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Credit Markets with Differences in Abilities: Education, Distribution, and Growth

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Abstract

This paper addresses the growth, welfare, and distributional effects of credit markets. We construct a general equilibrium model where human capital is the engine of growth and individuals differ in their education abilities. We argue that the existence of credit markets encourages specialization, by which individuals choose during their youth to work or to receive formal education. This specialization unambiguously increases growth and welfare. The model also shows that in economies with high (low) average level of education abilities, the opening of credit markets induces a more disperse (equal) income distribution.

JEL Classification Numbers:

015, 016, 040

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Contents

Summary

This paper addresses the growth, welfare, and distributional effects of credit markets. For this purpose, a general equilibrium model with human capital as the engine of growth is developed. Human capital is accumulated through formal education and individuals differ in their educational abilities. Depending on their ability, individuals choose, in early life, the optimal time allocation between work and education.

The model shows that the optimal decision on the amount of education to acquire depends critically on the existence of credit markets. In particular, it shows that the existence of credit markets induces specialization. Credit markets, by allowing individuals to smooth consumption through borrowing and lending, permit them also to specialize according to their comparative advantage (either education or work) to maximize human wealth. In contrast, in the absence of credit markets, individuals' decisions on specialization would be limited, since they would have to spend their youth both working and acquiring human capital.

We show that specialization, allowed by the existence of credit markets, unambiguously increases the rate of growth of the economy. The introduction of credit markets allows the more-able to specialize in education and the less-able in working, which enhances the economy's average efficiency of education. In response to this increase in efficiency, the total amount of time devoted to education in the economy may also increase. It may also be possible that the total time devoted to education declines, but this decline would not offset the increase in the average efficiency of education. Hence, in both cases, human capital accumulation and, consequently, growth increase. In addition, credit markets allow a more beneficial intertemporal allocation of consumption. The positive effects of credit markets on growth and on the intertemporal allocation of consumption lead to an increase in welfare for all current and future generations.

The paper also shows that in economies with a high (low) average level of educational abilities, the opening of credit markets will induce a more disparate (equal) income distribution. In economies with a high level of educational ability, most of the population will spend a large amount of time in education, which will enlarge earning differentials. In contrast, economies with a low level of educational ability, where few people acquire education, the majority will have the same level of earnings since they do not receive education and hence ability, which is the only source of differentiation, will not result in increased income differentials.

I. Introduction

This paper addresses the growth, welfare, and distributional effects of credit markets. In particular, we examine the effects that the existence of credit markets have on specialization. Credit markets, by allowing individuals to smooth consumption through borrowing and lending, permits them also to specialize in either education or work to maximize human wealth. In contrast, when credit markets are not open, individuals decisions on specialization will be limited, since they will need to spend their youth on both working and acquiring human capital to smooth consumption.

The role of credit markets on economic growth has long been investigated by economists. Most prominently, Goldsmith (1969), McKinnon (1973) and Shaw (1973) argue that financial markets can have important effects on economic development. On the one hand, credit markets allow a larger proportion of savings to be channeled to productive investment; thus, they increase capital accumulation. On the other hand, they allow investment opportunities to be exploited more efficiently, and hence, they increase the returns to capital accumulation.

More recently, several authors have provided formal underpinnings to the interactions between financial markets and economic growth. 1/ Bencivenga and Smith (1991) have examined the effects of financial markets in fostering savings in illiquid, but productive, assets. Greenwood and Jovanovic (1990) show how financial markets foster growth through better use of information, which in turn reinforces the creation of financial intermediaries. Along similar lines, Saint-Paul (1992) presents a model where financial markets allow individuals to diversify risk, while allowing firms to use more productive, but less flexible and hence more risky, technologies. The role of financial markets in allowing innovation and entrepreneurship is discussed in King and Levine (1993). Finally, De Gregorio (1993) discusses the role of financial markets in the accumulation of human capital vis-a-vis the accumulation of physical capital.

As explained above, in this paper we focus on a different channel: specialization. We present a general equilibrium model with two-period overlapping generations and heterogenous agents. The engine of growth in our model, as in Lucas (1988), is human capital, which is accumulated through formal education. 2/ The technology for human capital accumulation is linear, which allows endogenous growth.

1/ For overviews of the empirical and theoretical literature see Fry (1993), Greenwood and Smith (1993), Pagano (1993), De Gregorio and Guidotti (1993), and King and Levine (1993). The last two papers also present empirical evidence.

2/ The empirical relevance of human capital as an engine of growth has been most recently documented by Barro and Lee (1993) and Benhabib and Spiegel (1993).

A distinguishing feature of our model is that we introduce differences in education abilities. More concretely, for a given amount of time spent in education, individuals differ in the amount of skills they have in adulthood. Depending on their abilities, individuals choose, in their early stage of life, the optimal time allocation between work and education. The amount of education also depends critically on the existence of credit markets. The key role of credit markets is to allow individuals to borrow and lend to choose their optimal consumption plan. This possibility of financing through credit markets allows individuals to specialize in what they have comparative advantage. Individuals spend all of their non-leisure time of youth in either education or work to maximize their human wealth because of the linearity of returns to education (as in De Gregorio (1993)). In contrast, in the absence of credit markets, individuals cannot trade financial claims to smooth consumption, and therefore, they cannot specialize to maximize human wealth. In particular, individuals that in the presence of credit markets would spend all of their youth in education, will have to work a fraction of their time in order to have positive consumption. Individuals that would specialize in working, would also have to acquire some education because the only way they can save for the future is through increasing skills. 1/

We show that specialization, allowed by the existence of credit markets, unambiguously increases the rate of growth of the economy. The introduction of credit markets allows the more able to specialize in education and the less able in work, which enhances the economy's average efficiency of education. In response to the increase in the efficiency, total amount of time devoted to education in the economy may also increase. It may also be possible that total time devoted to education declines, but this decline will not offset the increase in the average efficiency of education. Hence, in both cases, human capital accumulation and, consequently, growth increases. In addition, for a given set of initial conditions, the feasible set of individuals increases in the presence of credit markets, and hence, together with a positive growth effect, we conclude that credit markets increase welfare for all current and future generations.

The heterogeneity of agents introduced in our model also allows us to address the issue of income (wealth, and utility) distribution. 2/ We show that in economies with high (low) average level of abilities to accumulate human capital, the opening of credit markets will induce a more disperse (equal) income distribution. The result for the case of high

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1/ The model assumes that in the absence of credit markets individuals cannot save and cannot borrow. The existence of a storage technology, through which individuals could save, could be easily introduced in the model, but would unnecessarily complicate it.

2/ For the issue of growth and income distribution in models with imperfect credit markets see Banerjee and Newman (1991), Galor and Zeira (1993), and Perotti (1993).

ability economies is in conformity with Becker (1964), who argues that although skill may not be so disperse in the economy, earnings dispersion may be enhanced by education. In our model, in high-ability economies most of the population will spend a large amount of time in education, which will enlarge earning differentials. In contrast, in low-ability economies, where few people acquire education, the majority will have the same level of earnings since they do not receive education and hence the only source of differences, abilities, will not be used to increase income differentials.

The paper is organized as follows. Section II describes the equilibrium growth in the economy without credit markets. Section III does the same when a perfect credit market is open. The main results are presented in sections IV and V. In Section IV we show that credit markets increase growth and analyze the impact of changes in the average and the dispersion of abilities. Section V contains the discussion of welfare and distributional effects of the opening of credit markets. Finally, the conclusions are presented in Section VI.

II. The Economy without Credit Market

This section presents an endogenous growth model with heterogeneous agents in the absence of credit market. The model economy consists of a large number of heterogeneous agents, who live two periods. It is assumed that each agent maximizes the following two period utility function:

$$U(c_{t,t},c_{t,t+1}) = u(c_{t,t}) + \beta u(c_{t,t+1}), \tag{1}$$

where $c_{t,\tau}$ is consumption during period τ of an individual born at period t and β is the subjective discount factor. Further, it is assumed that the momentary utility function takes the logarithmic form:

$$u(c_{t,\tau}) = \log c_{t,\tau}. \tag{2}$$

All agents born at time t are assumed to have the same level of human capital, equal to h_t. They are endowed with one unit of non-leisure time in each period of their life. When they are young, they can invest in human capital, by devoting υ unit of time to education, which is provided free of charge. Because of the absence of capital markets, however, they cannot invest in financial assets. Agents' income is derived from labor income proportional to his time spent on labor, $(1-\upsilon)$. When young, the j-th individual faces a budget constraint of the form:

$$c_{t,t} = \omega_t(1-\upsilon^j)h_t, \tag{3}$$

where ω_t is the real wage rate at time t.

When old, the agent derives his income from effective labor and spends all of it on consumption.

$$c_{t,t+1} = \omega_{t+1} h^j_{t+1}. \tag{4}$$

Although individuals cannot hold financial assets, they will engage in intertemporal smoothing by adjusting time devoted to human capital accumulation. It is assumed that human capital accumulation for individual j is a linear function of time spent on formal education, υ^j, as follows:

$$h^j_{t+1} - h_t = \delta^j \upsilon^j h_t, \tag{5}$$

where δ^j represents how efficiently agent j produces human capital. Note that all individuals are born with the average level of skills of their parents' generation, h_t. Therefore, there is an *intergenerational externality*, by which the aggregate level of skills of parents' generation is transferred to their children. At the individual level, however, parents cannot increase by themselves their offsprings' level of skills. 1/ The level of human capital in period $t+1$ is defined by:

$$h_{t+1} = \int_0^1 h^j_{t+1}\, dj.$$

A distinguishing feature of this model is that each agent has different education ability. For simplicity, it is assumed that human capital efficiency parameter δ^j is non-negative and uniformly distributed among continuum of individuals indexed by $j \in (0,1)$ in each cohort as follows:

$$\delta^j = bj + (m - \frac{b}{2}). \tag{6}$$

Here b reflects the degree of the difference in education abilities across agents and m is the average level of education efficiency of the economy. Indeed, given the distributional assumption on j, the random variable δ^j is uniformly distributed in the interval $[m-b/2,\ m+b/2]$, with an average of m and variance of $b^2/12$.

1/ Galor and Tsiddon (1994) call this type of externality *global technological externality*, and distinguish it from *home environment externality*, by which parents affect directly the ability of their children to increase skills. They show that the two types of externalities have opposite implications for the evolution of income distribution.

As argued before, intertemporal smoothing will be achieved through education. To see this we can combine (3) and (4) and use the equation for human capital accumulation, (5), to obtain the following intertemporal budget constraint:

$$\omega_t(1 - v^j)c_{t,t+1} = \omega_{t+1}(1 + \delta^j v^j)c_{t,t}. \tag{7}$$

The agent chooses consumption and educational investment to maximize utility, taking prices as given. Equation (7) reveals that in the absence of capital market, the only intertemporal linkage stems from human capital accumulation. Under the assumption of interior solutions, the first-order condition of agent j takes the following form:

$$u'(c_{t,t}) = u'(c_{t,t+1})\beta\delta^j \omega_{t+1}/\omega_t, \tag{8}$$

which under the assumption of logarithmic utility function, implies

$$\frac{c_{t,t+1}}{c_{t,t}} = \beta\delta^j\omega_{t+1}/\omega_t. \tag{9}$$

On the side of firms, a constant returns to scale production function of effective labor is assumed as follows:

$$Y_t = AH_t, \tag{10}$$

where H represents effective unit of labor employed, and A is the marginal product of effective labor. Along the balanced growth path, the marginal product of effective labor remains constant, which generates endogenous growth.

Firms choose optimal effective labor to maximize the firm value, taking prices as given. The firm's first-order condition for optimal employment is:

$$A = \omega_t, \tag{11}$$

which implies wage rates are constant over time.

The economy without capital market behaves like an economy consisting of a large number of Robinson Crusoes. The optimal choice of time allocation on education for each agent can be calculated using (5)-(11) as follows: 1/

$$v^j = \frac{\beta\delta^j - 1}{(1+\beta)\delta^j}. \tag{12}$$

The corresponding consumption in each period of life is given by:

$$c_{t,t} = Ah_t \left[\frac{1 + \delta^j}{(1 + \beta)\delta^j}\right], \tag{13}$$

$$c_{t,t+1} = Ah_t \left[\frac{\beta(1 + \delta^j)}{1 + \beta}\right]. \tag{14}$$

Then the steady-state growth rate of this economy in the absence of capital market (g^A) can be calculated as the average of the growth rates of all agents as follows:

$$\begin{aligned} g^A &= h_{t+1}/h_t - 1 \\ &= \int_0^1 \delta^j v^j dj \\ &= (\beta/(1+\beta))\int_0^1 \delta^j dj - (1/(1 + \beta)) \int_0^1 dj \\ &= (\beta/(1+\beta))m - (1/(1 + \beta)). \end{aligned}$$

Notice that in the absence of capital market the growth rate of the economy depends on the average level of talent m, not the variation of talents, b. The lower the average talent level in the economy is, the lower is the growth rate.

1/ In order for all individuals to have positive v^j we assume that $\beta(m-b/2)>1$. Relaxing this assumption does not change the main results of the model. If we suppose there are some individuals with $\delta^j<1/\beta$, they will decide not to accumulate human capital in both cases, with and without credit markets. In this case, however, the positive growth and welfare effects discussed in sections IV and V still hold.

III. The Economy with a Perfect Credit Market

The model economy in this section is identical to the heterogeneous agent model in the previous section except the presence of a perfect credit market.

The introduction of credit market allows agents to invest in financial assets as well as human capital. When young, the individual j faces a budget constraint of the form:

$$c_{t,t} + b_{t+1} = \omega_t(1 - \upsilon^j)h_t, \tag{15}$$

where b_{t+1} is the demand for bonds.

When old, the agent derives his income from bonds and effective labor, and spends the net income for consumption.

$$c_{t,t+1} = (1 + r_{t+1})b_{t+1} + \omega_{t+1}h^j_{t+1}, \tag{16}$$

where r_{t+1} is the real interest rate on bonds.

Contrary to the case of absence of credit markets, individuals can now use financial assets to do intertemporal smoothing, and they use education to maximize human wealth. This is a consequence of the fact that education has no direct effect on utility, and therefore the educational choice is made to maximize wealth as implied by the Fischer separation theorem. To see this, we can combine equation (15) and (16) into the following intertemporal budget constraint:

$$c_{t,t} + \frac{c_{t,t+1}}{1 + r_{t+1}} = \omega_t(1 - \upsilon^j)h_t + \frac{\omega_{t+1}h^j_{t+1}}{1 + r_{t+1}}. \tag{17}$$

The agent chooses consumption, educational investment and debt holdings to maximize utility, taking prices as given. The first-order conditions take different forms depending on the education ability of agents. Writing the lagrangian of individuals' optimization problem we have that:

$$£ = u(c_{t,t}) + \beta u(c_{t,t+1}) - \lambda\left(c_{t,t} + \frac{c_{t,t+1}}{1 + r_{t+1}} - \omega_t(1 - \upsilon^j)h^t - \frac{\omega_{t+1}h^j_{t+1}}{1 + r_{t+1}}\right). \tag{18}$$

Regardless of their education abilities, all agents choose the slope of the consumption path according to the following Euler equation:

$$u'(c_{t,t}) = u'(c_{t,t+1})\beta[1 + r_{t+1}]. \tag{19}$$

Nevertheless, the optimal choice of υ^j will depend on abilities of each individual. Since the Lagrangian is linear in υ^j, individuals will choose (except for one at the margin) either $\upsilon^j=1$ or $\upsilon^j=0$. Substituting (5) into (18), and then differentiating with respect to υ^j we have that:

$$\frac{\partial \pounds}{\partial \upsilon^j} = \omega_t + \frac{\delta^j}{1 + r_{t+1}} \omega_{t+1}. \tag{20}$$

Using the fact that wages are constant over time, the optimal choice of υ^j is:

$$\upsilon^j = \begin{cases} 1 & \text{if } \delta^j > 1 + r_{t+1} \\ 0 & \text{if } \delta^j \le 1 + r_{t+1} \ . \end{cases} \tag{21}$$

With the existence of capital markets individuals will choose to do intertemporal smoothing by borrowing or lending in the credit market, while they will use education to maximize human wealth.

There will be an individual in the margin, j^*, such that,

$$\delta^{j*} = 1 + r_{t+1}. \tag{22}$$

Thus, all individuals with abilities above j^* will specialize in education. In order to consume while they are young, they will borrow in the capital market and repay when they are old. On the other hand, individuals with abilities below j^* will not acquire any education, since for them it is optimal to work when they are young, and to save for the second period, what represents a better alternative to "savings through education." Agent j^* is indifferent between investment in human capital and financial assets, since the rates of return from these two investments are the same. This j^*-th agent is important since this agent's human capital efficiency (δ^{j*}) is directly related to the interest rate of the economy, as shown below.

Finally, to complete the description of the consumer problem, it can be shown that the consumption path for individuals with $j \ge j^*$ will be given by:

$$c_{t,t} = Ah_t \left[\frac{1 + \delta^j}{(1+\beta)(1+r_{t+1})}\right], \tag{23}$$

$$c_{t,t+1} = Ah_t \left[\frac{\beta(1 + \delta^j)}{1 + \beta}\right]. \tag{24}$$

while the consumption path of individuals with $j<j^*$ is:

$$c_{t,t} = Ah_t \left[\frac{2 + r_{t+1}}{(1 + \beta)(1 + r_{t+1})}\right], \tag{25}$$

$$c_{t,t+1} = Ah_t \left[\frac{\beta(2 + r_{t+1})}{1 + \beta}\right]. \tag{26}$$

Note that consumption of individuals with $j<j^*$ does not depend on δ^j, since they do not accumulate human capital. In contrast, in the economy without credit markets, all individuals accumulate human capital since it is the only intertemporal link available to individuals.

In this economy, a competitive equilibrium is determined as follows: The consumer's maximization problem yields a set of demand functions for consumption and bonds, and a supply function of human capital. Likewise, the firm's optimization behavior yields a demand function for human capital and a supply function for output in terms of price parameters. The equilibrium growth rate and rate of return are then obtained from the market clearing conditions. The goods market clearing condition or resource constraint of the economy is as follows:

$$C_t = Y_t \tag{27}$$

where C_t is aggregate consumption of the economy and Y_t is aggregate output. Note that this condition is equivalent to the financial market equilibrium condition by which there must be zero net supply of financial assets including interest payments (i.e., $\int_0^1 b_{t+1}^j dj + \int_0^1 (1+r_t) b_t^j dj = 0$).

Implementing the market clearing condition, we focus on the case where output, consumption, and human capital grow at the same rate g^C. 1/ Then we can establish the following result on the relation between the steady-state growth and interest rates:

Proposition 1:

$$g^C = r$$

Proof: See appendix A ‖

The proposition tells us that along the balanced growth path the equilibrium interest rate is equal to the growth rate.

Under the assumption of uniform distribution of ability given by (6), equation (22), together with the fact that $g^C = r$, yields a relation between the growth rate and the equilibrium j^* as follows:

$$1 + g^C = bj^* + \left(m - \frac{b}{2}\right). \tag{28}$$

Another relation between the steady-state growth rate and j^* can be obtained from the expression on human capital growth. The aggregate human capital of this economy at period $t+1$ (h_{t+1}) is determined by the sum of individual human capital accumulation at period t as follows:

$$h_{t+1} = \int_0^1 (1 + \delta^j v^j) h_t dj. \tag{29}$$

Then, the balanced-path growth rate of aggregate output and human capital is (analogously to the case of no credit market):

1/ The transitional dynamics off the balanced growth path are complicated. However, we can show that under some mild assumptions the steady state is stable.

$$
\begin{aligned}
g^C &= h_{t+1}/h_t - 1 \\
&= \int_0^1 \delta^j v^j dj \\
&= \int_0^{j^*} (bj + m - b/2) \times 0 dj + \int_{j^*}^1 (bj + m - b/2) \times 1 dj \\
&= b(1 - j^{*2})/2 + (m - b/2)(1 - j^*).
\end{aligned}
\tag{30}
$$

The steady state equation system is summarized by equations (28) and (30), which can be solved for the two unknowns g^C and j^*. The equation system has a unique solution that yields a non-negative j^*. The solution for j^* and g^C are as follows:

$$
j^* = -\left(\frac{m}{b} + \frac{1}{2}\right) + \left[\left(\frac{m}{b} + \frac{1}{2}\right)^2 + \frac{2}{b} + 1\right]^{1/2}, \tag{31}
$$

and

$$
g^C = -(1 + b) + \left[(1 + b)^2 + \left(m + \frac{b}{2}\right)^2 - 1\right]^{1/2}. \tag{32}
$$

Accordingly, in this model, a sustained growth can be achieved. And the resulting endogenous growth rate is a function of the first and second moment of the distribution of abilities, contrary to the absence of credit markets case where growth depends only on the first moment.

IV. Growth Effect of Credit Markets

The magnitude of the growth effect of credit markets can be calculated by the difference between the growth rates in the presence of credit markets and in the absence of them:

$$
\Delta g = g^C - g^A = -(1+b) + \left[(1+b)^2 + \left(m + \frac{b}{2}\right)^2 - 1\right]^{1/2} - \frac{\beta m - 1}{1 + \beta}. \tag{33}
$$

The magnitude depends on three parameters: average and variance of education abilities, and subjective discount rate. Within the appropriate range for these parameters, it can be shown that more efficient allocation made possible by the existence of capital markets brings a positive growth effect. The main result can be summarized as follows:

Proposition 2:

$$\Delta g > 0 \quad \text{and} \quad \frac{\partial(\Delta g)}{\partial m} > 0$$

Proof: See appendix A ‖

The main result of this proposition ($\Delta g > 0$) is strong since it shows that credit markets unambiguously increase the rate of growth of the economy. The intuition behind this result is as follows. The introduction of credit markets allows the more able to specialize in education and the less able in work, which enhances the average efficiency of education per unit time of the economy as a whole (from $\int_0^1 \delta^j dj$ to $\int_{j^*}^1 \delta^j dj/(1-j^*)$). In response to the increase in the efficiency, total amount of time devoted to education in the economy may also increase, in which case human capital accumulation and, consequently, growth increases. It may be possible, however, that total time devoted to education declines, but this decline will not be large enough to offset the increase in average efficiency of education, and hence, the rate of growth will still increase.

Another important implication is that in economies with high average level of abilities, the growth enhancing effect of credit markets is greater. The reason is as follows. In both cases (with and without credit markets), economies with higher m have a higher rate of growth. However, in the presence of credit market the increase in m has a bigger effect on human capital accumulation since the time devoted to education is at its maximum ($v=1$) while it is less than one in the absence of credit market.

The effects on aggregate level of education of m can be also examined. It is straightforward to show that:

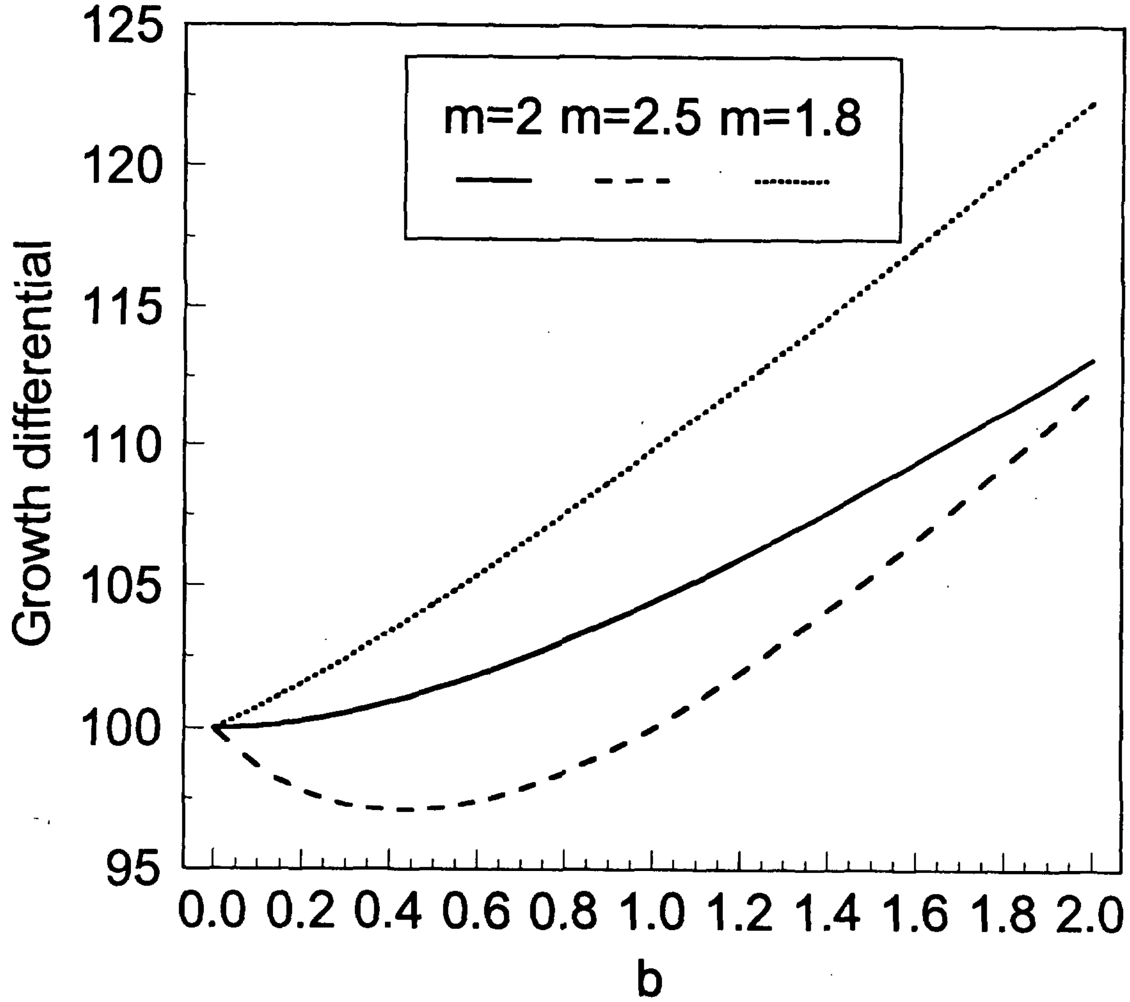
$$\frac{\partial j^*}{\partial m} < 0, \tag{34}$$

which implies, quite naturally, that increases in the average level of abilities reduces j^*, so more individuals will engage in education when young. 1/

Unlike m, the effect of b on growth is ambiguous. The sign of the effect depends on the values of b and m. Figure 1 depicts the relationship

1/ Since $v^j=1$ for $j>j^*$ and zero otherwise, total time spent in education is equal to $1-j^*$.

Figure 1
Effect of b on growth differentials



between Δg and b for three sets of parameters. 1/ It can be established that for values of b large enough there is a positive relationship between Δg and b, but for smaller values of b, that is small dispersion of skills, changes in b can either increase or decrease the growth rate in the economy with credit markets. To understand this result we first examine equation (30) (recall that b does not affect the rate of growth in the economy without credit markets). For a given value of j^*, an increase in b will increase the growth effect of credit markets since average skills of individuals that choose $v=1$ increases with b (only increases the upper portion of the distribution of individuals with $v=1$). However, differentiating equation (31) it can be seen that the effect of b on j^* is ambiguous. Therefore, the positive effect of higher average skills for a given j^* may be outweighed by a decline in total time devoted to education.

V. Welfare and Distributional Effects of Credit Markets

In addition to growth effects, the model can be used to examine the effects that credit markets have on welfare and income (or utility) distribution. Consider first the welfare effect. Using the expressions for consumption derived above it is possible to compare utility for all agents in the presence and in the absence of credit markets. The comparison is presented in Figure 2, for all individuals of the young generation born with the same h_t in both cases (with and without credit markets). The schedule C1C1 represents utility under credit markets, and N1N1 utility when no credit markets are open.

It is obvious that utility in the presence of credit markets will be at least the same as that in the absence of credit markets since the maximization problem of individuals in the presence of credit markets have a larger feasibility set (by allowing them to choose b_{t+1}). However, the expansion in the feasibility set does not necessarily imply an increase in welfare for all individuals. Indeed, the marginal individual j^* does not benefit with credit markets. Since intertemporal rate of substitution in the case of credit markets $(1+r)$ is the same as that of no credit markets (δj^*), his resource allocation is identical in both case. Hence, he attains the same level of utility with or without credit markets.

However, it is easy to see that for all $j \neq j^*$ utility increases. First, all agents below j^* have higher utility than what they could get in the absence of credit markets, since they do not use their inefficient technology for accumulation of human capital anymore. Regardless of their abilities, the individuals in this group have the same level of utility since they do not accumulate human capital. Of course the most benefitted

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1/ For presentation purposes we have rescaled all simulations to start at 100 when b equals 0. Nevertheless, as we formally show in proposition 1 growth differentials are increasing in m for all values of b, and hence, the figure only reveals the shapes of the relationship between b and Δg, and not the levels.

are those individuals with the lowest skills to accumulate human capital. Second, all individuals with j above j^* also benefit from spending all their youth in education. Within this group, those with higher j enjoy smaller increase in v ($v^{jC}-v^{jA}$ is decreasing in j), but larger increase in utility due to the increase in human capital accumulation since their δ is also larger. Since the latter effect dominates the former, the benefit from the existence of credit markets also increases with j.

Furthermore, the fact that utility of individuals in the current generation increases or at least remains constant when credit markets are introduced does not necessarily imply that welfare must increase. We need to examine in addition if the utility of future generations also increases. In our framework, however, the increase in utility of future generations is guaranteed by the fact that the rate of income growth increases, as we have already shown. Hence, it is immediate to show that:

Proposition 3: Starting with the same initial conditions all individuals have higher or equal utility in the economy with credit markets.

Proof: See appendix A ‖

Another important issue is the effect of credit markets on income and utility distribution. The effect depends critically on the level of education technology. First, consider an economy where most people spend their youth in education (i.e., j^* is close to zero). This can be considered a case of a high value of m (a very skillful economy), and therefore, as proposition 1 shows, an economy in which the growth effect of credit market is very large. In this case, as can be seen from the top panel of Figure 3, utility, and also income, distribution tends to be more unequal in the presence of capital markets. Alternatively, consider the opposite case, where few people accumulate human capital (i.e., j^* is close to one). As the bottom panel shows, utility distribution in this case is more equalized, since the factor that causes differentials (abilities enhanced by education) is not fully utilized.

To discuss more formally the effects of credit markets on the distribution of utility for the case where j is close to zero we can compare the Lorenz curves in the presence and in the absence of credit markets. 1/ The slope of Lorenz curve for the j-th agent is:

$$\frac{U^x(j)}{\int_0^1 U^x(i)di}, \tag{35}$$

1/ The analysis for j^* close to 1 is analogous, and it will not be discussed further.

Figure 2
Utility Distribution and Changes in m
$(m_2 > m_1)$

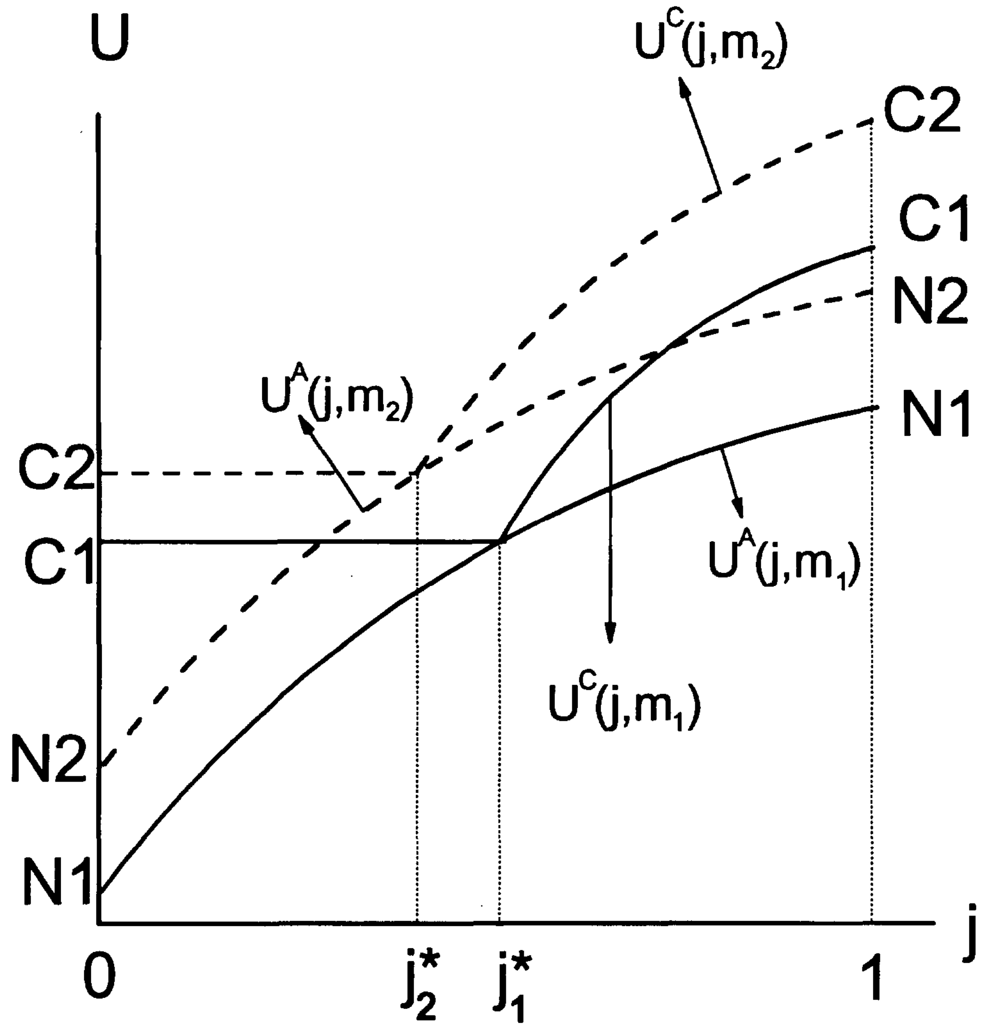
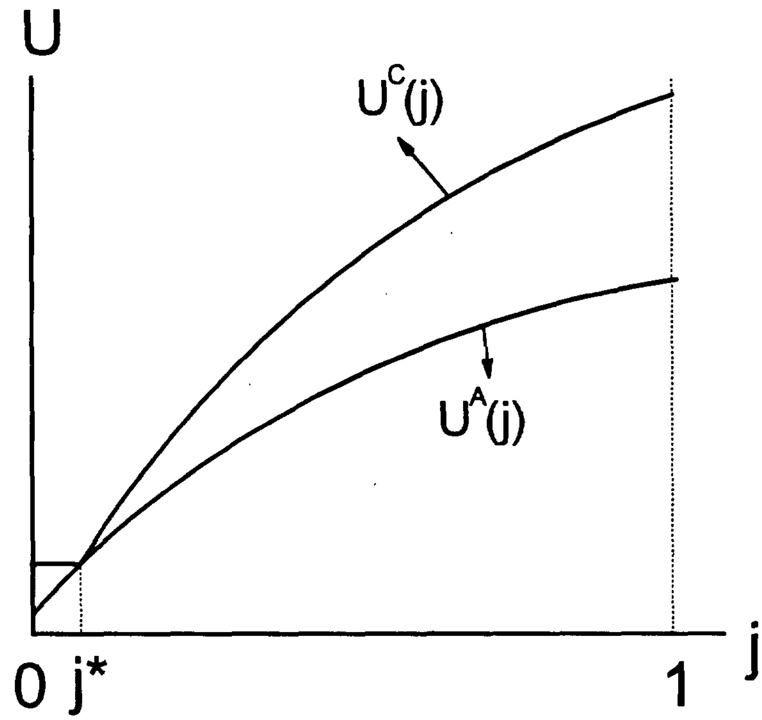
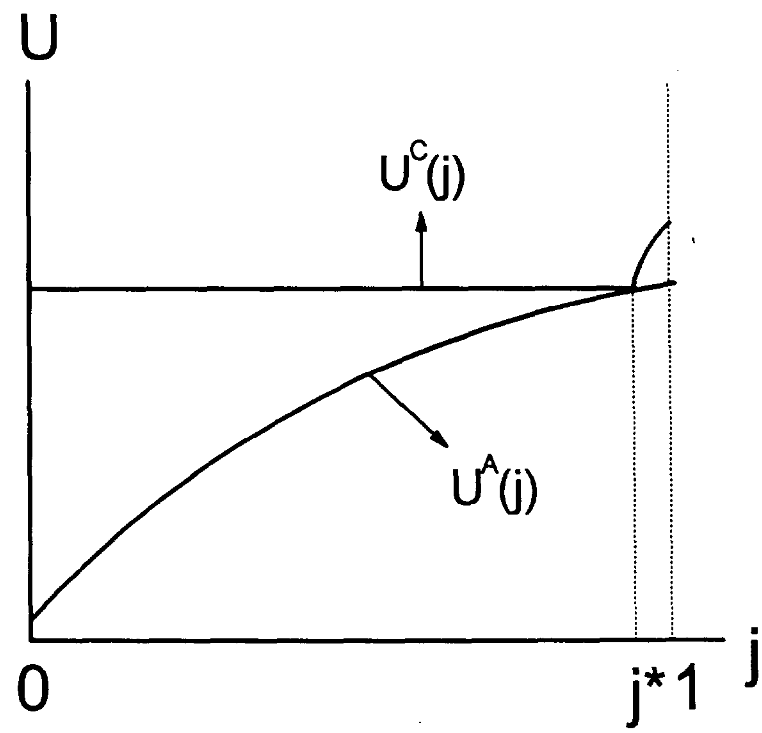


Figure 3
Distributional Effects: Extreme Cases





where $U^X(j)$ is indirect utility for individual j in the credit markets (X=C) and the no-credit markets (X=A) cases.

The following result can be established:

Proposition 4: For any $j^* \leq j_u^*$, where j^*_u is defined by:

$$U^C(j_u^*) \int_0^1 U^A(i)di = U^A(0) \int_0^1 U^C(i)di, \tag{36}$$

the utility distribution is more unequal in the presence of credit markets than without them.

Proof: See appendix A ‖

The proposition tells us that in economies with high average level of abilities (those where equilibrium j^* is at most j^*_u, and hence total time devoted to education is at least $1-j^*_u$) the opening of credit markets will induce a more unequal utility distribution. This proposition is illustrated in Figure 4, where the dashed (solid) Lorenz curve, L^A (L^C), represents the case of absence (presence) of credit markets. The figure shows that condition (36) insures that the "normalized" indirect utility $U^A(j)\int_0^1 U^C(i)di/\int_0^1 U^A(i)di$ cuts the j=0 axis above $U^C(j)$ (for all $j^*<j^*_u$). The figure also shows that below (above) j' the slope of L^A is greater (less) than that of L^C. This implies that $L^A < L^C$, and hence utility distribution deteriorates.

To sharpen intuition for the previous results and see how the utility distribution results extend to income distribution, let us consider income distribution for the old generation in an high ability economy. For the simplicity of exposition, consider a case where almost everybody accumulates human capital when they are young.

In general, the sources of income dispersion are differences in υ^j and δ^j across individuals, since effective labor of agent j grows at a rate $\delta^j\upsilon^j$. In the case of no credit market both δ^j and υ^j are increasing in j. Using equation (12), the variance of $\upsilon^j\delta^j$ is equal to $V(\delta^j)\beta^2/(1+\beta)^2$, where V is the variance operator. In the case of credit markets, however, almost everybody accumulates human capital with υ^j=1. Hence, the only source of variability is the dispersion of δ^j. The corresponding variance of income will be $V(\delta^j)$, which is greater than in the case of no credit markets. Despite the fact that the only source of variability is δ^j, income distribution is more unequal in the presence of credit markets because by spending the maximum time available in education, the dispersion of skills is maximized. In contrast, in the absence of credit markets, the difference of abilities does not translate in large differentials of skills since the amount of education is reduced. This effect resembles Becker's (1964) argument that although difference of abilities may not be large enough, education tends to increase income differentials. We can add that this is reinforced by the existence of credit markets.

Therefore, we can conclude that when the growth effects of credit markets are very large (i.e., j^* is close to zero), the income differentials are also large. The opposite happens when growth effects are very low (i.e., j^* is close to 1). In intermediate situations, there is no monotone relationship for the distributional effects of credit markets. However, as shown above, the existence of credit markets represents in all cases a Pareto improvement.

The effects of average education ability *m* on utility and distribution are also interesting. In figure 2, the schedules C2C2 and N2N2 represents a situation where *m* is higher than in the situation depicted by C1C1 and N1N1. An increase in *m* has a positive impact on utility of agents regardless of the existence of credit markets. However, as (32) shows, j^* declines with an increase in *m*, and hence, individuals in the interval (j_1^*, j_2^*), will engage in education with a higher level of average skills, which tends to enlarge the income differentials.

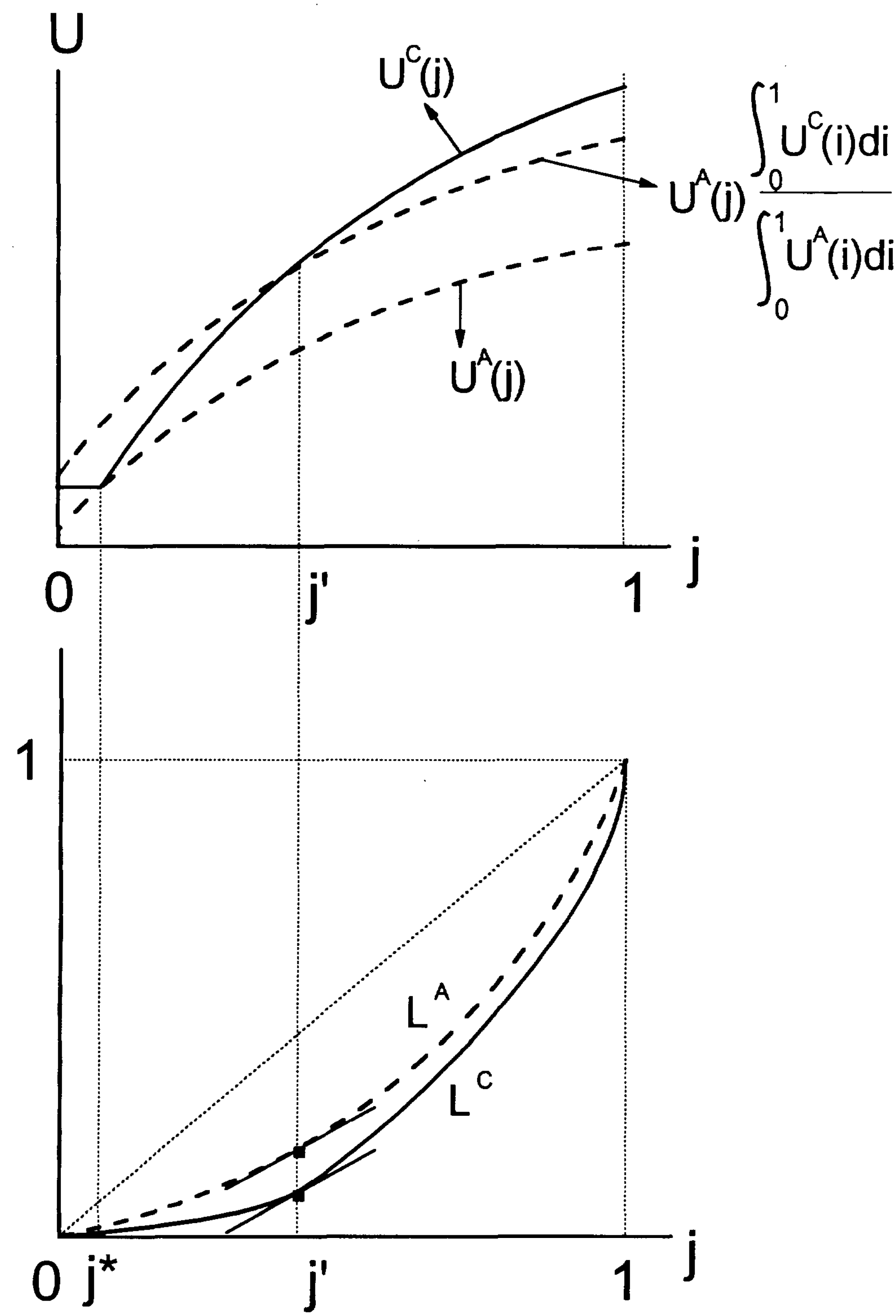
VI. Concluding Remarks

This paper shows that credit markets unambiguously increase growth and welfare by allowing individuals to specialize. In the presence of credit markets, individuals with high level of abilities can devote all of their youth to education, while the less able can decide to become full-time workers. In contrast, in the absence of credit markets, individuals have to perform both activities during their youth. The more able individuals are part-time workers since they cannot borrow, and the less able are part-time students, since they can save only by transferring labor (through increasing skills) to the future.

The current model allows for some natural extensions. Although not conclusive, the evidence suggests that there is a U-shaped relationship between income distribution and the degree of development as suggested by Kuznets (1955). A closer examination of the dynamics of the model might provide some conclusions about the conformity of our model with this stylized fact. In addition, we can think that due to setup costs, credit markets start to develop after certain threshold level of income is achieved. In this case our model would predict that when capital markets are created there is a discrete increase in output, and income distribution becomes more unequal (equal) if the average level of abilities in the economy is high (low). To extend the model in this direction, one could explore the effects of changes in average abilities (*m*) and the dispersion of abilities (*b*) in the process of development. 1/

1/ One alternative, for example, is that as countries develop and integrate to the world economy *m* and *b* may catch-up the world levels.

Figure 4
Lorenz Curve and Distribution



In the current framework, specialization refers to whether individuals decide to be students or workers since the activities that individuals perform in their youth are to accumulate human capital or to work. However, the idea of a positive growth effect of specialization could be also applied to other types of specialization. For example, we can consider the alternative activities as being to become an entrepreneur or a worker. If the only way to transfer income to the future is by being an entrepreneur and credit markets are not available, all individuals would have the incentive to become, at least for some part of their time, entrepreneurs. With the opening of credit markets, however, an optimal degree of specialization could be attained. This specialization would increase economic growth and welfare.

APPENDIX : Proof of Propositions

Proof of Proposition 1:

To write down the market clearing condition by aggregating all consumers' consumptions and incomes, we have that aggregate consumption is:

$$C_t = \int_0^1 c^j_{t,t}dj + \int_0^1 c^j_{t-1,t}dj, \tag{A.1}$$

and aggregate income (production):

$$Y_t = \int_0^1 (1 - \nu^j)\omega_t h_t dj + \int_0^1 (1+\delta^j\nu^j)h_{t-1}\omega_t dj, \tag{A.2}$$

where the first integral on the right hand side is income of the young generation and the second one is the income of the old generation. Since in steady state h_t and $c_{t,t+\tau}$ grow at the same rate g^C (for $\tau=0$ or 1), we can write the equilibrium condition as follows:

$$\int_0^1 c^j_{t,t}dj + \int_0^1 \frac{c^j_{t,t+1}}{1+g^C}dj = \omega_t h_t \int_0^1 (1 - \nu^j)dj + \frac{\omega_{t+1}h_t}{1+g^C}\int_0^1 (1 + \delta^j\nu^j)dj. \tag{A.3}$$

On the other hand, note that the resource constraint or goods market clearing condition of this economy can be also derived from the sum of budget constraints of all individuals. Integrating equation (17) over all agents we have that:

$$\int_0^1 c^j_{t,t}dj + \int_0^1 \frac{c^j_{t,t+1}}{1+r_{t+1}}dj = \omega_t h_t \int_0^1 (1 - \nu^j)dj + \frac{\omega_{t+1}}{1+r_{t+1}}\int_0^1 h^j_{t+1}dj \tag{A.4}$$

$$= \omega_t h_t \int_0^1 (1 - \nu^j) + \frac{\omega_{t+1}h_t}{1+r_{t+1}}\int_0^1 (1 + \delta^j\nu^j)dj.$$

Comparing equations (A.4) with (A.3), it can be seen that both expressions hold only if $g^C=r$. ‖

Proof of Proposition 2:

The first part of the proof establishes that $\partial(\Delta g)/\partial m > 0$ within the appropriate range of the parameters. To decide the range, the following information is used. First, it is obvious that b, which represents a variance, is non-negative. Second, since we assume all individuals in the non credit market have a positive investment on education, the following inequality holds: 1/

$$m \geq \frac{b}{2} + \frac{1}{\beta}. \tag{A.5}$$

Denote:

$$\chi = \frac{\partial(\Delta g)}{\partial m} = \left[\frac{(m + \frac{b}{2})^2}{(m+\frac{b}{2})^2 + b^2 + 2b}\right]^{1/2} - \frac{\beta}{1 + \beta}.$$

It is easy to verify that for any b the above expression valued at the minimum m ($= b/2+1/\beta$) is greater than zero. Now it can be also shown that, for any given b, $\partial\chi/\partial m > 0$. Hence χ is always positive within the above parameter range. Given that Δg is increasing in m, to complete the proof that the growth effect is positive it is enough to show that for the minimum values of m (depending on b) the expression Δg is greater than zero. For this we first consider $b=0$, which is the minimum b. In this case the minimum value of m is $1/\beta$, and hence the last term at the right hand side of δg is zero, and the expression in square brackets is greater than $1+b$, which implies that Δg valued at the minimum m and b is positive. It can be also shown that Δg valued at the minimum m is increasing in b, which implies that Δg valued at the minimum m's (for any b) are positive.

Then it follows that for any b the growth effect of credit markets is positive. ‖

Proof of Proposition 3:

Given the same initial conditions, figure 2 shows that individuals allowed to borrow and lend have higher (or equal for j^*) utility than those not allowed. In addition, the economy with credit market has a higher rate

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1/ Relaxing this assumption does not change the main results of the proposition. For example, under the very weak assumption that education does not have a negative effect on human capital accumulation (that is, all $\delta^j \geq 0$), it can be shown that the proposition still holds.

of growth (proposition 1) consequently all current and future generations are better off with credit markets, except individual j^* in the first period. ‖

Proof of Proposition 4:

(i) For $0 < j \leq j^*$,

Condition (36) insures that the "normalized" indirect utility $U^A(j)\int_0^1 U^C(i)di/\int_0^1 U^A(i)di$ cuts the $j=0$ axis above $U^C(j)$. Hence, as illustrated in Figure 4, the slope of the Lorenz curve for credit market case at j=0 ($= U^C(0)/\int_0^1 U^C(i)di$) is not greater than that of non-credit market case ($=U^A(0)/\int_0^1 U^A(i)di$). Furthermore, since $U^C(j)$ is constant for all $j \leq j^*$ and equal to $U^C(j^*)$, and $U^A(j)$ is increasing in j, the slope of the Lorenz curve in the presence of credit market is flatter within all of the above range. Hence, the Lorenz curve in the case of credit market is below that of non-credit markets.

(ii) For $j^* \leq j < 1$,

Using the expressions for consumption of agent j, above j^*, we can derive the following:

$$\begin{aligned} U^C(j) \int_0^1 U^A(i)di - U^A(j) \int_0^1 U^C(i)di &= (1+\beta)\log(1+r)[\log(1+\delta^j) \\ &-\int_0^1 \log(1+\delta^i)di] + [(1+\beta)\log(Ah_t) - \log(1+\beta) \\ &+\beta\log\frac{\beta}{(1+\beta)} - \log(1+r)]\ [\log(\delta^j) - \int_0^1 \log(\delta^i)di] \\ &+(1+\beta)[\log(\delta^j)\int_0^1 \log(1+\delta^i)di - \log(1+\delta^j)\int_0^1 \log(\delta^i)di]. \end{aligned} \tag{A.6}$$

After some algebra, it can be shown that the above expression is monotonically increasing in j and negative at j^*. Since

$$\int_0^1 [U^C(j) \int_0^1 U^A(i)di - U^A(j) \int_0^1 U^C(i)di]dj = 0 \tag{A.7}$$

it follows that there exists a unique value $j' \in (j^*, 1)$ that satisfies the following relationships:

For $j < j'$

$$U^C(j) \int_0^1 U^A(i)di - U^A(j) \int_0^1 U^C(i)di < 0,$$

and for $j>j'$

$$U^C(j) \int_0^1 U^A(i)di - U^A(j)\int_0^1 U^C(i)di > 0,$$

which implies that the slope of the Lorenz curve in the case of credit market is flatter around $j = j^*$ (up to j') and steeper around $j = 1$, and furthermore, that the Lorenz curve in the case of credit market is below that of non-credit market.

It follows from (i) and (ii) that Lorenz curve in the presence of credit markets is below that in the absence of credit markets. Then, utility inequality indices, such as Gini coefficients, are larger in the presence of credit markets. ‖

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