, 585-597 (2010).

Eckwert, B., Zilcha, I.: Private Investment in Higher Education: Comparing Alternative Funding Schemes. Economica (2011, forthcoming).

Englebrecht, H-J.: Human Capital and Economic Growth: Cross-Section Evidence for OECD Countries. The Economic Record **79**, 40-51 (2003).

Feldman, M., Gilles, C.: An Expository Note on Individual Risk without Aggregate Uncertainty. Journal of Economic Theory **35**, 26-32 (1985).

Friedman, M.: Capitalism and Freedom. Chicago: University of Chicago Press (1962).

Gary-Bobo, R.J., Trannoy, A.: Efficient Tuition Fees and Examinations. Journal of the European Economic Association **6**, 1211-1243 (2008).

Galor, O., Zeira, I.: Income Distribution and Macroeconomis. Review of Economic Studies **60**, 35-52 (1993).

Hanushek, E., Kimko, D.: Schooling Labor Force Quality and the Growth of Nations. American Economic Review **90**, 1181-1206 (2000).

Lleras, M.P.: Investing in Human Capital. Cambridge University Press: Cambridge, UK (2004).

Lucas, R., 1988, *On the Mechanics of Economic Development*, Journal of Monetary Economics **22**, 3-42.

Milgrom, P. R.: Good News and Bad News: Representation Theorems and Applications. Bell Journal of Economics **12**, 380-391 (1981).

Nerlove, M.: Some Problems in the Use of Income-contingent Loans for the Finance of Higher Education. The Journal of Political Economy **83(1)**, 157-184 (1975).