Essays on Imperfect Information and Economic Growth

by

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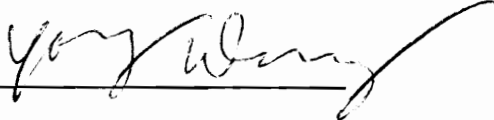
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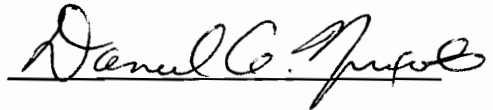
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Economics

(ABSTRACT)

This dissertation is a collection of essays on economic growth in the presence of asymmetric information between lenders and borrowers in the credit market.

The first chapter considers an endogenous growth model where lenders and capital producing borrowers are asymmetrically informed as to the borrower's ability to successfully operate an investment project. In contrast to the existing literature, lenders can induce self selection either by rationing a fraction of borrowers, or by using a costly screening technology, or by a mix of the two. The growth rate of the economy and the equilibrium contract's form are mutually dependent and are determined jointly. It is shown that a decline in the screening cost (representing a more sophisticated financial sector), paradoxically, may lower output growth and that benefit of an advanced financial sector becomes evident only when a threshold level sophistication is crossed.

The second chapter draws a connection between financial development

and economic growth in a neoclassical growth model. It is shown that at a low level of capital accumulation, lenders separates the borrowers by denying credit to a fraction of borrowers. As capital accumulates, credit market may function more like a modern credit market with less credit rationing and with an increasing number of lenders purchasing information to separate borrowers. The transition from rationing to screening results in a higher capital accumulation path and a higher steady state capital stock. The present chapter also highlights the conditions under which transition from rationing to screening regime will not occur and the economy may become trapped in a steady state with credit rationing and with a low level of capital.

The third chapter of the dissertation analyzes the effect of inflation rate on the growth rate of output via its effect on the agents' behavior in the credit market. It is shown that with inflation rate exceeding a critical level, a sharp fall in the growth rate of output takes place as the incentive to purchase information vanishes and borrowers are exclusively separated by means of credit rationing. This chapter also examines the panel data for a large group of countries for the period 1961-88, and shows that the relationship between the inflation rate and the growth rate of output closely follows the prediction of the theoretical model.

To my

Thakur/Lokenath Baba.

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Introduction:

The relationship between financial development and economic growth has been extensively studied by Schumpeter (1911), Gurley and Shaw (1955), Goldsmith (1969), McKinnon (1973) and others, who produced considerable evidence that financial markets play an important role in economic development. Their ideas, despite being insightful, were always marginalized by contemporary schools of thoughts which had stronger analytical foundations and, directly or indirectly, undermined the importance of financial factors in macroeconomics. During the Keynesian era, economists focused on the importance of money as opposed to credit and believed that financial intermediaries are important because of their significant role in the money supply process. A counter revolution initiated by Gurley and Shaw (1955) was dominated by the formal proposition by Modigliani and Miller (1958) that real economic decisions were independent of financial structure. The latter authors provided researchers with a rigorous justification for abstracting from financial considerations. Though dormant for a long period of time, interest in the relationship between the financial structure and the real economic activities revived in the late seventies and early eighties, particularly in the work of Mishkin (1978), and Bernanke (1983), who found strong evidence that the collapse of the financial system was an important determinant of the depth of the Great Depression and its persistence. However, this trend died quickly with the popularity of real business cycle theories in the

early eighties. Only in the last few years has interest in examining the link between financial markets and real economic activities gained momentum. This momentum has come about in a rather indirect way.

Since the mid eighties, there has been a explosion of interest in the field of economic growth and development being inspired by the work of Romer (1986), Lucas (1988) and others. Financial markets have surfaced as one among many factors that possibly contribute to economic growth and explain the difference in the rate of convergence across countries. In the mean time, rapid progress in the economics of information and incentives has created a solid microeconomic foundation (which the early researchers lacked) for analyzing behavior in a modern financial market. Papers providing such a foundation include Leland and Pyle (1977), Townsend (1979), Stiglitz and Weiss (1981), Diamond (1984), Ramakrishnan and Thakor (1984), Gale and Hellwig (1985), Boyd and Prescott (1986), Williamson (1986,1987). [For a survey see Williamson (1987b), Gertler (1988), Bhattacharya and Thakor (1993)]. A renewed interest in the theory of growth and development combined with access to such an analytical foundation, has resulted in a resurgence of interest in the relation between financial development and economic growth.

The current growing literature can be divided into two broad categories. The first group of literature focuses on several basic issues: (1) What determines

financial development? and (2) What are the channels through which financial development can possibly affect economic growth?. Answers to the first question can be found in the works of Greenwood and Jovanovic (1990), and Saint-Paul (1992), where financial development has been considered as a natural outcome of economic growth. In each, financial intermediation entails real resource costs that are fixed or less than proportional to the volume of funds intermediated. Thus, individual incentives to participate in financial markets increase with economic growth, as the benefits exceeds the cost with the scale of the funds invested. The result is that, economic growth expands the scale of the financial sector.

In answering the second question, economists have come more or less to a common consensus. Financial development affects economic growth either by increasing the social marginal productivity of investment, or/and by increasing the fraction of savings channelled to investment. For example, in Greenwood and Jovanovic (1990), capital may be invested in a safe, low yield technology or in a risky, high yield one, and the return to risky technology contains an aggregate and a project specific random shock. Unlike individual investors, financial intermediaries with their large portfolios can perfectly determine the nature of the aggregate shock, and thus choose the technology that is most appropriate for the current realization of the shock. As a result, savings channelled through financial intermediaries are allocated more efficiently, and higher productivity of capital

results in higher growth. Bencivenga and Smith (1991) have argued that in the absence of a developed financial sector, households facing an idiosyncratic liquidity shock insure themselves by investing in productive assets that can be liquidated and forgoing investments that are more productive but also more illiquid. Incorporating the argument, initially advanced by Diamond and Dybvig (1983) in a endogenous growth model, they have shown that development of the financial sector helps to pool the liquidity risk of the depositors and invest larger fraction of their funds in more illiquid and productive assets, and thus promotes economic growth. A similar treatment can be found in Saint-Paul (1992), where firms are subject to the idiosyncratic shocks rather then households. In this framework, firms can increase their productivity by specializing, but this increases the risk from sectoral demand shocks. With financial development, this risk can be shared efficiently via the stock market and the producers are encouraged to specialize, leading to higher productivity. In this presence of externalities, this productivity gain translates into higher steady state growth rate.

In comparison, the focus on the financial market is more rigorous in the second category of papers than the first. Recognizing that the modern financial markets are characterized by a wide variety of informational imperfections, this literature analyzes financial market in a principal - agent framework to determine the nature of the financial contract and then evaluates the outcome of such a contract on economic growth via its effect on capital accumulation. Examples

include Azariadis and Smith (1991), Aghion and Bolton (1991), Tsiddon (1992), and Bencivenga and Smith (1993). In all these papers, capital market imperfections are due to informational asymmetries between the borrowers and lenders. In Azariadis and Smith (1991) and Bencivenga and Smith (1993), the informational asymmetry arises as the project quality of the borrower is his private information. Such an informational problem results in adverse selection in the form of credit rationing which hinders the flow of resources from savers to investors and affects capital accumulation (and hence long run economic growth). In Aghion and Bolton (1991) and Tsiddon (1992), asymmetry of information arises between borrowers and lenders as the lenders do not have control over the use of funds. Such a moral hazard problem leads to a sub-optimal choice of investment project and adversely affects the long run economic growth.

The content of this dissertation, in part, belongs to both groups of literatures. In this dissertation, I address the problem of informational imperfection in the credit market in a rigorous manner and evaluate its effects on the capital accumulation process. The dissertation also highlights the link between financial development and economic growth. The first chapter of the dissertation considers an endogenous growth model in which informational asymmetry exists between capital producing borrowers and lenders as to the borrower's ability to successfully operate an investment project. In contrast to

the existing literature, I consider a more realistic framework where lenders can directly resolve the informational asymmetry by purchase information about borrowers at a resource cost. This possibility expands the variety of equilibrium contracts in the credit market as lenders can induce self selection either by rationing a fraction of borrowers, or by using a costly screening technology, or by a mix of the two. The other innovation in this chapter is to show the mutual dependency between the equilibrium contract's form and the growth rate of the economy and to determine them jointly. This chapter also examines the effect of a lower cost of screening (representing a more sophisticated financial sector) on the growth rate of output. I show that a decline in the screening cost, paradoxically, may lower output growth and that the benefit of an advanced financial sector becomes evident only when a threshold level of sophistication is crossed.

It has been typically observed that investors in developing countries face the prospect of credit rationing. Also, institutions, such as credit rating agencies and sound accounting, auditing, and disclosure regulations seldom exists in poor developing countries and increasingly emerge with higher stages of development. Such institutions and regulations, by providing information about borrowers, reduce the informational friction in transferring funds between the savers and the investors and facilitate the process of capital accumulation. The second chapter of this dissertation provides a theoretical explanation for the above stylized facts.

Incorporating the micro foundation of the credit market developed in the first chapter into a neoclassical growth model, I show that at a low level of capital accumulation, the rationing contract emerges as the equilibrium contract in the credit market. However, with capital accumulation, the incidence of rationing decreases as an endogenous outcome, as more and more lenders use the screening technology (purchase information) to separate borrowers. In this transition from the use of credit rationing to the use of at least some screening, the capital stock is pushed onto a higher dynamic path and to a higher steady state capital stock. These results show a connection between economic development and financial development (as exhibited by the lessened presence of credit rationing). In addition, this chapter derives the conditions under which a switch to the screening of borrowers may not occur. In such a situation the economy may be trapped in a steady state with credit rationing and low level of capital stock.

In the recent experiences of the Latin American countries, inflation appears to be an important factor in explaining low growth performances. Further, recent empirical evidences, that include the works of Fisher (1991, 1993), De Dregorio (1992, 1993), Levine and Renelt (1992), suggest that a higher inflation rate adversely affects the growth rate of output and productivity. The third chapter of this dissertation provides an explanation for such a relationship. By introducing a cash-in-advance constraint into the endogenous growth model described in chapter one, I have shown that higher inflation rate

may adversely affect economic growth via its effect on the behavior of the agents in the credit market. The rate of inflation not only determines the lending behavior within a lending regime (be it rationing or screening) but also determines the nature of the equilibrium lending regime. The results show that, a low level of inflation creates incentives for the lenders to separate the borrowers by purchasing information. However, as the inflation rate exceeds a critical level, a sharp fall in the growth rate of output takes place as the incentive to purchase information vanishes and borrowers are exclusively separated by means of credit rationing. The negative relationship between the inflation rate and the growth rate of output is also maintained within the screening and rationing regime. This chapter also examines the panel for a large group of countries for the period 1961-1988, and shows that the relationship between the inflation rate and the growth rate of output closely follows the prediction of the theoretical model.

Chapter 1: Equilibrium Loan Contracts and Endogenous Growth in the Presence of Asymmetric Information

For much of the history of macroeconomics financial markets have been treated in a much simpler fashion than they deserve. Consider, for example, the standard macroeconomic model in which the role of financial markets is to transfer funds from lenders to investors. Traditionally this transfer has been modeled in a setting where the agents are symmetrically informed and markets are competitive. In contrast to this tradition, recognizing that financial markets are characterized by a variety of informational imperfections, researchers have shed light on the role financial institutions play in the modern economy by analyzing agents' choices in the presence of asymmetric information. [For a survey see Williamson (1987b), Gertler (1988), or the more recent Bhattacharya and Thakor (1993)].

Parallel to the increased interest in financial markets has been an increased interest in economic growth, spawned by the work of Lucas (1988) and especially that of Romer (1986). Although the growth literature is large, relatively few papers have incorporated the theory of modern financial markets into models of growth and development [see, as exceptions, Greenwood and Jovanovic (1990), Tsiddon (1992), Azariadis and Smith (1993) and the recent work of Bencivenga

and Smith (1991,1993)]. This is true despite the fact, as King and Levine [1993(a),(b)] note, earlier work has emphasized the importance of financial markets for economic growth and development. To see the potential importance of this connection, consider the problem that arises when a lender cannot observe a borrower's type with regard to risk. As commonly encountered in the modern microeconomic literature, this asymmetry of information will result in lenders offering loan contracts that separate high risk from low risk borrowers. As a standard outcome of such contracts, a fraction of borrowers is credit rationed. Thus the problem of asymmetric information, and the resulting credit rationing, may hinder the flow of resources from savers to investors, and may hinder economic development. This issue has been addressed in Bencivenga and Smith (1993).

Our paper attempts to integrate further modern growth and financial market theory by analyzing an endogenous growth model in which a borrower knows his default risk but where the lender cannot costlessly determine whether the borrower has a high or a low probability of default. Our model differs from the standard case by allowing the means of separating borrowers to take two possible forms. One possibility is for a lender to ration credit. As noted, credit rationing and the effects of same have been analyzed by Bencivenga and Smith (1993). In contrast to these authors, as a second possibility we assume a lender can screen a borrower by expending resources to determine his type. Thus the

separation of borrowers as to type also can be achieved through the costly screening of some fraction of borrowers. Whether contracts specify rationing, or screening, or some combination of the two is an endogenous decision, depending upon exogenous parameters and related to other endogenous outcomes.

To illustrate this last point, we show the equilibrium contract's terms depend upon the marginal product of capital and hence upon the economy's growth rate, and vice versa. Thus given an interdependency between the loan contract's terms and the economy's growth rate, we show how each is jointly determined in equilibrium. We conclude that the equilibrium contract may not be of the form that maximizes growth and investigate how the growth rate and the equilibrium contract respond to the changes in the level of financial sophistication (as measured by the cost of screening). For example, a decrease in the cost of screening will move the economy from the rationing of borrowers to screening of the borrowers (as intuition would suggest). However, as the screening cost falls, the economy initially may experience a lower growth rate. Only if the cost falls far enough will growth be enhanced.

This paper proceeds as follows: Section 1 describes the basic structure of our model. In section 2, we determine the equilibrium contract in a partial equilibrium setting. In section 3, we find the economy's growth rate as a function of the loan contract's form, be it a rationing or a screening contract.

Section 4 determines the equilibrium loan contract after allowing for the fact that the contract's form and the marginal product of capital are jointly determined. Also, Section 4 evaluates the effects of changes in the cost of screening. Section 5 concludes.

1. The model

In this paper we adopt an environment modified slightly from Bencivenga and Smith (1993). We consider an infinite horizon economy, with discrete time indexed by $t = 0,1,2,...$ The economy consists of an infinite sequence of two period lived overlapping generations. All generations are identical in size and composition. For convenience's sake, we normalize the size of each generation to one.

Young agents are divided into two groups of equal sizes, referred to as borrowers and lenders. Each young borrower has a single investment project at his disposal. This project is either a type H or a type L project, indicating a high risk or a low risk project respectively. The high risk project has a lower probability of success than the low risk project. We assume that a fraction λ of the borrowers has a type H project. Each investment project requires one unit of labor and converts consumption goods into capital goods using a linear technology. Investment projects differ only in terms of their probabilities of

success.

With probability p_i, the investment project of the type i borrower converts x units of time t output and one unit of labor into Q.x units of time t+1 capital. With probability $(1 - p_i)$, the project is a failure and the conversion yields zero units of capital. The values of p_i satisfy $1 \geq p_L > p_H \geq 0$.

Young borrowers are endowed with a single unit of labor and can run their own projects. However, they are not endowed with output and therefore must seek external funds to finance their investment projects. If such funding is available, the borrower proceeds with his project utilizing his labor endowment. If no funds are forthcoming, the high risk borrower, having no outside opportunity, consumes nothing over his life time.[1] In contrast, the low risk borrower, if unfunded, can offer his unit of labor on the labor market for the prevailing real wage rate. Output from this wage is stored for consumption in the second period of life and yields a return of $\beta_L \leq 1$ per unit of output. Borrowers wish to consume in the second period of life and are risk neutral.

The operator of a successful time t investment project becomes a firm owner at time t+1. The firm owners are able to rent capital (in positive or

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This assumption is not necessary for our results. However, it simplifies the calculations to a large extent.

negative amounts) and hire labor at the competitively determined rental rates ρ_{t+1} and w_{t+1}, respectively. A firm employing k units of capital and L units of labor produces y units of output, as given by

$$y_t = \psi_t{}^{\alpha} \cdot k_t{}^{\theta} \cdot L_t{}^{1-\theta} \quad (1)$$

where Ψ_t is the average per firm capital stock. For simplicity, we assume that $\alpha = 1 - \theta$. This assumption transforms the output production technology into a linear one as in the 'AK model' developed by Rebelo (1991). Of course, as noted this output can be consumed or used for investment projects.

Each young lender is endowed with one unit of labor which is supplied inelastically to the competitive market earning the ruling wage rate. The lender can convert his time t wage, w_t, into $Q.\epsilon.w_t$ units of capital in time $t+1$ and can rent this amount to firms. Alternatively, the lender can lend his wage to a borrower in return for capital in $t + 1$. We assume that ϵ is sufficiently smaller than p_H to ensure loans between borrowers and lenders occur. The lender is risk neutral and wishes to consume in the second period of life.

There exists an informational asymmetry between the borrower and the lender as each borrower's type is private information. However, we also assume that a lender can determine a borrower's type at a resource cost which is

proportional to the amount lent.[2] Thus if q units of output are lent to the

borrower, the resource required to determine the borrower's type is $\delta.q$, where

δ is an exogenously given variable greater than zero.

2. The Credit market

The credit market operates in the following way: At the beginning of a

period, each lender posts a set of loan contracts whose terms are observed by all

borrowers. If a lender's contracts are not dominated by those of any other

lender, he is approached by a potential borrower who selects an offered contract.

We assume that each potential borrower can apply to one lender only for a loan[3],

and that, competition drives the lender's economic profit to zero. Because the

high risk and the low risk borrowers face different opportunities apart from

running investment projects ensures that the indifference curves of the two types

satisfy the single crossing property in the contract plane.   The only possible

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The proportionality assumption between the amount lent and the cost of screening can be motivated as follows. Suppose a project consists of a variety of tasks. Whether a project is a high risk or a low risk type depends on the ability of the borrower to carry out these tasks successfully. Typically, any project that uses a larger amount of resources also involves a larger variety of tasks. Therefore, screening the borrower's type when a project is large requires the lender to evaluate whether the borrower can perform a larger set of tasks successfully. This in turn implies a larger resource cost for screening.

This assumption provides a bound on the loan size which is necessary in the presence of a linear production technology.

equilibrium in such a 'menu contract' type model is a separating equilibrium. Following Bencivenga and Smith (1993), we assume λ is sufficiently large that an equilibrium exists. The equilibrium loan contracts at time t, denoted C_H and C_L, are incentive compatible and are such that there is no incentive for any lender to offer an alternative contract, taking the marginal product of capital at time $t+1$ and the offers of the other lenders as given. As noted, we assume that competition in the credit market drives the lender's economic profit to zero on each contract C_H and C_L.

It is easy to show in this model that the separation of borrowers is achieved by 'distorting' the first best contract of the low risk borrowers, as a low risk borrower has no incentive to be considered as a high risk one. Thus each lender posts a contract C_H which is the first best contract attainable by a type H borrower, given his type and given the zero economic profit constraint of the lender. This contract specifies the loan rate $R_{Ht} = Q\epsilon\rho_{t+1}/p_H$ and the maximum attainable loan quantity $q_{Ht} = w_t$. In contrast, the lender must distort the C_L contract acceptable to low risk borrowers in such a way that the type H is at least as well off accepting C_H. In our framework, this can be achieved by rationing a fraction of low risk borrowers [as in Bencivenga and Smith (1993)], by screening a fraction of low risk borrowers, or by a combination of the two. Determining when one method will prevail over the other is one of the main purposes of this section.

In its most general form, $C_L = [\{\phi_t, \pi_{Lt}^n, q_{Lt}^n, R_{Lt}^n\}; \{(1-\phi_t), q_{Lt}', R_{Lt}'\}]$, where ϕ_t is the probability the borrower is <u>not</u> screened. When not screened, the borrower's project is funded with probability π_{Lt}^n. If the borrower's project is funded, the loan quantity and the gross interest rate are q_{Lt}^n and R_{Lt}^n respectively. The borrower is screened with probability $(1-\phi_t)$. If the borrower is found to be a low risk borrower, the lender offers the loan quantity q_{Lt}' and the gross interest rate R_{Lt}'. If the borrower is found to be a high risk borrower, as a maximum penalty, the borrower will be denied a loan.[4] Note that if $\phi_t = 1$, rationing alone occurs and the Bencivenga and Smith type contract emerges as a special case.

Recall that when screening occurs there is a loss of $\delta.q_{Lt}'$ units of output. Thus the total amount lent to a screened low risk borrower is constrained by $q_{Lt}' \leq w_t - \delta.q_{Lt}'$, that is, $q_{Lt}' \leq w/(1 + \delta)$. Lenders always offer the contract $C_H = (q_{Ht}, R_{Ht}) = (w_t, Q\epsilon\rho_{t+1}/p_H)$, the first best contract for the low risk borrowers. The optimal contract C_L is determined as follows:

One can easily show that imposing the maximum penalty on the high risk borrower is optimal behavior for the lenders. By imposing the maximum penalty, the lender can increase the utility of the low risk borrower in equilibrium.

Proposition 1:

(1)   If $\beta^* \equiv Q\rho_{t+1}[p_L-\epsilon]/(1+\delta) > \beta_L$,   or   equivalently,   if $\rho_{t+1} > \rho^* \equiv \{\beta_L(1+\delta)\}/\{Q(p_L-\epsilon)\}$, then in equilibrium lenders offer the contract C_L $= C_L^s$, whose terms are

$$\pi_{Lt}^n = 1 \text{ and } \phi_t \equiv \phi^s = 1 - (1/p_H - 1/p_L).\epsilon \qquad 2(a)$$

$$R_{Lt}^n = Q.\epsilon.\rho_{t+1}/(\phi.p_L) \text{ and } R_{Lt}^s = 0 \qquad 2(b)$$

$$q_{Lt}^n = w_t \text{ and } q_{Lt}^s = w_t / (1 + \delta) \qquad 2(c)$$

(2)   If $\beta^* \equiv Q\rho_{t+1}[p_L-\epsilon]/(1+\delta) < \beta_L$,   or   equivalently,   if $\rho_{t+1} < \rho^* \equiv \{\beta_L(1+\delta)\}/\{Q(p_L-\epsilon)\}$, then in equilibrium lenders offer the contract C_L $= C_L^r$, whose terms are

$$\phi_t = 1 \text{ and } \pi_{Lt}^n \equiv \pi^r = \{1 - \epsilon/p_H\}/\{1 - \epsilon/p_L\} \qquad 2(d)$$

$$q_{Lt}^n = w_t \text{ and } R_{Lt}^n = Q.\epsilon.\rho_{t+1}/p_L \qquad 2(e)$$

(3)   If $\beta^* \equiv Q\rho_{t+1}[p_L-\epsilon]/(1+\delta) = \beta_L$,   or   equivalently,   if $\rho_{t+1} = \rho^* \equiv \{\beta_L(1+\delta)\}/\{Q(p_L-\epsilon)\}$,   then in equilibrium lenders are indifferent between offering C_L^s or C_L^r.

Proof: See Appendix 1A

The explanation underlying Proposition 1 is reasonably straight-forward. When rationed, the net payoff to the low risk borrower is $w_t.\beta_L$. The net expected payoff in a screening state is $Q\rho_{t+1}w_t[p_L-\epsilon]/(1+\delta)$. Clearly screening

dominates rationing if $\beta^* \equiv Q\rho_{t+1}[p_L-\epsilon]/(1+\delta) > \beta_L$. As noted in equation 2(a), if $\beta^* > \beta_L$, screening occurs with non-zero probability, $(1 - \phi)$. With probability ϕ, the borrower is not screened and the probability of rationing, $(1 - \pi_{Lt}^n)$, is zero. Conversely, as equation 2(d) states, if $\beta^* < \beta_L$, there is rationing but no screening. In this case the Bencivenga and Smith contract holds. Thus, unless $\beta^* = \beta_L$, the optimal contract will have screening or rationing but not both.

The other results in Proposition 1 worthy of discussion are as follows: First, as equation 2(b) shows, the interest rate for the screened borrower is zero. The intuition behind this result is straight-forward. When using the probability of screening to elicit separating behavior by the borrowers, the lender optimizes by making the non-screening contract as unattractive as possible for a dissembling high risk borrower. This implies that the lender should make the screening interest rate, R_{Lt}^*, zero while setting the non-screening rate, R_{Lt}^n, high enough to offset potential losses. As the lender will earn zero expected profit, this latter requirement is that $R_{Lt}^n = Q.\epsilon.\rho_{t+1}/(\phi.p_L)$. (Of course, this result hinges upon the lender's being risk neutral. Nonetheless, one expects that some subsidization of the screened borrowers by the non-screened borrowers ought to hold still with more general specifications of the lender's utility.)

Finally as β^* is increasing in p_L, Q, and ρ_{t+1}, screening becomes more attractive when either of these variables increases.

3. The Equilibrium Growth Rate

Proposition 1 shows how the equilibrium contract depends upon ρ_{t+1}, the rate of return to capital and other parameters. In turn, as we show in this section, the rate of return to capital and growth depend upon the form of the equilibrium contract. Throughout this section recall that borrowers and lenders each make up 50% of any generation.

Case 1: $Q \cdot \rho_{t+1}(p_L - \epsilon)/(1 + \delta) < \beta_L$ or equivalently,

$$\rho_{t+1} < \rho^{\bullet} \equiv \{\beta_L(1 + \delta)\}/\{Q(p_L - \epsilon)\}$$

If the above inequality holds, $\phi_t \equiv \phi^{\mathbf{s}} = 1$ and the borrowers are not screened. Therefore, the equilibrium contracts are given by the pair (C_H, C_L^r), where C_L^r is described in Proposition 1 (part 3).

Given that only successful borrowers operate firms in the second period of life and that $(1-\pi^r)$ of the low risk borrowers are credit rationed, there are $0.5[\lambda p_H + (1-\lambda)p_L \pi^r]$ firms t. The labor supply at t is given by $0.5[1 + (1-\lambda)(1-\pi^r)]$. In equilibrium all firms employ equal amounts of labor and capital. The quantity of labor employed by each firm is given by

$$L_t = [1 + (1 - \lambda)(1 - \pi^r)] / [\lambda \cdot p_H + (1 - \lambda) \cdot p_L \cdot \pi^r] \equiv L^r. \qquad (3)$$

L_t, being independent of time, is denoted by L^r. The superscript 'r' denotes the rationing case. As follows from equation 1, the wage rate and the marginal product of capital are given by $w_t = (1-\theta)\Psi_t^\alpha k_t^\theta L_t^{-\theta} = (1-\theta)k_t L_t^{-\theta}$ and $\rho_t = \theta \Psi_t^\alpha k_t^{\theta-1} L_t^{1-\theta} = \theta L_t^{1-\theta}$. Given equation 3 this implies

$$\rho_t \equiv \rho^r = \theta \cdot (L^r)^{1-\theta} = \theta \left(\frac{1 + (1-\lambda) \cdot (1-\pi^r)}{\lambda \cdot p_H + (1-\lambda) \cdot p_L \cdot \pi^r} \right)^{1-\theta}. \quad (4)$$

ρ_t, being a constant independent of time, is denoted by ρ^r.

The capital stock at $t+1$ comes from the successful, funded borrowers and from the lenders who converted their wages into capital after rationing the low risk borrowers. The former amount is $0.5.Qw_t[\lambda p_H + (1-\lambda)p_L \pi^r]$ and the latter is $0.5Q\epsilon w_t(1-\pi^r)(1-\lambda)$. Given that successful borrowers become firm operators, the per firm capital stock at time $t+1$ is thus

$$k_{t+1} = Q[1 + (1-\pi^r)(1-\lambda)\epsilon/\{\lambda p_H + (1-\lambda)p_L \pi^r\}]w_t \equiv Q(1+\epsilon^r)w_t. \quad (5)$$

Since $w_t = (1-\theta).k_t.(L^r)^{-\theta}$, the above equation implies that under credit rationing the growth rate of the capital stock per firm (and hence the growth rate of output per firm) is

$$k_{t+1}/k_t = g_t = Q(1+\epsilon^r)(1-\theta)(L^r)^{-\theta} = Q(1+\epsilon^r)(1-\theta)(\rho^r/\theta)^{-\theta/(1-\theta)} \equiv g^r \quad (6)$$

Note that the growth rate g_t is independent of time and is denoted by g^r.

Case 2: $Q \cdot \rho_{t+1}(p_L - \epsilon)/(1+\delta) > \beta_L$ or equivalently,

$$\rho_{t+1} < \rho^* \equiv \{\beta_L(1+\delta)\}/\{Q(p_L - \epsilon)\}$$

In this case lenders will screen a fraction of low risk borrowers. In such a situation, all low risk borrowers obtain loans. However, the loan amount and the loan rates will differ across the low risk borrowers. This case leads us to a different equilibrium growth rate for the economy. To differentiate from the previous case, we write the equilibrium variables in this section with a superscript 's'.

Given that all the low risk borrowers' projects are funded, the labor supply consists of young lenders only. The number of young lenders and the number of firms at time t are given by 0.5 and $0.5\{\lambda p_H + (1-\lambda)p_L\}$ respectively. The total capital stock at period $t+1$ emanates from successful high risk borrowers and low risk borrowers (some of whom are screened) at time t. Its value is $0.5Qw_t[\lambda p_H + (1-\lambda)\phi^s p_L + (1-\lambda)(1-\phi^s)p_L/(1+\delta)] = 0.5Qw_t[\lambda p_H + (1-\lambda)p_L(1+\delta\phi^s)/(1+\delta)]$. The labor supply per firm at period t is given by

$$L_t = [\lambda \cdot p_H + (1-\lambda) \cdot p_L]^{-1} \equiv L^s, \tag{7}$$

and the capital per firm at period $t+1$ is given by

$$k_{t+1} = Q.w_t.[\lambda.p_H + (1 - \lambda).p_L.(1 + \delta.\phi^s)/(1 + \delta)]/[\lambda.p_H + (1 - \lambda).p_L] \equiv Q\nu w_t,$$

(8)

where ν is defined implicitly. The marginal product of capital in this case is given by

$$\rho_t{}^s = \theta \cdot (L^s)^{(1-\theta)} = \theta \left(\frac{1}{\lambda \cdot p_H + (1 - \lambda) \cdot p_L} \right)^{1-\theta} \equiv \rho^s. \quad (9)$$

Substituting for w_t into equation 10, we see that the economy's growth rate is

$$g^s \equiv \frac{k_{t+1}}{k_t} = Q \cdot (1-\theta) \cdot \nu (L^s)^{-\theta} = Q \cdot \nu \cdot (1-\theta) \left(\frac{\rho^s}{\theta} \right)^{\frac{-\theta}{1-\theta}}, \quad (10)$$

Comparing equations (3) and (7), since $\pi^r > 0$, we see L^r is larger than L^s. Given equations (4) and (9), this implies $\rho^r > \rho^s$.

A comparison of equations (6) and (10) shows that the growth rates g^r and g^s are not likely to be equal. Both g^r and g^s are directly related to the real wage rate w_t and hence inversely related to the amount of labor employed per firm. As the unfunded low risk borrowers supply their labor endowments to the market, the supply of labor per firm is larger in a rationing regime. This lowers the growth rate in a rationing regime relative to that in a screening regime. On the

other hand, as seen from equations (8) and (12), for a given supply of labor and given k_t, the capital stock per firm is higher under a rationing regime (as fewer borrowers are funded, there are fewer firms). This raises the growth rate relative to a screening regime. To see that any case is possible, note that from equations (6) and (10) $g^s \geq g^r$ as

$$\nu.(\rho^r/\rho^s)^{\theta/(1-\theta)} \geq 1 + \epsilon^r \qquad (11)$$

where ν, ρ^s, ρ^r, and ϵ^r are given by equations 8,9,4, and 5, respectively. Since $\rho^r > \rho^s$ and $\nu < 1$, any relationship between g^s and g^r is possible. By way of seeing this, note that ν is decreasing in δ and converges to 1 as δ goes to zero. Thus, if ϵ and hence ϵ^r are sufficiently small, there exists δ^* such that $g^s \geq g^r$, as $\delta \leq \delta^*$. We assume that such a $\delta^* \in (0,1)$, in fact, does exist. To see that $g^s < g^r$ is possible, note that $(\rho^r/\rho^s)^{\theta/(1-\theta)}$ converges to 1 as θ converges to zero. Thus for a small θ, $\nu.(\rho^r/\rho^s)^{\theta/(1-\theta)} < 1 < 1 + \epsilon^r$ and $g^s < g^r$. Throughout the remainder of the paper we assume that

$$\left.\begin{array}{c} g^s \geq g^r \quad \text{for} \quad \delta \leq \delta^* \\[4pt] \text{and} \\[4pt] g^s < g^r \quad \text{for} \quad \delta > \delta^* \end{array}\right\} \qquad (12)$$

4. Existence of Equilibrium and the Effects of Changes in δ

Section 3 determines the marginal product of capital (and the growth rate) as a function of the contract's form -- be it rationing or screening. Of course, whether rationing or screening occurs depends on the marginal product of capital. Thus to determine the economy's full equilibrium, we must determine whether the implied marginal product of capital is consistent with the assumed contract form. We now investigate this issue.

According to Proposition 1.1, if $\rho_{t+1} > \rho^* \equiv \{\beta_L(1 + \delta)\}/\{Q.(p_L - \epsilon)\}$, lenders will offer the screening contract (C_H, C_L^s). If the inequality holds in the reverse direction, (C_H, C_L^r) is offered in equilibrium. Since $\rho^r > \rho^s$, we need only consider three cases - - Case 1: $\rho^* \geq \rho^r > \rho^s$, Case 2: $\rho^r > \rho^s \geq \rho^*$, and finally Case 3: $\rho^r > \rho^* > \rho^s$.

If case 1 holds, the (C_H, C_L^r) is the unique equilibrium contract pair in the credit market. To see this suppose lenders offer the contracts (C_H, C_L^r). As a result the economy has the constant marginal product of capital ρ^r. Given, $\rho^* \geq \rho^r$, no lender has the incentive to deviate and to offer (C_H, C_L^s) when all others offer (C_H, C_L^r). Therefore, (C_H, C_L^r) is an equilibrium contract. To see that this is the unique equilibrium, suppose that lenders are offering (C_H, C_L^s). The equilibrium marginal product of capital in such a situation is ρ^s. Given $\rho^* \geq \rho^r$

$> \rho^s$, the optimal behavior of an individual lender will be to deviate and offer (C_H, C_L'). Therefore, the (C_H, C_L^s) cannot be an equilibrium contract pair.

By a similar line of argument it is easy to see that (C_H, C_L^s) is the unique equilibrium contract when $\rho^r > \rho^s \geq \rho^*$ holds. Finally, if case 3 holds, then neither (C_H, C_L^s) nor (C_H, C_L') can exist as an equilibrium contract. However, in such a case, there exists an equilibrium where the lenders randomize between the two strategies, offering the contract (C_H, C_L') with probability μ and the contract (C_H, C_L^s) with probability $(1-\mu)$. Of course, the randomized strategy can be an equilibrium only if the borrowers are indifferent between offering (C_H, C_L') and (C_H, C_L^s). This requires that ρ_{t+1} be exactly equal to ρ^*.[5] It is easy to show that there exist $\mu \in (0,1)$ for which $\rho_{t+1} = \rho^*$. As a realized outcome of such an equilibrium we will find that some of the lenders offer the rationing contract while others offer the screening contract. More over, some of the borrowers' projects will be totally funded, some of the borrowers will be denied loans, and some will get loans of lesser amount than others due to the cost of screening.

Changes in δ: To see the effect of an improved financial infrastructure (measured by a lower cost of screening, δ) on the economy's growth rate, first note that a decrease in δ may increase the incidence of screening in equilibrium

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Since (C_H, C_L') and (C_H, C_L^s) are both incentive compatible and each individually yields zero profit to the lender, the randomized strategy, being the convex combination of the two, easily satisfies the incentive compatibility and zero profit condition.

contracts. To see this note from equations 4 and 9 that $\partial\rho^r/\partial\delta = \partial\rho^s/\partial\delta = 0$, and from Proposition 1 that $\partial\rho^*/\partial\delta > 0$. Now let δ_r be that δ yielding $\rho^* = \rho^r$ and let δ_s be that δ yielding $\rho^* = \rho^s$. Since $\rho^r > \rho^s$, it follows that $\delta_r > \delta_s$.[6]

We now have the following results. For $\delta \geq \delta_r$, $\rho^* \geq \rho^r > \rho^s$ (Case 1 above) and the rationing contract is the equilibrium one. For $\delta_r > \delta > \delta_s$, $\rho^r > \rho^* > \rho^s$ (Case 3 above) and there will be a mix of rationing and screening in equilibrium. For $\delta_s \geq \delta$, $\rho^r > \rho^s \geq \rho^*$ (Case 2 above), and the screening contract is the equilibrium one. Thus as δ falls from large values the economy will move from a rationing regime to a mixed regime, with an increasing use of screening, and then from a mixed regime to an exclusively screening regime.

The effects of a decrease in δ on growth rate are complicated by the fact that $g^r > , = , < g^s$, as $\delta > , = , < \delta^*$ (see equation 12). Given that δ_r and δ_s depend upon β_L, but δ^* does not, it is meaningful to consider the possibility that $\delta^* < \delta_s$ or $\delta_s < \delta^* < \delta_r$. In the former case (the latter follows a similar argument) a decrease in δ yielding $\delta_s < \delta < \delta_r$ will push the economy from rationing to a mix of rationing and screening. However, since $\delta_s > \delta^*$, the use of some screening will <u>decrease</u> the economy's growth rate. As δ falls further this effect is exacerbated until $\delta = \delta_s$ and screening is used exclusively to separate borrowers.

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[6] Implicitly we have assumed $\beta_L < Q\rho^s(p_L - \epsilon)$, so that loans are individually rational for low risk borrowers in the screening equilibrium. This condition is sufficient to assume $\delta_s > 0$

Only when δ falls below δ^* will the economy grow faster. Interpreting a small δ as a sophisticated financial sector, the above result implies that some threshold level of sophistication must be crossed before the benefits of an advanced financial sector become evident in higher growth. We have illustrated this situation by a numerical example in Appendix 1B.

5. Conclusion:

This paper considers an endogenous growth model in which an informational asymmetry exists between capital producing borrowers and lenders. One of our innovations is allowing flexibility in the means by which lenders can separate high risk borrowers from low risk borrowers. In contrast to the existing literature [for example, Bencivenga and Smith, 1993] the lender can induce self selection either by using a costly screening technology, or by rationing a fraction of borrowers, or by a mix of the two. Our other innovation is to show the mutual dependency between the equilibrium contract's form and the growth rate of the economy and to determine them jointly. The effect of the lower cost of screening (representing a more sophisticated financial sector) on the growth rate of output has been considered. We show that a decline in the screening cost, paradoxically, may lower the growth rate of output. In this case, only when some threshold level of sophistication is crossed will the benefit of an advanced financial sector become evident in a higher growth rate.

We have also shown the market determined equilibrium contract may not maximize output growth. Suppose, for example, that $g^s > g^r$, but the equilibrium contract is the rationing one. Then a policy inducing screening will increase the economy's growth rate, but initially will transfer incomes across generations. (For example, as $L^s < L^r$, the move from rationing to screening at time t will decrease marginal product of capital for time t old capital holders while increasing the real wage rate of young workers.) Only if the policy maker can borrow against future higher output levels to offset such transfers, could such a policy be a Pareto improvement.

Finally, due to the simple structure of our model, the marginal products of capital, the growth rate, and the contract regime are invariant with respect to time for a fixed δ. An interesting extension of our analysis would be to focus on the endogenous process by which the capital stock and the contracting regime jointly evolve over time. This could provide some additional insight in understanding the link between the credit market and the stages of economic development.

Appendix 1A

Proof of Proposition 1.1:

As noted in the text, the high risk borrower receives his first best contract $C_H = (R_{Ht}, q_{Ht}) = (Q\epsilon\rho_{t+1}/p_H, w_t)$. Given C_H, and also given the assumption that the lenders earn zero profits, the alternative contract acceptable to the low risk borrowers is determined by solving the following program:

Select: $(\phi_t, \pi_{Lt}^n, R_{Lt}^n, q_{Lt}^n, R_{Lt}^s, q_{Lt}^s)$ to maximize

$$\phi_t \{p_L \pi_{Lt}^n (Q\rho_{t+1} - R_{Lt}^n) q_{Lt}^n + (1 - \pi_{Lt}^n)\beta_L w_t\} + (1 - \phi_t)\{p_L(Q\rho_{t+1} - R_{Lt}^s)q_{Lt}^s\} \quad (A1)$$

Subject to :

$$\phi_t \pi_{Lt}^n (R_{Lt}^n q_{Lt}^n p_L - Q\epsilon\rho_{t+1}q_{Lt}^n) + (1 - \phi_t)[R_{Lt}^s p_L q_{Lt}^s - (1+\delta)q_{Lt}^s Q\epsilon\rho_{t+1}] = 0 \quad (A2)$$

$$p_H(Q\rho_{t+1} - \frac{Q\epsilon\rho_{t+1}}{p_H})w_t \geq \phi_t \pi_{Lt}^n p_H(Q\rho_{t+1} - R_{Lt}^n)q_{Lt}^n \quad (A3)$$

$$0 \leq \phi_t \leq 1; \ 0 \leq \pi_{Lt}^n \leq 1; \ 0 \leq q_{Lt}^n \leq w_t; \ 0 \leq q_{Lt}^s \leq \frac{w_t}{(1+\delta)}; \ 0 \leq R_{Lt}^n; \ 0 \leq R_{Lt}^s$$

Equation (A1) refers to the expected utility of the low risk borrower's accepting the contract C_L. Equations (A2) and (A3) refer to the zero profit constraint of the lender and the incentive compatibility constraint for the high risk borrower respectively. The zero profit constraint (A2) implies

$$\phi_t \pi_{Lt}^n (R_{Lt}^n q_{Lt}^n p_L) - (1 - \phi_t)R_{Lt}^s p_L q_{Lt}^s = [(1+\delta)q_{Lt}^s(1 - \phi_t) + \phi_t q_{Lt}^n \pi_{Lt}^n]Q\epsilon\rho_{t+1} \quad (A4)$$

Substituting this expression into (A1) we obtain a simplified objective function

$$\phi_t \pi_{Lt}^n (p_L Q\rho_{t+1}q_{Lt}^n - \beta_L w_t - Q\epsilon\rho_{t+1}q_{Lt}^n) + \phi_t \beta_L w_t + (1 - \phi_t)q_{Lt}^s\{p_L Q\rho_{t+1} - Q\epsilon\rho_{t+1}(1+\delta)\},$$
$$(A5)$$

which is maximized subject to (A2), (A3), and the inequality constraints noted above. Let us assume that the optimal solution is such that it satisfies $\phi_t \pi_{Lt}^n > 0$. We shall show later that this is indeed the case.

The problem can be further simplified by making the following obsevations: First, if screening occurs at all, we see that $\{p_L Q\rho_{t+1} - (1+\delta)\}$ must be positive. Since q_{Lt}^s does not appear in (A3), the optimal q_{Lt}^s is $w_t/(1+\delta)$. Second, neither of the interest rates appear (A5),

the simplified objective function, and R^n_{Lt} alone appears in (A3), the incentive compatibility constraint.

Note also from (A3) and (A5) that $\phi_t \pi^n_{Lt}$, and hence (A5) can be maximized by setting R^n_{Lt} as high as possible (i.e. by setting R^s_{Lt} as low as possible) while still satisfying (A2). Clearly then the optimal R^s_{Lt} is $R^s_{Lt} = 0$. Substituting the optimal values for q^s_{Lt} and R^s_{Lt} into (A4) yields,

$$R^n_{Lt} = Q\epsilon\rho_{t+1}\frac{[\phi_t \pi^n_{Lt} q^n_{Lt} + (1-\phi_t)w_t]}{\phi_t \pi^n_{Lt} q^n_{Lt} p_L} \tag{A6}$$

Substituting the expression for R^n_{Lt} in (A3) we rewrite the incentive compatibility constraint as

$$\left(1 - \frac{\epsilon}{p_{II}}\right)w_t \ge \phi_t \pi^n_{Lt} q^n_{Lt}\left(1 - \frac{\epsilon}{p_L}\right) - \epsilon(1-\phi_t)\frac{w_t}{p_L} \tag{A3$'$}$$

Finally the problem reduces to maximizing

$$\phi_t \pi^n_{Lt} q^n_{Lt}(p_L Q\rho_{t+1} - Q\epsilon\rho_{t+1}) + \phi_t \beta_L w_t(1 - \pi^n_{Lt}) + (1-\phi_t)Q\rho_{t+1}w_t\left(\frac{p_L}{(1+\delta)} - \epsilon\right) \tag{A5$'$}$$

subject to (A3$'$) and the resrictions on ϕ_t, π^n_{Lt}, and q^n_{Lt} .

Claim 1: The incentive compatibility constraint (A3$'$) is binding.

Let $(\phi_t, \pi^n_{Lt}, q^n_{Lt})$ be a triplet for which (A3$'$) is not binding. We need only to show that this triplet is dominated by one for which (A3$'$) is binding.

Subcase 1: (A3$'$) is not binding and $q^n_{Lt} < w_t$.

If the above is true then (A5$'$) can be increased by increasing q^n_{Lt} until (A3$'$) is binding or until $q^n_{Lt} = w_t$. If (A3$'$) is binding for $q^n_{Lt} = \tilde{q} < w_t$ then (A3$'$) is binding for the triplet $(\phi_t, \pi^n_{Lt}, \tilde{q})$ and this triplet dominates the original. Suppose (A3$'$) is not binding for $q^n_{Lt} = w_t$. Then we consider the following sub case:

Subcase 2: (A3$'$) is not binding and $q^n_{Lt} = w_t$, $\pi^n_{Lt} < 1$.

The individual rationality criterion of the low risk borrowers implies $Q\rho_{t+1}(p_L - \epsilon) > \beta_L$. Thus (A5') is increasing in π_{Lt}^n. If $\pi_{Lt}^n < 1$, increasing π_{Lt}^n until (A3') binds or until $\pi_{Lt}^n = 1$ will increase (A5'). If (A3') becomes binding for $\pi_{Lt}^n = \tilde{\pi} < 1$, then $(\phi_t, \tilde{\pi}, w_t)$ dominates the original and (A3') is binding. If (A3') is not binding for $(\phi_t, 1, w_t)$ then we consider the following subcase:

Subcase 3: (A3') is not binding and $q_{Lt}^n = w_t$, $\pi_{Lt}^n = 1$.

If $q_{Lt}^n = w_t$ and $\pi_{Lt}^n = 1$, then from (A3'), it must be the case that $\phi_t < \phi^s \equiv 1 - \epsilon\left(\frac{1}{p_H} - \frac{1}{p_L}\right)$ < 1. Note that (A5') is increasing in ϕ_t, given $q_{Lt}^n = w_t$ and $\pi_{Lt}^n = 1$. Thus increasing ϕ_t to ϕ^s, at which point (A3') becomes binding again increases (A5'). Therefore $(\phi^s, 1, w_t)$ dominates the original.

Thus in either case we can find a triplet for which (A3') is binding and which dominates the original $(\phi_t, \pi_{Lt}^n, q_{Lt}^n)$. Therefore (A3') must bind at the optimal contract. $\square$

Claim 2: The optimal $q_{Lt}^n = w_t$.

Let $(\phi_t, \pi_{Lt}^n, q_{Lt}^n)$ be a triplet for which (A3') is binding and $q_{Lt}^n < w_t$. To see this triplet is dominated by one for which $q_{Lt}^n = w_t$, note two things. First, π_{Lt}^n and q_{Lt}^n enter (A3') as the product $\pi_{Lt}^n q_{Lt}^n$. Second, (A5') is decreasing in π_{Lt}^n, if one holds $\pi_{Lt}^n q_{Lt}^n$ fixed. From these facts, it follows that one can increase q_{Lt}^n to w_t and decrease π_{Lt}^n to $\tilde{\pi}$, holding $\pi_{Lt}^n q_{Lt}^n$ fixed. Doing this one obtains a triplet $(\phi_t, \tilde{\pi}, w_t)$ which satisfies (A3') as an equality and which dominates the original triplet. Therefore the optimal q_{Lt}^n is w_t. $\square$

As (A3') binds and $q_{Lt}^n = w_t$, we obtain the expression for $\phi_t \pi_{Lt}^n$ from (A3')

$$\phi_t \pi_{Lt}^n = \frac{p_L\left(1 - \frac{\epsilon}{p_H}\right) + \epsilon(1 - \phi_t)}{(p_L - \epsilon)} \tag{A3''}$$

Substituting the expression for $\phi_t \pi_{Lt}^n$ from (A3'') and $q_{Lt}^n = w_t$ into the objective function (A5') we get

$$Q\rho_{t+1}w_t\left(p_L\left(1 - \frac{\epsilon}{p_H}\right) + \epsilon(1 - \phi_t)\right) + \phi_t \beta_L w_t - \beta_L w_t\left(\frac{p_L\left(1 - \frac{\epsilon}{p_H}\right) + \epsilon(1 - \phi_t)}{(p_L - \epsilon)}\right)$$

$$+ (1 - \phi_t)Q\rho_{t+1}w_t\left(\frac{p_L}{1+\delta} - \epsilon\right)$$

$$= w_t p_L \left(1 - \frac{\epsilon}{p_H}\right)\left(Q\rho_{t+1} - \frac{\beta_L}{p_L - \epsilon}\right) + \phi_t \beta_L w_t + (1 - \phi_t) w_t \left(Q\rho_{t+1}\epsilon - \frac{\beta_L \epsilon}{p_L - \epsilon}\right.$$

$$\left. + Q\rho_{t+1}\left(\frac{p_L}{1+\delta} - \epsilon\right)\right)$$

$$= w_t p_L \left(1 - \frac{\epsilon}{p_H}\right)\left(Q\rho_{t+1} - \frac{\beta_L}{p_L - \epsilon}\right) + \phi_t \beta_L w_t + (1 - \phi_t) w_t \left(Q\rho_{t+1}\frac{p_L}{1+\delta} - \frac{\beta_L \epsilon}{p_L - \epsilon}\right) \tag{A5''}$$

Now the objective function is linear in ϕ_t. Thus the optimal ϕ_t is $\phi_t = 1$ or the smallest ϕ_t compatible

with (A3'). If $\beta_L > \left(Q\rho_{t+1}\frac{p_L}{1+\delta} - \frac{\beta_L \epsilon}{p_L - \epsilon}\right)$ or equivalently $\beta^* \equiv Q\rho_{t+1}\frac{p_L - \epsilon}{1+\delta} < \beta_L$, it is

optimal for the lender to set $\phi_t = 1$. This, in turn, implies that no screening takes place. The corresponding expressions for π^n_{Lt} and R^n_{Lt} can be obtained from (A3'') and (A6) respectively. If the inequality holds in the reverse direction, the lender sets ϕ_t as small as possible. This is achieved by setting $\pi^n_{Lt} = 1$.

Substituting $\pi^n_{Lt} = 1$, the optimal values for ϕ_t and R^n_{Lt} follow immediately from equations (A3'') and (A6) respectively. The optimal ϕ_t lies between 0 and 1. Thus we have either $\phi_t = 1$, $0 < \pi^n_{Lt} < 1$ or $0 < \phi_t < 1$ and $\pi^n_{Lt} = 1$. There is rationing or screening but not both. Finally to verify $\phi_t \pi^n_{Lt} \neq 0$, one simply compares low risk borrower's payoff when $\phi_t \pi^n_{Lt} = 0$ with the solutions when $\phi_t \pi^n_{Lt} > 0$. This completes our proof. $\square$

Appendix B

$p_H = 0.4$, $p_L = 0.7$, $\epsilon = 0.25$, $\beta_L = 0.35$, $\theta = 0.3$, $Q = 2$, $\lambda = 0.75$

	$\delta=0.6$	$\delta=0.4$	$\delta=0.25$	$\delta=0.21$	$\delta=0.05$
τ	0.58	0.58	0.58	0.58	0.58
ϕ	0.73	0.73	0.73	0.73	0.73
g^r	1.100	1.100	1.100	1.100	1.100
g^s	1.078	1.08	1.097	1.100	1.114
ρ^r	0.608	0.608	0.608	0.608	0.608
ρ^s	0.505	0.505	0.505	0.505	0.505
ρ^*	0.622	0.544	0.486	0.470	0.408

When $\delta=0.6$, $\rho^* > \rho^r > \rho^s$. Thus rationing regime prevails and the economy's growth rate is $g^r = 1.10 > 1.07 = g^s$. The relation $\rho^r > \rho^* > \rho^s$ sets in as δ falls to 0.4. The resulting equilibrium lending regime is a mixed one. The growth rate, being the convex combination of $g^r(=1.10)$ and $g^s(=1.08)$, falls below $g^r(=1.10)$. A pure screening regime sets in when δ falls to 0.25 and the corresponding growth rate is $g^s(=1.097) < g^r(=1.10)$. Only when δ falls below the threshold level 0.21, g^s exceeds g^r.

Diagram 1

Relation Between Growth rate of Output and Cost of Screening (δ)
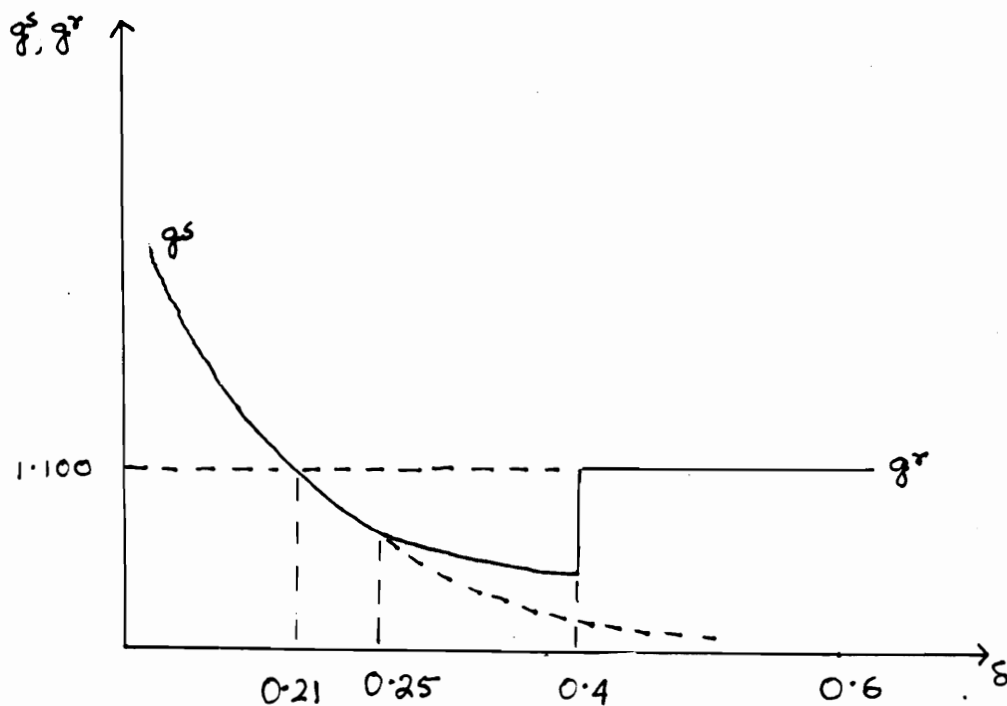
The above diagram is based on the numerical example in Appendix B. The solid line represents the relation between growth rate of output and the cost of screening.

Chapter 2:   Asymmetric Information and Loan Contracts in a Neoclassical Growth Model

As external funding is an important source of funds for investors, any friction in transferring funds from lenders to investors affects the process of ital formation and therefore the growth and development of an economy. Recognizing that such frictions may arise due to informational asymmetries between lenders and investors, recent research has provided microeconomic foundations for analyzing credit markets in the presence of informational imperfections. Parallel to this interest in the functioning of credit markets has been an increased interest in economic growth. Not surprisingly, economists have begun to integrate the two literatures. Important contributions in this direction are Tsiddon (1992), Azariadis and Smith (1993), and Bencivenga and Smith (1993). Also, in recent years there has been a resurgence of interest in the relationship between the financial development and economic growth. References include Greenwood and Jovanovic (1990), Bencivenga and Smith (1991), King and Levine (1993a, 1993b). This paper continues these lines of research by investigating the mutual dependency between economic development and the structure of loan contracts in the presence of asymmetric information.

In our paper, we consider a neoclassical growth model in which a borrower (an investor) knows his risk type but a lender does not.   This

asymmetry of information induces lenders to offer loan contracts that separate borrowers as to type by means of the borrower's contract choice (that is, by self selection). In previous works [see, for example, Azariadis and Smith (1993), Bencivenga and Smith (1993)], separation has been achieved through the use of credit rationing. However, in contrast to previous models, our lenders can screen a fraction of the borrowers by expending resources to determine a borrower's type. As a result of this possibility, separating high risk from low risk borrowers takes one of two possible forms. First, as in previous papers, a lender can choose to separate borrowers by offering a contract that rations credit. As a second possibility, in contrast to previous works, our lenders may separate borrowers by acquiring relevant information about a fraction of the borrowers. In this case, the loan contract involves a specified probability of screening. We call this contract a screening contract. The question arises as to what determines the loan contract's form. We show that the equilibrium contract's form -- be it a rationing contract, a screening contract, or a mix of the two -- depends on the level of capital accumulation in the economy and vice versa. Thus, there exists a mutual dependency between the contract form and the level of capital accumulation. Given this interdependency, we jointly determine the equilibrium contract and the equilibrium dynamic path along which capital accumulates.

It has been observed that investors, particularly in developing countries,

face the prospect of credit rationing.[7] In addition, institutions, which provide information about borrowers, such as credit rating agencies and sound accounting, auditing, and disclosure regulations, seldom exist in poor developing economies and increasingly emerge in the higher stages of development.[8] Results in our model support these stylized facts. We show that at a low level of capital accumulation, the rationing contract is the equilibrium contract. As capital accumulates, a fraction of lenders may begin to use the screening technology to separate borrowers and thus there may exist both rationing and screening contracts in equilibrium. The fraction of lenders offering the rationing contract decreases with further capital accumulation. Finally, if the capital stock reaches a critical level, the rationing contract will disappear and the credit market will be in a pure screening equilibrium. We also show that an economy with screening contracts grows along a higher capital accumulation path and will attain a higher steady state capital stock than one with rationing contracts. Thus, in a transition from the use of credit rationing to the use of at least some screening, the capital stock is pushed onto a higher dynamic path and to a higher steady state capital stock. These results show a connection between economic development and financial development (as exhibited by the lessened presence of credit rationing). However, it is possible that as capital accumulates, the economy may become trapped in a steady state with credit rationing and with a low level of capital. A

See McKinnon (1973), Basu (1984, p 120,152). For further evidence, see references mentioned in Bencivenga and Smith (1993).

For details, see to World Bank Report (1989) on financial systems and development.

switch to the screening of borrowers may not occur. We derive the condition under which this is the case.

Our paper also investigates the effect of an increase in the degree of financial sophistication (represented by a decrease in the cost of screening) on the economy's growth path and steady state. In an economy where the screening regime prevails, a decrease in the cost of screening results in a higher capital accumulation path and a higher steady state capital stock. In an economy where the rationing regime holds, a decrease in the cost of screening may move the credit market from the rationing equilibrium to the screening one and thus may push the economy to a higher steady state capital stock. However, for this to happen, the cost of screening must fall below a threshold level[9], since otherwise, the credit rationing equilibrium will still prevail and the economy will remain trapped in a low state of development.

The paper proceeds as follows: Section 1 describes the basic structure of the model. In section 2, we analyze the credit market in a partial equilibrium setting. In section 3, we determine the capital accumulation path and steady state corresponding to each contacting regime. Section 4 and section 5 jointly

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The existence of such a threshold level has also been discussed in Bose and Cothren (1994). In Bose and Cothren (1994) we determine the equilibrium growth rate and the contracting regime jointly in a simple endogenous growth model. However, due to the model's simple structure, the equilibrium growth rate and loan contract are time invariant. Thus the model fails to show how loan contracts and the capital stock evolve over time and therefore the link between financial and economic development is not established.

determine the equilibrium loan contract and capital's dynamic path. Also section 5 discusses the effect of an improved financial infrastructure (measured by lower cost of screening) on the steady state of the economy. Section 6 concludes.

1.The model

With some variation, the description of our economy closely follows that of Bencivenga and Smith (1993). We consider an infinitely lived economy with discrete time indexed by $t = 0,1,2, \ldots$. The economy consists of an infinite sequence of two period lived overlapping generations. All generations are identical in size and composition. For convenience, we normalize the size of each generation to one.

Young agents are divided into two groups of equal sizes, referred to as borrowers and lenders. Each young borrower has a single investment project at his disposal. This project is either a type H or a type L, indicating a high risk or a low risk project. The high risk project has a lower probability of success than the low risk project. We assume that a fraction λ of the borrowers have type H projects and investment projects differ only in terms of their probabilities of success. Each investment project requires one unit of labor and converts consumption goods into capital goods using a linear technology. With probability

p_i, the investment project of the type i borrower converts x units of time t output and one unit of labor into Q.x units of time $t+1$ capital. With probability (1 - p_i), the project is a failure and yields zero units of capital. The p_i's satisfy $1 \geq p_L > p_H \geq 0$.

Young borrowers are endowed with a single unit of labor and can run their own projects. However, they are not endowed with output and therefore must seek external funds to finance their investment projects. If such funding is available, the borrower proceeds with his project utilizing his labor endowment. If no funds are forthcoming, the high risk borrower, having no outside opportunity, consumes nothing over his life time. In contrast, the low risk borrower, if unfunded, can use his labor in the home production of goods. Output produced at home at time t yields β_L units of time $t+1$ consumption, β_L < 1. Borrowers wish to consume in the second period of life and are risk neutral.

The class of agents called borrowers become firm operators at time $t+1$. The firm operators are able to rent capital (in positive or negative amounts) and hire labor at the competitively determined rental rates ρ_{t+1} and w_{t+1}, respectively. A firm employing k units of capital and L units of labor produces y units of output, as given by

$$y_t = k_t^{\theta} \cdot L_t^{1-\theta} \cdot \quad \textbf{(5)}$$

As noted, this output can be consumed or used for investment projects.

Each young lender is endowed with one unit of labor which is supplied inelastically to the competitive market, earning the ruling wage rate. The lender is risk neutral and wishes to consume in the second period of life. To obtain goods in the second period of life, the lender can convert his wage at time t, w_t, into $Q.\epsilon.w_t$ units of capital in time $t+1$ and can rent this amount to firms. Alternatively, the lender can lend his wage to a borrower in return for capital in $t+1$. We assume that ϵ is sufficiently smaller than p_H to ensure that loans will be made.

There exists an informational asymmetry between the borrower and lender in the credit market as each borrower's type is private information. However, we also assume that a lender can determine a borrower's type at a resource cost which is proportional to the amount lent.[10] Thus if q units of output are lent to the borrower, the resource required to determine the borrower's type is $\delta.q$, where δ is an exogenously given positive number.

The proportionality assumption between the amount lent and the cost of screening can be justified as follows. Operating a project requires performing a variety of tasks. Whether a project is a high risk or a low risk type depends on the ability of the borrower to carry out these tasks successfully. Typically, any project that uses larger amounts of resources also involves a larger variety of tasks. Therefore, to screen a project that involves larger resources, a lender needs to evaluate the borrower's ability to perform a larger set of tasks. This in turn implies a larger resource cost for screening.

2. The Credit market

At the beginning of a period each lender offers a set of loan contracts. The borrowers have complete knowledge about the types of loan contracts offered by each lender. If a lender's contracts are not dominated by those of any other lender, the lender is approached by a potential borrower. We assume that each potential borrower can apply only to one lender for a loan[11]. The credit market equilibrium at time t is defined to be a set of loan contracts such that there is no incentive for any lender to offer a alternative set, taking the marginal product of capital at $t+1$ and the offers of the other lenders as given.

Recall that the high risk and the low risk borrowers face different opportunities apart from running investment projects. This ensures that the indifference curves of the two types satisfy the single crossing property in the contract plane. As discussed by Azariadis and Smith (1993) and Bencivenga and Smith (1993), the only equilibrium contract in this setting has each lender offering a set of contracts that induces the separation of borrowers as to type. As do Bencivenga and Smith, we assume that the fraction of the high risk borrowers is sufficiently large that such an equilibrium exists. The equilibrium loan contracts at time t, denoted C_H and C_L, and are such that the C_H contract is selected by the

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This assumption provides a bound on the loan size which is necessary in the presence of a linear production technology for capital.

type H borrowers and the C_L contract, by the type L borrowers. We assume that competition in the credit market drives the lender's economic profit to zero on each contract.

In our framework, a low risk borrower has no incentive to be considered as a high risk. In such a situation, the separation of borrowers is induced by distorting the first best contract of low risk borrowers, while high risk borrowers are offered their first best contract, given their type and the zero profit constraint of the lender. Thus, in equilibrium the C_H contract specifies a loan size of $q_{Ht}=w_t$ and a loan rate of $R_{Ht}=Q.\epsilon.\rho_{t+1}/p_H$, which assures a zero economic profit for the lender. Given that a lender can acquire information about a borrower's type by expending resources, the C_L loan contract includes terms other than the loan rate and quantity. In its most general form, the C_L loan contract comes in the form $[\{\phi_t,\pi_{Lt}^n,q_{Lt}^n,R_{Lt}^n\}; \{(1-\phi_t),q_{Lt}^s,R_{Lt}^s\}]$, where ϕ_t denotes the probability with which the borrower is <u>not</u> screened. If not screened, the borrower's project is funded with probability π_{Lt}^n (credit is rationed if $\pi_{Lt}^n < 1$). If the borrower's project is funded, the loan quantity and the gross interest rate offered are q_{Lt}^n and R_{Lt}^n respectively. The borrower is screened with probability $(1-\phi_t)$. In this event, if the borrower is a low risk one, the loan quantity and the gross interest rate are q_{Lt}^s and R_{Lt}^s respectively. If, when screened, the borrower is found to be a high risk one, the lender's optimal behavior is to deny a loan to the borrower, since by imposing this maximum penalty, the lender can make the contract C_L as

unattractive as possible to a high risk borrower and thereby increase the utility of the low risk borrower in equilibrium. In this framework, the distortion of low risk borrower's first best contract can be achieved by rationing a fraction of low risk borrowers i.e. $\pi_{Lt}^n < 1$ [as in Bencivenga and Smith (1993)], or by screening a fraction of low risk borrowers i.e. $\phi_t < 1$, or by a combination of the two. This section determines when one method prevails over the other.

Before we fully characterize the equilibrium contract C_L, consider the possibility that, in equilibrium, C_L involves some screening ($\phi_t < 1$). When screening occurs there is a loss of δ units of output per unit lend. Thus the total amount lent after screening is constrained by $q_{Lt}^s \leq w - \delta.q_{Lt}^s$, that is, by $q_{Lt}^s \leq w/(1 + \delta)$. The optimal contract is determined as follows:

Proposition 2.1:

(1) If $\beta^* \equiv \{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta) > \beta_L$, then in equilibrium, the lenders offer the contract $C_L = C_L^s$, whose terms are

$$\pi_{Lt}^n = 1 \text{ and } \phi_t \equiv \phi^s = 1 - (1/p_H - 1/p_L).\epsilon \qquad 2(a)$$

$$R_{Lt}^n = Q.\epsilon.\rho_{t+1}/(\phi^s.p_L) \text{ and } R_{Lt}^s = 0 \qquad 2(b)$$

$$q_{Lt}^n = w_t \text{ and } q_{Lt}^s = w_t / (1 + \delta) \qquad 2(c)$$

(2) If $\beta^* \equiv \{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta) < \beta_L$, then in equilibrium, the lenders offer the contract $C_L = C_L^r$, whose terms are,

$$\pi_{Lt}{}^n \equiv \pi^r = (1-\epsilon/p_H)/(1-\epsilon/p_L) \quad \text{and} \quad \phi_t = 1 \qquad\qquad 2(d)$$

$$R_{Lt}{}^n = Q.\epsilon.\rho_{t+1}/p_L \quad \text{and} \quad q_{Lt}{}^n = w_t \qquad\qquad 2(e)$$

(3) If $\beta^* \equiv \{p_L.Q.\rho_{t+1} - Q.\epsilon.\rho_{t+1}\}/(1+\delta) = \beta_L$, then in equilibrium, the lender is indifferent between offering $C_L{}^s$ and $C_L{}^r$.

Proof: See Appendix 2A

Several results in Proposition 2.1 deserve comment. First, note that when rationing occurs the net payoff to the low risk borrower is β_L, as he reverts to home production. The net expected payoff in screening states is $\{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta)$. Clearly screening dominates rationing if $\beta^* \equiv \{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta) > \beta_L$. Also, note that the optimal contract will have screening or rationing but not both. As noted in equation 2(a), if $\beta_L < \beta^*$, screening occurs with non-zero probability, $1 - \phi^*$. With probability ϕ^*, the borrower is not screened and the probability of rationing, $1 - \pi_t{}^n$, is zero. Conversely as equation 2(d) states, if $\beta_L > \beta^*$, there is rationing but no screening.

Equation 2(b) shows, the interest rate for the screened borrower is zero. The intuition behind this result is straight-forward. When using the possibility of screening to separate borrowers, the lender optimizes by making the non-

screening contract as unattractive as possible for the dissembling high risk borrower. This implies that the lender should make the screening interest rate, R_{Lt}^*, zero while setting the non-screening rate, R_{Lt}^n, high enough to offset potential losses. (Of course this result hinges upon the lender's being risk neutral. Nonetheless, one expects some subsidization of screened borrowers by non-screened borrowers ought to hold still with more general specifications of the lender's utility).

Finally, note β^* is increasing in p_L and Q and decreasing in δ. Thus screening becomes more attractive when p_L or Q increases and less so when δ increases.

3. The Capital Accumulation Path For the Economy

Proposition 2.1 shows that the equilibrium contract, among the other factors, depends upon the rate of return to capital, ρ_{t+1} and the wage rate w_t. These facts imply the equilibrium contract at time t depends on the levels of capital at time t and t+1. In turn, as we show in this section, the capital accumulation path depends upon the terms of the equilibrium contract.

Case 1: $\{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta) < \beta_L$

If the above inequality holds, $\phi^* = 1$ and borrowers are not screened. Therefore, the equilibrium contract is given by (C_H, C_L'), where C_L' is described in Proposition 1 by equations 2(d) and 2(e).

The capital stock at $t+1$ comes from successful, funded borrowers and from lenders who converted their wages into capital after rationing low risk borrowers. The former amount is $0.5 \times Q.w_t.[\lambda.p_H + (1 - \lambda).p_L.\pi^*]$ and the latter is $0.5 \times Q.\epsilon.w_t.(1 - \pi^*)(1 - \lambda)$. Thus the per firm capital stock is

$$k_{t+1} = [\{\lambda.p_H + (1-\lambda)p_L.\pi^*\} + \{(1-\pi^*)(1-\lambda).\epsilon\}].Q.w_t. \qquad (4)$$

In equilibrium all firms employ an equal amount of labor. Since there is equal number of borrowers and lenders, labor/firm $\equiv L_t = 1$ at each time period. The wage rate at time t is

$$w_t = (1-\theta).k_t^\theta.(L_t)^{-\theta} = (1-\theta).k_t^\theta. \qquad (5)$$

Substituting (5) in (4) we get,

$$k_{t+1}^r = [\{\lambda p_H + (1-\lambda)p_L\pi^*\} + \{(1-\pi^*)(1-\lambda)\epsilon\}]Q(1-\theta)k_t^\theta \equiv A.(k_t)^\theta, \qquad (6)$$

and where the superscript 'r' denotes the rationing case.

Figure (1) shows the dynamic path of capital represented by equation (6). From now on we shall refer to this path as 'Path R'. For Path R, the only non-trivial steady state is given by

$$k^r_{ss} = [A]^{1/(1-\theta)}. \tag{7}$$

Also note that, since $p_L > \epsilon$, $\partial A/\partial \pi^* = Q(1-\theta)(1-\lambda)(p_L-\epsilon) > 0$, implying that a decrease in credit rationing shifts the capital accumulation curve up resulting in a higher steady state capital stock.

Case 2: $\{(p_L - \epsilon).Q.w_t.\rho_{t+1}\}/(1+\delta) > \beta_L$

In this case, lenders will screen a fraction of the low risk borrowers. In such a situation, all low risk borrowers obtain loans; however, the loan amount and the loan rates will differ across the low risk borrowers. So to differentiate from the previous case, we write the equilibrium variables in this section with a superscript 's'.

The total capital stock at $t+1$ emanates from successful high risk borrowers and low risk borrowers (some of whom are screened). Its value is

$$0.5Qw_t[\lambda p_H + (1-\lambda)\phi^s p_L + (1-\lambda)(1-\phi^s)p_L/(1+\delta)] = 0.5Qw_t[\lambda p_H + (1-\lambda)p_L(1+\delta.\phi^s)/(1+\delta)]$$

The capital stock per firm is thus given by

$$k^s_{t+1} = Qw_t[\lambda p_H + (1-\lambda)p_L(1+\delta\phi^s)/(1+\delta)] = Q(1-\theta)[\lambda p_H + (1-\lambda)p_L(1+ \cdot\phi^s)/(1+\delta)]k_t^\theta$$

$$\equiv B.(k_t)^\theta \tag{8}$$

Figure (1) shows the capital accumulation path represented by equation (8). We shall refer to this path as 'Path S'. Note $\partial B/\partial\phi^s > 0$ and $\partial B/\partial\delta < 0$, implying that as the incidence of screening $(1-\phi^s)$ and the cost of screening fall, the economy moves to a higher capital accumulation path. For Path S, the only non-trivial stable steady state is given by

$$k^s_{ss} = [B]^{1/(1-\theta)} \tag{9}$$

A comparison of equations (6) and (7) with (8) and (9) shows that the screening and the rationing contracts lead to different capital accumulation paths for the economy. The distinction between the two paths is delineated in the next proposition.

Proposition 2.2: The screening contract yields a higher capital accumulation path and a higher steady state level of capital per firm than does the rationing contract. That is, for a given k_t, $k^s_{t+1} > k^r_{t+1}$ and $k^s_{ss} > k^r_{ss}$.

Proof: Note that the proof of Proposition 2.2 is equivalent to showing B > A. Recall that under both the rationing and the screening regime the high risk borrower obtains his first best contract. Let U^*_H denote the utility of the high risk borrowers in their first best contract. The incentive compatibility constraint for the high risk borrower binds in both the screening and rationing regimes. Using Proposition 1 we obtain

$$U^*_H = p_H.\pi^r.[Q.\rho_{t+1} - Q\epsilon\rho_{t+1}/p_L].w_t \quad \text{and} \quad U^*_H = \phi^s.p_H.[Q.\rho_{t+1} - Q\epsilon\rho_{t+1}/\phi^s p_L].w_t$$

The above expressions yield,

$$Q.\rho_{t+1}.\phi^s - Q.\rho_{t+1}.\epsilon/p_L = Q.\rho_{t+1}.\pi^r - Q.\rho_{t+1}.\pi^r.\epsilon/p_L.$$

Since $p_L > \epsilon$, we can set $\epsilon = x.p_L$, where $0 < x < 1$. Substituting for ϵ in the above expression yields,

$$\phi^s = \pi^r + x.(1 - \pi^r). \tag{10}$$

Equation 12 implies that $\phi^s > \pi^r$, so the probability of screening, $1-\phi^s$, is less than the probability of rationing, $1-\pi^*$. [The intuition for this is as

follows: Under a screening contract the lender, by shifting the entire burden of interest payments from the 'screening' to the 'non- screening' event makes the contract less attractive to the high risk borrowers. This fact gives the screening contract a degree of freedom unavailable to the rationing contract.]

From equation (6) and (8),

$$B > A \Leftrightarrow (1 + \delta.\phi')/(1 + \delta) > \pi^* + x.(1 - \pi^*) = \phi^s,$$

where the equality sign holds from equation (10). As $(1 + \delta.\phi')/(1 + \delta) > \phi^s$, we have $B > A$ and the desired results hold. [Given equation (10), the intuition behind this result is clear. Since $\phi^s > \pi^r$, in a screening regime more projects are fully funded and hence more capital is accumulated.]

4. The Equilibrium Contract

Although the screening contract yields a higher capital accumulation path and a higher steady state capital stock, this does not guarantee that the screening contract will be the equilibrium contract in or out of the steady state. From Proposition 1 it follows then that the contract's form depends upon the wage rate, w_t, and the marginal product of capital, ρ_{t+1}, and hence upon the time t and time t+1 capital stock. Of course, the time t+1 capital stock depends upon the contract's form at time t; so there exists a mutual dependency between the time path of the capital stock and the contracting regime. The objective of this section

is to illustrate more clearly this mutual dependency and to determine the time t

equilibrium loan contract. This will enable us to determine the equilibrium

dynamic path for capital in the next section.

To address these issues, first note from equation (1) and the fact that L_t

$= 1$, the time $t+1$ marginal product of capital is $\rho_{t+1} = \theta k_{t+1}^{\theta-1}$. Thus if the time

t contract is the rationing one, the marginal product of capital at $t+1$ is

$$\rho^r_{t+1} = \theta.(k^r_{t+1})^{\theta-1} = \theta.[Ak^\theta]^{\theta-1},$$

(11)

as follows from equation (6). If the time t contract is the screening one, equation

(8) yields

$$\rho^s_{t+1} = \theta.(k^s_{t+1})^{\theta-1} = \theta.[B.k^\theta_t]^{\theta-1},$$

(12)

Since $B > A$, for a given k_t we have, $k^s_{t+1} > k^r_{t+1}$ and hence $\rho^s_{t+1} < \rho^r_{t+1}$.

Consider the variables $\beta^*_r = \{(p_L - \epsilon).Q.w_t.\rho^r_{t+1}\}/(1+\delta)$ and $\beta^*_s = \{(p_L -$

$\epsilon).Q.w_t.\rho^s_{t+1}\}/(1+\delta)$. β^*_r and β^*_s are the expressions for β^* (in Proposition 1) for

the rationing and screening case respectively. Substituting the values of w_t, ρ^r_{t+1},

and ρ^s_{t+1} from equations (5), (11), and (12) respectively we can rewrite β^*_r and β^*_s as

$$\beta^*_r = \{(p_L - \epsilon)/(1+\delta)\}.Q.\theta.(1-\theta).A^{\theta-1}.(k^\theta_t)^\theta \equiv \beta^*_r(k_t) \qquad (13)$$

$$\beta^*_s = \{(p_L - \epsilon)/(1+\delta)\}.Q.\theta.(1-\theta).B^{\theta-1}.(k^\theta_t)^\theta \equiv \beta^*_s(k_t) \qquad (14)$$

Note that $\beta^*_r(k_t)$ and $\beta^*_s(k_t)$ are both increasing function of k_t and as $B > A$, we have $\beta^*_s(k_t) < \beta^*_r(k_t)$. We have plotted the functions $\beta^*_r(k_t)$ and $\beta^*_s(k_t)$ in Figure 2. Given $\beta^*_r(k_t) > \beta^*_s(k_t)$, we need only to consider the three following cases.

Case 1: $\beta_L \geq \beta^*_r(k_t) > \beta^*_s(k_t)$

If for a given k_t Case 1 holds, then the rationing pair (C_H, C_L^r) is the only equilibrium pair at time t. To see this, suppose lenders offer the contracts (C_H, C_L^r), and as a result, the marginal product of capital is $\rho^r_{t+1} = \theta.[Ak^\theta_t]^{\theta-1}$. Given $\beta_L \geq \{(p_L - \epsilon).Q.w_t.\rho^r_{t+1}\}/(1+\delta) = \{(p_L - \epsilon)/(1+\delta\}.Q.\theta.(1-\theta).A^{\theta-1}.(k^\theta_t)^\theta = \beta^*_r(k_t)$, no lender has the incentive to deviate and to offer (C_H, C_L^s) while others are offering (C_H, C_L^r). Therefore, at time t, (C_H, C_L^r) is an equilibrium contract pair. To see that this is the unique equilibrium, suppose lenders offer (C_H, C_L^s). The equilibrium marginal product of capital in such a situation is ρ^s_{t+1}. Given $\beta_L > \{(p_L - \epsilon).Q.w_t.\rho^s_{t+1}\}/(1+\delta) = \{(p_L - \epsilon)/(1+\delta\}.Q.\theta.(1-\theta).B^{\theta-1}.(k^\theta_t)^\theta = \beta^*_s(k_t)$, the optimal behavior of a lender will be to deviate and offer (C_H, C_L^r). Therefore (C_H, C_L^s) cannot be an equilibrium contract pair.

Case 2: $\beta^*_r(k_t) > \beta^*_s(k_t) \geq \beta_L$

Using the line of argument from Case 1, it is easy to see that in this case (C_H, C_L^s) is unique equilibrium pair.

Case 3: $\beta^*_r(k_t) > \beta_L > \beta^*_s(k_t)$

If the above relation holds, no pure strategy equilibrium exists in the credit market. To see this, suppose the lenders are offering the rationing contract (C_H, C_L^r). Given $\beta^*_r(k_t) > \beta_L$, it is optimal for any lender to deviate and offer the screening contract (C_H, C_L^s). Therefore (C_H, C_L^r) cannot be the equilibrium contract. Suppose lenders are offering the screening contract (C_H, C_L^s). Given $\beta_L > \beta^*_s(k_t)$, it is optimal for any lender to deviate and offer the rationing contract (C_H, C_L^r). Therefore (C_H, C_L^s) cannot be an equilibrium pair. In this case there exists an equilibrium where the lenders randomize between the two strategies, offering the contract (C_H, C_L^r) with probability μ and the contract (C_H, C_L^s) with probability $(1-\mu)$. we show this in the following proposition:

Proposition 2.3: If for any k_t the relation $\beta^*_r(k_t) > \beta_L > \beta^*_s(k_t)$ holds, then there exists a $\mu^* \in (0,1)$ and an equilibrium at time t, where lenders offer (C_H, C_L^r), the rationing contracts, and (C_H, C_L^s), the screening contracts, with probabilities μ^* and $(1-\mu^*)$ respectively. As a result, the capital accumulation path

will lie between Path R and Path S.

Proof: Let k^m_{t+1} and ρ^m_{t+1} denote the time $t+1$ capital stock and the marginal product of capital when lenders at time t offer the rationing contract with probability μ and the screening contract with probability $(1-\mu)$. It is easy to see that $k^m_{t+1} = [\mu A + (1-\mu)B]k^\theta_t$ implying that the capital accumulation path lies between the Path R and Path S.

Consider the function $\beta^*_m = \{(p_L - \epsilon).Q.w_t.\rho^m_{t+1}\}/(1+\delta)$. β^*_m is the expression for β^* (in Proposition 2.1) for $\rho_{t+1} = \rho^m_{t+1}$. Of course if β^*_m is strictly greater or less than β_L, then clearly the randomized strategy will fail to be an equilibrium strategy. The mixed strategy is the equilibrium strategy if and only if $\beta^*_m = \beta_L$. Substituting for ρ^m_{t+1} we get

$\beta^*_m = \{(p_L - \epsilon)/(1+\delta)\}Q\theta(1-\theta)[\mu A + (1-\mu)B]^{\theta-1}.[k^\theta_t]^\theta$. Clearly β^*_m lies between $\beta^*_r(k_t)$ and $\beta^*_s(k_t)$ [given by equations (13) and (14) respectively]. Since for the given k_t, $\beta^*_r(k_t) > \beta_L > \beta^*_s(k_t)$, there always exists a unique μ^* yielding $\beta^*_m = \beta_L$. For this μ^*, the described scenario is an equilibrium outcome in mixed strategies ◉

Let k^r_c and k^s_c denote the capital stock levels that solve the equations $\beta^*_r(k_t)$
$\equiv \{(p_L - \epsilon)/(1+\delta)\}.Q.\theta.(1-\theta).A^{\theta-1}.(k^\theta)^\theta = \beta_L$ and $\beta^*_s(k_t) \equiv \{(p_L - \epsilon)/(1+\delta)\}.Q.\theta.(1-\theta).B^{\theta-1}.(k^\theta)^\theta = \beta_L$ respectively. The determination of k^r_c and k^s_c

has been shown in Figure 2 and the expressions for k^s_c and k^r_c are given by

$$k^r_c = \left(\frac{\beta_L \cdot (1+\delta)}{Q\theta \cdot (1-\theta) \cdot (p_L - \epsilon)}\right)^{\frac{1}{\theta^2}} \cdot A^{\frac{(1-\theta)}{\theta^2}} \quad (15)$$

$$k^s_c = \left(\frac{\beta_L \cdot (1+\delta)}{Q\theta \cdot (1-\theta) \cdot (p_L - \epsilon)}\right)^{\frac{1}{\theta^2}} \cdot B^{\frac{(1-\theta)}{\theta^2}} \quad (16)$$

Given $B > A$, $k^s_c > k^r_c$. As $\beta^*_r(k_t)$ and $\beta^*_s(k_t)$ are increasing in k_t, we now can rewrite the above three cases in terms of k^s_c and k^r_c as follows:

Case 1: $\beta_L \geq \beta^*_r(k_t) > \beta^*_s(k_t)$, or equivalently, $k^s_c > k^r_c \geq k_t$: a rationing equilibrium

Case 2: $\beta^*_r(k_t) > \beta^*_s(k_t) \geq \beta_L$, or equivalently, $k_t \geq k^s_c > k^r_c$: a screening equilibrium

Case 3: $\beta^*_r(k_t) > \beta_L > \beta^*_s(k_t)$, or equivalently, $k^s_c > k_t > k^r_c$: both screening and rationing in equilibrium.

The above relations show that for low levels of capital, the rationing regime prevails in the credit market. As capital accumulates and k_t lies in the interval $[k^r_c, k^s_c]$, a fraction of lenders start using the information gathering technology to separate the borrowers. Notice further that for the randomized strategy to hold as an equilibrium strategy in the interval $[k^r_c, k^s_c]$, the relation $\beta^*_m \equiv \{(p_L - \epsilon)/(1+\delta)\}Q\theta(1-\theta)[\mu A + (1-\mu)B]^{\theta-1} \cdot [k^\theta_t]^\theta = \beta_L$ must always hold. Therefore as k_t

increases in the interval $[k^r_c, k^s_c]$, μ must decrease to maintain the equality. This implies that a larger fraction of lenders will use the information gathering technology to separate the borrowers. As a result, the capital accumulation path will move closer to Path S in Figure 2. This transition from the rationing to screening behavior will continue as capital accumulates up to k^s_c. For $k_t > k^s_c$, the screening contract alone will prevail in the credit market.

5. Capital Dynamics and Effect of Changes in δ

Given the results in Section 4, it is not surprising that the equilibrium dynamic path for capital will depend upon k_0, the initial capital stock, and the relationships of k^s_c and k^r_c with k^r_{ss} and k^s_{ss} (the candidate steady state capital stocks). Throughout the remaining analysis we assume that the initial capital stock k_0 is less than k^s_c, k^r_c, k^r_{ss} and k^s_{ss}. Since $k^s_c > k^r_c$ and $k^s_{ss} > k^r_{ss}$, to determine the capital stock's dynamics and steady state, we need only to consider the three following cases:

Case 1: $k^r_c > k^r_{ss}$

We divide the present case into the following sub cases:

Case 1a: $k^r_c > k^r_{ss}$ and $k^s_c > k^s_{ss}$

Case 1b: $k^r_c > k^r_{ss}$ and $k^s_c < k^s_{ss}$

In each case capital accumulates along Path R and the steady state capital stock is k^r_{ss}. To see that, assume Case 1a holds. The economy reaches the lower steady state capital stock k^r_{ss} before the capital stock reaches the critical level (k^r_c) at which the switch from pure credit rationing to the mix of rationing and screening occurs. Thus, the rationing regime prevails in the credit market at all times. The capital stock per firm evolves along Path R and the steady state is k^r_{ss}. Given k^r_{ss} is independent of the cost of screening δ, and k^r_c is an increasing function of δ, the present case implies that a high cost of screening may trap the economy in a low level of development. The dynamics for the present case are depicted in Figure 3a.

Now assume Case 1b holds. In this case the dynamic path is as given in Figure 3b. There are three possible steady state equilibria; however, k^s_{ss} and k^r_{ss} are stable, and the one labeled k^*_{ss} is not. As long as k_0, the initial capital stock, is less than k^*_{ss} the economy will converge to k^r_{ss}.

Case 2: $k^r_c < k^r_{ss}$ and $k^s_{ss} > k^s_c$

In this case, initially the contracting regime is the rationing one and capital accumulates along the path R. The contracting regime will change to a mix of rationing and screening as capital is accumulated and the capital stock lies between k^r_c and k^s_c . As a result, in the interval $[k^r_c, k^s_c]$ the capital accumulation path will lie between Path R and S and capital will accumulate along the path joining k^r_c and k^s_c. As capital stock accumulates further and exceeds k^s_c, the only equilibrium contract is the screening one and the capital will grow along the Path S till the economy converges to the higher steady state k^s_{ss}. The situation is depicted in Figure 4.

Case 3: $k^r_c < k^r_{ss}$ and $k^s_{ss} < k^s_c$

This situation has been depicted in Figure 5. Initially the capital stock will evolve along the Path R until it reaches the critical level of capital stock k^r_c. As in Case 2, the capital accumulation path will deviate from Path R in the interval $[k^r_c, k^s_c]$ and capital will accumulate along the path joining k^r_c and k^s_c. Since, $k^s_{ss} < k^s_c$, the path joining k^r_c and k^s_c will intersect the 45° line at a point that lies between k^r_{ss} and k^s_{ss}. The steady state is labeled as k^*_{ss} in Figure 5.

The effects of changes in δ:

The effect of a improved financial infrastructure (measured by the lower cost of information, δ) on the economy's growth path and steady state can easily be seen from the above three cases. Note that $\beta^*_r(k_t)$ and $\beta^*_s(k_t)$ [given by equations (13) and (14)] are both decreasing in δ. Therefore the curves β^*_r and β^*_s in Figure 2 shift down as δ increases, implying k^r_c and k^s_c are increasing in δ. Also, from equations (8) and (9), it follows that k^s_{ss} is a decreasing function of δ. Finally, from equation (6) and (7), it follows that k^r_{ss} is independent of δ.

Now, suppose that cost of information (δ) falls while we are in Case 1. This will lower k^r_c and k^s_c. Let δ_{min} to be that value of δ solving $k^r_{ss} = k^r_c$. As long as $\delta \geq \delta_{min}$, Case 1 will still hold and the capital stock will converge to k^r_{ss} along the Path R. If δ falls below δ_{min}, the relation $k^r_{ss} > k^r_c$ will hold and the capital accumulation path will deviate from Path R at k^r_c. In this case k_t will converge to k^s_{ss} or k^*_{ss}. Therefore the cost of information must fall below a threshold level (δ_{min}) before it can affect the economy's growth path and the steady state capital stock.

Now, suppose δ falls while we are in Case 2. Recall that in Case 2 the economy converges to the higher steady state k^s_{ss}. Therefore the fall in δ will simply increase the steady state capital stock by increasing k^s_{ss}. More over, as

k^r_c and k^s_c decrease as δ falls, the capital accumulation path will deviate from Path R at a relatively lower level of capital accumulation.

Finally, consider the economy in Case 3. With the fall in δ, k^r_c and k^s_c decrease and the capital accumulation path joining k^r_c and k^s_c will shift up and intersect the 45° at a higher point. Therefore the steady state capital stock will increase as the cost of information falls in the credit market. This situation is shown in Figure 5.

6. Conclusion

This paper integrates the functioning of credit markets with economic development in a more realistic framework than typically encountered as it makes the structure of the loan contract an endogenous variable. This framework is useful as it illustrates how the loans market evolves with capital accumulation. We show that at a low level of capital accumulation, lenders separate borrowers by denying credit to a fraction of borrowers. As capital accumulates, credit markets may function more like modern credit markets with less credit rationing and with an increasing number of lenders purchasing information to separate borrowers. The transition from rationing to screening results in a higher capital accumulation path and a higher steady state capital stock. These results are complementary to the literature that highlights the link between financial

development and economic growth.

Another highlight of our paper has been to investigate the effect of an increase in the degree of financial sophistication (represented by a decrease in the cost of screening, δ) on the economy's growth path and steady state capital stock. We show that when screening contracts are utilized, a decrease in the cost of screening results in a higher capital accumulation path and a higher steady state capital stock for an economy. However, for an economy in which rationing is the equilibrium contracting regime, a threshold level of financial sophistication is required to push the economy to a higher growth path and higher steady state capital stock.

An interesting extension of our model would be to endogenize the marginal cost of screening δ. This could be done, for example, by making δ dependent on the total volume of lending, or equivalently, on the capital stock per firm. The idea being that there is an externality in learning how to evaluate lenders. Thus, as more loans are extended, the cost of distinguishing high risk from low risk borrowers falls. As no individual lender will internalize the learning externality, there may be too little learning taking place in this setting, and the economy needlessly may become trapped in a rationing equilibrium with a low steady state capital stock in the sense that less rationing could be a Pareto improvement.

Appendix 2A

Proof of Proposition 2.1:

As noted in the text, the high risk borrower receives his first best contract $C_H = (R_{Ht}, q_{Ht}) = (Q\epsilon\rho_{t+1}/p_H, w_t)$. Given C_H, and also given the assumption that the lenders earn zero profits, the alternative contract acceptable to the low risk borrowers is determined by solving the following program:

Select: $(\phi_t, \pi^n_{Lt}, R^n_{Lt}, q^n_{Lt}, R^s_{Lt}, q^s_{Lt})$ to maximize

$$\phi_t \{p_L \pi^n_{Lt}(Q\rho_{t+1} - R^n_{Lt})q^n_{Lt} + (1 - \pi^n_{Lt})\beta_L\} + (1 - \phi_t)\{p_L(Q\rho_{t+1} - R^s_{Lt})q^s_{Lt}\} \qquad (A1)$$

Subject to :

$$\phi_t \pi^n_{Lt}(R^n_{Lt}q^n_{Lt}p_L - Q\epsilon\rho_{t+1}q^n_{Lt}) + (1 - \phi_t)[R^s_{Lt}p_L q^s_{Lt} - (1+\delta)q^s_{Lt}Q\epsilon\rho_{t+1}] = 0 \qquad (A2)$$

$$p_H(Q\rho_{t+1} - \frac{Q\epsilon\rho_{t+1}}{p_H})w_t \geq \phi_t \pi^n_{Lt}p_H(Q\rho_{t+1} - R^n_{Lt})q^n_{Lt} \qquad (A3)$$

$$0 \leq \phi_t \leq 1; \ 0 \leq \pi^n_{Lt} \leq 1; \ 0 \leq q^n_{Lt} \leq w_t; \ 0 \leq q^s_{Lt} \leq \frac{w_t}{(1+\delta)}; \ 0 \leq R^n_{Lt}; \ 0 \leq R^s_{Lt}$$

Equation (A1) refers to the expected utility of the low risk borrower's accepting the contract C_L. Equations (A2) and (A3) refer to the zero profit constraint of the lender and the incentive compatibility constraint for the high risk borrower respectively. The zero profit constraint (A2) implies

$$\phi_t \pi^n_{Lt}(R^n_{Lt}q^n_{Lt}p_L) + (1 - \phi_t)R^s_{Lt}p_L q^s_{Lt} = [(1+\delta)q^s_{Lt}(1 - \phi_t) + \phi_t q^n_{Lt}\pi^n_{Lt}]Q\epsilon\rho_{t+1} \qquad (A4)$$

Substituting this expression into (A1) we obtain a simplified objective function

$$\phi_t \pi^n_{Lt}(p_L Q\rho_{t+1}q^n_{Lt} - \beta_L - Q\epsilon\rho_{t+1}q^n_{Lt}) + \phi_t\beta_L + (1 - \phi_t)q^s_{Lt}\{p_L Q\rho_{t+1} - Q\epsilon\rho_{t+1}(1+\delta)\},$$
$$(A5)$$

which is maximized subject to (A2), (A3), and the inequality constraints noted above. Let us assume that the optimal solution is such that it satisfies $\phi_t \pi^n_{Lt} > 0$. We shall show later that this is indeed the case.

The problem can be further simplified by making the following obsevations: First, if screening occurs at all, we see that $\{p_L Q\rho_{t+1} - (1+\delta)\}$ must be positive. Since q^s_{Lt} does not appear in (A3), the optimal q^s_{Lt} is $w_t/(1+\delta)$. Second, neither of the interest rates appear (A5),

the simplified objective function, and R_{Lt}^n alone appears in (A3), the incentive compatibility constraint.

Note also from (A3) and (A5) that $\phi_t \pi_{Lt}^n$, and hence (A5) can be maximized by setting R_{Lt}^n as high as posssible (i.e. setting R_{Lt}^s as low as possible) while still satisfying (A2). Clearly then the optimal R_{Lt}^s is $R_{Lt}^s = 0$. Substituting the optimal values for q_{Lt}^s and R_{Lt}^s into (A4) yields,

$$R_{Lt}^n = Q\epsilon\rho_{t+1}\frac{[\phi_t \pi_{Lt}^n q_{Lt}^n + (1 - \phi_t)w_t]}{\phi_t \pi_{Lt}^n q_{Lt}^n p_L} \tag{A6}$$

Substituting the expression for R_{Lt}^n in (A3) we rewrite the incentive compatibility constraint as

$$\left(1 - \frac{\epsilon}{p_H}\right)w_t \geq \phi_t \pi_{Lt}^n q_{Lt}^n\left(1 - \frac{\epsilon}{p_L}\right) - \epsilon(1 - \phi_t)\frac{w_t}{p_L} \tag{A3'}$$

Finally the problem reduces to maximizing

$$\phi_t \pi_{Lt}^n q_{Lt}^n(p_L Q\rho_{t+1} - Q\epsilon\rho_{t+1}) + \phi_t \beta_L(1 - \pi_{Lt}^n) + (1 - \phi_t)Q\rho_{t+1}w_t\left(\frac{p_L}{(1+\delta)} - \epsilon\right) \tag{A5'}$$

subject to (A3') and the resrictions on ϕ_t, π_{Lt}^n, and q_{Lt}^n.

Claim 1: The incentive compatibility constraint (A3') is binding.

Let $(\phi_t, \pi_{Lt}^n, q_{Lt}^n)$ be a triplet for which (A3') is not binding. We need only to show that this triplet is dominated by one for which (A3') is binding.

Subcase 1: (A3') is not binding and $q_{Lt}^n < w_t$.

If the above is true then (A5') can be increased by increasing q_{Lt}^n until (A3') is binding or until $q_{Lt}^n = w_t$. If (A3') is binding for $q_{Lt}^n = \bar{q} < w_t$ then (A3') is binding for the triplet $(\phi_t, \pi_{Lt}^n, \bar{q})$ and this triplet dominates the original. Suppose (A3') is not binding for $q_{Lt}^n = w_t$. Then we consider the following sub case:

Subcase 2: (A3') is not binding and $q_{Lt}^n = w_t$. $\pi_{Lt}^n < 1$.

The individual rationality criterion of the low risk borrowers implies $Q\rho_{t+1}w_t(p_L - \epsilon) > \beta_L$. Thus (A5') is increasing in π_{Lt}^n. If $\pi_{Lt}^n < 1$, increasing π_{Lt}^n until (A3') binds or until $\pi_{Lt}^n = 1$

will increase (A5′) . If (A3′) becomes binding for $\pi^n_{Lt}=\bar\pi<1$, then $(\phi_t,\bar\pi,w_t)$ dominates the original and (A3′) is binding. If (A3′) is not binding for $(\phi_t,1,w_t)$ then we consider the following subcase:

Subcase 3: (A3′) is not binding and $q^n_{Lt} = w_t$, $\pi^n_{Lt} = 1$.

If $q^n_{Lt} = w_t$ and $\pi^n_{Lt} = 1$, then from (A3′), it must be the case that $\phi_t < \phi^s \equiv 1 - \epsilon\left(\frac{1}{p_H} - \frac{1}{p_L}\right)$ <1. Note that (A5′) is increasing in ϕ_t, given $q^n_{Lt} = w_t$ and $\pi^n_{Lt} = 1$. Thus increasing ϕ_t to ϕ^s, at which point (A3′) becomes binding again increases (A5′). Therefore $(\phi^s,1,w_t)$ dominates the original.

Thus in either case we can find a triplet for which (A3′) is binding and which dominates the original $(\phi_t,\pi^n_{Lt},q^n_{Lt})$. Therefore (A3′) must bind at the optimal contract. □

Claim 2: The optimal $q^n_{Lt}=w_t$.

Let $(\phi_t,\pi^n_{Lt},q^n_{Lt})$ be a triplet for which (A3′) is binding and $q^n_{Lt}<w_t$. To see this triplet is dominated by one for which $q^n_{Lt} = w_t$, note two things. First, π^n_{Lt} and q^n_{Lt} enter (A3′) as the product $\pi^n_{Lt}q^n_{Lt}$. Second, (A5′) is decresing in π^n_{Lt}, if one holds $\pi^n_{Lt}q^n_{Lt}$ fixed. From these facts, it follows that one can increase q^n_{Lt} to w_t and decrease π^n_{Lt} to $\bar\pi$, holding $\pi^n_{Lt}q^n_{Lt}$ fixed. Doing this one obtains a triplet $(\phi_t,\bar\pi,w_t)$ which satisfies (A3′) as an equality and which dominates the original triplet. Therefore the optimal q^n_{Lt} is w_t. □

As (A3′) binds and $q^n_{Lt}= w_t$, we obtain the expression for $\phi_t\pi^n_{Lt}$ from (A3′)

$$\phi_t\pi^n_{Lt} = \frac{p_L\left(1 - \frac{\epsilon}{p_H}\right) + \epsilon(1-\phi_t)}{(p_L - \epsilon)} \tag{A3″}$$

Substituting the expression for $\phi_t\pi^n_{Lt}$ from (A3″) and $q^n_{Lt}=w_t$ into the objective function (A5′) we get

$$Q\rho_{t+1}w_t\left(p_L\left(1 - \frac{\epsilon}{p_{II}}\right) + \epsilon(1-\phi_t)\right) + \phi_t\beta_L - \beta_L\left(\frac{p_L\left(1 - \frac{\epsilon}{p_H}\right) + \epsilon(1-\phi_t)}{(p_L - \epsilon)}\right)$$

$$+ (1-\phi_t)Q\rho_{t+1}w_t\left(\frac{p_L}{1+\delta} - \epsilon\right)$$

$$= p_L\left(1 - \frac{\epsilon}{p_H}\right)\left(Q\rho_{t+1}w_t - \frac{\beta_L}{p_L-\epsilon}\right) + \phi_t\beta_L + (1-\phi_t)\left(Q\rho_{t+1}w_t\epsilon - \frac{\beta_L\epsilon}{p_L-\epsilon}\right)$$

$$+Q\rho_{t+1}w_t\left(\frac{p_L}{1+\delta}-\epsilon\right)\Bigg)$$

$$= p_L\left(1-\frac{\epsilon}{p_H}\right)\left(Q\rho_{t+1}w_t-\frac{\beta_L}{p_L-\epsilon}\right)+\phi_t\beta_L+(1-\phi_t)\left(Q\rho_{t+1}w_t\frac{p_L}{1+\delta}-\frac{\beta_L\epsilon}{p_L-\epsilon}\right) \qquad (A5'')$$

Now the objective function is linear in ϕ_t. Thus the optimal ϕ_t is $\phi_t = 1$ or the smallest ϕ_t compatible

with (A3'). If $\beta_L > \left(Q\rho_{t+1}w_t\frac{p_L}{1+\delta}-\frac{\beta_L\epsilon}{p_L-\epsilon}\right)$ or equivalently $\beta^* \equiv Q\rho_{t+1}w_t\frac{p_L-\epsilon}{1+\delta} < \beta_L$, it

is optimal for the lender to set $\phi_t=1$. This, in turn, implies that no screening takes place. The corresponding expressions for π_{Lt}^n and R_{Lt}^n can be obtained from (A3'') and (A6) respectively. If inequality holds in the reverse direction, the lender sets ϕ_t as small as possible. This is achieved by setting $\pi_{Lt}^n=1$. Substituting $\pi_{Lt}^n=1$, the optimal values for ϕ_t and R_{Lt}^n follow immediately from equations (A3'') and (A6) respectively. The optimal ϕ_t lies between 0 and 1. Thus we have either $\phi_t = 1$, $0< \pi_{Lt}^n<1$ or $0<\phi_t<1$ and $\pi_{Lt}^n=1$. There is rationing or screening but not both. Finally to verify $\phi_t\pi_{Lt}^n \neq 0$, one simply compares low risk borrower's payoff when $\phi_t\pi_{Lt}^n = 0$ with the solutions when $\phi_t\pi_{Lt}^n>0$. This completes our proof.
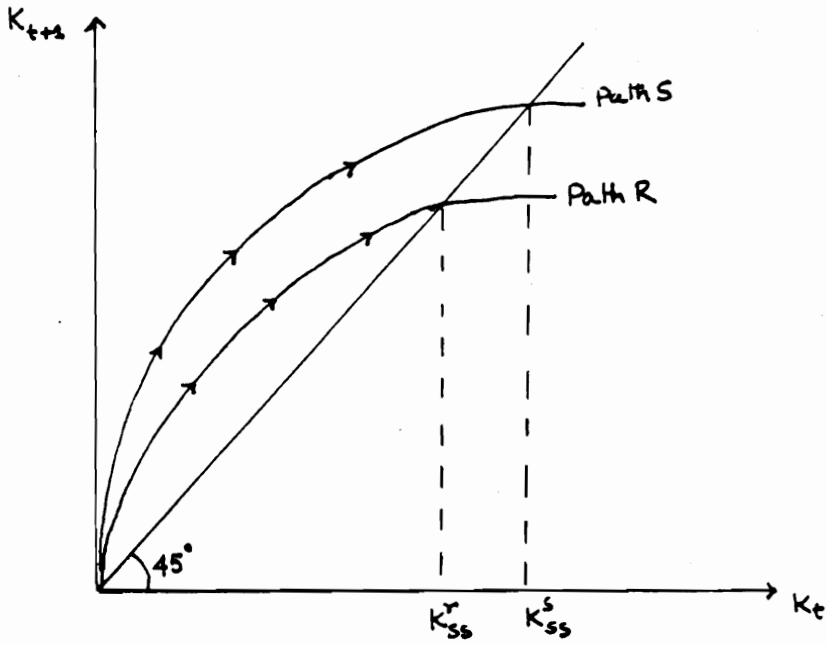
FIGURE 1
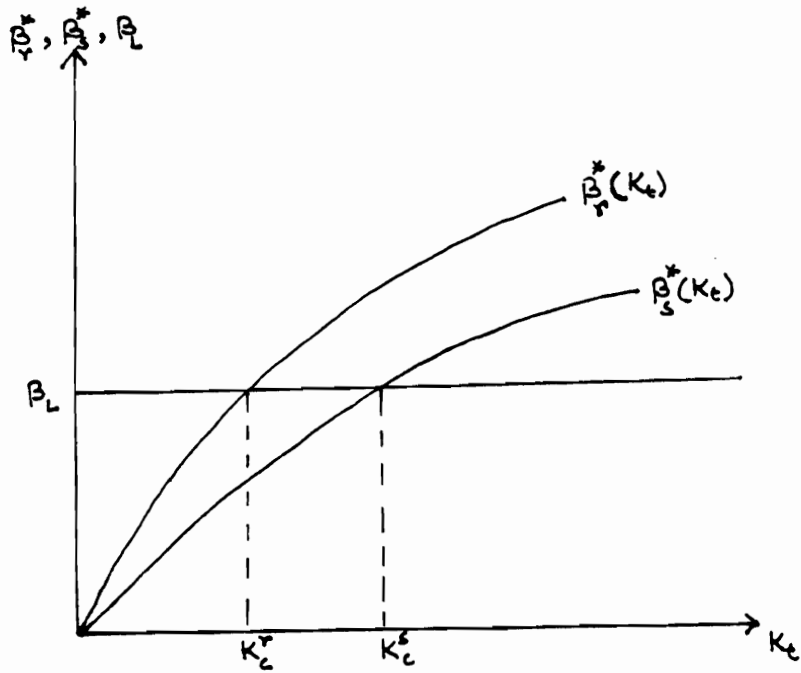
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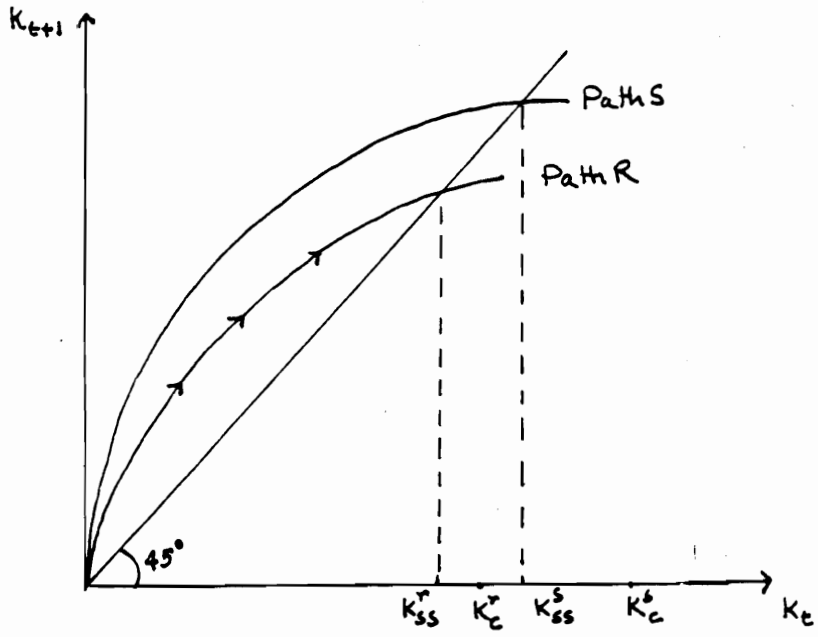
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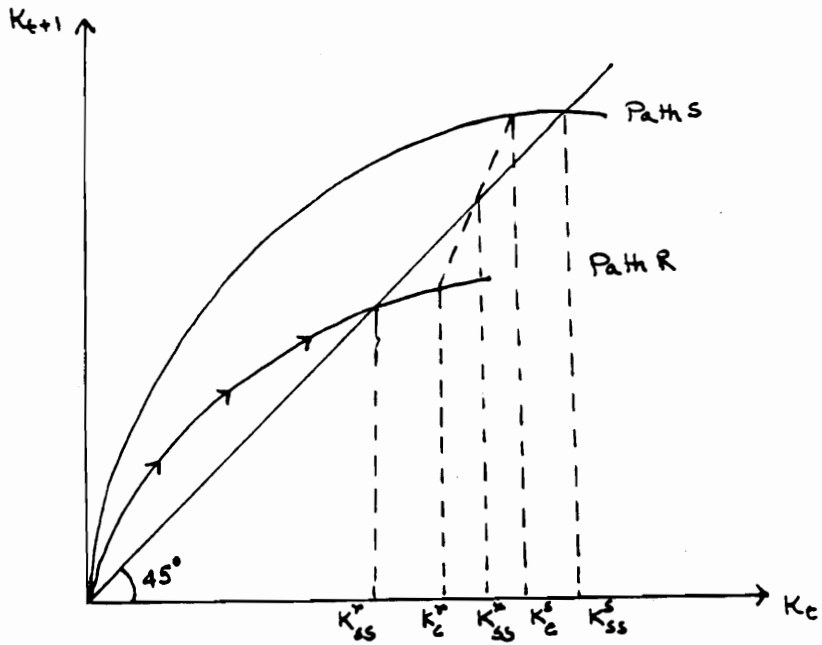
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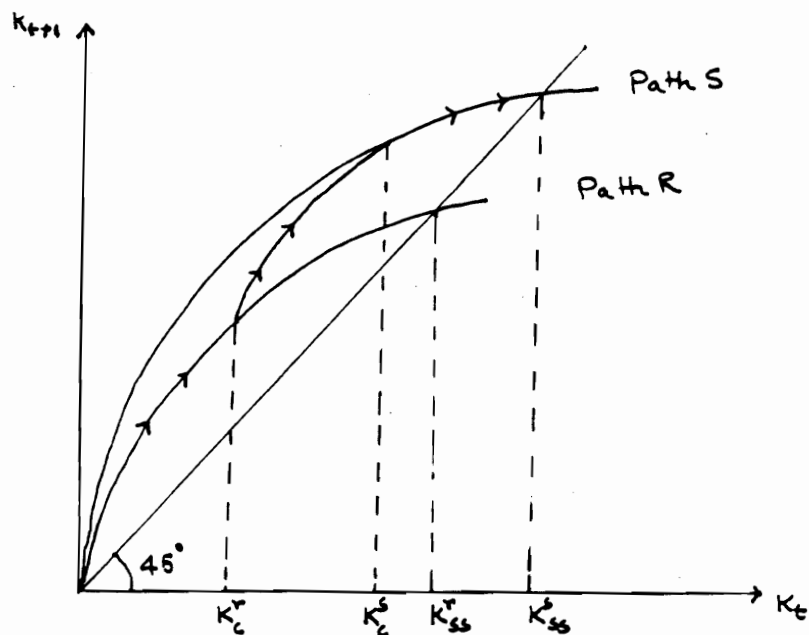
FIGURE 4
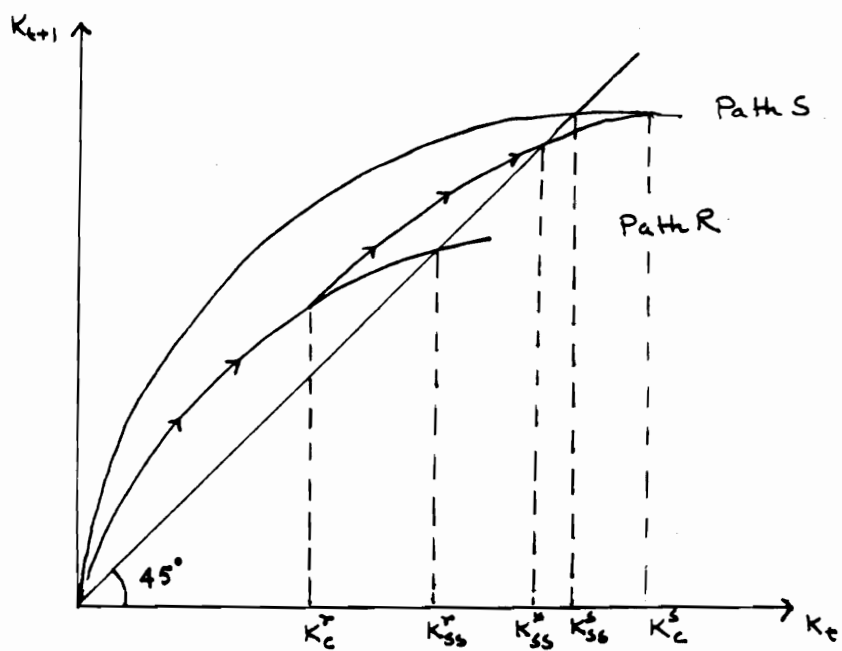
FIGURE 5

Chapter 3: Inflation, Credit market, and Economic Growth

Almost three decades ago, economic theorists postulated that steady state output and the steady state capital labor ratio are positively correlated with the steady state inflation rate. Examples include the descriptive growth models of Mundell (1965), Tobin (1965), Shell, Sidrauski, and Stiglitz (1969), Diamond (1965), and others. Other models [Sidrauski (1967) and later Brock (1974, 1975)], however, suggested that steady state output level and steady state capital labor ratio are unaffected by the inflation rate. In contrast, recent empirical evidence [for example, Fischer (1991, 1993), De Dregorio (1992, 1993), Levine and Renelt (1992)], suggests that inflation and growth of per capita output (also productivity growth) are negatively related. Further, in the recent experiences of the Latin American countries, inflation appears to be an important factor in explaining low growth performances. Not surprisingly, the interest in studying the relationship between inflation and long run growth has revived in the recent years. The purpose of the present chapter is to examine this relationship by introducing a standard informational asymmetry in a monetary growth model.

This chapter considers a modified version of the economy described in

chapter 1 with a cash-in-advance constraint. Agents are divided between borrowers and lender, and the borrower's type, defined in terms of the probability of default, is private information. As in the previous two chapters, informational an asymmetry between the borrowers and the lenders can be resolved either through rationing or screening of a fraction of borrowers and the economy's equilibrium growth rate of output depends on the prevailing contracting regime.

The cash-in-advance constraint is introduced into the model in the following way. We assume that the amount of nominal money that is required for a transaction between borrowers and lenders must be held for one period in advance. Given this constraint, the rate of inflation affects the growth rate of output through two possible channels. First, the inflation rate determines the real amount of loanable funds that can be transformed into capital. Second, the inflation rate affects the growth rate of output through its effect on the equilibrium loan contract.

We show that inflation rate not only determines the lending behavior within a lending regime (be it rationing or screening) but also determines the nature of the equilibrium lending regime. At a reasonably low inflation level, the screening contract is the equilibrium contract, and an increase in inflation increases the fraction of borrowers screened within the screening regime. Screening being costly in terms of lost resources, an increase in screening

decreases output available for lending and lowers the growth rate of output. As the inflation rate exceeds a critical level, there is a sharp fall in the growth rate of output as the equilibrium lending regime changes from screening to rationing. Within the rationing regime, an increase in the inflation rate increases the incidence of credit rationing. This effect, together with the loss of real loanable fund reverses the so called Mundell-Tobin effect in the rationing regime.

The chapter is divided into 5 sections. In section 1 we present the basic structure of the model. Section 2 shows the relationship between the inflation rate and the equilibrium loan contract in the credit market. Section 3 determines growth rate of output corresponding to each contracting regime and draws the complete relationship between the growth rate and inflation rates. The empirical evidence is presented in Section 4 and the results are interpreted in the light of the model presented in the previous section. Section 5 summarizes.

1. The model

We consider an economy that consists of an infinite sequence of three period overlapping generations. All generations are identical in size and composition. Young agents are divided into two groups of equal sizes, referred to as firms (borrowers) and households (lenders). The division between the agents is on a functional basis. The households are the provider of funds in the

economy. They sell their labor endowment to generate savings, which is transformed into capital, to be used in output production. The capital and the output production technology are owned by firms who need external funding to run the technologies. Thus, for the economy to function, loan transactions between the households and firms are necessary. Our model differs from the standard overlapping generation models, as we assume that there exists an informational asymmetry between capital producing firms and households as to the firm's ability to successfully operate an investment project. As this generates friction in transferring funds between households and firms, the growth rate of the economy will depend on the means by which the informational asymmetry is resolved in the credit market. The rest of the section provides a detailed description of the economy.

A young agent belonging to the firm sector has access to an investment project in the second period of his life. As in the previous two chapters, a firm's project is a type H or type L, indicating a high risk or a low risk project. The high risk project has a lower probability of success than the low risk project. We assume that a fraction λ of firms have type H projects and that investment projects differ only in terms of their probabilities of success. Each investment project requires one unit of labor and converts consumption goods to capital goods using a linear technology. With probability p_i, the investment project of the type i agent converts x units of time t output and one unit of labor into $Q.x$

units of time $t+1$ capital. With probability $(1 - p_j)$, the project is a failure and yields zero units of capital. By assumption $1 \geq p_L > p_H \geq 0$.

Each firm is endowed with a single unit of labor in the second period of its life. We assume that this labor is non tradable. However, they are not endowed with output and therefore must seek external funds to finance their investment projects. If such funding is available, a firm proceeds with its project, utilizing his labor endowment. If no funds are forthcoming, the low risk firm can use its labor in the home production of goods. The high risk firm does not have access to a home production technology. To simplify the ensuing analysis, we assume the amount produced at home in time t is proportional to the previous period market wage rate w_{t-1}. (This assumes some spill over effects from market productivity to home productivity. However it takes one period for such spill over to take place). Output produced at home at time t yields $\beta_L.w_{t-1}$ units of time t consumption, $\beta_L < 1$.

The agents in the firm sector have access to an output production technology the final period of their lives. They are able to produce output by renting capital and hiring labor at the competitively determined rental rates. A firm employing k units of capital and L units of labor produces y units of output, as given by

$$y_t = \psi_t^{\alpha} \cdot k_t^{\theta} \cdot L_t^{1-\theta} \cdot \quad (8)$$

This output can be consumed or used for investment projects. For simplicity we assume $\alpha = 1-\theta$. All agents belonging to the firm sector wish to consume in the final period of life and are risk neutral.

Each young household is endowed with one unit of labor which is supplied inelastically to the market for the ruling wage rate. Agents belonging to the household sector are risk neutral and wish to consume at the end of their lifetimes. We assume that households develop contact with borrowers when they are young. Recall that a firm can only operate his investment project at the second period of his life time. However, the terms and conditions of the loan transaction are finalized one period in advance. At time t, a young household decides whether to fund the investment project at $t+1$, as well as the loan amount and the interest rate. If the young household decides to fund the investment project, he simply hands over the funds at $t+1$ when the firm has access to the investment project. However, households are also capable of producing capital goods by themselves. In order to produce capital, households need to invest their wage earnings when they are young. One unit of investment in period t yields $Q.\epsilon$ units of time $t+2$ capital. We also assume that $\epsilon < p_H$. Thus the investment technology owned by households is not only inferior to that owned by firms in terms of the yield, but it also takes longer to convert consumption good into capital good.

In order to ensure the consumption in the old age, a household can invest his wage earning in its own project in return for capital in period $t+2$ and rent out this capital and consumes the proceeds from the rental. Alternately, the household can store his labor earning in the form of money. He can purchase output with this money in the second period of his life and hand over this output to a capital producing firm in return for the interest rate paid in the form of output. We assume that the return from holding money is always dominated by the return from the household's own investment project (This can be assured if Q is sufficiently large). Thus a household only stores his wage earning in terms of money if he decides to lend to a firm.

We assume that there exists an informational asymmetry between firms and households, as each firm's ability is private information. However, as in the previous two chapters, we also assume that a household can determine a firm's ability at a resource cost which is proportional to the amount lent. Thus if q units of output are lent to the borrower, the resource required to determine the borrower's ability is $\delta.q$, where $0 \leq \delta \leq 1$ is an exogenously given parameter.

Finally, we assume that this economy has a government liability like money. We let M_t denote the outstanding stock of fiat money at time t, and p_t denote the corresponding price level. Any monetary injections or withdrawals are accomplished by lump-sum transfers to all old agents. Also the money supply

evolves according to the rule

$$M_{t+1} = \sigma_t . M_t \qquad (2)$$

σ_t can be viewed as the policy variable.

In the following section we analyze the credit market. We assume that the rate of inflation over the periods is constant and is denoted by τ.

2. The Credit market

The credit market operates in the same way as in the previous two chapters. Each young household offers a set of loan contracts. The firms have complete knowledge about the types of loan contracts offered by each household. If a household's contracts are not dominated by those of any other household, he is approached by a firm. We assume that each firm can apply only to one household for a loan[12], and that competition drives the household's economic profit to zero.

As it is typical in a 'menu contract' type model, the high risk borrower's

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This assumption provides a bound on the loan size which is necessary in the presence of a linear production technology for capital.

contract (C_H) is unaffected by the consideration of self-selection, and the separation is induced by distorting the contract (C_L) targeted towards the low risk borrowers. High risk borrowers receive their first best contract in equilibrium, which specifies the loan rate $R_{Ht} = Q\epsilon(1+\tau)\rho_{t+2}/p_H$, and the maximum attainable loan quantity $q_{Ht} = w_t/(1+\tau)$.

Given the possibility of screening, the contract C_L comes in the form $C_L = [\{\phi_t, \tau_{Lt}^n, q_{Lt}^n, R_{Lt}^n\}; \{(1-\phi), q_{Lt}^s, R_{Lt}^s\}]$. Here ϕ_t is the probability the borrower is not screened. In that event, the project is funded with probability τ_{Lt}^n. If the project is funded, the loan quantity and the gross interest rate are q_{Lt}^n and R_{Lt}^n respectively. The borrower is screened with probability $(1-\phi_t)$. In that event, if the borrower is found to be a low risk borrower, the loan quantity and gross interest rate offered are given by q_{Lt} and R_{Lt}^s respectively.

In order to induce separation between the high and low risk type borrowers, a household can distort the contract C_L by two possible means. As in the previous chapters, the separation can be achieved by rationing ($\tau_{Lt}^n < 1$ and $\phi_t = 1$) some fraction of the low risk capital producing firm, or by costly screening ($\tau_{Lt}^s = 1$ and $\phi_t < 1$) a fraction of the borrowers. The method of finding the optimal contract form being similar to one in the previous two chapters, we omit further discussion and simply describe the equilibrium contract in the following proposition:

Proposition 3.1:

The household always offers the first best contract for the high risk firms, $C_H = (q_{Ht}, R_{Ht}) = [w_t/(1+\tau), Q\epsilon(1+\tau)\rho_{t+2}/p_H]$. This is accepted by the high risk firm. The household offers the contract C_L which is described as follows:

(1) If the relation $\tau < [\{(p_L.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1 = \tau^*$ holds, then in equilibrium, households offer the contract $C_L = C_L^*$, whose terms are

$$\pi_{Lt}^a = 1 \quad \text{and} \quad \phi_t \equiv \phi^* = 1 - (1/p_H - 1/p_L).\epsilon.(1+\tau) \qquad 3.1(a)$$

$$R_{Lt}^a = Q.\epsilon.\rho_{t+1}/[(\phi.p_L)(1+\tau)] \quad \text{and} \quad R_{Lt}^* = 0 \qquad 3.1(b)$$

$$q_{Lt}^a = w_t/(1+\tau) \quad \text{and} \quad q_{Lt}^* = w_t /[(1 + \delta)(1+\tau)] \qquad 3.1(c)$$

(2) If the relation $\tau > [\{(p_L.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1 = \tau^*$ holds, then in equilibrium, the households offer the contract $C_L = C_L^r$, whose terms are

$$\phi_t = 1 \quad \text{and} \quad \pi_{Lt}^a = \pi^r = [1-\epsilon(1+\tau)/p_H]/[1-\epsilon(1+\tau)/p_L] \qquad 3.1(d)$$

$$q_{Lt}^a = w_t/(1+\tau) \quad \text{and} \quad R_{Lt}^a = Q\epsilon(1+\tau)\rho_{t+2}/p_L \qquad 3.1(e)$$

(3) If the relation $\tau = [\{(pL.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1 = \tau^*$ holds, then in equilibrium, the type 1 households are indifferent between offering either C_L^* or C_L^r.

The above proposition indicates that, among other factors, lending behavior in the economy depends on the inflation rate. If the inflation rate is lower than the critical inflation rate τ^*, the screening contract is the equilibrium contract. The rationing contract emerges as the inflation rate exceed τ^*. Under the rationing contract, each low risk borrower faces a positive probability of being denied of loan. When rationed, a low risk borrower engages in the home production and the net payoff from home production is $w_{t-1}\beta_L$ units of output. If a low risk borrower is screened, the net expected payoff in the screening state is given by $[Q.\rho_{t+2}.w_{t-1}\{p_L-\epsilon(1+\tau)\}]/[(1+\tau)(1+\delta)]$. Under competition, the lenders are maximizing the utility of the borrower. Thus the screening contract dominates the rationing contract if $[Q.\rho_{t+2}.w_{t-1}\{p_L-\epsilon(1+\tau)\}]/[(1+\tau)(1+\delta)] > w_{t-1}\beta_L$, or equivalently, if $\tau < [\{(pL.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1 = \tau^*$.

Further, the probability of screening $(1-\phi)$ and rationing $(1-\pi^*)$ are increasing functions of the inflation rate. Thus an increase in the inflation rate decreases the volume of funds transferred from lenders to borrowers in each regime, either by increasing the loss of output due to screening or by denying loans to a large fraction of borrowers.

3. The Growth Rate of Capital

In the previous section we have shown that loan contract in the economy depends upon the inflation rate. The present section establishes the link between the lending behavior and growth rate of output in the economy as a final step to connect output growth and inflation. In this section we explicitly determine the growth rates corresponding to the screening and rationing regime and evaluate the impact of changes in the inflation rate on growth in each regime.

Case 1: $\tau > [\{(p_L.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1$

If the above inequality holds, $\phi = 1$ and firms are not screened. Therefore, the equilibrium contract is given by (C_H, C_L'), as described in Proposition 3.1.

Part of the capital stock at $t+2$ comes from successful firms who receive funding for their investment project from households. The other part of the time $t+2$ capital stock comes from households who converted their time t wages into capital after rationing a fraction of low risk firms. The former amount is $0.5Qw_t[\lambda p_H + (1-\lambda)p_L\pi^*]1/(1+\tau)$ and the latter is $0.5Q\epsilon w_t(1-\pi^*)(1-\lambda)$. The total number of firms producing output at $t+2$ is 0.5. Thus the per firm capital stock is

$$k_{t+2} = [\{\lambda.p_H+(1-\lambda)p_L.\pi^*\}+\{(1-\pi^*)(1-\lambda).\epsilon.(1+\tau)\}].Qw_t/(1+\tau)$$

(4)

The wage rate at time t is

$$w_t = (1-\theta).k_t.(L_t)^{-\theta}.$$

(5)

Where L_t stands for labor employed per firm. In equilibrium all firms employ an equal amount of labor. Since there is 0.5 units of firms producing output and 0.5 units of labor available at t, the labor/firm $= L_t = 1$. This labor/firm ratio is constant over the time period. Substituting the value of L_t in (5) we get

$$w_t = (1-\theta).k_t$$

(5')

Substituting (5') in (4) we get,

$$k_{t+2} = [\{\lambda p_H+(1-\lambda)p_L\pi^*\}+\{(1-\pi^*)(1-\lambda)\epsilon(1+\tau)\}]Q(1-\theta).k_t(1+\tau)^{-1}.$$

Thus, $k_{t+2}/k_t = g^r = [\{\lambda p_H+(1-\lambda)p_L\pi^*\}+\{(1-\pi^*)(1-\lambda)\epsilon(1+\tau)\}]Q(1-\theta)(1+\tau)^{-1}$ (6)

Equation (6) yields the growth rate of per firm capital stock when rationing contract prevails in the credit market and superscript 'r' denotes the rationing

case.

The growth rate of capital stock in the rationing regime is inversely related to the rate of inflation τ. An increase in the rate of inflation decreases π^* and therefore increases the incidence of rationing. Also, a higher inflation rate reduces the amount of fund available for lending. Both effects together reduce the growth rate of capital stock.

Case 2: $\tau < [\{(p_L.Q.\rho_{t+2})/\{Q.\epsilon.\rho_{t+2} + \beta_L(1+\delta)\}] - 1$

In this case, instead of rationing a fraction of firms, households will screen a fraction of the low risk capital producing firms. As a result, all low risk firms obtain loans. To differentiate from the previous case, we write the equilibrium variables in this section with a superscript 's'. In this case part of the capital stock at $t+2$ comes from successful high risk firms and successful low risk firms (some of whom are screened). Its value is

$$[0.5Qw_t/(1+\tau)][\lambda p_H+(1 - \lambda)\phi^s p_L+(1-\lambda)(1-\phi^s)p_L/(1+\delta)]$$

$$= [0.5zQw_t/(1+\tau)][\lambda p_H+(1-\lambda)p_L(1+\delta.\phi^s)/(1+\delta)]$$

The capital stock per firm is thus given by

$$k^s_{t+2} = Qw_t.(1+\tau)^{-1}.(1-z)^{-1}[\lambda p_H + (1-\lambda)p_L(1+\delta\phi^s)/(1+\delta)] \tag{7}$$

Substituting the value of w_t from (5'), we get

$$g^s = k_{t+2}/k_t = [\lambda p_H + (1-\lambda)p_L(1+\delta\phi^s)/(1+\delta)]Q(1-\theta)(1+\tau)^{-1}. \tag{8}$$

Equation (8) gives the growth rate of capital stock in the screening case. As in the rationing regime, growth rate of capital stock is inversely related to the rate of inflation τ. The increase in inflation rate decreases ϕ^s and therefore increases the incidence of screening. As screening is costly in terms of resource cost, this leads to a larger volume of output lost. Also, higher τ reduces the amount of fund available for lending. Both effects together reduce the growth rate of capital stock and hence output growth.

Finally, we should note that the marginal product of capital is given by $\rho_t = \theta.(L_t)^{1-\theta}$. Since $L_t = 1$ both in the rationing and the screening case, we have $\rho^r = \rho^s = \theta$ for all t.

Proposition 3.2: For a given rate of inflation, the growth rate of the capital stock associated with the screening contract is higher than that associated with the

rationing contract. In other words, for a given τ, $g^s > g^s$.

Proof: From equations (6) and (8),

$$g^s > g^r \Leftrightarrow \phi^s.p_L + \{(1-\phi^s).p_L\}/(1+\delta) > p_L.\pi + (1-\pi)\epsilon.(1+\tau) \qquad (9)$$

Throughout the analysis we have assumed that $p_L > \epsilon.(1+\tau)$. Let us define $x = \epsilon.(1+\tau)/p_L$. Then a little manipulation leads to the following equality:

$$\phi^s = \pi + (1-\pi)x \qquad (10)$$

Substituting $\epsilon = x.p_L/(1+\tau)$ in equation (13) yields

$$g^s > g^r \Leftrightarrow (1+\delta\phi^s)/(1+\delta) > \pi + (1-\pi)x = \phi^s.$$

As the right hand side is always true we have $g^s > g^r$.

Based on the result we obtained so far, the relation between the inflation rate and growth rate of output is shown in diagram 1.

4. A look at the data

Theoretical analysis in the previous sections imply that inflation rate and growth rate of output are negatively correlated in each of the lending regimes. Also, when inflation exceeds a critical level, the growth rate of output declines sharply, as the lending regime changes from screening to rationing . The objective of the present section is to look at a panel data for a large group of countries[13] for the period 1961-88 to examine if there exists such a relationship between inflation rate and output growth. If the data conform the relationship between growth rate and inflation rate, as illustrated in diagram 1, the theory developed in Section 2 and Section 3 can be considered as a possible explanation for such a relationship.

Our theoretical analysis leads us to consider the following linear specification

$$zpgdp = constant + \alpha.Dum + \alpha_1.inflat + u,$$

where, zpgdp represents the growth rate of real GDP computed from the Heston and Summers data set. The variable inflat in the right hand side represents

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[13] Table 1 lists the countries and their corresponding mean inflation rate and growth rate of output.

inflation rate, obtained from the CPI series in International Financial Statistics. The dummy variable 'Dum' takes the value 0 when inflation rate exceeds the critical level (τ^*) at which switch from rationing to screening regime takes place. Choosing values of τ^* stating from 7% to 25% with an increment of 0.5%, we run panel regressions with both country and time specific dummy. Based on previous analysis, we expect that the coefficient of Dum and inflat should have positive and negative sign respectively, and the coefficient of dum to be significantly different from zero within the specified range of τ^*. The preliminary cross sectional study, where the mean inflation rates are regressed on the mean GDP growth rate, produces mixed results. We find that at 15% critical inflation level, the sign of the coefficient of the dummy and inflation follows our expectation. However, the coefficient of the dummy is only significant at the level of 16%. The result of the regression is presented in Table 2. The results of the panel regressions are presented in Table 3 and 4.

Table 3 summarizes the results with country dummy variable. In all cases, coefficients of the dummy variable are positive and coefficients of inflation are negative. The log-likelihood ratio is maximized at the critical inflation level 17%, where the coefficient of the dummy variable takes the largest value. Also, at the critical inflation level 17%, the coefficient of dummy variable and inflation are significantly different from zero. An increase in the inflation rate by 1% reduces the growth rate of output by 0.03% and growth rate falls sharply by

0.02% at 17% inflation rate.[14]   In Table 4 we summarize results with the country dummy variable and period effects. In this case, the log-likelihood ratio is maximized at 18.5%, and as before, the coefficients of dummy and inflation are significantly different from zero. An increase in the inflation rate by 1% reduces the growth rate of output by 0.02% and there is sharp decline in growth rate by 0.0192% at the inflation level 18.5%.

In the works of Fischer (1993), Levine and Zervos (1992) and De Gregorio (1993), it is suggested that the true relation between growth rate and inflation rate are nonlinear. Thus the possibility exists that our results could simply be a manifestation of nonlinear relationship between inflation rate and growth. To test that we consider the following more general specification:

$$zpgdp = constant + \alpha_1.inflat + \alpha_{12}.(inflat)^2 + \beta_0.Dum + \beta_1.Dum.(inflat)$$
$$+ \beta_2.Dum.(inflat)^2 + u$$

If the nonlinearity is driving our previous result then the null hypothesis: $\beta_i = 0$, $i = 0,1,2$, must be true at the derived critical inflation level (17% and 18.5%). Table 5 summarizes the regression results of the above specification with country dummy variable and the critical inflation level 17%. In Table 6 we

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[14]   Based on our theoretical models, a reasonable choice of parameter values, for example, p_L = 0.75, p_H = 0.4, β_L = 0.35, δ = 0.5, ϵ = 0.175, λ = 0.75, θ = 0.325, Q = 3.5, results in a critical inflation level 17%

summarize the regression results with both country and time dummy variable and the critical inflation level 18.5%. The results show that, in both cases, coefficient of $(\text{inflat})^2$ is significantly different from zero. Thus the nonlinear hypothesis is a reasonable one. However, in both cases, the coefficient of the dummy variable remains positive and significantly different from zero. Thus the nonlinearity assumption does not contradicts our hypothesis regarding the critical inflation level.

5. Summary

The present chapter introduces money into a modified version of the growth model described in Chapter 1 with the intention of drawing a connection between inflation rate and growth rate of output. In this framework, a change in inflation affects the growth rate through its effect on the credit market. We show that, a higher inflation rate not only lowers the funds available for lending, but also alters the lender's behavior in such a way (either by increasing the incidence of rationing, or, by increasing the volume of screening, or by changing from screening to rationing behavior) that growth is adversely affected. A preliminary examination of the data on inflation and output growth rates indicates a critical inflation rate at which growth rate declines sharply. Our theoretical analysis rationalizes the existence of such a critical level of inflation rate and explains this sharp fall in the growth rate as the result of a change in the lending regime.

OUTPUT GROWTH RATE____
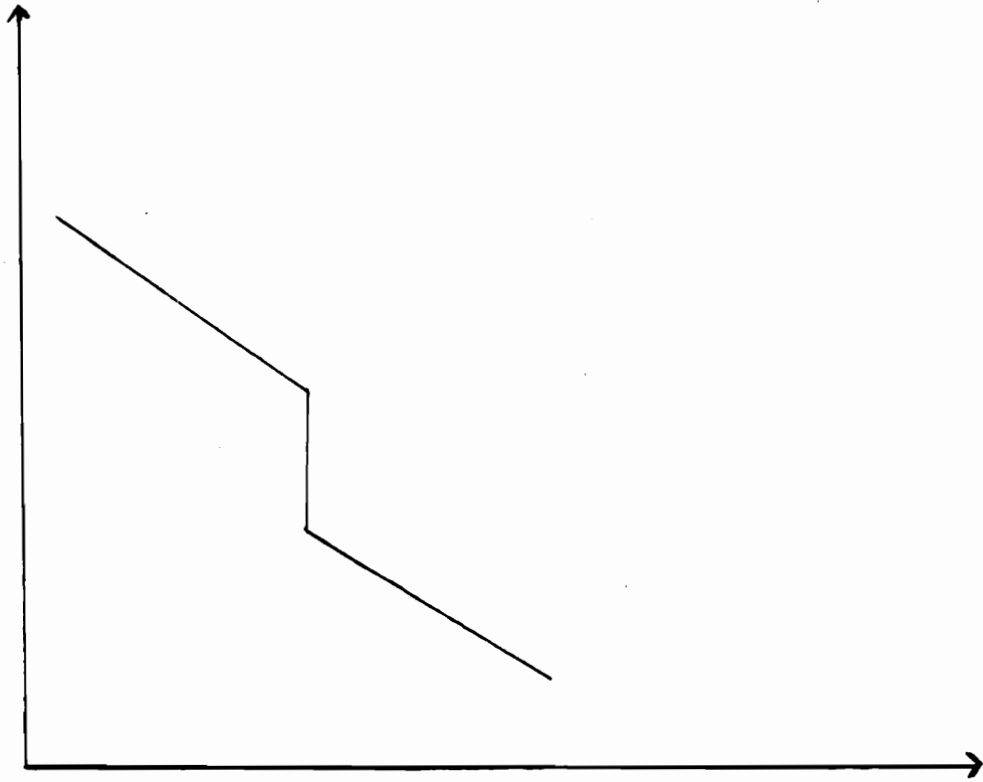
INFLATION RATE ____

DIAGRAM 1

Table 1
List of Countries
Mean Inflation and Output Growth Rates

Country	Mean Inflation	Mean Output Growth Rate
Algeria	0.0819	0.0537
Botswana	0.1071	0.0764
Burkina Faso	0.0557	0.0399
Burundi	0.0774	0.4828
Cameroon	0.0883	0.0482
Central African	0.0951	0.0122
Congo	0.0678	0.0549
Egypt	0.0862	0.0647
Ethiopia	0.0606	0.0310
Gabon	0.0799	0.0738
Ghana	0.2861	0.0182
Cote d' Ivoire	0.0690	0.0483
Kenya	0.0754	0.0500
Madagascar	0.1028	0.0078
Malawi	0.1142	0.0330
Mauritius	0.0832	0.0424
Morocco	0.0588	0.0564
Niger	0.0614	0.0214
Nigeria	0.1120	0.0227
Rwanda	0.0738	0.0478
Senegal	0.0756	0.0211
Sierra Leone	0.1898	0.0209
Somalia	0.1719	0.0256
South Africa	0.0847	0.0366
Sudan	0.1499	0.0234
Swaziland	0.0416	0.0542
Tanzania	0.1729	0.0508
Togo	0.0639	0.0345
Tunisia	0.0540	0.0345
Zaire	0.3280	0.0205
Zambia	0.1290	0.0133
Zimbabwe	0.0775	0.0482
Canada	0.0563	0.0399
Costa Rica	0.1146	0.0471
Dominican Rep.	0.0908	0.0468
El Salvador	0.0872	0.0336
Guatemala	0.0674	0.0390

Haiti	0.0597	0.0155
Honduras	0.0517	0.0470
Jamaica	0.1141	0.0239
Mexico	0.2284	0.0477
Nicaragua	0.3956	0.0072
Trinidad	0.0842	0.0230
United States	0.0512	0.0327
Argentina	0.7130	0.0214
Bolivia	0.4883	0.0313
Brazil	0.4919	0.0673
Chile	0.4345	0.0280
Colombia	0.1647	0.0460
Ecuador	0.1344	0.0508
Paraguay	0.1057	0.0527
Peru	0.3670	0.0365
Uruguay	0.4252	0.0117
Venezuela	0.0661	0.0481
Bangladesh	0.1094	0.0309
Burma	0.0607	0.0474
China	0.0515	0.0751
Hong Kong	0.0598	0.0844
India	0.0736	0.0310
Indonesia	0.2783	0.0541
Iran	0.0839	0.0560
Iraq	0.0433	0.0790
Israel	0.3628	0.0574
Japan	0.0412	0.0364
Jordan	0.0744	0.0419
South Korea	0.1111	0.0820
Malaysia	0.0331	0.0607
Nepal	0.0736	0.0294
Pakistan	0.0714	0.0528
Philippines	0.1062	0.0449
Singapore	0.0357	0.0761
Sri Lanka	0.0681	0.0313
Syr. Arab Rep.	0.0945	0.0629
Thailand	0.0526	0.0641
Yemen Rep.	0.1526	0.0980
Belgium	0.0512	0.0310
Denmark	0.0747	0.0296
Finland	0.0778	0.0383
France	0.0691	0.0366

Greece	0.1058	0.0470
Hungary	0.0628	0.0446
Iceland	0.2750	0.0446
Ireland	0.0915	0.0320
Italy	0.0943	0.0400
Luxembourg	0.0461	0.0304
Netherlands	0.0491	0.0346
Norway	0.0700	0.0418
Portugal	0.1216	0.0470
Spain	0.0984	0.0448
Sweden	0.0686	0.0287
Turkey	0.2107	0.0513
Yugoslavia	0.2305	0.0462
Australia	0.0699	0.0388
New Zealand	0.0873	0.0232

Table 2

Least Square with dummy variable
Dependent variable = mean growth rate of output
Critical inflation rate = 15%

Variable	Coefficient	Std. error	t-ratio
Mean Inflation	-0.062448	0.0276	-2.257
Dum	0.011143	0.0080	-1.416

Table 3
Least Squares with country dummy variable
Dependent Variable = Growth rate of output (zpgdp)

Critical Inflation	Inflat (Coeff.)	Dum (Coeff.)	Log-Likelihood
7%	-0.0421	0.0087	3559.17
	(-6.406)	(3.264)	
7.5%	-0.0421	0.0084	3558.75
	(-6.366)	(3.139)	
8%	-0.0402	0.0103	3561.23
	(-6.057)	(3.826)	
8.5%	-0.0400	0.0106	3561.38
	(-6.011)	(3.863)	
9%	-0.0402	0.0103	3560.77
	(-6.025)	(3.709)	
9.5%	-0.0399	0.0104	3560.71
	(-5.961)	(3.692)	
10%	-0.0404	0.0097	3559.61
	(-6.003)	(3.391)	
10.5%	-0.0389	0.0113	3561.52
	(-5.776)	(3.899)	
11%	-0.0380	0.0123	3562.56
	(-5.623)	(4.147)	
11.5%	-0.0380	0.0125	3562.21
	(-5.607)	(4.065)	
12%	-0.0373	0.0133	3562.96
	(-5.492)	(4.240)	
12.5%	-0.0359	0.0151	3564.86
	(-5.275)	(4.654)	
13%	-0.0360	0.0148	3564.02
	(-5.256)	(4.475)	
13.5%	-0.0361	0.0148	3563.63
	(-5.254)	(4.391)	
14%	-0.0372	0.0137	3561.58
	(-5.387)	(3.914)	
14.5%	-0.0358	0.0154	3563.36
	(-5.177)	(4.330)	
15%	-0.0347	0.0167	3564.56
	(-4.988)	(4.592)	
15.5%	-0.0352	0.0160	3563.17
	(-5.026)	(4.289)	

16%	-0.0338	0.0180	3564.96
	(-4.812)	(4.675)	
16.5%	-0.0329	0.0193	3566.11
	(-4.677)	(4.908)	
17%	-0.0323	0.0202	3566.58
	(-4.589)	(5.000)	
17.5%	-0.0327	0.0197	3565.61
	(-4.628)	(4.807)	
18%	-0.0327	0.0199	3565.29
	(-4.609)	(4.743)	
18.5%	-0.0312	0.0215	3566.46
	(-4.360)	(4.975)	
19%	-0.0335	0.0195	3563.80
	(-4.611)	(4.427)	
19.5%	-0.0331	0.0195	3563.66
	(-4.593)	(4.398)	
20%	-0.0325	0.0203	3564.18
	(-4.511)	(4.511)	
20.5%	-0.0347	0.0228	3566.48
	(-4.201)	(4.981)	
21%	-0.0307	0.0228	3565.78
	(-4.231)	(4.842)	
21.5%	-0.0298	0.0236	3566.15
	(-4.070)	(4.915)	
22%	-0.0290	0.0226	3566.03
	(-3.951)	(5.086)	
22.5%	-0.0302	0.0239	3565.32
	(-4.092)	(4.750)	
23%	-0.0308	0.0233	3564.49
	(-4.175)	(4.577)	
23.5%	-0.0298	0.0247	3565.59
	(-4.025)	(4.804)	
24%	-0.0297	0.0252	3565.44
	(-3.997)	(3.888)	
24.5%	-0.0307	0.0239	3563.93
	(-4.127)	(4.457)	
25%	-0.0301	0.0250	3564.35
	(-4.015)	(4.546)	

* t-ratios are in the parenthesis.

Table 4
Least Squares with country dummy variable and period effects
Dependent Variable = Growth rate of output (zpgdp)

Critical Inflation	Inflat (Coeff.)	Dum (Coeff.)	Log-Likelihood
7%	-0.0333	0.0060	3630.71
	(-5.048)	(1.915)	
7.5%	-0.0329	0.0062	3630.85
	(-4.967)	(1.985)	
8%	-0.0313	0.0088	3632.90
	(-4.720)	(2.799)	
8.5%	-0.0308	0.0095	3633.49
	(-4.625)	(2.992)	
9%	-0.0308	0.0093	3633.22
	(-4.614)	(2.908)	
9.5%	-0.0305	0.0094	3633.30
	(-4.549)	(2.932)	
10%	-0.0307	0.0085	3632.45
	(-4.565)	(2.644)	
10.5%	-0.0292	0.0109	3634.58
	(-4.335)	(3.323)	
11%	-0.0284	0.0118	3635.54
	(-4.197)	(3.587)	
11.5%	-0.0280	0.0122	3635.65
	(-4.134)	(3.617)	
12%	-0.0270	0.0135	3637.07
	(-3.974)	(3.973)	
12.5%	-0.0257	0.0154	3639.06
	(-3.774)	(4.427)	
13%	-0.0258	0.0149	3638.09
	(-3.766)	(4.212)	
13.5%	-0.0258	0.0148	3637.75
	(-3.756)	(4.134)	
14%	-0.0269	0.0131	3635.45
	(-3.896)	(3.564)	
14.5%	-0.0259	0.0146	3636.81
	(-3.742)	(3.911)	
15%	-0.0247	0.0161	3638.17
	(-3.559)	(4.229)	

15.5%	-0.0253	0.0150	3636.56
	(-3.616)	(3.850)	
16%	-0.0244	0.0162	3637.54
	(-3.490)	(4.085)	
16.5%	-0.0239	0.0171	3638.18
	(-3.409)	(4.233)	
17%	-0.0239	0.0170	3637.83
	(-3.398)	(4.152)	
17.5%	-0.0237	0.0172	3637.69
	(-3.358)	(4.120)	
18%	-0.0236	0.0171	3637.41
	(-3.326)	(4.054)	
18.5%	-0.0217	0.0192	3639.07
	(-3.027)	(4.429)	
19%	-0.0234	0.0171	3636.66
	(-3.249)	(3.874)	
19.5%	-0.0237	0.0166	3636.08
	(-3.294)	(3.729)	
20%	-0.0237	0.0167	3636.03
	(-3.277)	(3.716)	
20.5%	-0.0219	0.0189	3637.80
	(-3.023)	(4.145)	
21%	-0.0220	0.0190	3637.42
	(-3.071)	(4.057)	
21.5%	-0.0210	0.0198	3637.79
	(-2.865)	(4.142)	
22%	-0.0203	0.0209	3638.43
	(-2.753)	(4.288)	
22.5%	-0.0215	0.0195	3636.82
	(-2.899)	(3.913)	
23%	-0.0218	0.0192	3636.38
	(-2.941)	(3.805)	
23.5%	-0.0211	0.0202	3637.03
	(-2.841)	(3.964)	
24%	-0.0213	0.0200	3636.49
	(-2.862)	(3.832)	
24.5%	-0.0226	0.0182	3635.03
	(-3.011)	(3.449)	
25%	-0.0218	0.0193	3635.45
	(-2.893)	(3.563)	

* t-ratios are in the parenthesis.

Table 5
Least Squares with country dummy variable
Dependent variable = growth rate of output (Zpgdp)
Critical inflation rate = 17%

Variable	Coefficient	Std. error	t-ratio
Inflat	-0.0808	0.0142	-5.666
Dum	0.0131	0.0058	2.263
$(Inflat)^2$	0.0187	0.0043	4.287
Inflat.Dum	-0.0272	0.0707	-0.385
$(Inflat)^2.Dum$	0.0301	0.4671	0.065

Table 6
Least Squares with country dummy and period dummy variable
Dependent variable = growth rate of output (Zpgdp)
Critical inflation rate = 18.5%

Variable	Coefficient	Std. error	t-ratio
Inflat	-0.0598	0.0146	-4.082
Dum	0.0165	0.0067	2.445
$(Inflat)^2$	0.0143	0.0043	3.284
Inflat.Dum	-0.0064	0.0697	-0.092
$(Inflat)^2.Dum$	-0.2271	0.4062	-0.561

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