Loanable Funds, Monitoring and Banking*

Huberto M. Ennis†
Department of Economics
Cornell University

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Abstract

This paper studies financial intermediation in a general equilibrium overlapping generations model. Indivisible investment projects combine with informational imperfections to create a (hidden action) moral hazard problem and introduce a role for third-party monitoring. Agency costs at the intermediary level are also considered. Under some conditions, monitors can be viewed as banks facing a non-trivial portfolio diversification problem. Equilibria are derived in which a large national bank coexists with a number of regional banks, a structure of strong empirical relevance. Policies such as a mandatory reserve requirement are shown to have substantial effects on the levels of investment in the economy. **JEL Classification**: E44, G21, G28

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†Address: *Department of Economics, 449A Uris Hall, Cornell University, Ithaca NY 14853.* E-mail: *hme1@cornell.edu.*

1 Introduction

After the banking system turmoil of the beginning of the 1990's, on February 5, 1991 the US Treasury released a proposal for banking reform (see Mishkin (1992)). Two of the most important areas of improvement suggested by the Treasury were the restoration of the competitiveness of the system and the strengthening of the role of bank capital. To improve competitiveness, portfolio diversification was taken to be the crucial instrument. In the words of Mishkin, "nationwide branching would enable banks to diversify their loan portfolios substantially, since they would find it easier to make loans in broader geographical areas." With respect to bank capital, Mishkin suggest that bank categorization and other provisions in the proposal were "all directed at encouraging banks to hold more capital... Since increasing capital is probably the most effective way of reducing moral hazard incentives for the bank to take on too much risk. These rules are among the most important and welcome Treasury recommendations."

On September 29, 1994 the Riegle-Neal Interstate Banking and Branching Efficiency Act was signed into law by the US President. The act eliminates most restrictions on interstate banking and makes nationwide branching possible for the first time in seventy years.

As a consequence of these recent developments a whole new set of issues related to the functioning of the financial intermediation system has emerged. Is interstate banking efficient? Will banks still operate with branches in one, two, or several states? Or will *all* banks become national banks? Will the banking system become more stable?, more efficient? What are the macroeconomic implications of the change in the regulation? My purpose in this paper is to introduce a framework where some of these questions can be studied in an organized manner.

The literature on financial intermediation is vast. Several varieties of models have recently been constructed to formally study the nature of intermediation in modern economies. In a recent paper, Holmstrom and Tirole (1997) have proposed a somewhat novel way to motivate the existence of financial institutions. Their model is based on a specific information asymmetry between investors: a principal cannot observe an action that an agent is supposed to perform during the realization of the production process (a "hidden action"). In particular, there is a certain level of effort (or some other activity) that the agent needs to exert in order to increase the probability of a good outcome for the jointly-financed project. This situation opens the possibility of shirking by the agent and therefore full leveraging of investment projects ceases to be incentive-compatible. Hence, the Modigliani-Miller Proposition fails to hold and financial arrangements become important. An intermediary performing personalized monitoring of effort can ameliorate this principal-agent problem. However, there still exists a potential conflict of interest between the principal and the intermediary. If the activity of the intermediary (monitoring the agent) is costly and not observable by the principal, incentive restrictions on the intermediary can also be important.

In this paper, I embed this hidden action problem in a fully specified general equilibrium overlapping generations model. There is a group of agents (called informed investors) that start their economic life with a potentially implementable investment project. If such an agent can obtain sufficient funds in the financial market, she will be able to undertake her project and produce a certain amount of capital. This capital is then available in the next period for use, along with labor, in the production of the final consumption good. The informational problem arises in the production of the capital goods because the probability of success in the investment project depends on the unobservable level of effort exerted by the project owner. Limited liability and costly monitoring result in some level of equilibrium credit rationing.

With the model in place, I move on to study a number of implications for the performance of the aggregate economy of alternative financial intermediation arrangements. I relax some of the crucial assumptions in Holmstrom and Tirole (1997) (mainly the perfect correlation of investment projects in an individual bank's portfolio) and study in a systematic way the formation of an equilibrium banking system. I divide the economy into a large number of differentiated geographical "zones". Projects inside a zone are perfectly correlated, while projects in different zones are independent. Banks have access to projects in different zones only at a cost of diversification associated to branching. In this framework, I study the banks' optimal decisions on portfolio diversification. I show that several regional nondiversified banks *coexists in equilibrium* with a nationwide diversified institution. Diversification, although costly, may allow agents to save in agency costs. As a consequence, equilibrium investment and aggregate production under diversification can be greater than in the case when (for some reason) diversification is not permitted in the system. Also, I show that a government policy that imposes some level of reserve requirement on deposits may result in the equilibrium having no diversification by banks. This is true even when, in the absence of this policy, the banking system would include a large completely diversified "national" bank. This phenomenon occurs because a reserve requirement increases the cost of financing a project by both regional (non-diversified) banks and the national bank, but relatively more so when the bank is diversified. As a consequence, diversification become less attractive. The reason why the reserve requirement is more costly for the diversified bank is that this bank relies more on external financing of projects and the reserve requirement increases the cost of those funds.

The next section relates the paper to previous literature on the subject. Section 3 presents the model and Section 4 studies thoroughly some of its basic characteristics. I choose to do this within the simplest possible financial arrangement: the case where monitoring of effort is not possible. Diversification has no effect under this regime. Section 5 allows for monitoring and diversification and presents different possible financial market organizations within this enriched setup. Mandatory reserve requirements are shown to have important economic implications. Section 6 is saved for conclusions.

2 Related Literature

One of the first papers where financial intermediation appears as the optimal arrangement for a given investment technology is Diamond (1984). Following ideas first presented in Townsend (1979), Diamond develops a partial equilibrium model of financial intermediation with a costly state verification (CSV) problem. He shows that the optimal contract is a debt contract (see also Gale and Hellwig, 1985) and that a financial intermediary, pooling deposits to finance investment projects, may be an efficient solution to the monitoring problem. Monitoring will be an important part of our model. But, while Diamond assumed that any agent could potentially be a monitor (although they join together in coalitions to economize the cost of monitoring; see also Boyd and Prescott (1986)), in the model presented herein only a subset of agents can monitor and these will be the natural candidates to become financial intermediaries. Agency costs at the level of the monitor are an important feature shared by this model and Diamond's; and, as in his paper, diversification plays an important role in the design of efficient solutions to this problem.

As mentioned in the introduction, the basic informational problem in the present paper is taken directly from Holmstrom and Tirole (1997).[1] As in the CSV literature, the Holmstrom-Tirole model is also in the principal-agent tradition. However, the foundations of the market imperfection are fundamentally different. While in the CSV models the imperfect information arises from a "hidden state," in the Holmstrom-Tirole environment it is a "hidden action" that brings about the incentives problems. This "hidden action" framework for studying the economic implications of imperfect financial intermediation has been already successfully applied to the issues of economic growth and income distribution.[2] Developing a general equilibrium version of the Holmstrom-Tirole model and relaxing some of their assumptions throughout the analysis will allow me to handle issues of portfolio diversification and of "regulatory" policies imposed by a monetary-financial authority.

The model in this paper is close in spirit to the model presented in Bernanke and Gertler (1989), but it differs in some important ways. First, Bernanke and Gertler introduce the financial system as a consequence of a costly (hidden) state

[1] A thorough analysis of a similar moral hazard problem can be found in Besanko and Kanatas (1993). In that article, though, the effort of both project-owners and monitors takes values in a continuum and bank monitoring is perfect, i.e. it singles out a specific level of effort and eliminates entrepreneurial moral hazard.

[2] See Aghion and Bolton (1997). Another important model of growth, financial intermediation and income distribution is the one proposed by Greenwood and Jovanovic (1990). There also exists an extensive literature on models of economic growth with imperfect financial intermediation (eg. Bencivenga and Smith (1991), Greenwood and Smith (1997)). See Levine (1997) for a recent survey on the general subject.

verification problem. Second, the present paper differs from theirs in the emphasis of subjects. Bank formation and loan portfolio diversification are important subjects to be analyzed in the following sections but were only tangentially discussed in Bernanke and Gertler.

Another closely related paper is Boyd and Smith (1998) (see also Huybens and Smith (1998), sections 3 and 4). They study an economy with similar characteristics to the ones described above, but their financial sector is motivated by the existence of a costly state verification problem of the type studied by Williamson (1986, 1987a). Properties of the dynamic equilibrium are dramatically changed by this alternative assumption. In addition, in their work diversification is simply assumed. Huybens and Smith study the implications of imposing a reserve requirement in the Boyd-Smith model (with somewhat different properties than the ones assumed here). The focus of their analysis, though, is fundamentally different from that in the present paper.

Similarly, our model economy has several features in common with Williamson (1987).[3] Williamson studies a different information problem (costly state verification) and, in particular, the effect on business-cycle fluctuations of a very specific set of shocks to the fundamentals of the economy (he considers mean preserving spreads to the distribution of project's returns). Although one could not perform the same kind of experiment in my model, I think that comparing aggregate fluctuations within these two models may help improve our understanding of the role of financial arrangements in the macro-economy. I will not present any results along this line here, but I believe that these issues constitute an essential part of any further research.

Finally, two other papers need to be mentioned: (*i*) Azariadis and Smith (1996) analyze an overlapping generations economy with similar characteristics to the ones in this paper but where the information problem in the production of capital goods generates an adverse selection effect similar to that in Stiglitz and Weiss (1981);[4]

[3] Boyd and Smith (1998) borrow features from both Williamson (1987) and Bernanke and Gertler (1989). Three important differences between these papers are worth mentioning. First, while in Williamson the investment projects produce consumption goods directly, in Bernanke-Gertler they produce investment goods to be later used as inputs in the production of a final good (in this Boyd and Smith follow Bernanke and Gertler). Second, in Bernanke-Gertler monitoring reveals the return of the project to everybody in the economy. This is not so in either Williamson or Boyd and Smith (they assume that only the monitor knows the observed state) and this creates incentives for the formation of large financial intermediaries in those two models. Third, Bernanke and Gertler assume that the project return is a random variable with finite support and allow for stochastic monitoring. Alternatively, Boyd and Smith, following Williamson, consider random returns taking values in a continuum and rule out by assumption stochastic monitoring.

[4] Many papers on the effects of imperfect information on credit arrangements find inspiration in the early work by Stiglitz and Weiss (1981). The focus of the Stiglitz and Weiss paper was mainly on the role of adverse selection in creating equilibria with credit rationing. However, several interesting discussions provided in that paper motivated the work of several other authors and would surely become highly relevant if we were to think about possible extensions and generalizations of the arguments presented here.

(*ii*) Hart and Moore (1993) (see also Hart (1995), Chapter 5) study the incomplete contracting theory of debt (see also Aghion and Bolton (1992)), and show that the existence of non-verifiable and non-transferable returns from the investment projects generates some second best inefficiencies that resemble the ones to be discussed in the following sections. Note however that in Hart and Moore there is no asymmetric information. It is only the fact that some private benefits associated with projects are not contractible that makes the financial relationships interesting. Kiyotaki and Moore (1998) present a general equilibrium version of that model of financial contracting which could be specially relevant for comparisons with the business-cycle implications of the model studied in the present paper.

3 The Model

Consider an economy populated by a large number of individuals with names in the unit interval. Agents live two periods each, in overlapping generations. There are three types of agents. A proportion $(\alpha - \phi)$ of the population are of type 1, which are called uninformed investors. They own h units of raw labor when young and each of these units of labor have productivity $\overline{\overline{\theta}}$. They have lifetime preferences represented by the utility function $\xi v(c_t, l_t) + Ec_{t+1}$, where c_t and l_t are period t consumption and leisure and ξ is a parameter. Type 2 agents also own h units of raw labor when young but they have different levels of productivity associated with their supply of labor. Raw labor productivity for type 2 agents has a uniform distribution between zero and one, i.e. $\widetilde{\theta} \sim U[0, 1]$. A fraction $(1 - \alpha)$ of agents are of type 2. Each of these agents own an investment project, and they are called informed investors. Finally, there is a measure ϕ of type 3 agents that have the same characteristics as type 1 agents, but they are also able to partially monitor informed investors in the realization of projects. These agents are called intermediaries; they are the agents potentially suited to set up a bank.[5]

There are three commodities: labor (in efficiency units), consumption goods and capital goods. The consumption goods are produced by perfectly competitive firms with a constant returns to scale technology. The production function is given by $Y_t = v_t F(K_t, L_t)$ where v_t represent a technology shock, K_t is capital good input and L_t is the amount of efficiency units of labor used in production of the consumption good. Standard Inada conditions are assumed to hold. For simplicity it is assumed that capital fully depreciates each period.

Each investment project owned by a type 2 agent requires I units of the consumption good and has a return of R units of the capital good at the beginning of the

[5] It is not hard to endogenize the number ϕ of monitors in the economy. Suppose that any agent can potentially acquire the monitoring technology at the beginning of their lifetime but that they have differential costs of doing it. Then, only the agents with a comparative advantage in the acquisition of the technology will become monitors in equilibrium.

following period.[6] However, the projects are successful only with certain probability and informed investors can exert different levels of effort that result in different probabilities of success. The utility function of type 2 agents is given by $B - \vartheta_t + Ec_{t+1}$ where ϑ_t represent the level of effort exerted in the project. Assume ϑ can take only three possible values, B, $(B - b)$ or 0 with $B > B - b > 0$. Redefine $\vartheta_t^* \equiv B - \vartheta_t$ as the utility return associated with performing projects with different probability of success. Then, as in Holmstrom and Tirole (1997), the investment alternatives of type 2 agents are summarized by the following table.

Utility Return	0	b	B
Prob. of Success	p_H	p_L	p_L

Note that the project with utility return b gives the same probability of success as the project with utility return B. Since we assume $p_H > p_L$, under normal conditions the informed investor will always want to follow the latter alternative. However, we will assume that type 3 agents can monitor informed investors at a cost per project c in utility terms to determine whether investors are exerting effort or not. Monitoring is not observable by third parties. Under certain conditions, when this kind of monitoring is possible, type 2 agents will be able to misrepresent *high* levels of effort by only performing *some* level of effort and in those cases the alternative (b, p_L) will become relevant.

The dynamic economy functions as follows. At the beginning of each period t, there is a level K_t of capital goods for use in the production of consumption goods. Firms buy efficiency units of labor at price w_t and capital goods at price q_t. Perfect competition implies that factor prices (w_t, q_t) equal the marginal productivity of labor and capital, respectively. Type 2 agents make the necessary financing arrangements to undertake the investment projects and all agents make their consumption-leisure-savings decisions. Projects undertaken at period t will provide the capital goods K_{t+1} with which the economy will start the next period. In the following sections, we will present different financial systems and the conditions under which they constitute an equilibrium in this environment. The financial system will in turn determine the way investment projects are undertaken, the returns for informed and uninformed investors, and the overall dynamics of the aggregate economy.

For the analysis in this paper I will be assuming that $\xi = 0$ holds and, hence, that agents type 1 and type 3 only care about consumption in the second period of life according to a risk neutral utility function. Also, I will let $\upsilon_t = \upsilon$ for all t. These assumptions surely ought to be relaxed in order to study the business cycle implications of the model. I do not pursue this route of research in the present paper but I consider it a natural next step to the work described here.

[6] R could be heterogeneous. This has interesting implications for which projects are undertaken in equilibrium and its relation with the financing constraint and the distribution of funds (income) across investors (see footnote 11 below).

4 The No-Monitoring Economy

In this section I analyze the model under the simplest possible financial arrangement (no monitoring). For this, assume that $c = \infty$ so that type 3 agents never monitor informed investors and hence they behave exactly as type 1 agents. The main purpose of the section is then to highlight some of the characteristics of the newly provided model. However, I also consider the case with no monitoring as a good benchmark for other (more complicated) situations.

Uninformed Investors. Type 1 and type 3 agents supply h units of raw labor inelastically. Suppose that there are only two possible ways of saving in this economy, money and investment in capital-producing projects. Then uninformed investors solve the following problem

$$\text{maximize } Ec^1_{t+1}$$

subject to

$$b^1_{t+1} + p_t m^1_{t+1} \leq w_t \bar{\bar{\theta}} h$$
$$c_{t+1} \leq \widetilde{r}_{ut} b^1_{t+1} + p_{t+1} m^1_{t+1} + p_{t+1} T_{t+1}$$
$$c^1_{t+1}, b^1_{t+1}, m^1_{t+1} \geq 0,$$

where p_t is the price of money in period t.[7] The quantity b^1_{t+1} is the amount loaned to informed investors, with $\widetilde{r}_{ut}$ being its random return, and T_{t+1} is a government money transfer. Each project will pay r_{ut} if successful and zero otherwise. Lenders could try to dilute the risk of failure by investing in a diversified portfolio. However, since agents are risk neutral, this diversification will not improve their lifetime utility. It is important to keep in mind that the introduction of banks is not justified by this type of pooling of risks.

In this economy, as is usual in monetary theory, there always exists an equilibrium with $p_t = 0$ for all t. If $p_t > 0$ along the equilibrium path we will call this a *monetary equilibrium*. From the first order conditions of type 1 agents we have that in every monetary equilibrium[8]

$$\gamma_t \equiv \frac{p_{t+1}}{p_t} = p_H r_{ut}.$$

Let $s^1_t \equiv b^1_{t+1} + p_t m^1_{t+1} = w_t \bar{\bar{\theta}} h$ be the equilibrium saving function for agents of types 1 and 3.

[7] See Wallace (1980) for this convenient way of defining the price system. An alternative way (the present value prices) is exploited thoroughly in Balasko and Shell (1981) for the case of endowment economies with multiple commodities. We choose the first method only because it saves notation in the present setup.

[8] This is a direct implication of a no-arbitrage condition originating from the fact that only type 1 agents use money as a store of value in equilibrium. For them investment in projects or in money should be perfect substitutes. Note however that the model does not have perfect securities markets (due to the information problems) and that there will be some assets that actually dominate money in rate of return. For an interesting discussion on the subject see the classic paper by Wallace (1988).

Informed Investors. Assume that $hw_t < I$ along the equilibrium path[9] so that informed agents need external financing to carry out their project. Also along the equilibrium path assume that

$$p_L q_{t+1} R - \gamma_t I < 0 < p_H q_{t+1} R - \gamma_t I - B \tag{1}$$

holds, so that it is optimal to exert effort in the realization of projects and projects become unprofitable if effort is not effectively put forth. The only way that no effort (or, for the matter, low effort) can be profitable is if a higher share of the cost is borne by the uninformed investors being deceived. With these assumptions in place, the problem of a type 2 agent is to

$$\max \vartheta_t^* + E c_{t+1}^2 \tag{2}$$

subject to

$$b_{t+1}^2 + p_t m_{t+1}^2 + A_t^2 \leq w_t \widetilde{\theta} h,$$
$$c_{t+1}^2 = \widetilde{r}_{it}(\vartheta_t^*, A_t^2) + \widetilde{r}_{ut} b_{t+1}^2 + p_{t+1} m_{t+1}^2 + p_{t+1} T_{t+1},$$
$$c_{t+1}^2, b_{t+1}^2, m_{t+1}^2 \geq 0,$$

where $\widetilde{r}_{it}(0, A_t^2) = q_{t+1} R - \widetilde{r}_{ut} \left(I - A_t^2\right)$, A_t^2 is the amount of own funds invested in the own project and b_{t+1}^2 is the amount of own funds invested in other agents' projects.[10]

We will consider equilibria where *(i)* condition (1) holds and *(ii)* it is incentive compatible for the agent to exert high effort. Note that when it is not incentive compatible for the informed investor to exert high effort and every agent in the economy (especially the uninformed investors) can foresee this, the project will not be economically viable and it will not be carried out (see expression (1)). Define $\Delta p \equiv p_H - p_L$. Then the following condition makes *internal financing* essential for incentives to point in the right direction:

$$q_{t+1} R - (\gamma_t / p_H) I < B / \Delta p. \tag{3}$$

Hence, we will consider equilibria where the following incentive compatibility (IC) constraint holds whenever a project is being carried out:

$$p_H \left[q_{t+1} R - r_{ut} \left(I - A_t^2\right)\right] \geq p_L \left[q_{t+1} R - r_{ut} \left(I - A_t^2\right)\right] + B. \tag{4}$$

Note that in this formulation it is implicit that asset holdings A_t^2 are observable. Assuming that condition (3) holds implies that incentive compatibility requires $A_t^2 > 0$ to hold. In other words, internal funding is necessary to be able to make high effort

[9] Note that w_t and q_t depend on $k_t \equiv K_t / L_t$ in equilibrium and that k_t potentially moves along the equilibrium path (see Assumption 4 in Huybens and Smith, 1998).

[10] The restriction $c_{t+1}^2 \geq 0$ implies a certain degree of limited liability. No exogenous punishment schemes are allowed. See Diamond (1984) for some of the consequences of nonpecuniary incentives in environments of this kind.

incentive compatible. It is not hard to see from the first order condition to problem (2) that one can assume, without loss of generality, that $b^2_{t+1} = m^2_{t+1} = 0$ for every t. Then, $A^2_t(\widetilde{\theta}) = \widetilde{\theta} h w_t$ must hold whenever the project is undertaken and, hence, informed investors use all of their funds in the enterprise.

We can rewrite expression (4) as

$$q_{t+1}R - r_{ut}\left(I - w_t\widetilde{\theta}h\right) \geq B/\Delta p. \tag{5}$$

Define $\overline{\theta}_t \in (0,1]$ to be the value of $\widetilde{\theta}$ for which equation (5) holds with equality in period t. All type 2 agents with labor productivity less than the threshold $\overline{\theta}_t$ will not be able to credibly carry out their projects (exerting high effort) and therefore they will drop the project altogether (zero-effort projects are not economically viable). Internal financing of projects increases the contingent payoff received when the project succeeds. This, in turn, fosters incentives towards increasing the probability of success and hence makes high levels of efforts incentive compatible (see **Figure 1**).[11]

Net savings for type 2 agents are then given by the function

$$s^2_t(\widetilde{\theta}) = \begin{cases} 0 & \text{if } \widetilde{\theta} \geq \overline{\theta}_t \\ b^2_{t+1} + p_t m^2_{t+1} = w_t\widetilde{\theta}h & \text{if } \widetilde{\theta} < \overline{\theta}_t \end{cases} \tag{6}$$

and $A^2_t(\widetilde{\theta}) + s^2_t(\widetilde{\theta}) = w_t\widetilde{\theta}h$ for every $\widetilde{\theta} \in [0,1]$.

Firms. Firms buy efficiency units of labor and capital services and produce consumption goods in a perfectly competitive environment. Define $k_t \equiv K_t/L_t$. From the first order conditions of the firm's optimization problem (firms maximize profit in what turns out to be a standard static problem) we obtain that in equilibrium the following must hold:

$$w_t = \upsilon\frac{\partial F(K_t, L_t)}{\partial L_t} \equiv \upsilon\omega(k_t),$$

$$q_t = \upsilon\frac{\partial F(K_t, L_t)}{\partial K_t} \equiv \upsilon q(k_t).$$

To close the model we assume a first period old generation that has K_0 units of capital goods and H_0 units of money.

Market Clearing. The capital market clearing condition for period $t+1$ is given by

$$K_{t+1} = (1-\alpha)(1-\overline{\theta}_t)p_H R. \tag{7}$$

[11] An interesting possibility in this model is to consider the case of heterogeneous R, i.e. different projects having different productivity. In this situation, informed investors will differ not only in their level of labor efficiency $\widetilde{\theta}$, but also on the productivity R of their respective endowed projects. The correlation of $\widetilde{\theta}$ with R becomes important in this setup since it is possible that projects with high productivity never get done because the owner has available low levels of internal financing. Also, it is natural to think that a market for projects could appear. However, in the rest of the present paper we will focus on other implications of the model and assume homogeneous R for clarity of exposition.

The period-t market clearing condition for efficiency units of labor is given by

$$L_t = \alpha\overline{\overline{\theta}}h + (1-\alpha)h\int_0^1 \widetilde{\theta}d\widetilde{\theta},$$

where the first term in the right hand side is the total supply provided by type 1 and type 3 agents and the second term is the total supply provided by type 2 agents. Finally, the asset market clearing condition is given by

$$(1-\alpha)\int_0^{\overline{\theta}} s_t^2(\widetilde{\theta})d\widetilde{\theta} + \alpha s_t^1 = p_t(H_{t-1}+T_t) + (1-\alpha)\int_{\overline{\theta}}^1 \left[I - A_t^2(\widetilde{\theta})\right]d\widetilde{\theta}. \tag{8}$$

where H_{t-1} is the total stock of fiat money available at period $t-1$.

Equilibrium. Equation (7) imposes an obvious restriction on the feasible level of capital along the equilibrium path (after period 1):

$$K_t \leq (1-\alpha)p_H R. \tag{9}$$

This restriction, together with $hw_t < I$ and condition (1), imposes upper and lower bounds on the level of k_t along the equilibrium path. Let Φ be the set of possible levels of capital for which all three restrictions are satisfied.[12]

Note that $H_t = H_{t-1} + T_t$ holds. Assume that $T_t = (\mu - 1)H_{t-1}$ defines the monetary policy in place. Then we have $H_t = \mu H_{t-1}$ and we can express $\gamma_t \equiv p_{t+1}/p_t = z_{t+1}/(\mu z_t)$ in terms of $\{z_t\}$, where $z_t \equiv p_t H_t$. Assume for simplicity that $h = 2/[\alpha(2\overline{\overline{\theta}}-1)+1]$ so that $L_t = 1$ for all t in equilibrium (this is just a normalization). Using equation (7) we can define

$$\theta(k_{t+1}) \equiv 1 - \frac{k_{t+1}}{(1-\alpha)p_H R}. \tag{10}$$

Finally, let the set $\Gamma \subset \mathbb{R}^3$ be the set where $k \in \Phi$ and condition (3) hold.

Definition 1 [13]*A Monetary IC Equilibrium is a sequence* $\{k_t,\ z_t,\ \overline{\theta}_t\} \subset \Gamma$ *for which equations (7) and (8) hold and (5) holds with equality for all* t *given the initial condition* k_0 *for capital.*

Proposition 2 *A Monetary IC Equilibrium satisfies the following system of difference equations for all* t*:*

$$z_t - \upsilon\omega(k_t) + \frac{k_{t+1}I}{p_H R} = 0 \tag{11}$$

[12]Note the difference between condition (9), which has to hold for any equilibrium, and, for example, condition $hw_t < I$ which corresponds to a special interest in equilibria where external financing is necessary. One could certainly analyze other possible equilibria where the second type of condition does not hold (although if $hw > I$ the information problem vanishes).

[13]In this paper, I concentrate on the monetary equilibria of the model. For a short characterization of the non-monetary equilibrium ($p_t = 0$ for all t) see **Appendix 1**.

$$\theta(k_{t+1}) - \frac{1}{h\upsilon\omega(k_t)}\left[I - p_H\frac{\mu z_t}{z_{t+1}}\left(\upsilon q(k_{t+1})R - \frac{B}{\Delta p}\right)\right] = 0. \qquad (12)$$

given $k_t = K_0$ *for* $t = 0$.

Steady State. In steady state $z_{t+1} = z_t = z^{ss}$ and $k_{t+1} = k_t = k^{ss}$. Then, using equation (12) we have that the steady state per capita capital stock has to satisfy the following equation

$$G(k^{ss}) \equiv p_H\mu\left[\upsilon q(k^{ss})R - \frac{B}{\Delta p}\right] - I + h\upsilon\omega(k^{ss})\left(1 - \frac{k^{ss}}{(1-\alpha)p_H R}\right) = 0. \qquad (13)$$

Note that $\lim_{k\to 0} G(k) = \infty$. Since $G(k)$ is a continuous function, if there exists a steady state (SS) capital, then the smallest SS capital have $G'(k^{ss}) < 0$. The following lemma suggests conditions under which this SS is unique.

Lemma 3 *Whenever* $h < \mu/(1-\alpha)$, $G'(k^{ss}) < 0$ *for any steady state capital* k^{ss}.

Proof. See **Appendix 2**. ■

Corollary 4 *Assume* $h < \mu/(1-\alpha)$. *Then, if there exists a steady state, it is unique.*

Note that the condition in the lemma is only sufficient. This result is important because there are examples in the literature of economies with imperfect financial intermediation where two steady state levels of capital is the rule. The lemma is intended to suggest that the forces that generate multiple steady states in other models are not in full play here. Note that in my model, as in the previous models in the literature (specifically Boyd and Smith, 1998), higher capital levels imply higher levels of internal financing of projects because $\upsilon\omega(k)$ is higher. In the Boyd and Smith (1998) model then, there are two forces interacting. On one side, higher capital stocks decrease the returns on the project $\upsilon q(k)R$. On the other side, since projects can be carried out with more internal financing, the return on loans can be sustained. Consequently, two possible steady states appear, one with low capital, low internal financing, and high returns to projects and the other with high capital, high internal financing, and low returns to projects.

In my model however, there is a third force that unbalances the first two. Higher capital levels not only increase internal financing but also necessarily relax the incentive compatibility constraints. This is the only way one can have higher levels of capital, as can be clearly seen in equation (7). This implies though that more projects with less internal financing are being undertaken. In consequence, the marginal project is not necessarily more internally financed and the steady state rate of return on loans cannot be sustained.

Transitional Dynamics. Consider the transitional dynamics in a neighborhood of the steady state equilibrium. From equation (11) we have $k_{t+1} \geq k_t$ if and only if

$z_t \leq \upsilon\omega(k_t) - (k_t/a)$ holds, where $a \equiv p_H R/I$ (see **Figure 2)**. Also, from equation (12) we have $z_{t+1} \geq z_t$ if and only if

$$\widetilde{G}(k_t, z_t) = p_H \mu \left[\upsilon q \left[g(k_t, z_t) \right] R - \frac{B}{\Delta p} \right] - I + h\upsilon\omega(k) \left(1 - \frac{g(k_t, z_t)}{(1-\alpha) p_H R} \right) \geq 0$$

holds, where $g(k_t, z_t) = a \left[\upsilon\omega(k_t) - z_t \right]$. Note that $\widetilde{G}(k_t, z_t)$ is increasing in z_t. Whenever $\partial g(k_t, z_t)/\partial k_t > \varphi$, where φ is a threshold value with $\varphi \leq 1$ (that translates into an upper bound for the capital stock k_t), using that $G'(k) < 0$ around the steady state capital, we have that $\widetilde{G}(k_t, z_t)$ is decreasing in k_t. Then, we can draw the $z_{t+1} = z_t$ curve as in **Figure 2.** Now we can see that the equilibrium converging to the steady state under these conditions will be a saddle path. Note that starting with a low level of capital stock, in the transition to the steady state situation, the demand for money grows with the stock of capital and the inflation level converges to the steady state level from below (the increase in capital increases the level of young-agents' income which then increases their demand for monetary assets).

Steady State Comparative Statics. Consider first the comparative statics for the steady state level of capital k^{ss} with respect to some important parameters, an exercise that gives new insights to the economics of the problem. The first result, well known in the literature on Overlapping Generations Models of Money, is the *Mundell-Tobin effect.*[14] Note that the steady state inflation in the model is equal to μ, the rate of money growth decided exogenously by the government. Then, using the Implicit Function Theorem, we obtain,

$$\frac{\partial k^{ss}}{\partial \mu} = -\frac{\frac{\partial G}{\partial \mu}}{\frac{\partial G}{\partial k}} > 0.$$

Money is not super-neutral in the model. Higher inflation rates make the channels for alternative-to-investment savings (mainly money) less attractive and therefore investment and the capital stock increase. There have been extensive discussions about the empirical validity of this feature (that our model shares with several other monetary models). Based on evidence presented by Bullard and Keating (1994) we propose that the analysis here be interpreted to refer to economies with a relatively low rate of inflation.

Another important result (especially when interested in business cycles implications) is that

$$\frac{\partial k^{ss}}{\partial \upsilon} > 0.$$

Increases in "total factor productivity" not only increase the return to investment but also increase the availability of internal funds for the financing of the investment projects. This allows more agents to credibly commit to high effort performance

[14]See Azariadis and Smith (1996) and the references therein.

and as a consequence to greater aggregate levels of investment. Finally, note that $\partial k^{ss}/\partial B < 0$, i.e. greater costs in terms of utility from exerting high effort imply that it is more costly to make an investment project incentive compatible and hence this reduces the aggregate level of attainable steady state capital.[15]

Consider now the effects of changes in the inflation rate on the steady state level of credit. It is easily seen that the steady state level of credit is given by

$$SScredit = (1-\alpha)\left[\left(1-\overline{\theta}\right)I - \frac{h\upsilon\omega(k)}{2}(1-\overline{\theta}^2)\right].$$

When steady state inflation increases, two opposing effects come into play. On one hand, since higher inflation implies higher steady state levels of capital, a larger number of projects will be undertaken in the economy, i.e., $\overline{\theta}$ will be lower. And, since $\left[I - h\upsilon\omega(k)\overline{\theta}\ \right] > 0$ holds, the amount of credit necessary in the economy will tend to increase. On the other hand, higher levels of capital imply higher internal funds for all the agents in the economy, and specifically for *all* informed investors. This obviously will tend to decrease the level of credit in the economy. Which of these two effects dominates depends mainly on the number of projects being undertaken in equilibrium and on the response of wages to changes in the capital stock (the higher is either of these two, the higher the chances that the second effect will dominate).

Similar conclusions follow from analyzing the response of steady state aggregate credit to changes in total factor productivity. Here however the chances that the second effect (increase on wages) will dominate are higher. The increase in υ increases wages in a *direct* way, in addition to the indirect way through the increase in the capital stock, which was also present when we consider the increases in μ.

Example 5 *Consider a Cobb-Douglas production function with parameter η (capital's share of income). Table 1 shows the assumed parameter values.*

Table 1

R	B	I	h	α	p_H	p_L	$\overline{\overline{\theta}}$	η
1.7	*0.55*	*1.2*	*1.2*	*0.85*	*0.9*	*0.45*	*0.8*	*0.36*

The next table present the steady state values for the main economic variables in the model under two alternative values for μ and two alternative values of υ.

Table 2

\	$\mu = 1,\ \upsilon = 1$	$\mu = 1.1,\ \upsilon = 1$	$\mu = 1,\ \upsilon = 1.042$
k^{ss}	0.1108	0.1182	0.1182
w^{ss}	0.3003	0.3074	0.3203
z^{ss}	0.1852	0.1858	0.1975
$\overline{\overline{\theta}}^{ss}$	0.5171	0.4850	0.4850
$Credit^{ss}$	0.0671	0.0715	0.0706

[15] One could think of a model where B represents the value of some non-market activities that agents have to trade off with effort (e.g., attendance in the workplace) in the realization of the investment projects. See Greenwood, Rogerson and Wright (1995) for other general equilibrium implications of non-market activities.

Two observations are worth mentioning: first note that when inflation increases to 10%, the level of the steady state capital stock and therefore the level of output increases in line with the Mundell-Tobin effect; second, note that for both the increase in inflation μ and the increase in factor productivity υ, the increase in the number of projects being made over-balances the increase in internal financing (due to wage increases) causing a net increase in total credit in the economy. However, one can see that the increase in total credit is smaller in the case of increases in productivity because of the direct effect on wages associated to this type of change.

The Diversification Issue. One of the main subjects of this paper will be the implications for portfolio diversification that arise in this particular structure of the economy. To study the issue we need to make new assumptions on the correlation structure of the set of available projects every period. Holmstrom and Tirole (1997) assume complete correlation of projects (or equivalently, that no agent can diversify his/her portfolio of projects). Since our particular interest is in what drives the level of diversification (if any) in the described financial environment, we will require more general assumptions. Note that for each level of labor productivity $\widetilde{\theta}$ we have a density $(1-\alpha)$ of type 2 agents. Hence, the total population of this type is given by

$$\int_0^1 (1-\alpha) d\widetilde{\theta} = (1-\alpha).$$

Now assume there is a continuum of "zones" with total measure ρ and that type 2 agents (and therefore projects) are distributed uniformly over these zones. Note that $(1-\alpha)/\rho$ is the density of projects in each zone. Also assume that the projects in each zone are perfectly correlated so that the uncertainty about the return of the projects (success or failure) is not an idiosyncratic shock to the project but instead, an idiosyncratic shock to the zones. Assume that the realization of the shock in a particular zone is independent of the realization of the shock in any other zone. Then since we have a continuum of zones with independent random variables associated to each of them, we can assume that there will be no aggregate uncertainty.[16] Suppose now that a continuum of banks could be created. Let ϕ/ρ be the density of banks in each zone.[17] Assume agents of types 1 and 3 deposit their savings in the bank and that the bank gives loans to type 2 agents undertaking investment projects. The question we are interested in is: what will be the level of portfolio diversification chosen by banks in this situation?[18]

[16]See Judd (1985) for an elaboration on the validity of this assumption.

[17]Note that we are using ϕ as the total mass of banks. In this section banks can be created by any individual and we are only proposing this mass of banks (which is equal to the mass of type 3 agents) because it will prove convenient for comparison with later section where type 3 agents are the natural candidates to run a bank.

[18]We are associating the subsets of correlated projects with "zones" that could be thought of as geographical regions. This can be relevant for the case of the U.S. banking system. In the words

Suppose a bank can handle projects from its own zone at zero cost but to be able to select projects from other zones it has to incur an "administrative" cost with the following structure: let $n = 1, 2, 3, ...$ be the number of zones where the bank intends to attract projects and let $\iota(n)$ be the cost for the bank to be participating in n different zones. Assume $\iota(n) \leq \iota(n+1)$ for $n = 1, 2, 3, ...$, $\iota(1) = 0$ and $\lim_{n\to\infty} \iota(n) = \delta < \infty$. The banks are perfectly competitive in this environment and as a consequence they obtain zero profits from operation and are unable to cross-subsidize projects with different levels of internal financing.[19] As is clear from equation (6), we can index the different levels of internal financing by $\widetilde{\theta}$. The bank will then chose a contract that specifies how much the owner of a project with internal funds $\widetilde{\theta}$ ought to pay to the bank when the project succeeds. Call this payment $R_b(\widetilde{\theta})$. Note that in any period t, a bank will only take projects with $\widetilde{\theta} \geq \overline{\theta}_t$. The bank has to pay an interest rate on deposits so that the expected return equals γ_t (note that depositors are risk neutral and γ_t is the return on holding money). Then, the contract function at time t offered by a bank choosing to participate in n^* zones must satisfy

$$E_t \left[\frac{\sum_{j=1}^{n^*} \left(u_j R_{bt}(\widetilde{\theta}) X_j \right) - \iota(n^*)}{\sum_{j=1}^{n^*} u_j \left(I - \widetilde{\theta} h \upsilon \omega(k_t) \right)} \right] = \gamma_t \tag{14}$$

for $\widetilde{\theta} \geq \overline{\theta}_t$, and where u_j is the proportion of projects of "type" $\widetilde{\theta}$ taken from zone j and X_j is a Bernoulli trial that indicates success or failure of projects in zone j. Note that limited liability implies that the owner of the project pays zero to the bank in case of failure. Equation (14) can be expressed as

$$R_{bt}(\widetilde{\theta}) = \frac{\gamma_t}{p_H} \left(I - \widetilde{\theta} h \upsilon \omega(k_t) \right) + \frac{1}{p_H} \frac{\iota(n^*)}{\sum_{j=1}^{n^*} u_j}$$

for $\widetilde{\theta} \geq \overline{\theta}_t$. Clearly a bank needs to minimize this payoff if it is to attract any investors. From this, it is straightforward to see that $n^* = 0$ is the optimal policy.

Lemma 6 *With risk neutral agents, no monitoring and positive costs of diversification, financial intermediaries will choose in equilibrium the minimum possible level of diversification.*

In the model as it stands, there are no benefits from diversification. Hence, for any positive cost of diversification, the banks have no incentive to diversify and will

of Mishkin "...Regulatory restrictions on branching and activities have led to less diversification by banks; thus, the restrictions on interstate banking meant that when a decline in oil prices dragged down the Texas economy in the mid-1980's many banks and thrifts in Texas were dragged down as well."

[19] This Nash equilibrium type of competition is the same that Rothschild and Stiglitz had in mind for the insurance companies in their seminal work (Rothschild and Stiglitz, 1976). See Smith (1984) for an application to the banking system.

only handle projects in their own zone, all of them perfectly correlated, just as in Holmstrom and Tirole (1997). Note that this result depends strongly on the assumptions of risk neutrality of agents. Although we do not think this is necessarily the most realistic assumption, it will allow us to isolate a novel informational reason for diversification that we will explain in **Section 5**. In conclusion, each operating bank will only handle projects in its own zone and the size of the representative bank is indeterminate. Assuming that the ϕ/ρ density of banks in each zone remains in operation, the density of projects per bank at time t will be given by $(1-\alpha)(1-\overline{\theta}_t)/\phi$. This density can also be written as

$$\int_{\overline{\theta}_t}^{1} \frac{(1-\alpha)}{\phi} d\widetilde{\theta}$$

and we can think that each bank is actually taking projects in the whole range of possible levels of internal financing when in operation. In summary, banks play no role in the economy with no monitoring.

5 Financial Intermediation and Monitoring

This section considers different financial arrangements in the case where $c < \infty$, that is, where type 3 agents can monitor informed investors (type 2) to find out whether or not they have exerted some of the necessary level of effort to attain the high rate of project success. Note that as long as type 2 agents put some effort into developing the investment projects, even if this effort is low, type 3 agents will consider this a fulfillment of the requirement. Monitors cannot distinguish low from high effort, they can only distinguish between effort and no effort.

The first financial system we will consider is the case of Certification (see Holmstrom and Tirole, 1997). In this case, each type 3 monitor treats each project independently and no diversification arrangements can be made. The owner of the project joins a monitor who will "certify" that effort is being made. This, in turn, allows the informed investor to go to the market for funds and take loans *directly* from uninformed investors.[20] The monitor, since her monitoring activity is not observable by third parties, invests part of her funds in the projects that she is monitoring. Each type 3 agent can monitor as many projects as she wants with only the cost c in utility terms. This creates perfect competition among monitors. There is no explicit reason why agents cannot form banks in this environment; this is just exogenously assumed. However, in **Subsection 5.2** we show that this system is equivalent to a banking

[20] Note that in a way, the certification regime is relatively efficient. It implies that only one agent perform the monitoring even though many of them may be lending to the project-owner under the assumption that he/she will comply and exert effort. Yet more interesting is that this type of efficiency considerations has been proposed in the literature on costly state verification to justify the very existence of intermediation (see Diamond (1984) and Williamson (1987)).

system where the cost of total diversification is very high and, as a consequence, the bank only hold projects from its own "zone."

In the second part of this section, we study how banks may arise in this economy. We show that even though there is no risk-pooling benefit from forming a bank (see **Section 4**), monitors can reveal that they are performing the necessary level of monitoring by creating a bank and holding a completely diversified portfolio. The size of the diversification costs determines whether diversified banks will arise in equilibrium. We also study the consequences of a system of mandatory reserve requirements on the equilibrium structure of financial institutions.

5.1 Certification

Assume that $c < \infty$, and therefore type 3 agents may be able to monitor investment projects to reduce the agency cost associated to them.[21] Since this assumption changes the nature of the participation of type 3 agents in the economy, we need to consider their economic problem anew. Assume the monitors cannot set up a bank and intermediate deposits. The monitor signs a separate contract with each project-owner. For the moment, this is exogenously assumed but these are the types of issues that will constitute the central subject of discussion in what follows.[22]

The Monitors' Problem. Assume κ_{mt} is the amount of own funds that the monitor invests in the projects that she monitors and let ψ be the density of projects per monitor. Then, type 3 agents solve the following optimization problem

$$\max \; E_t \, c^3_{t+1} - c\psi_t(\kappa_{mt})$$

subject to

$$\kappa_{mt} + p_t m^3_{t+1} = \overline{\overline{\theta}} h \upsilon \omega(k_t)$$

$$c^3_{t+1} = \widetilde{r}_{mt}\psi_t(\kappa_{mt}) + p_{t+1}\left[m^3_{t+1} + T_{t+1}\right]$$

$$c^3_{t+1}, m^3_{t+1}, \kappa_{mt} \geq 0,$$

[21] We assume that due, for example, to some technological reasons, random monitoring is not possible. If random monitoring were possible then monitors would certainly use it. Monitoring every period implies excessive monitoring to induce agents not to choose a zero level of effort. Although interesting, the details of a fully efficient random monitoring system are especially complicated in models with heterogeneous agents. For a related result when the effort level that can be monitor (b) is a function of amount spent on monitoring (c) see Holmstrom and Tirole (1997).

[22] One may still recognize some intrinsic relevance in the study of this case. In fact, in the past the US banking system has been for many years regulated in ways that discourage the type of diversification feasible in the model. If banks can only handle projects at the regional level there is no possible diversification in the model economy and, hence, no benefit from forming a bank. Possibly, if there were a setup cost for banks then it would render the equilibrium analogous to the certification system studied in this section.

where $\widetilde{r}_m$ is the random payoff to the monitor, which is equal to zero if the project fails.[23] The monitor "certifies" each project independently. We will consider equilibria where it is incentive compatible to actually perform the monitoring even though this action is not observable by third parties (specifically, the uninformed type 1 agents).[24] For this to be so, the following incentive compatibility constraint needs to hold in equilibrium:

$$p_H r_{mt} - c \geq p_L r_{mt}. \tag{15}$$

This can be re-written as $r_{mt} \geq c/\Delta p$. Define I_{mt} as the amount of investment the monitor assigns to each project. Then $I_{mt} = \kappa_{mt}/\psi_t$ holds.[25] Since there is perfect competition among monitors, equation (15) holds with equality in equilibrium. Let β_t be the (implicit) return to the funds the monitor invests in the project. Then we have

$$\beta_t I_{mt} \equiv p_H r_{mt} = p_H \frac{c}{\Delta p}. \tag{16}$$

As we will see below, I_{mt} in equilibrium is such that the market for monitors' funds clear. Then, β_t solves equation (16) given I_{mt}.[26] There is an equilibrium lower bound for β_t given by

$$\beta_t \geq \underline{\beta}_t = \frac{p_H}{p_L}\gamma_t > \gamma_t \tag{17}$$

that is obtained by manipulating the monitors' participation constraint $\beta_t I_{mt} - c \geq \gamma_t I_{mt}$.[27] It is not hard to see that for any $\beta_t \geq \underline{\beta}_t$, the solution for the problem of type 3 agents gives $m^3_{t+1} = 0$. Let $\overline{I}_{mt} \equiv p_H c/\underline{\beta}_t \Delta p$. This is the largest value that I_{mt}

[23] There is a number of possible alternative assumptions regarding the monitoring-cost structure (e.g. Bernanke and Gertler (1989) assume that the monitoring cost depletes some of the capital produced in the projects). Their implications though, would not contribute in any essential way to the substance of the problem we intend to study. Also, the current setup allows us to maintain our incentives problem as close as possible to the one in Holmstrom and Tirole (1997). The assumption used is equivalent to assume that c is a cost in terms of consumption goods and that type 3 agents receives a fix endowment $\varpi > c\psi_t(\kappa_{mt})$ when old that is partly used to pay the monitoring costs.

[24] Krasa and Villamil (1992) consider the incentive problem at the intermediary level (that is, the monitor) in a costly state verification environment similar to that in Diamond (1984).

[25] Since the amount $p_H c/\Delta p$ needs to be paid to the monitor for each project, the only way that the return per unit of funds invested by the monitor is uniform across projects is if I_{mt} is uniform across projects, namely $I_{mt} = p_H c/\beta_t \Delta p$.

[26] We will work with an equilibrium concept (Nash) where each monitor takes as given by the market the necessary investment I_{mt} per project, and in deciding how much she wants to invest in total in the projects technology (κ_{mt}) she implicitly determines the density of projects that she handles $\psi_t(\kappa_{mt}) = \kappa_{mt}/I_{mt}$.

[27] Note that the equilibrium return on monitors' funds β_t is greater than the interest rate γ_t. One would think that perhaps monitors could borrow funds directly from the (uninformed) market at rate γ_t to invest later at rate β_t. This clearly would tend to drag down the equilibrium return over monitors' capital. However, limited liability for the monitors implies that the incentive compatibility conditions still requires that $\beta_t I_{mt} = p_H c/\Delta p$ hold (where I_{mt} are the *strictly* own – not borrowed – funds invested by the monitor) and hence the same equilibrium β_t obtains. Information restrictions imply that money is dominated in rate of return for some assets (see Wallace 1988).

could take in equilibrium. Note then that $\left(\underline{\beta}_t - \gamma_t\right) \overline{I}_{mt} = c$ holds and the monitor just breaks even in this case.

Informed Investors' Incentive Compatibility. Assume that equation (1) and the following inequality hold along the equilibrium path:

$$p_H \upsilon q(k_{t+1})R - \gamma_t I - (\beta_t - \gamma_t)I_{mt} - B \geq 0 \tag{18}$$

(otherwise, monitored projects are not efficient). Then there will be two types of projects undertaken in equilibrium, those which need monitoring and those which do not. Whenever the informed investor has available a level of internal financing for which the incentive compatibility constraint

$$\upsilon q(k_{t+1})R - \frac{\gamma_t}{p_H}\left[I - \widetilde{\theta} h \upsilon \omega(k_t)\right] \geq \frac{B}{\Delta p} \tag{19}$$

holds, there will be no monitoring. Define $\overline{\theta}_t$ to be the level of labor efficiency that makes equation (19) hold with equality. Now, if the internal funds of the project are such that equation (19) does not hold there is still the possibility that the informed investor finds a monitor that will certify that "some" level of effort is being made. Then the investment project can still be carried out under certain conditions. Some remuneration to the monitor is necessary, according to equation (16). The following incentive compatibility constraint needs to hold if the high effort project is to be undertaken under monitoring:

$$\upsilon q(k_{t+1})R - \frac{\gamma_t}{p_H}\left[I - \widetilde{\theta} h \upsilon \omega(k_t) - I_{mt}\right] - \frac{\beta_t}{p_H} I_{mt} \geq \frac{b}{\Delta p}. \tag{20}$$

Define $\underline{\theta}_t$ to be the solution of equation (20) when it holds with equality.[28] Assume

$$\frac{B}{\Delta p} > \frac{b}{\Delta p} + \frac{c}{p_H},$$

which implies that the monitoring cost is moderate and that in equilibrium we have $\underline{\theta}_t < \overline{\theta}_t$.[29]

Market Clearing. The market clearing condition for capital goods now becomes

$$k_{t+1} = (1 - \alpha)(1 - \underline{\theta}_t)p_H R. \tag{21}$$

[28] If the solution of (20) is negative, then take $\underline{\theta}_t = 0$. In the discussions that follow consider that $\underline{\theta}_t > 0$ holds. This is the more interesting case with some equilibrium credit rationing. A sufficient condition for $\underline{\theta}_t > 0$ is that $b > (p_H - p_L)[\upsilon q(k_{t+1})R - \gamma_t I - c]$ holds.

[29] As in Bernanke and Gertler (1989), we have three groups of "informed" investors: "Poor" agents with low labor productivity that cannot implement their project, "Middle Class" agents that carry out their project in association with a monitor, and "Rich" entrepreneurs that do not use the monitoring technology and that obtain external financing directly from the market of "uninformed" funds.

The assets market clears when the following equation holds

$$(1-\alpha)\int_0^{\underline{\theta}_t} s_t^2(\widetilde{\theta})d\widetilde{\theta} + (\alpha-\phi)s_t^1 = p_t(H_{t-1}+T_t)$$

$$+ (1-\alpha)\left[\int_{\underline{\theta}_t}^{\overline{\theta}_t}\left[I - A_t^2(\widetilde{\theta}) - I_{mt}\right]d\widetilde{\theta} + \int_{\overline{\theta}_t}^{1}\left[I - A_t^2(\widetilde{\theta})\right]d\widetilde{\theta}\right].$$

Finally, the market clearing condition for funds provided by monitors is

$$(1-\alpha)(\overline{\theta}_t - \underline{\theta}_t)I_{mt} = \phi\kappa_{mt} = \phi\overline{\overline{\theta}}h\upsilon\omega(k_t) \tag{22}$$

Using equation (22) we can transform the asset market clearing condition to be

$$\upsilon\omega(k_t) = z_t + (1-\alpha)(1-\underline{\theta}_t)I, \tag{23}$$

which is the analogue of condition (8) in the previous section.

Equilibrium. Using, as in the previous section, that $L_t = 1$ for all t, that $H_t = \mu H_{t-1}$, and that $\gamma_t = z_{t+1}/(\mu z_t)$ holds, we can proceed to define an equilibrium with effort monitoring. Let $\Gamma' \subset \mathbb{R}^5$ be the set of $(k, z, I, \overline{\theta}, \underline{\theta})$ for which equation (18) is satisfied, $\beta \geq \underline{\beta}$ and the pairs $(k, z) \in \Gamma$.

Definition 7 *A Monetary Financial Equilibrium with Monitoring is a sequence* $\{k_t$, z_t, I_{mt}, $\overline{\theta}_t$, $\underline{\theta}_t\} \subset \Gamma'$ *such that equations (21), (23), (22) hold, and equations (19) and (20) hold with equality for* $\overline{\theta}_t$ *and* $\underline{\theta}_t$ *respectively, given the initial condition* $k_t = k_0$.

Proposition 8 *A Monetary Financial Equilibrium with Monitoring satisfies the following system of difference equations in* $\{k_t,\ z_t,\ \beta_t\}$ *for all* t*:*

$$z_t - \upsilon\omega(k_t) + \frac{k_{t+1}I}{p_H R} = 0,$$

$$\theta(k_{t+1}) - \frac{1}{h\upsilon\omega(k_t)}\left[I - \frac{p_H c}{\Delta p \beta_t} - p_H \frac{\mu z_t}{z_{t+1}}\left(\upsilon q(k_{t+1})R - \frac{c+b}{\Delta p}\right)\right] = 0,$$

$$(1-\alpha)\frac{p_H}{\Delta p h\upsilon\omega(k_t)}\left[\mu(B-c-b) + \frac{c}{\beta_t}\right]\frac{p_H c}{\Delta p \beta_t} - \phi\overline{\overline{\theta}}h\upsilon\omega(k_t) = 0$$

given $k_t = k_0$ *for* $t = 0$ *and* $\theta(k_{t+1})$ *as defined in expression (10).*

5.2 Banks, Diversification, and Reserve Requirements

Suppose monitors (type 3 agents) can set up a bank and handle an arbitrary number of projects for monitoring. Assume, as in the previous section, that there is no limit to such number except for the utility cost c per project. This creates perfect competition in the banking sector. As before, assume that the bank, to shape the composition of its portfolio, can choose from independent projects in different zones or from projects in the same zone that are perfectly correlated. There is an administrative cost s_1 that the project-owner needs to incur in order to be able to obtain external financing (see Townsend (1978)). Also assume that another transaction cost s_2 needs to be paid if the project-owner wish to contact a bank-monitor. The monitoring institution however has a cost advantage in collecting external funds; it can obtain external funds at zero cost (a normalization).[30]

The project-owners with high enough wealth will go directly to the impersonal market for funds to obtain external financing of their projects. This is because they can credibly commit to exerting high levels of effort by investing large amounts their of own wealth in the realization of the project.[31] It was shown in the previous section (see **Lemma 6**) that when monitoring is not possible and diversification is costly, banks chose not to diversify their portfolios. Agents being risk neutral, no economic benefits arise from bank portfolio diversification under those conditions. However, when monitoring is possible, there exists an important benefit from diversification. Holding a completely diversified portfolio of projects, a bank lowers the agency costs that are created by the fact that monitoring activities are not observable by third parties. The idea is as follows: with a completely diversified portfolio, the bank can offer to pay uninformed investors a non-contingent return. Since monitored projects are more efficient, and since now cheating by the bank is ruled out by the type of contract that depositors have, monitoring will take place in equilibrium without the surge of positive agency costs. This clear benefit of diversification needs to be compared with its direct costs in order to determine the final equilibrium outcome. We will show that there are actually three possible outcomes. When diversification costs are very high, no bank will diversify and banks operate only with projects in their own zone of location. This outcome is equivalent to the one studied previously under the label "Certification." When the diversification cost is zero, diversification is optimal because it minimizes agency costs at the monitor's level. In this case, monitoring of investment projects can potentially be handled by a unique, large, completely diversified intermediary institution. Finally, there will be an intermediate case, where diversification cost are positive but not too high and a "mixed" system

[30] Note that even if monitoring is not necessary, contacting a bank costs s_2 to the project owner. This transaction costs structure will imply that intermediating external funds through the banking system is more efficient for projects that need monitoring but it is not for projects that do not need monitoring (specially if $s_2 > s_1$).

[31] Bill Gates holds a large proportion of Microsoft stock (clearly, his financial portfolio is not fully diversified).

results as the equilibrium outcome (i.e., there will be some non-diversified "regional" banks coexisting with a completely diversified national "bank").

No Diversification. Let $s_1 = s_2 = s$ for simplicity. Consider first the situation where the cost of diversification is very high and there is no diversified (ND) bank in equilibrium. This case is almost equivalent to Certification. Note that project-owners satisfying the condition

$$\upsilon q(k_{t+1})R - \frac{\gamma_t}{p_H}\left[I + s - \widetilde{\theta} h\upsilon\omega(k_t)\right] \geq \frac{B}{\Delta p} \tag{24}$$

do not need a monitor and will not go to the bank to obtain external financing.[32] Define $\overline{\theta}_t$ to be the value of $\widetilde{\theta}$ such that equation (24) holds with equality.

Type 2 agents (project-owners) with an intermediate level of internal funds to finance own projects will need a monitor. As a consequence, they will necessarily have to contact a bank-monitor and therefore pay the cost s_2 $(= s)$. The *net* payoff to the monitor when the project succeeds, $NR_b^{ND}\left(\widetilde{\theta}\right)$, must satisfy incentive compatibility constraints as monitoring activities are not observable. In particular, the absence of cross-subsidization among projects requires that the (measurable) function $NR_b^{ND}\left(\widetilde{\theta}\right)$ satisfy

$$NR_b^{ND}\left(\widetilde{\theta}\right) \geq \frac{c}{\Delta p}. \tag{25}$$

As we have seen in the case of certification, competition in the monitors market implies that in equilibrium the monitor will have to invest some of her own funds (I_m) in the project and that equation (25) will hold with equality. It is straightforward to see that in the case where project-owners obtain their external financing through bank-monitors, the *gross* payoff to the bank $R_b^{ND}\left(\widetilde{\theta}\right)$ (a measurable function) when the project succeeds has to satisfy the following expression

$$R_{bt}^{ND}\left(\widetilde{\theta}\right) - \frac{\gamma_t}{p_H}\left[I + s - \widetilde{\theta} h\upsilon\omega(k_t) - I_{mt}\right] = \frac{c}{\Delta p} \tag{26}$$

for all $\widetilde{\theta}$. When the project fails, the gross payoff to the bank will be zero. Recall from the section on Certification that we may express $c/\Delta p = (\beta_t/p_H)\, I_{mt}$.[33]

[32] "Large" firms with high levels of own capital to debt ratio (low leverage levels) usually have advantages to go directly to the market for funds (and not through the bank). Note that in fact, in the model, by going to the bank the project-owner with high levels of wealth would get the same payoff but we assume that they chose not to. With the reserve requirement introduce later in the paper this assumption will not be needed. Similarly, the same analysis here could be done with $s_2 > s_1$, in which case the assumption is not necessary either. We choose not to do this just to keep some parsimony in notation.

[33] Actually, equation (26) needs to hold *a.e.*. However, if we assume that the function $R_b^{ND}\left(\widetilde{\theta}\right)$ has to be piecewise continuous (say by assuming that agents cannot offer a contract that is too complicated), then the claim follows. We then proceed to analyze the contract $R_b^{ND}\left(\widetilde{\theta}\right)$ pointwise.

Would the owners of the projects being monitored use the bank as an intermediary for external funds? The answer is yes. If informed investors want to obtain funds directly from the market, they will have to incur the cost s_1 in addition to the cost s_2 from contracting a monitor. If they just use a bank-monitor that intermediates uninformed funds, then they only incur the second cost s_2 which is clearly better.

Finally, incentive compatibility constraints for the informed investors require that

$$\upsilon q(k_{t+1})R - \frac{\gamma_t}{p_H}\left[I + s - \widetilde{\theta}h\upsilon\omega(k_t) - I_{mt}\right] - \frac{c}{\Delta p} \geq \frac{b}{\Delta p} \tag{27}$$

hold. Let $\underline{\theta}_t$ be the value of $\widetilde{\theta}$ so that equation (27) holds with equality. The rest of the equilibrium analysis in the no-diversification case closely follows that in the study of the Certification system.

Diversification. Consider now the equilibrium when the diversification cost is not too large (potentially zero) and there exist a completely diversified bank in equilibrium. Note that in the no-diversification system if $\beta > \underline{\beta}$, or in other words, if monitors' own funds are relatively scarce, then there is positive agency cost as a consequence of the non-observability of the monitoring activity. In such a case, diversification could potentially economize on those costs. Note though that the only way that bank-monitors can eliminate the incentive compatibility requirement is by making the payoff to the uninformed investors nonstochatic. Thus, *total* diversification is necessary for this purpose. As no other benefits arise from diversification, the bank-monitor will only choose between achieving total diversification or no diversification at all.

Consider a completely diversified bank. The zero profit condition and the no cross-subsidization condition imply that the measurable function $R_b^D\left(\widetilde{\theta}\right)$, the gross payoff to the diversified bank in case of success of the "type $\widetilde{\theta}$" project, satisfies [34]

$$R_{bt}^D\left(\widetilde{\theta}\right) = \frac{\gamma_t}{p_H}\left[I + s - \widetilde{\theta}h\upsilon\omega(k_t)\right] + \frac{c + \widehat{\delta}_t}{p_H} \tag{28}$$

where $\widehat{\delta}_t = \delta/[d_t(1-\alpha)(\overline{\theta}_t - \underline{\theta}_t)]$ and d is the proportion of intermediated projects that are handled by the diversified bank.[35] This implies that the diversified bank has zero profits. Note that the bank has positive profits in the no-diversification case (given by $(\beta_t - \gamma_t)\, I_{mt}$). However, when diversification is efficient, anyone could open a completely diversified bank since no own capital is needed for its operation. As a

[34] Note that project-owners being monitored use the bank intermediation to access to external uninformed funds.

[35] There is at most one completely diversified bank-monitor in equilibrium. This is so because of a phenomenon of cost diffusion implicit in the analysis. The minimum cost $\widehat{\delta} = \delta/u\left(\overline{\theta}_t - \underline{\theta}_t\right)$ is attained when $u = d(1-\alpha)$. Also note that diversification is more likely the higher the proportion of projects being monitored in equilibrium.

consequence, competition among potential bankers will drive equilibrium profits to zero in this case.

Even when diversification is possible the projects satisfying equation (24) will not be monitored and will not use intermediation by banks. Let then $\overline{\theta}_t$ be defined as before.

For the projects that do need monitoring, the following incentive compatibility constraints must hold. If the project is being monitored by a *diversified* bank, then the incentive compatibility constraint is

$$\upsilon q(k_{t+1})R - R_{bt}^D\left(\widetilde{\theta}\right) =$$

$$\upsilon q(k_{t+1})R - \frac{\gamma_t}{p_H}\left[I + s - \widetilde{\theta}h\upsilon\omega(k_t)\right] - \frac{c+\widehat{\delta}}{p_H} \geq \frac{b}{\Delta p}. \tag{29}$$

Define $\underline{\theta}_t$ to be the value of $\widetilde{\theta} \in (0,1)$ for which the equation above holds with equality.

A couple of additional conditions are needed at this juncture. First, let the inequality

$$p_H\upsilon q(k_{t+1})R - \gamma_t\left(I+s\right) - B - \left(c+\widehat{\delta}_t\right) > 0 \tag{30}$$

hold for all t along the equilibrium path. This condition implies that monitoring is efficient under complete diversification (this is just a new version of inequality (18)). Second, assume that

$$\frac{B}{\Delta p} > \frac{b}{\Delta p} + \frac{c+\widehat{\delta}_t}{p_H} \tag{31}$$

holds, so that we have $\underline{\theta}_t < \overline{\theta}_t$ in equilibrium. This last condition only calls for the cost of monitoring to be low enough so that it is in fact "socially" useful.

Notice now that if we were to have $d_t = 1$, then funds owned by monitors would no longer be scarce. In this case, a project-owner might benefit from contracting a monitor that invests enough funds in the project so that $\beta = \underline{\beta}$. In this case, $(\underline{\beta}_t - \gamma_t)I_{mt} = c$ and the project-owners economize on diversification costs. Therefore, some non-diversified *regional* banks would exist in equilibrium. The incentive compatibility constraint for projects handled by regional banks is given by equation (27), and the market clearing for monitors' funds is now given by

$$(1-d_t)(1-\alpha)(\overline{\theta}_t - \underline{\theta}_t)I_{mt} = \phi\overline{\overline{\theta}}h\upsilon\omega(k_t). \tag{32}$$

In equilibrium, d_t will be such that a project-owner with efficiency index $\widetilde{\theta}$ would be as well off when handled by the totally diversified bank as when handled by the regional banks. This will require that the following equation hold in equilibrium

$$p_H\upsilon q(k_{t+1})R - \gamma_t\left[I + s - \widetilde{\theta}h\upsilon\omega(k_t) - I_{mt}\right] - \beta_t I_{mt} =$$

$$p_H \upsilon q(k_{t+1})R - \gamma_t \left[I + s - \widetilde{\theta} h \upsilon \omega(k_t)\right] - \left(c + \widehat{\delta}_t\right), \qquad (33)$$

or equivalently that $\left(\beta_t - \gamma_t\right) I_{mt} = \left(c + \widehat{\delta}_t\right)$.

Equilibrium with diversification. The important difference between this regime and Certification is the determination of $\underline{\theta}_t$ and d_t. The asset and capital market clearing conditions are

$$\upsilon \omega(k_t) = z_t + (1-\alpha)(1-\underline{\theta}_t)\left(I + s\right) \qquad (34)$$

and

$$k_{t+1} = (1-\alpha)(1-\underline{\theta}_t) p_H R. \qquad (35)$$

Let $\Gamma'' \subset \mathbb{R}^6$ be the set of $(k,\, z,\, I_m,\, \overline{\theta},\, \underline{\theta},\, d)$ so that conditions (30) and (31) hold, $I_m > \overline{I}_m$ for $d = 0$ and the projection of Γ'' to $\mathbb{R}^5$ is contained in Γ'.

Definition 9 *A Monetary Financial Equilibrium with a fully diversified intermediary-monitor is a sequence* $\{k_t, z_t, I_{mt}, \overline{\theta}_t, \underline{\theta}_t, d_t\} \subset \Gamma'$ *satisfying equations (35), (34), (32), and (33), and (24) and (29) with equality, given the initial capital* k_0 *and where* d_t *is the highest possible solution of (33) for every* t*.*

Steady state and transitional dynamics properties can be studied the same way as in the previous types of equilibrium. Note that by equation (31) the steady state capital will be higher in the present regime than in the No-Monitoring Economy. Additionally, since $\left(\beta_t - \gamma_t\right) I_{mt}$ is decreasing in d_t, we have that the steady state capital will be also higher than the one under Certification (or, for the matter, when $d_t = 0$). This is important. It tells us that *under certain conditions we can expect aggregate GDP to increase if we allow the economy to switch from a "unit" banking system (imposed by legal restrictions for example) to a "national" banking system. A transitional period of economic growth would then come associated to the change in the (interstate branching) regulation.*

Jayaratne and Strahan (1996) present some evidence that corresponds with this finding. Since the beginning of the 1990's the US states have moved gradually and at a different pace towards allowing for interstate branching. This variability is what permits some econometric identification of the effects of lifting branching restrictions. The authors find that states that have moved faster in the direction of removing the regulation have experienced sharp falls in bank operating costs. This reduction in costs has largely been passed along to the bank borrowers in the form of lower loan rates. This is exactly what the model in the present paper predicts. Additionally, Jayaratne and Strahan find that the change in the banking structure had important implications for the overall economies. In particular, the states that have been more aggressive on changing the regulation have experience significantly faster rates of economic growth. However, the model presented here seems to suggest that those will only constitute transitional phenomena.[36]

When equation (33) has no solution in equilibrium (see **Figure 4**) the equilibrium has no fully diversified national bank. This is the case where the diversification cost are so high that it is not economically efficient to try to save agency costs through diversification.

Define $\overline{d_t}$ as the value of d_t such that $I_{mt} = \overline{I}_{mt}$ holds. Note that $\left(\underline{\beta}_t - \gamma_t\right) \overline{I}_{mt} = c$. If a solution to (33) exists, then there are two of them, both with $d \in (0, \overline{d})$ (note that $c + \widehat{\delta}_t \geq c$ for all d_t) However, the actual equilibrium value of d_t will be given by the largest of these.[37] For the case of $\delta = 0$ we have that equation (33) is satisfied for every $d \geq \overline{d}$ (as long as $\beta_t > \underline{\beta}_t$ when diversification is not allowed ($d = 0$) as in the Certification system)(see **Figure 4**).

Proposition 10 *Assume $\overline{d}_t > 0$. Then, for small enough diversification costs $\delta > 0$, there exists an equilibrium outcome where non-diversified (regional) banks and diversified (national) banks coexist.*

One interesting comparison between this equilibrium with monitoring and diversification and the previously studied case of Certification is the following. For a given level of capital, it is not hard to show that for $\beta_t \geq \underline{\beta}_t$, the difference $\left(\overline{\theta}_t - \underline{\theta}_t\right)$ is higher in the case of total diversification. In other words, intermediation of funds would tend to be higher under the "national" bank system.

Note that the totally diversified bank performs another function usually attributed to the financial system: the asset transformation function (in this case from "risky" loan contracts into financial claims (CDs) that are perfect substitutes for currency).

An interesting comparative static result for the case when there is a national bank in operation is that increases in the interest rate γ_t reduce the size of the portfolio of the diversified institution d_t (see **Figure 4**). Under certain conditions the increase in the interest rate may cause the disappearance of the fully diversified intermediaries.

Mandatory Reserve Requirement.[38] Suppose the monetary authority, for

[36] Note that the model identifies also an interesting *new* channel by which technological change can generate sustained growth. The cost δ obviously have a technological component associated to it and we can think that as technology in communications (for example) improves, the cost δ will lower and this will translate into higher levels of investment and hence in growth for the aggregate economy.

[37] For the low value of d_t, increasing d_t results in the RHS of (33) being greater than the LHS; the diversified bank being more convenient for investors would cause the value of d_t to tend to increase (towards the equilibrium high d_t).

[38] Huybens and Smith (1998) study a reserve requirement in a model with costly state verification problems in the financial sector. Their reserve requirement is different than the one imposed here: lenders have to hold a fraction of their loans in currency reserves and the reserve requirement is binding only when the total demand for money is small enough not to automatically cover the required level of reserves. In their model, the return on loans can be higher than the return on money holdings and this is the situation in which the reserve requirement becomes relevant.

whatever reason, decides to impose a mandatory reserve requirement on bank deposits. For each "dollar" of deposits *lent* by the bank, an amount ρ of funds needs to be deposited in an account in the Central Bank (CB) as a form of reserve requirement. The CB will pay back $\rho/(1+\rho)$ per dollar of deposits to uniformed investors if the bank goes bankrupt or will return the total sum to the bank if this one does not fail. Note that the policy also plays the role of a partial deposit insurance (equally unnecessary in this "risk-neutral" economy).

Consider first the case of the bank that holds a completely diversified portfolio. Equation (28) becomes

$$p_H R_{bt}^D\left(\widetilde{\theta}\right) - \left[\gamma_t(1+\rho)-\rho\right]\left[I+s-\widetilde{\theta}h\upsilon\omega(k_t)\right] - \left(c+\widehat{\delta}\right) = 0,$$

and equation (29) becomes

$$\upsilon q(k_{t+1})R - \frac{\widetilde{\gamma}_t}{p_H}\left[I+s-\widetilde{\theta}h\upsilon\omega(k_t)\right] - \frac{c+\widehat{\delta}}{p_H} \geq \frac{b}{\Delta p}, \tag{36}$$

where $\widetilde{\gamma}_t = \gamma_t + (\gamma_t - 1)\rho$.

For the regional non-diversified banks we have that equation (27) becomes

$$\upsilon q(k_{t+1})R - \frac{\widetilde{\gamma}_t}{p_H}\left[I+s-\widetilde{\theta}h\upsilon\omega(k_t) - I'_{mt}\right] - \frac{c}{\Delta p} \geq \frac{b}{\Delta p}, \tag{37}$$

where I'_{mt} solves equation (32) but for the new values of ($\underline{\theta}_t$, $\overline{\theta}_t$).

Total deposits in the banking system is given by

$$D_t = (1-\alpha)\int_0^{\overline{\theta}} s_t^2(\widetilde{\theta})d\widetilde{\theta} + (\alpha-\phi)s_t^1 - z_t - (1-\alpha)\int_{\overline{\theta}_t}^1 \left[I+s-A_t^2(\widetilde{\theta})\right]d\widetilde{\theta}.$$

The demand for Loans in the diversified national bank is given by

$$P_t^D = (1-\alpha)(1+\rho)d_t\int_{\underline{\theta}_t}^{\overline{\theta}_t}\left[I+s-A_t^2(\widetilde{\theta})\right]d\widetilde{\theta},$$

and the demand for Loans in the regional banks is

$$P_t^{ND} = (1-\alpha)(1+\rho)(1-d_t)\int_{\underline{\theta}_t}^{\overline{\theta}_t}\left[I+s-A_t^2(\widetilde{\theta}) - I'_{mt}\right]d\widetilde{\theta}.$$

Market clearing for funds, $D_t = P_t^D + P_t^{ND}$, can then be simplified to

$$\begin{aligned}\upsilon\omega(k_t) &= z_t + (1-\alpha)(1-\underline{\theta}_t)(I+s)\\ &\quad + (1-\alpha)\rho\left[\left(\overline{\theta}_t-\underline{\theta}_t\right)\left(I+s-(1-d_t)I'_{mt}\right) - \frac{1}{2}\left(\overline{\theta}_t^2-\underline{\theta}_t^2\right)h\upsilon\omega(k_t)\right].\end{aligned} \tag{38}$$

Using equations (33), (35), (38), and (24) and (29) (holding with equality to determine $(\underline{\theta}_t, \overline{\theta}_t)$), we can compute equilibrium under the "mixed" regime (if it exists) with regional and national banks and a mandatory reserve requirements. Note that when $\gamma_t = 1$ only z_t adjust to the imposition of a mandatory reserve requirement.[39]

Which equilibrium will exist depends on the payoff of project-owners. By bank competition, if there exists a value of d_t so that a diversified bank can give a better payoff to project-owners than the non-diversified banks (i.e., if (33) has a solution), then a national bank will be established. The project-owners will go to the national bank, increasing d_t until payoff are equalized across banks. If there is no d_t so that the payoff of the diversified bank is higher than the one on regional banks, then only regional banks will operate in equilibrium.

Example 11 *Following the constructions just explained, we proceed to compute steady state equilibria for the Financial Equilibrium economy in an extended version of* ***Example 5****. The parameter values are as shown in* ***Table 3*** *(see also* ***Table 1*** *in* ***Example 5*** *for comparison).*

R	B	I	h	α	p_H	p_L	$\overline{\overline{\theta}}$	η	b
1.7	*0.55*	*1.2*	*1.2*	*0.85*	*0.9*	*0.45*	*0.8*	*0.36*	*0.37*

c	γ	δ	ϕ	υ	s
0.15	*1.03*	*0.0015*	*0.03*	*1*	*0.0001*

Table 3

Equilibrium values for the main variables are given in ***Table 4****.*

\	$\rho = 0$	$\rho = 0.05$	$\rho = 0.10$
k	*.124944*	*.124718*	*.123483*
$\underline{\theta}$	*.455582*	*.456567*	*.461947*
$\overline{\theta}$	*.977145*	*.971924*	*.942983*
z	*.186154*	*.182998*	*.180239*
I_m	*.138047*	*.136883*	*.124657*
d	*.163628*	*.146917*	*0*

Table 4

Then, for this parameter values, when $\rho = 0$ we have a mixed banking system with 16% of the monitored projects in the economy being handled by a "national" totally diversified bank and the rest being handled by local banks. A positive but not too high reserve requirement implies (since $\gamma > 1$) a decrease in the benefits of diversification, lowering the percentage of projects handle by the national bank (from 16% to 14%). Finally, when the reserve requirement is 10%, only regional banks exist in equilibrium.

[39]It is usual in the literature to find arguments against indiscriminate deposit insurance because it would tend to stress the moral hazard problem in the risk taking behavior of banks. In this model agents are risk neutral and these problems do not arise. But it is interesting to note that even though with the implementation of a reserve requirement uninformed investors receive positive payoff when the bank fail, this does not discourage diversification by banks because the extra payoff to depositors in the case of failure is indirectly discounted from the proper interest payments to finally arrive at the same net expected return on deposits as with no reserve requirement.

The Example just described allows us to uncover an interesting implication of the imposition of mandatory reserve requirements in this type of economy. Note that the equilibrium without reserve requirements has a bank with a fully diversified portfolio. This bank never fails in equilibrium. It actually pays the interest rate on deposits γ every period. In this situation it is natural to think that a reserve requirement will not be imposed on this bank. However, the example also shows that once the reserve requirement is in place, the bank's optimal equilibrium policy may be not to diversify. In this situation every bank fails with certain probability. We can then expect that the reserve requirement system will have greater chances of being "politically" sustainable.[40] However, if we were to bring to an end this regulation, the new steady state equilibrium (with diversification) would make apparent how unnecessary the policy was at least for certain banks.

Why do mandatory reserve requirements discourage diversification? The intuition is clear. When $\gamma > 1$, reserve requirements make external (uninformed investors) funds more costly ($\widetilde{\gamma}_t > \gamma_t$). Since it is optimal to have only one completely diversified bank in equilibrium, the direct financing of investment projects by the bank-owner becomes negligible.[41] For the case of non-diversified banks, every type 3 agent invests her wealth in the business. As a consequence, the diversified bank is relatively more intensive in the use of external funds subject to reserve requirement than the non-diversified banks and it becomes less "efficient" when the coefficient ρ increases. In this economy, there is a direct cost to diversification and it may not be convenient even when $\rho = 0$. However, since diversification saves in agency costs, it may be more efficient than non-diversification for some feasible values of d_t. But the implementation of a positive reserve requirement policy can alter this situation and allow the non-diversified banks to become the most convenient in equilibrium for any possible value of d_t, hence attracting all of the monitored projects on the economy.

Note that the reserve requirement also increases the chances of disintermediation. The extra cost implied by the reserve requirement is only borne by funds that are intermediated by banks. In this environment, Certification may become a better alternative. We abstract from this possibility, however, and assume that certification is always dominated in payoffs by the banking system.

One interesting possibility is that the monetary authority supervises banks' portfolios and imposes a reserve requirement only in certain categories of banks (those that are less diversified and more likely to fail). This is part of the proposal for bank-

[40] Note that since agents are risk neutral in the model, this type of reserve requirement cannot be beneficial in this economy.

[41] This is so only under certain conditions. In fact, increasing the number of banks with completely diversified portfolios under positive reserve requirements has two opposing effects. On one hand, it increases the costs of diversification because it diminishes the diffusion of fixed-cost effect. On the other hand, it brings new cheaper funds (not subject to the reserve requirement) to the diversified institutions. It can be shown that for the parameter values on the example, the first effect is always stronger than the second and therefore, diversification takes place under complete concentration of deposits in a unique institution.

ing reform put forth by the US Treasury in 1991 (see Mishkin, 1992). In our model this will imply an increase in the proportion of projects being handled by the diversified bank (i.e., higher d_t, see **Figure 4**) something that could be consider a "good" outcome since it reduces the proportion of the economy subject to bank failures.[42]

As a final comment, notice that when the equilibrium interest rate γ_t is also paid on mandatory deposits in the CB (financed by earnings on a CB portfolio reinvested in the economy) the system of reserve requirement has no effect on the equilibrium outcomes. For a discussion on the traditional views on this issue see Sargent and Wallace (1985).

6 Conclusion

The paper introduces a general equilibrium overlapping generations model that generates the following interesting macroeconomic-financial system facts. Under certain conditions, we may observe two types of banks in equilibrium: on one side, a highly diversified large financial intermediary with widespread business across the economy (branching) and with an investment portfolio showing high leverage ratios (low bank equity capital); on the other side, a large number of small financial institutions, restricting their operation to a particular geographical area of the aggregate economy, holding not very diversified portfolios and low leverage ratios. Higher levels of total production are observed when diversified institutions play a role in the model economy. Additionally, across the board reserve requirements and certain types of deposit insurance tend to discourage diversification and increase the chances of 'unit banking' in the system.

Boyd and Gertler (1993) provide evidence suggesting that in the US commercial banking system several of these features are commonly observed. For example, they calculate the capital/asset ratios for the period 1987-1991 (averages) for the different sizes of banks and show a strong negative correlation between the two variables (see **Table A1** in Appendix 3). Also, they show that most of the bank failures (although not the most important according to their argument) over the period 1980-1991 are associated with regional economic difficulties and have been concentrated in number on the small-size category of banks (see **Table A2** in Appendix 3).[43] The model introduced in this paper provides interesting insights on theoretical explanations of these empirical facts.

The main motivation for the existence of the banking system in this paper has been its ability to monitor the behavior of investors with financial needs. Several other possible functions that banks could perform in an economy are not fundamental in the model (mobilizers of funds, risk-sharing, etc.). The recent trends in development of

[42] Note however that in the model as it stands, bank failures are not really a "problem."

[43] The oil states, principally Texas, accounted for nearly 700 failures during the period 1986-1990, when oil and real state prices collapsed in this region. The agricultural states during the mid-1980s experienced great difficulties and also had nearly 200 bank failures.

modern financial system seem to suggest some plausibility for this kind of assumption. Schmidt, Hackethal, and Tyrell (1999), for example, present a detailed empirical study of the recent evolution of financial institutions in the U.K., Germany and France. One of their main findings is that of a change in roles for banks in those economies: towards "lending specialist" that monitor borrowers and away from the savings mobilizing type of institutions.

Another important feature of the model presented here is the specific financial structure required for firms to operate in the information intensive sector (capital goods production). In particular, the leverage ratio is restricted by the effect of informational asymmetries. The financial restrictions can be identified across firms and across time. The heterogeneity of projects-owners determines the amount of internal funds that each of them has available to finance their investment project. Some of these investors will not be able to attract lenders in equilibrium and therefore will not carry out their project. Others, showing low levels of internal financing, will tend to be intermediated and will be the ones dropping investment opportunities in response to aggregate shocks. Finally, there is a group of wealthy investors that are able to maintain high levels of internal financing and hence obtain funds in the market without the assistance of an intermediary.

Factors generating aggregate changes on the sources of internal funds in the economy will change the composition of the population among the three groups. This, in turn, generates fluctuations in the aggregate level of investment as a consequence of the strengthening or weakening of the agency problems underlying the production of capital goods.

There exists an extensive empirical literature reporting how movements in internal finance significantly determine investment spending in modern economies (see Levine (1997), Section III E, for a brief overview). Two findings are worth noticing as being consistent with the present paper. First, large manufacturing firms in the US using the corporate bonds market tend to behave as if they were not affected by informational asymmetries (see Whited (1992)). In the model presented above, firms with enough internal finance also completely solve the information problem and have access to the *direct* private loans market (with no intermediaries). Second, working with a large sample of relatively small US firms (< 500 employees) Petersen and Rajan (1994) found that close ties to financial institutions reduce the frictions in the flow of funds towards the borrowing firms. A version of this result can be found in the model developed here. Financial intermediaries, through monitoring of managerial-productive activities that increase the probability of a successful enterprise, improve the availability of external funds for firms that otherwise would be credit constrained.

Finally, let me mention some important factors that tend to often appear in the empirical and theoretical studies and that are not part of the model in this paper. First, the size of the firms has long been recognized as a determining factor of financial arrangements: small firms tend to show investment behavior strongly conditioned by financial considerations, but this is not true for large firms (see for example Petersen and Rajan (1994)). Size plays no role in the model presented here. Second, long lasting relationships and reputation have also been recognized as important factors in shaping the financial relationships among the different participants in the economy. This is not considered in the present paper. These two elements constitute potentially interesting extensions worth further analysis.

References

[1] Aghion, P. and P. Bolton (1992), An Incomplete Contracts Approach to Financial Contracting, *Review of Economic Studies*, **59**, 473-494.

[2] Aghion, P. and P. Bolton (1997), A Trickle-Down Theory of Growth and Development with Debt Overhang, *Review of Economic Studies* **64**, 151-172.

[3] Azariadis, C. and B. Smith (1996), Private Information, Money, and Growth: Indeterminacy, Fluctuations, and the Mundell-Tobin Effect, *Journal of Economic Growth* **1**, 309-332.

[4] Balasko, Y. and K. Shell (1981), The Overlapping-Generations Model. II. The Case of Pure Exchange with Money, *Journal of Economic Theory* **24**, 112-142.

[5] Bencivenga, V. and B. Smith (1991), Financial Intermediation and Endogenous Growth, *Review of Economic Studies* **58**, 195-209.

[6] Bernanke, B. and M. Gertler (1989), Agency Costs, Net Worth, and Business Fluctuations, *American Economic Review* **79**, 14-31.

[7] Besanko, D. and G. Kanatas (1993), Credit Market Equilibrium with Bank Monitoring and Moral Hazard, *Review of Financial Studies* **6**, 213-232.

[8] Boyd, J. and M. Gertler (1993), US Commercial Banking: Trends, Cycles, and Policy, *NBER Macroeconomic Annual*, 319-368.

[9] Boyd, J. and E. C. Prescott (1986), Financial Intermediary-Coalitions, *Journal of Economic Theory* **38**, 211-232.

[10] Boyd, J. and B. Smith (1998), Capital Market Imperfections in a Monetary Growth Model, *Economic Theory* **11**, 241-273.

[11] Bullard, J. and J. Keating (1995), The Long-Run Relationship Between Inflation and Output in Postwar Economies, *Journal of Monetary Economics* **36**, 477-496.

[12] Diamond, D. (1984), Financial Intermediation and Delegated Monitoring, *Review of Economic Studies* **51**, 393-414.

[13] Gale, D. and M. Hellwig (1985), Incentive-Compatible Debt Contracts: The One-Period Problem, *Review of Economic Studies* **53**, 647-663.

[14] Greenwood, J., R. Rogerson and R. Wright (1995), Household Production in Real Business Cycle Theory, Chapter 6 in *Frontiers of Business Cycle Research*, ed. T. Cooley. Princeton University Press.

[15] Greenwood, J. and B. Smith (1997), Financial Markets in Development, and the Development of Financial Markets, *Journal of Economic Dynamics and Control* **21**, 145-181.

[16] Greenwood, J. and B. Jovanovic (1990), Financial Development, Growth, and the Distribution of Income, *Journal of Political Economy* **98**, 1076-1107.

[17] Hart, O. and J. Moore (1994), A Theory of Debt Based on the Inalienability of Human Capital, *Quarterly Journal of Economics*, **109**, 841-879.

[18] Hart, O. (1995), Firms Contracts and Financial Structure, Oxford University Press, Oxford, UK.

[19] Holmstrom, B. and J. Tirole (1997), Financial Intermediation, Loanable Funds, and The Real Sector, *Quarterly Journal of Economics* **62**, 663-691.

[20] Huybens, E. and B. Smith (1998), Financial Market Frictions, Monetary Policy, and Capital Accumulation in a Small Open Economy, *Journal of Economic Theory* **81**, 353-400.

[21] Jayaratne, J. and P. Strahan (1996), The Finance-Growth Nexus: Evidence from Bank Branch Deregulation, *Quarterly Journal of Economics* **111**, 639-670.

[22] Judd, K. (1985), The Law of Large Numbers with a Continuum of IID Random Variables, *Journal of Economic Theory* **35**, 19-25.

[23] Krasa, S. and A. Villamil (1992), Monitoring the Monitor: An Incentive Structure for a Financial Intermediary, *Journal of Economic Theory* **57**, 197-221.

[24] Kiyotaki, N. and J. Moore (1998), Credit Cycles, *Journal of Political Economy* **105**, 211-248.

[25] Levine, R.(1997), Financial Development and Economic Growth: Views and Agenda, *Journal of Economic Literature* **35**, 688-726.

[26] Mishkin, F. (1992), An Evaluation of the Treasury Plan for Banking Reform, *Journal of Economic Perspective* **6**, 133-153.

[27] Petersen, M. and R. Rajan (1994), The Benefits of Lending Relationships: Evidence from Small Business Data, *Journal of Finance* **49**, 3-37.

[28] Rothschild, M. and J. Stiglitz (1976), Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information, *Quarterly Journal of Economics* **80**, 629-649.

[29] Sargent, T. and N. Wallace (1985), Interest on Reserves, *Journal of Monetary Economics* **15**, 279-290.

[30] Schmidt, R., A. Hackethal, and M. Tyrell (1999), Disintermediation and the Role of Banks in Europe: An International Comparison, *Journal of Financial Intermediation* **8**, 36-67.

[31] Smith, B. (1984), Private Information, Deposit Interest Rates, and the 'Stability' of the Banking System, *Journal of Monetary Economics* **14**, 293-317.

[32] Stiglitz, J. and A. Weiss (1981), Credit Rationing in Markets with Imperfect Information, *American Economic Review* **71**, 393-410.

[33] Townsend, R. (1978), Intermediation with Costly Bilateral Exchange, *Review of Economic Studies* **45**, 417-425.

[34] Townsend, R. (1979), Optimal Contracts and Competitive Markets with Costly State Verification, *Journal of Economic Theory* **21**, 265-293.

[35] Wallace, N. (1980), The Overlapping Generations Model of Fiat Money, in *Models of Monetary Economics*, eds. J. Kareken and N. Wallace, F.R.B of Mnpl, 49-82.

[36] Wallace, N. (1988), A Suggestion for Oversimplifying the Theory of Money, *The Economic Journal* **98**, 25-36.

[37] Whited, T. (1992), Debt, Liquidity Constraints, and Corporate Investment: Evidence from Panel Data, *Journal of Finance* **47**, 1425-1460.

[38] Williamson, S. (1986), Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing, *Journal of Monetary Economics* **18**, 159-179.

[39] Williamson, S. (1987a), Costly Monitoring, Loan Contracts and Equilibrium Credit Rationing, *Quarterly Journal of Economics* **102**, 135-146.

[40] Williamson, S. (1987b), Financial Intermediation, Business Failures, and Real Business Cycles, *Journal of Political Economy* **95**, 1196-1216.

• Appendix 1

Consider the economy with no money, and look at equilibria where the information problem is relevant. For this, restriction (1) in the text needs to be adapted as follows,

$$p_L\left(q_{t+1}R - r_{ut}I\right) < 0 < p_H\left(q_{t+1}R - r_{ut}I\right) - B.$$

Now equilibrium is given by the following system of difference equations,

$$\upsilon\omega(k_t) - \frac{k_{t+1}I}{p_H R} = 0 \tag{39}$$

$$\theta(k_{t+1}) - \frac{1}{h\upsilon\omega(k_t)}\left[I - \frac{1}{r_{ut}}\left(\upsilon q(k_{t+1})R - \frac{B}{\Delta p}\right)\right] = 0.$$

Note that the Inada conditions assumed for the production function of consumption goods guarantee that a steady state solution for (39) exists. This equation completely determines the equilibrium path for k_t that strongly resembles the usual Solow Model dynamics.

• Appendix 2

Lemma 12 *Whenever $h < \mu/(1-\alpha)$, $G'\left(k^{ss}\right) < 0$ for any steady state capital k^{ss}.*

Proof. From equation (13) we have

$$G'(k) = \left[p_H\mu\upsilon R - h\upsilon\theta(k)k\right]f''(k) - \frac{h\upsilon\omega(k)}{(1-\alpha)p_H R}.$$

Clearly, $G'(k) < 0$ if $p_H\mu\upsilon R - h\upsilon\theta(k)k > 0$. Now, since $k < (1-\alpha)p_H R$ in steady state and $0 \leq \theta(k) \leq 1$, we have,

$$p_H\mu\upsilon R - h\upsilon\theta(k)k > \left[\mu - h(1-\alpha)\right]p_H R.$$

Hence, if $\mu - h(1-\alpha) > 0$ then we know that $G'(k) < 0$. ∎

- Appendix 3

Table A1: Bank Equity Capital as a Percentage of Total Assets
By Bank Asset Size (Averages over the period 1987-1991)

Small ($0-$300 mil.)	8.3%
Medium ($300-$5 bil.)	6.7%
Large ($ 5 bil.)	5.5%
10 Largest Banks	4.7%
All	6.2%

(Data form Boyd and Gertler (1993))

Table A2: Bank Failures. By Bank Asset Size (1986-1990)

Asset Size	Number of failed banks	Percent of total failures
Less than $500 mil.	912	96.6 %
$500 mil.-$1 bil.	19	2.0 %
$1 bil.-$ 5 bil.	10	1.1 %
More than $5 bil.	3	0.3 %

(Data form Boyd and Gertler (1993))

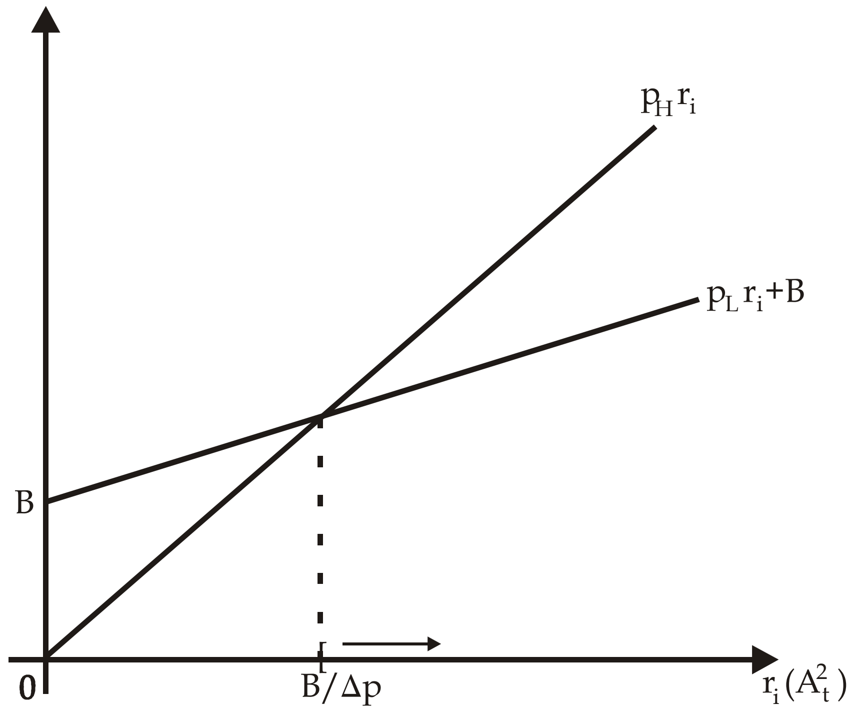

Figure 1:

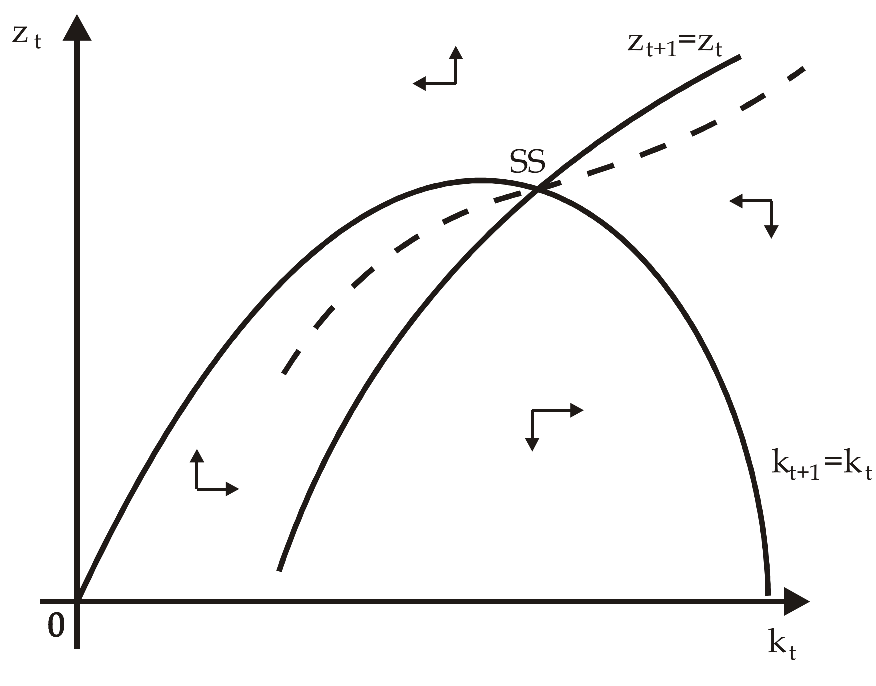

Figure 2:

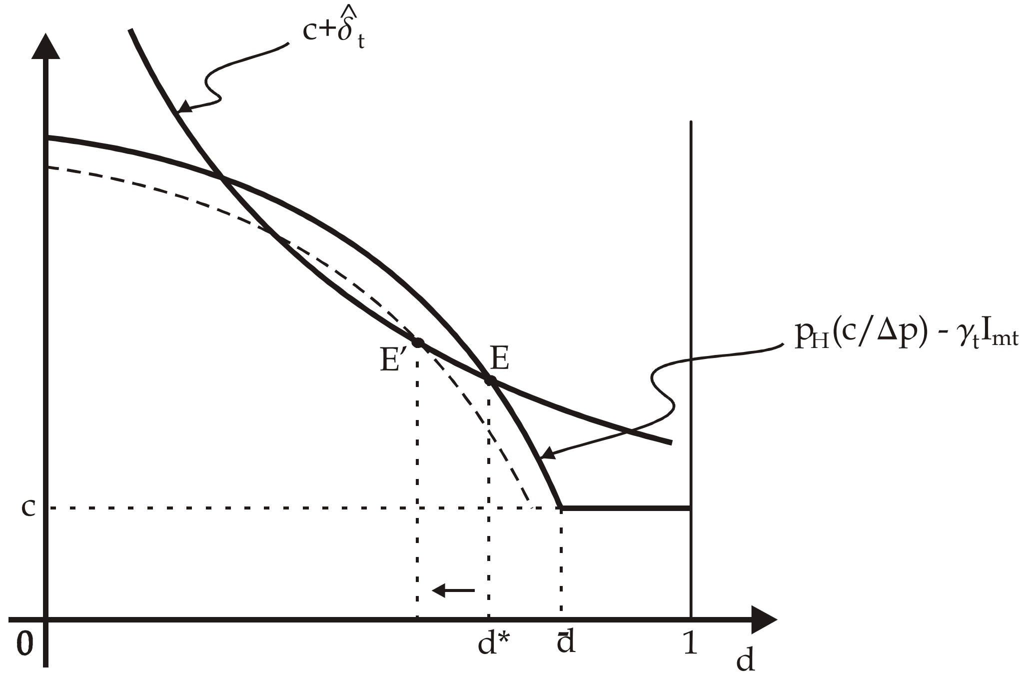

Figure 3: