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A NOTE ON CREDIT MARKET DEVELOPMENT AND HUMAN CAPITAL ACCUMULATION

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This paper explores the interplay between credit market development and human capital accumulation in a two-period overlapping-generations economy with asymmetric information under the assumption that young lenders channel credits to young borrowers and acquire education. We find that, at the self-selection equilibrium, lenders will allocate more time to acquire education if the cost of screening borrowers falls. Furthermore, a longer duration of lenders' schooling time suppresses borrowers' incentive to cheat thereby enabling lenders to screen less frequently. Our preliminary cross-country empirical analysis appears to support these findings.

Keywords: Credit Market Imperfection, Human Capital

1. INTRODUCTION

There has been profound interest in studying the impact of credit market development on human capital accumulation and economic growth in the past two decades. Most prominently, Galor and Zeira (1993) demonstrate that imperfect credit markets in association with indivisibilities in human capital investment keep individuals who inherit too little wealth unskilled and their offspring also. De Gregorio (1996) argues that even though borrowing constraints encourage saving, they hamper human capital accumulation and growth. Khan (2001) shows that financial development lowers the cost of raising external funds and increases the economic growth rate. Recently, Azariadis and de la Croix (2006) find a positive long-run growth effect of removing financial constraints in a model with both human and physical accumulation. Azariadis and Kaas (2008) study a growth model with limited commitment to loan repayment and find that a low-growth equilibrium with an underdeveloped credit market may exist because of weak property rights. Although the main concern of these papers is the negative growth

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effect that credit market imperfection may bring about, the implications of human capital accumulation for credit market development have largely been overlooked, and this is the subject of the current paper. In particular, we want to study through what mechanism education may exert a positive impact on financial institutional improvement. This is certainly an important issue, because financial development and human capital are both indispensable to a country's growth process.

We model credit markets as a composition of borrowers and lenders looking for pairwise investment opportunities, as in Bencivenga and Smith (1993) and Bose and Cothren (1996, 1997)[1]. More precisely, we consider an overlapping-generations economy populated with heterogeneous agents who live for two periods. Lenders are endowed with one unit of labor time in each period and they are responsible for human capital accumulation and credit provision. When the lenders are young, they first decide the fractions of time allocated to schooling and working. Subsequently, they supply their wage income as the source of external investment funds in the credit market. When they are old, they consume the sum of the wage income they earn when old and the interest payment from the loan they made when young. Borrowers are endowed with investment projects. They work when they are young and their wage incomes are invested as internal funds for running their projects. Because project outputs are strictly increasing with the amount of funds, the borrowers approach the lenders for extra investment funds. However, because the risk types of the investment projects are known only to their owners, not to the lenders, the problem of asymmetric information arises. By using costly screening contracts, the lenders can induce the borrowers to reveal their true types. In such an environment, the main question we want to address is how the lenders' duration of schooling time interacts with credit market development.[2] We find that, in the steady state, reducing the screening cost will induce the lenders to acquire more education. Furthermore, a longer duration of lenders' schooling suppresses the borrowers' incentive to cheat and hence enables lenders to screen with lower frequency. Taking these findings together, we demonstrate that the avenue through which the interaction between credit market development and education takes place can be two-way—when credit market development facilitates human capital accumulation, it also benefits from it.

The preceding findings have the following empirical cross-country implications. First, the duration of schooling time should be greater in countries where credit markets are less susceptible to informational frictions. Second, if we interpret the screening probability as a measure of the quality of the institutional arrangement for contractual enforcement, a high screening probability being associated with a low quality of institutional arrangement, then those countries with longer duration of schooling should have financial institutions that enforce contracts more efficiently.[3] By using different macro proxies, we find some preliminary empirical support for these results from our cross-country samples.

The rest of this paper is organized as follows. Section 2 lays out the structure of the overlapping-generations framework and the human capital accumulation process. Section 3 is about the equilibrium loan contracts. Section 4

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derives the steady state. Section 5 provides some cross-country empirical evidence for the major findings. We conclude and discuss some possible extensions in Section 6. The stability properties of the steady state are discussed in Appendix A. The data sources and the countries in our data set are reported in Appendix B.

2. THE MODEL

In the economy, there is an infinite sequence of two period–lived overlapping generations. All generations are identical in size and composition. The population size of each generation is normalized to one. Young agents in each period are equally divided into lenders and borrowers. All agents have one unit of labor time to supply. When a lender is young, he spends a fraction of his time on work to earn wage income, which in turn becomes the only source of external investment funds in the credit market. The rest of his time is used for education. When he becomes old, he works and consumes. Let h_{t+1} be the human capital produced in period t and to be used in period $t+1$. h_{t+1} is measured by units of effective labor. Human capital during the lifetime of a lender evolves according to

$$h_{t+1} = (1-\alpha)h_t + f(n_t); \quad 0 < \alpha < 1, \tag{1}$$

where α is the depreciation rate of human capital, n_t is the fraction of the lenders' time allocated to education, and h_t is the average level of the parental generation's human capital. We assume that $f(n_t) = \gamma n_t$, where γ is a constant satisfying $1 \leq \gamma$. Therefore, as in Lucas (1988), the human capital accumulation process exhibits constant returns with respect to the time devoted to education. We will take h_0 to be given as an initial condition.

A young borrower earns the real wage rate, w_t, by supplying his labor to firms.[4] In old age, he implements his investment project, which requires exactly one unit of labor time to convert inputs of the consumption good into capital. However, the risk levels of borrowers' investment projects are not identical. Specifically, a fraction λ of borrowers have type H projects with a lower probability of success and a fraction $1-\lambda$ of borrowers have type L projects. A type $i \in \{L, H\}$ investment projects can succeced with probability P_i in converting one unit of time-t output into Q units of capital goods at time $t+1$. The investment projects may fail and produce zero capital goods with probability $1 - P_i$. We assume that $0 \leq P_H < P_L \leq 1$. The owner of a successful investment project will become a firm operator in old age.

A young lender can lend his wage to a borrower in exchange for consumption goods in the next period. Another option he has is to convert his time-t wage into $Q\varepsilon$ units of time-t capital using a risk-free technology, where ε is assumed to be sufficiently smaller than P_H to guarantee that loan business will take place between lenders and borrowers. An old lender works for a firm to earn wage income. Because this is the end period of his life, he simply consumes all his income. To obtain maximum simplicity, both lenders and borrowers are assumed to be risk-neutral and consume only when they are old. Consequently, the utility function of a lender or a borrower born at time t is given by

$$U_t = d_{t+1},$$

where d_{t+1} is the agent's consumption level at time $t+1$.

The total effective labor supply in period t, L_t, comes form the young borrower, the young lenders, who supply the fraction of labor not used for human capital accumulation, and the old lenders, who supply human capital measured by effective labor. Hence, its value is $L_t = 0.5 + 0.5(1 - n_t) + 0.5h_t = 0.5(2 - n_t + h_t)$.

Now we will turn to the description of the credit market. In each time period, a lender offers a set of loan contracts designed for different type of borrowers. If these contracts are not dominated by others, a borrower will approach this lender and select a contract. Following Bencivenga and Smith (1993) and Bose and Cothren (1996, 1997), each borrower can apply to one lender only, to impose an upper bound on the loan size.[5] Furthermore, the credit market is assumed to be perfectly competitive and hence the lenders' economic profit is zero. Because lenders cannot observe the risk types of borrowers, the problem of asymmetric information arises. However, by squandering a fraction δ of the amount lent, a lender can determine a borrower's type. Therefore, the maximum amount of loan a lender can make is equal to a fraction $(1-\delta)$ of the lender's wage when screened. If a borrower is caught mimicking the other type of borrowers, he will be expelled from the credit market. The contracts offered at time t to a type $i \in \{H, L\}$ take the form $C_t^i = [(\phi_t^i, R_{st}^i, q_{st}^i), (1-\phi_t^i, R_{nt}^i, q_{nt}^i)]$, where ϕ_t^i is the probability that a type i borrower is screened, and R_{st}^i and q_{st}^i are the gross loan rate and the loan size for a type i borrower in the event of screening, respectively. Likewise, R_{nt}^i and q_{nt}^i are the gross loan rate and the loan size, respectively, when screening does not take place.

A firm produces the final output according to the production function

$$y_t = k_t^{\beta} l_t^{1-\beta},$$

where y_t is the output per firm, k_t is the capital input per firm, and l_t is the units of effective labor per firm. β is a constant between 0 and 1. Profit maximization by firms yields

$$\rho_t = \beta k_t^{\beta-1} l_t^{1-\beta}, \tag{2}$$

$$w_t = (1-\beta) k_t^{\beta} l_t^{-\beta}. \tag{3}$$

where ρ_t is the rental rate of capital and w_t is the wage rate. We assume that physical capital is fully depreciated after one period of use and output can be used as consumption goods or capital goods.

3. EQUILIBRIUM LOAN CONTRACTS

A type $i \in \{H, L\}$ borrower of generation t has an expected payoff function of the following form:

$$\begin{aligned}\phi_t^i P_i \left[Q\rho_{t+1}\left(w_t+q_{st}^i\right)-R_{st}^i q_{st}^i\right]+\left(1-\phi_t^i\right)P_i\left[Q\rho_{t+1}\left(w_t+q_{nt}^i\right)-R_{nt}^i q_{nt}^i\right] \\ = P_i Q\rho_{t+1}w_t + \phi_t^i P_i\left(Q\rho_{t+1} - R_{st}^i\right)q_{st}^i + \left(1-\phi_t^i\right)P_i\left(Q\rho_{t+1} - R_{nt}^i\right)q_{nt}^i.\end{aligned} \quad (4)$$

At equilibrium, borrowers will self-select by choosing the contracts that match their own risk type. In other words, the following incentive-compatibility constraints must be satisfied:

$$\begin{aligned}\phi_t^H P_H \left[Q\rho_{t+1}\left(w_t+q_{st}^H\right)-R_{st}^H q_{st}^H\right]+\left(1-\phi_t^H\right)P_H\left[Q\rho_{t+1}\left(w_t+q_{nt}^H\right)-R_{nt}^H q_{nt}^H\right] \\ \geq \left(1-\phi_t^L\right)P_H\left[Q\rho_{t+1}\left(w_t+q_{nt}^L\right)-R_{nt}^L q_{nt}^L\right],\end{aligned} \quad (5)$$

$$\begin{aligned}\phi_t^L P_L \left[Q\rho_{t+1}\left(w_t+q_{st}^L\right)-R_{st}^L q_{st}^L\right]+\left(1-\phi_t^L\right)P_L\left[Q\rho_{t+1}\left(w_t+q_{nt}^L\right)-R_{nt}^L q_{nt}^L\right] \\ \geq \left(1-\phi_t^H\right)P_H\left[Q\rho_{t+1}\left(w_t+q_{nt}^H\right)-R_{nt}^H q_{nt}^H\right].\end{aligned} \quad (6)$$

Because the credit market is assumed to be perfectly competitive, lenders always earn zero expected economic profit at equilibrium. This zero-profit condition can be expressed as

$$\phi_t^i P_i R_{st}^i q_{st}^i + (1-\phi_t^i)P_i R_{nt}^i q_{nt}^i = \left[\phi_t^i Q\varepsilon \frac{q_{st}^i}{1-\delta} + (1-\phi_t^i)Q\varepsilon q_{nt}^i\right]\rho_{t+1} \quad (7)$$

for $i \in \{H, L\}$. The left-hand side of this equation is the expected income from making loans and the right-hand side is the forgone income of the loan. The equilibrium contracts must satisfy the following two feasibility conditions:

$$q_{st}^i \leq (1-\delta)(1-n_t)w_t, \quad (8)$$

$$q_{nt}^i \leq (1-n_t)w_t \quad (9)$$

for $i \in \{H, L\}$.

Because $\varepsilon < P_H < P_L$, $Q\rho_{t+1} - R_{st}^i$ and $Q\rho_{t+1} - R_{nt}^i$ must be positive at equilibrium. It follows that (8) and (9) must hold with equality signs at equilibrium, which determine the loan sizes in different states for both types of borrowers. After the equilibrium loan sizes are substituted into (7), the zero-profit condition for lenders can be rewritten as

$$(1-\delta)\phi_t^i P_i R_{st}^i + \left(1-\phi_t^i\right)P_i R_{nt}^i = Q\varepsilon\rho_{t+1}. \quad (10)$$

In what follows, we will proceed by assuming that at equilibrium, the incentive-compatibility constraint (5) is binding, but not (6).[6]

Because the incentive-compatibility constraint for type-H borrowers is never binding, it can be shown that the expected payoff to a high-risk borrower is strictly

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decreasing with the screening probability. Therefore, at equilibrium, it will be optimal to set $\phi_t^H = 0$, implying that lenders never screen borrowers who claim to be high-risk type. As a result, from (10) with $i = H$, the equilibrium loan rate for high-risk borrowers is

$$R_{nt}^H = \frac{Q\varepsilon\rho_{t+1}}{P_H}. \tag{11}$$

Hence, the equilibrium loan contract for a high-risk borrower can be summarized as $C_t^H = (R_{nt}^H, q_{nt}^H)$, where R_{nt}^H is given by (11), q_{nt}^H by (9) with equality for $i = H$ and $\phi_t^H = 0$.

Because $q_{nt}^i = q_{nt}^H = q_{nt}^L$ from (9) with equality sign and $\phi_t^H = 0$, the binding incentive-compatibility constraint (5) yields

$$\phi_t^L = \frac{(1-n_t)\left(R_{nt}^H - R_{nt}^L\right)}{(2-n_t)Q\rho_{t+1} - (1-n_t)R_{nt}^L}. \tag{12}$$

For $i = L$, we substitute (8), (9) with equality sign, (10), and (12) into (4). It can be shown that the expected payoff to a low-risk borrower is strictly increasing in R_{nt}^L. From the lenders' zero-profit condition, it is easy to check that setting R_{nt}^L as high as possible is indeed equivalent to setting R_{st}^L as low as possible. With $R_{st}^L = 0$, from (10), the equilibrium loan for low-risk borrowers in the event without screening is

$$R_{nt}^L = \frac{Q\varepsilon\rho_{t+1}}{P_L\left(1-\phi_t^L\right)}. \tag{13}$$

If we substitute (11) and (13) into (12), we will obtain the equilibrium screening probability for low risk-borrowers:

$$\phi_t^L \equiv \phi_t = \frac{1-n_t}{2-n_t}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right). \tag{14}$$

Because $\varepsilon < P_H < P_L$, the equilibrium screening probability is between 0 and 1 for any plausible values of n_t. It is worth noting that the equilibrium screening probability ϕ_t is inversely related to the lenders' duration of schooling at period t, n_t. In view of the importance of this linkage between ϕ_t and n_t in the subsequent discussion, we state it in a corollary.

COROLLARY 1. *A longer duration of lenders' schooling leads to a lower equilibrium screening probability for low-risk borrowers.*

This result can be understood in the following intuitive perspective. If the lenders choose to allocate a longer (shorter) time to schooling (work), the size of loanable funds in credit markets will become smaller. The borrowers' investment output then will rely more on the internal funds (i.e., their wage income). Internal financing lowers the expected monitoring cost, and this makes the asymmetric information problem less pronounced.[7]

Now we summarize these results in the following proposition.

PROPOSITION 1. *In each period t, the equilibrium contract for type-H borrowers is given by* $C_t^H = (R_{nt}^H, q_{nt}^H)$ *with* $R_{nt}^H = \frac{Q\varepsilon\rho_{t+1}}{P_H}$, $q_{nt}^H = (1-n_t)w_t$, *and no screening. The equilibrium contract for type-L borrowers is given by* $C_t^L = [(\phi_t, R_{st}^L, q_{st}^L), (1-\phi_t, R_{nt}^L, q_{nt}^L)]$ *with* $\phi_t = \frac{1-n_t}{2-n_t}(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L})$, $R_{st}^L = 0$, $q_{st}^L = (1-\delta)(1-n_t)w_t$, $R_{nt}^L = \frac{Q\varepsilon\rho_{t+1}}{P_L(1-\phi_t)}$, *and* $q_{nt}^L = (1-n_t)w_t$.

The equilibrium in the credit market derived in the preceding takes the marginal product of labor, the marginal product of capital, the fraction of time devoted to education, and the flow of human capital as given. In the following section, we will establish the general equilibrium of the model.

4. THE STEADY STATE

We first study the lender's utility-maximization problem. A representative lender maximizes his utility,

$$U_t = d_{t+1},$$

subject to the budget constraint

$$d_{t+1} = Q\varepsilon\rho_{t+1}(1-n_t)w_t + w_{t+1}h_{t+1},$$

where d_{t+1} is the consumption in period $t+1$ of a lender born in period t. After we substitute for h_{t+1} with (1) and solve for the lender's maximization problem, the following first-order condition is obtained:

$$Q\varepsilon\rho_{t+1}w_t = \gamma w_{t+1}. \quad (15)$$

This equation exhibits the well-known equilibrium trade-off between the forgone current income and the returns to education with given w_t, w_{t+1}, and ρ_{t+1}. Substituting (2) and (3) for w_t, w_{t+1}, and ρ_{t+1} into (15) gives

$$\frac{Q\varepsilon\beta}{\gamma} = \frac{k_{t+1}}{k_t^\beta}\frac{l_t^\beta}{l_{t+1}}. \quad (16)$$

Because none of the borrowers cheats at equilibrium, all projects of both types will be financed. The total number of firms in each period is $0.5[\lambda P_H + (1-\lambda)P_L]$. Therefore, the effective labor supply per firm is equal to

$$l_t = \frac{2-n_t+h_t}{\lambda P_H + (1-\lambda)P_L}. \quad (17)$$

The total capital stock in period $t+1$ is given by the successful investment projects. Recalling that a fraction of low-risk borrowers are screened with probability ϕ_t and physical capital is fully depreciated after one period of usage, we can determine that the capital stock per firm at $t+1$ is

$$k_{t+1} = \frac{Q\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - (1-n_t)\delta\phi_t(1-\lambda)P_L\}w_t}{\lambda P_H + (1-\lambda)P_L}.$$

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Combining (3) and (17) and substituting for w_t in this equation yields

$$k_{t+1} = \frac{Q(1-\beta)\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - (1-n_t)\delta\phi_t(1-\lambda)P_L\}k_t^{\beta}}{[\lambda P_H + (1-\lambda)P_L]^{1-\beta}(2-n_t+h_t)^{\beta}}. \quad \mathbf{(18)}$$

A competitive equilibrium for the economy is defined as a set of quantities $\{h_{t+1}, k_{t+1}, l_{t+1}, n_t, w_t, \rho_t, l_t, \phi_t, h_t, k_t\}$ satisfying equations (1), (2), (3), (14), (16), (17), and (18). In the steady state equilibrium, all endogenous variables are constant over time; i.e., $w_{t+1} = w_t = w$, $\rho_{t+1} = \rho_t = \rho$, $k_{t+1} = k_t = k$, $h_{t+1} = h_t = h, l_{t+1} = l_t = l, \phi_{t+1} = \phi_t = \phi$, and $n_{t+1} = n_t = n$. The steady state equilibrium can be characterized by the following equations:

$$h = \frac{\gamma n}{\alpha}, \quad \mathbf{(19)}$$

$$w = (1-\beta)k^{\beta}\left[\frac{2-n+h}{\lambda P_H + (1-\lambda)P_L}\right]^{-\beta}, \quad \mathbf{(20)}$$

$$\rho = \beta k^{\beta-1}\left[\frac{2-n+h}{\lambda P_H + (1-\lambda)P_L}\right]^{1-\beta}, \quad \mathbf{(21)}$$

$$\phi = \frac{1-n}{2-n}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right), \quad \mathbf{(22)}$$

$$k = \left(\frac{Q\varepsilon\beta}{\gamma}\right)^{\frac{1}{1-\beta}} \frac{(2-n+h)}{\lambda P_H + (1-\lambda)P_L}, \quad \mathbf{(23)}$$

$$k = \frac{\{Q(1-\beta)\{[\lambda P_H + (1-\lambda)P_L](2-n) - (1-n)\delta\phi(1-\lambda)P_L\}\}^{\frac{1}{1-\beta}}}{[\lambda P_H + (1-\lambda)P_L](2-n+h)^{\frac{\beta}{1-\beta}}}. \quad \mathbf{(24)}$$

Equations (19), (20), (21), (22), and (24) are simply steady state versions of (1), (3), (2), (14), and (18) respectively. Substituting (17) into (16) and assuming a steady state give (23). Furthermore, combining (19), (23), and (24) gives the equation

$$F(n) \equiv \frac{[\lambda P_H + (1-\lambda)P_L](2-n) - (1-n)\delta\phi(1-\lambda)P_L}{(2-n+\frac{\gamma n}{\alpha})} = \frac{\varepsilon\beta}{\gamma(1-\beta)}, \quad \mathbf{(25)}$$

where ϕ is given by (22). Some properties of the function $F(n)$ are summarized in the following lemma.

LEMMA 1. *(a)* $F(0) = \lambda P_H + (1-\lambda)P_L[1 - 0.25\delta(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L})]$, *(b)* $F(1) = \frac{\lambda P_H + (1-\lambda)P_L}{1+\frac{\gamma}{\alpha}}$, *and (c) the function* $F(n)$ *is strictly decreasing in* n *for* $n \in (0, 1)$.

Lemma 1 indicates that the function $F(n)$ is downward-sloping. Because the right-hand side of (25) is independent of n, a unique steady state value of n between

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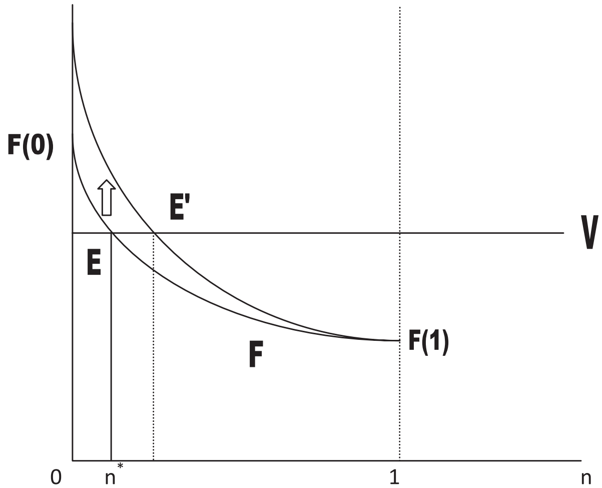

FIGURE 1. The effect of decreasing δ.

0 and 1 will exist if the following conditions are met:

$$\frac{[\lambda P_H + (1-\lambda)P_L]}{\frac{\beta}{\gamma(1-\beta)}(1+\frac{\gamma}{\alpha})} < \varepsilon < \frac{[\lambda P_H + (1-\lambda)P_L]}{\frac{\beta}{\gamma(1-\beta)} + 0.25(1-\lambda)\delta P_l(\frac{1}{P_H} - \frac{1}{P_L})}.$$

We state this result in the following proposition.

PROPOSITION 2. *Given that*

$$\frac{[\lambda P_H + (1-\lambda)P_L]}{\frac{\beta}{\gamma(1-\beta)}(1+\frac{\gamma}{\alpha})} < \varepsilon < \frac{[\lambda P_H + (1-\lambda)P_L]}{\frac{\beta}{\gamma(1-\beta)} + 0.25(1-\lambda)\delta P_l(\frac{1}{P_H} - \frac{1}{P_L})}$$

is satisfied, there exists a unique steady state value of lenders' schooling time, n, called n^*, which lies in the internal (0, 1).

Now let us examine the effect of changing δ on the duration of the lender's schooling time in the steady state, n^*, which is of special interest because varying this parameter corresponds to changing the degree of sophistication of credit markets. Let $V = \frac{\varepsilon\beta}{\gamma(1-\beta)}$. The consequence of decreasing δ is depicted in Figure 1. It is easy to see from (25) that F is negatively associated with δ, because

$$\frac{\partial F}{\partial \delta} = -\frac{(1-n)(1-\lambda)\phi P_L}{(2-n+\frac{\gamma n}{\alpha})} < 0.$$

Graphically, as δ becomes smaller, the F curve shifts upward, resulting in a longer duration of schooling. (The economy moves from the steady state E to another steady state E' in Figure 1.) The intuition behind this result is very straightforward. Decreasing screening cost enables young lenders to increase the supply of external investment funds. When more capital goods are produced,

TABLE 1. Correlations between schooling time and macro governance

	AYOS15	AYOS25	Judiciary System	Rule of Law	Expropriation Risk	Repudiation Risk
AYOS15	1.00					
AYOS25	.99***	1.00				
Judiciary System	.74***	.77***	1.00			
Rule of Law	.73***	.77***	.70***	1.00		
Expropriation Risk	.75***	.78***	.73***	.87***	1.00	
Repudiation Risk	.74***	.76***	.72***	.87***	.93***	1.00

Notes: The measures of schooling time are period averages from 1975–1995 and the measures of macro governance are from 1982 to 1995. The sample sizes are 39–40. *** represents 1% significance level.

the equilibrium rental rate of capital must go down. Relative to physical capital accumulation, human capital accumulation then becomes more attractive, which will motivate the lenders to allocate more time to acquire education. We state this finding in a lemma.

LEMMA 2. *As the cost of screening, δ, falls, lenders will increase their duration of schooling time, n^*, at the steady state.*

The analysis so far primarily focuses on the steady state. It is certainly important to see if the economy will converge given any initial conditions. We show in Appendix A that the dynamic system of the model can be described by two equations with n_t and h_t as variables, and there exists a saddlepath converging to the steady state. Therefore, corresponding to h_0, there is a unique value of n, for which the system converges to the steady state.

5. SOME EMPIRICAL EVIDENCE

We now turn to the empirical component of this paper. In this section, we are going to use our cross-country data to empirically test the two major findings of the paper, including the conjectures that a longer duration of the lenders' schooling leads to a lower screening probability (Corollary 1) and a lower screening cost will increase the duration of schooling (Lemma 2). To this end, we have performed correlation tests, and their results are reported in Tables 1 and 2.

If the screening probability is interpreted as a measure of the quality of institutional arrangements that enforce financial contracts, what Corollary 1 will suggest is that the educational level may explain the varying quality of financial institutions across countries. Specifically, an economy with high (low) education level should associate with a credit market with high (low) quality of institutional arrangements to enforce financial contracts. We try to test this result empirically using the data set on "macro governance" developed by La Porta et al. (1998) to proxy the degree of financial institutional quality. There are four proxies for

TABLE 2. Correlations between schooling time and financial development

	AYOS15	AYOS25	Credit1	Credit 2	Liquid Liability	Bank Assets
AYOS15	1.00					
AYOS25	.99***	1.00				
Credit 1	.47***	.50***	1.00			
Credit 2	.59***	.60***	.87***	1.00		
Liquid Liability	.26*	.29**	.81***	.72***	1.00	
Bank Assets	.44***	.47***	.94***	.79***	.86***	1.00

Notes: The measures of schooling time are period averages from 1975 to 1995 and other measures are from 1986 to 1995. The sample sizes are 39–40. * Represents 10% significance level, ** represents 5% significance level, and *** represents 1% significance level.

"macro governance" being used. Specifically, Judiciary System is a proxy for the efficiency and integrity of the judicial system, rating from 1 to 10, with 10 being the most efficient. Rule of Law is a measure of the law and order tradition in a country, rating from 1 to 10, with 10 being the highest degree of the rule of law. Expropriation Risk assesses the risk of confiscation or forced nationalization, rating from 1 to 10, with 10 being the lowest expropriation risk. The final proxy used for financial institutional quality is Repudiation Risk, which measures the risk of modification of a contract in the form of repudiation, postponement, or scaling down. Its rating goes from 1 to 10, with 10 being the lowest repudiation risk. For educational attainment, we use the following two different measures: AYOS15 is the average years of schooling of the total population of a country aged 15 or above and AYOS25 is that for the population aged 25 or above. The sample period 1982–1995 and the sample size of 40 for the tests are mainly due to the data limitation on "macro governance" as developed by La Porta et al. (1998).[8] We run correlation tests using cross-country samples of the period averages of the measures of the duration of schooling time and those for "macro governance." To measure the correlation between any two relevant series of data, the Spearman rank correlation coefficient is used. The critical values for the significance tests of this coefficient come from Zar (1972). The results in Table 1 [see columns (1) and (2)] indicate that the correlation between "duration of schooling time" and "macro governance" proxies is significantly positive at the 1% level, in accordance with the result stated in Corollary 1.[9]

To test the cross-country implications of Lemma 2, we have again performed correlation tests. Four commonly used indicators of financial development are adopted as proxies for the cost of screening δ: Credit 1 is the share of private credit issued by deposit money banks to a country's GDP. Credit 2 is the share of private credit issued by deposit money banks and other financial institutions to GDP. Liquid Liability is the amount of liquid liability as a percentage of GDP, and Bank Assets are deposit money assets as a percentage of GDP. Using the period averages between 1975 and 1995 of the two measures for "duration of schooling time" and the four for "financial development" in countries, we find that their empirical correlation is positive and significant at the 1%, 5%, or 10% level, which is consistent with our model's prediction in Lemma 2. The test results are reported in Table 2 [see columns (1) and (2)].

6. CONCLUSION

We have argued that credit market development and human capital accumulation co-evolve. Our starting point is a neoclassical growth model being extended with credit markets that are plagued with asymmetric information problems. What differentiates the model from the others in the literature is that the lenders have the discretion to distribute their endowed unit of labor time between acquiring education and working. We show that, in the steady state, reducing screening cost increases the supply of external investment funds and hence provide a higher level of physical capital production, leading to a lower equilibrium capital rental rate. Lenders will then find it beneficial to allocate more time to acquire education. Furthermore, a longer duration of the lenders' schooling suppresses the borrowers' cheating incentive, allowing a lower screening probability to sustain the separating equilibrium. These findings not only conform with the well-established proposition that credit market development facilitates human capital accumulation, but also suggest that these two themes may actually go hand in hand during the course of economic development. These above findings are supported by our preliminary empirical cross-country tests.

Now we propose two possible extensions of the model. The first interesting extension is to endogenize the lender–borrower mix. One possible way to do this is to extend the model to the situation with heterogeneous agents that are endowed with both investment projects and labor force. Each agent is indexed by a success probability for his own investment project, which is his private knowledge. In the first period of their life before the credit markets are open, agents have to decide their own occupational choices. Obviously, agents with high enough success probabilities will choose to be borrowers, whereas those with low success probabilities will become lenders. We conjecture that, as long as the expected return to a borrower is maintained in proportion to the loan size, the negative relation between the lenders' duration of schooling and the screening probability should still hold in this setting. But decreasing the screening cost may affect the lenders' duration of schooling through two channels. First, when there is a decline in δ, borrowers can obtain more funds to produce physical capital, yielding a lower capital rental rate. Second, a lower δ implies a higher expected return to an investment project and hence more temptation to become borrowers. As a result, the number of borrowers rises and the number of lenders (and the total amount of loans) falls. This effect damages physical capital production and thus pushes up the capital rental rate. So whether the lenders will allocate a longer time to education after the decrease of the screening cost depends on the relative

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magnitude of these two counterbalancing forces. Another possible extension is to include government spending as an input into human capital production. This kind of government spending can be financed by taxes on lenders' wage income and borrowers' capital income. This framework would allow us to study how the degree of capital market imperfection may affect the structure of the fiscal policies.

NOTES

1. Without considering human capital accumulation, a collection of papers emphasizing the effect of information asymmetry in credit markets on growth has burgeoned. For instance, Bencivenga and Smith (1993) and Bose and Cothren (1996, 1997) find the adverse selection problem prohibiting the use of the first-best loan contract and suppressing long-run growth. Ho and Wang (2005) show similar effects of asymmetric information on growth in a model with tax-financed public capital.

2. In this paper, the term "credit market development" refers to a process in which a credit market experiences a decreasing cost of screening or a declining probability of screening.

3. The proposition that education or high income may cause institutional improvement is not entirely new. There is a small but growing empirical literature on this topic, including Barro (1999) and Glaeser et al. (2004).

4. Although the borrowers never invest in human capital, they benefit from higher real wages because of human capital accumulation, which is solely contributed by the lenders. This assumption amounts to a complete knowledge spillovers in the economy.

5. Equalizing the number of lenders and borrowers keeps the formation of the credit market as simple as possible. If we assume, instead, that the lenders outnumber the borrowers, each borrower will have to transact with more than one lender for credit market clearance. Then it will immediately follow that a financial intermediation must emerge in order to economize on the screening cost.

6. Please refer to the working paper version [Ho (2011)] for the proofs of this assumption and other claims and lemmas of the model.

7. It is well known that internal financing mitigates the agency problems in the costly state verification (CSV) literature, as Bernake and Gertler (1989) and Boyd and Smith (1997) have demonstrated. We have a similar finding in a setting with adverse selection.

8. Please refer to Appendix B for data sources and the names of those countries in the data set.

9. What Corollary 1 suggests is a causality relationship going from "schooling time" to "macro governance." We want to emphasize that our correlation tests in Tables 1 and 2 do not contain any definitive messages about causality. Without moving beyond the scope of the current paper, the purpose of these tests is to give some preliminary support for our model's implications.

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APPENDIX A: THE STABILITY PROPERTY OF THE STEADY STATE

Combining (16) and (17) gives

$$\frac{Q\varepsilon\beta}{\gamma} = \frac{k_{t+1}}{k_t^{\beta}} \frac{[\lambda P_H + (1-\lambda)P_L]^{1-\beta}(2-n_t+h_t)^{\beta}}{2-n_{t+1}+h_{t+1}}.$$

Rewriting (18) in conjunction with $\phi_t = \frac{1-n_t}{2-n_t}(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L})$ yields

$$\frac{k_{t+1}}{k_t^{\beta}} = \frac{Q(1-\beta)\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - \delta\frac{(1-n_t)^2}{(2-n_t)}(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L})(1-\lambda)P_L\}}{[\lambda P_h + (1-\lambda)P_l]^{1-\beta}(2-n_t+h_t)^{\beta}}.$$

Taking these two equations together, we obtain

$$n_{t+1} = 2 + h_{t+1} - \frac{\gamma(1-\beta)}{\varepsilon\beta}\left\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - \delta(1-\lambda)P_L\frac{(1-n_t)^2}{(2-n_t)}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right)\right\}.$$

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Substituting (1) into this equation gives

$$n_{t+1} = 2 + (1-\alpha)h_t + \gamma n_t - \frac{\gamma(1-\beta)}{\varepsilon\beta}\left\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - \delta(1-\lambda)P_L\frac{(1-n_t)^2}{(2-n_t)}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right)\right\}.$$

Then, it follows that

$$\triangle n_t = n_{t+1} - n_t = 2 + (1-\alpha)h_t + (\gamma-1)n_t - \frac{\gamma(1-\beta)}{\varepsilon\beta}\left\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - \delta(1-\lambda)P_L\frac{(1-n_t)^2}{(2-n_t)}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right)\right\}.$$

Using (1) gives $\triangle h_t = h_{t+1} - h_t = \gamma n_t - \alpha h_t$. The dynamics of this system is characterized by $\triangle n_t = 0$ and $\triangle h_t = 0$.

Now if $\triangle n_t = 0$, we have

$$h_t = \frac{\gamma(1-\beta)}{\varepsilon\beta(1-\alpha)}\left\{[\lambda P_H + (1-\lambda)P_L](2-n_t) - \delta(1-\lambda)P_L\frac{(1-n_t)^2}{(2-n_t)}\left(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L}\right)\right\} - \frac{2}{1-\alpha} - \frac{(\gamma-1)n_t}{1-\alpha}.$$

Because $\frac{\partial h_t}{\partial n_t} = -\frac{\gamma(1-\beta)}{\varepsilon\beta(1-\alpha)}\{\lambda P_H + (1-\lambda)P_L[1 - \delta\frac{(1-n_t)(3-n_t)}{(2-n_t)}(\frac{\varepsilon}{P_H} - \frac{\varepsilon}{P_L})]\} - \frac{(\gamma-1)}{1-\alpha} < 0$ for any plausible values of n_t, the equation $\triangle n_t = 0$ and its associated dynamics in the (n_t, h_t) space can be described by Figure A.1. When $\triangle h_t = 0$, it follows that $\gamma n_t - \alpha h_t = 0$. This equation and its associated dynamics are given in Figure A.2.

Combining Figures A.1 and A.2 gives the phase diagram of this dynamic system (Figure A.3), which shows that there exists a convergent saddlepath through the upper and the lower quadrants.

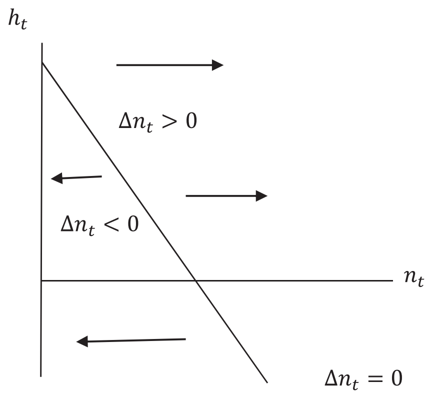

FIGURE A.1. $\triangle n_t = 0$ and its associated dynamics.

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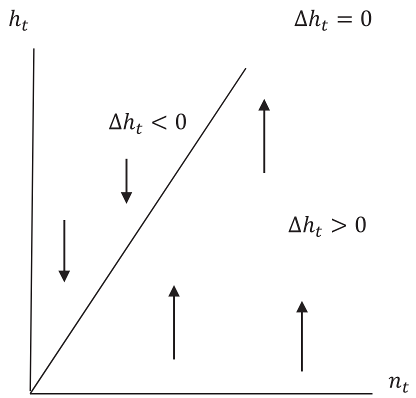

FIGURE A.2. $\Delta h_t = 0$ and its associated dynamics.

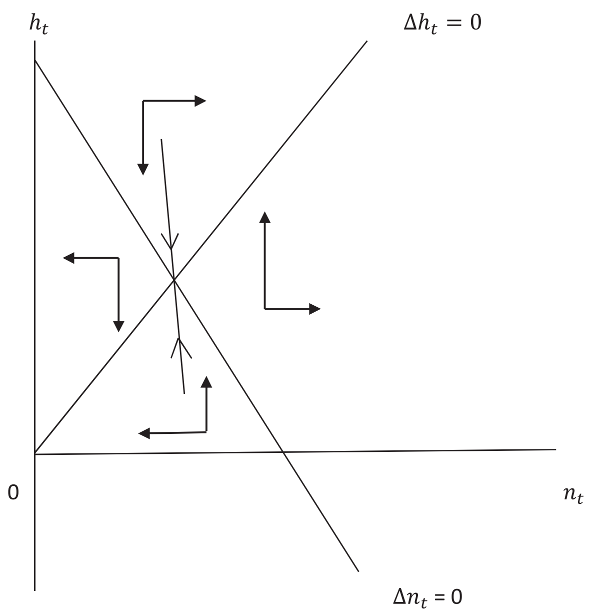

FIGURE A.3. The phase diagram of (n_t, h_t).

APPENDIX B DATA SOURCES AND NAMES OF COUNTRIES IN THE DATA SET

Data used in Section 5 were obtained from the following sources:

(1) The data on "macro governance" for the proxies: Judicial System, Rule of Law, Expropriation Risk, and Repudiation Risk come from La Porta et al. (1998).

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(2) The data on financial development for constructing the proxies: Credit 1, Credit 2, Liquid liability and Bank assets come from Financial Structure Dataset, World Bank (2008).
(3) The data on educational attainment for constructing the proxies: AYOS15 and AYOS25 come from Barro and Lee (2000).

The following 40 countries are included in our data set:

Australia, Austria, Belgium, Canada, Chile, Denmark, Ecuador, Egypt, Finland, France, Greece, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kenya, Korea, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Pakistan, Philippines, Portugal, Singapore, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, the United States, Uruguay, Venezuela, and Zimbabwe.