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Fiscal, Monetary, and Reserve Requirement Policy in an Endogenous Growth with Financial Market Imperfections

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A simple endogenous growth model is developed in a framework where informational imperfections in financial markets give rise to adverse selection as well as costly state verification problems and the government needs to intervene financial markets to monetize its deficits. In the model, adverse selection problem raises credit rationing and financial intermediaries arise endogenously due to costly state verification. Inflation is shown to influence the amount of credit rationing and economic growth. We then examine the effects of government fiscal and monetary policies on equilibrium inflation, the amount of credit rationing, and thus economic growth. Results show that multiple equilibria arise when the share of government deficits is relatively large. We also illustrate how the use of reserve requirement policy can eliminate high inflation equilibrium and enable the government to reduce the inflation rate. In sum, it is found that Tobin effect hold when there is no reserve requirement or it is not binding. However, if the reserve requirement is set too high, such a policy will raise the equilibrium inflation rate and reduce economic growth, leading to a violation of Tobin effect.

I. Introduction

It is widely believed that informational imperfections in financial markets create problems in transferring funds from lenders to borrowers. Spurred by the development of endogenous growth model, recent studies (as in Bencivenga and Smith (1993) and Bose and Cothren (1996)) have further recognized that informational problems in financial markets impede the accumulation of capital and thus economic growth. On the other hand, recent empirical research (as in Boyd *et al.* (1996) and English (1999)) has documented that inflation affects significantly the operations of financial markets. Furthermore, beginning with the pioneering work of Tobin (1965), much effort has been devoted to examining the relationship between inflation and economic growth. These works have also induced economists to consider the effects of government policies on the relationship between inflation and economic growth (as in Bhattacharya *et al.* (1997) and Fung *et al.* (1999)).

Though each aforementioned problem has aroused much discussion, little attention has been paid to integrate these problems and demonstrate how government polices affect informational problems and thus the operations of financial markets. This is true although government policies influence to a large extent the efficiency of resource allocation

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performed by financial markets (see Fry (1995)). This paper aims to extend the recent literature by integrating the above problems. This extension is important particularly to the less developed countries (LDCs) since informational problems are more severe in LDCs[1] and government of LDCs usually face large deficits and thus need to intervene the financial markets to monetize deficits.

To this end, we construct a model in which adverse selection and costly state verification problems coexist (as in Boyd and Smith (1993)) in a framework where the government finances large deficits by issuing money and bonds. The adverse selection problem gives rise to credit rationing and financial intermediaries arises endogenously due to costly state verification problem. In the model, an increase in the rate of return from holding money will raise the opportunity cost of financial intermediaries in lending to borrowers. This will raise the amount of credit rationing and thus reduce the amount of resources channeled to capital investment. We then examine how government financing policies influence the equilibrium inflation rate, operations of financial intermediation, and thus economic growth. Moreover, the existence of financial intermediaries also allows us to consider the effects of one commonly encountered regulation policy on financial institutions: the reserve requirement.

We first examine the case where there is no financial regulation. Results show that if the share of government deficits is relatively large, multiple equilibria arise, of which one is characterized with a relatively high inflation rate and the other with a low inflation rate. In this case, effects of an increase in government deficits on the equilibrium inflation rate and economic growth depend crucially on the initial equilibrium. Specifically, an increase in government spending will increase inflation rate if the initial equilibrium inflation rate is low. Since money is an alternative choice of intermediaries' portfolio (as in Tobin's model), an increase in the inflation rate will lower the return from holding money and thus financial intermediaries will adjust their portfolio by holding less money. As shown in the model, this will alleviate adverse selection problems and increase the amount of resources allocated to capital investment, thus increasing the rate of economic growth. On the other hand, if the initial inflation rate is high, an increase in government spending share will lower the inflation rate and economic growth. Consequently, regardless of high- or low-inflation equilibrium, Tobin effect holds when there is no financial regulation. Moreover, an open market operation in which the government reduces the bonds to money ratio has no real effect on the equilibrium if there is no reserve requirement or if it is not binding.

We also conclude that if there are no financial market imperfections, multiple equilibria vanish. This result is consistent with the belief (see Benhabib and Farmer (1999) for a survey) that asymmetric information in financial markets is one of the sources in obtaining indeterminate equilibria. Moreover, it is often argued (see Bhattacharya *et al.* (1997)) that government regulations in financial markets may be able to eliminate unwanted equilibrium and therefore solve for the problem of indeterminacy. To explore this issue in this framework, we then impose an arbitrary reserve requirement and examine how the equilibrium consequences change. It is found that a moderate level of the reserve

1. See Bencivenga and Smith (1993) for discussion.

requirement will not bind but it can eliminate the high inflation equilibrium. If the level of the reserve requirement is large, it becomes fully binding. In this case, such imposition will generally reduce the inflation rate and economic growth. Nonetheless, this does not imply that the government can always reduce equilibrium inflation rate by increasing the required reserve-deposit ratio. In fact, if the required reserve-deposit ratio is set too large, the imposition of this reserve requirement will raise the inflation rate and reduce economic growth. In other words, Tobin effect does not hold when the reserve requirement is set too high. We obtain this critical ratio of reserve requirement. Moreover, an open market operation in which the government reduces the debts to money ratio will increase the equilibrium inflation rate and economic growth under binding reserve requirement. Finally, an increase in the government deficits under a binding reserve requirement will increase the equilibrium inflation rate and economic growth.

A number of studies related to this paper are as follows. Azariadis and Smith (1996) present a model with a structure of informational imperfections different from that described in this paper. They then show that inflation exacerbates informational imperfections and may reduce economic growth. However, due to their simple structure in modeling government behaviors, the roles played by government policies cannot be examined. Bhattacharya *et al.* (1997), on the other hand, examine government policies in a neoclassical growth model where financial intermediaries arise solely to provide liquidity service. Informational problems are missing in their framework, however.

The rest of this paper is organized as follows. Section II describes the basic model and Section III determines the equilibrium contract that intermediaries offer to capital borrowers. Section IV characterizes the equilibrium consequences without government regulations on financial intermediation. In Section V, we consider the effects of government regulations - the reserve requirement - on the equilibrium consequences. Section VI concludes.

II. Model

Consider a model economy populated with two-period-lived agents. Each generation has the same size and composition. For the sake of convenience, the population of each generation is normalized to one, of which a fraction α of agents are lenders and the rest $(1-\alpha)$ are borrowers.

1. Behaviors of Agents

Each young lender at t is endowed with one unit of labor in the first period of life and wishes to consume in their last period of life. A young lender at time t will sell his labor to firms and earn the ruling wage rate w_t. Then, each lender can save this wage for consumption in the next period by directly holding money and government bonds, by directly lending to borrowers, or by making deposits into a financial intermediary. Ultimately, we will focus on the case where all savings are intermediated; that is, lenders will not directly hold money and government bonds or directly lend to borrowers. Conditions for this will be described later.

Each young borrower is endowed with a risky investment project that, with a non-negative probability, can successfully convert time t output into time $t+1$ capital with inputs. Borrowers are not endowed with any other resources at any date; thus to implement his project, a borrower has to seek external funding. Financial market frictions arise from asymmetric information which is derived by the following two assumptions. First, there are two types of borrowers and only a borrower knows his type. With probability $p_i, i = h, l$, the investment project operated by a Type i borrower can convert z units of time t consumption good into Qz units of time $t+1$ capital. With probability $1-p_i$, the project fails and produces nothing. Assuming that $1 \geq p_l > p_h \geq 0$, Type l borrowers are low-risk. A fraction l of borrowers is Type h. This assumption, as in Bencivenga and Smith (1993), raises an issue of distinguishing Type l borrowers from Type h ones (known as adverse selection problem).

The second assumption is that a project's outcome can be observed at zero cost only by the borrower who operates the project. To learn the true outcome of the project, any other agent has to monitor the borrower. Monitoring is costly as it incurs d units of consumption good per unit input of the project. As in Williamson (1986) and Boyd and Smith (1993), this creates incentives for a borrower to claim bankruptcy, independent of the true outcome of his project. It is also well known that the optimal contract in this content is a standard debt contract in which monitoring takes place when the borrower claims bankruptcy.[2]

Note that borrowers' capital technology is a linear one;[3] thus, a maximal scale is needed to bound the size of loan. As discussed by Bencivenga and Smith (1993, hereafter B-S), this maximal scale has to tie the economy's current capital stock. Similar to B-S, I assume that this maximal scale at t is equal to the current real wage rate xw_t, $x > 1$.[4] In other words, a borrower can implement his investment project at the scale less than or equal to xw_t; nonetheless, every borrower will want to implement his project at the maximal scale given the linear technology of the project.

The capital stock produced between time $t-1$ and t is available for producing output in time t. We assume that each borrower becomes a firm operator regardless of his project's outcome in the second period of life. An old borrower is able to produce output by renting capital (in positive or negative amounts) and hiring labors (including all young

2. For simplicity, only non-stochastic monitoring is allowed. Moreover, the outcome of borrowers' projects has a two-state distribution. As pointed out by Boyd and Smith (1993), the latter assumption makes the debt contract the optimal contract.

3. We may assume a capital production technology with decreasing returns to scale and allow the borrower to choose the size of loans (see Ho (1996) for the example). However, as in Bencivenga and Smith (1993) this paper focuses on adverse selection problems in which the amount of credit rationing is defined by the number of loans made to the borrower (not the size). Thus, this assumption is maintained. See Bencivenga and Smith (1993) for discussion.

4. The assumption of $x > 1$ implies that it needs more one lender to finance a borrower. As in Diamond (1984), this will give rise to financial intermediary under costly state verification problem. See below.

lenders) at the competitively determined rental rates. The production function of output is given as

$$y_t = \boldsymbol{F}_t^h k_t^s N_t^{1-s} \ , \tag{1}$$

where k_t and N_t are the amount of capital and labor employed by each firm respectively; and $\boldsymbol{F}_t$ is the average per firm capital stock. Capital depreciates fully after production. In equilibrium, each firm will employ the same amount of capital; thus, $\boldsymbol{F}_t = k_t$. Furthermore, for simplicity $h = 1 - s$. Labor and capital markets are competitive so that the rental rates of labor (w_t) and capital ($\boldsymbol{r}_t$) at time t are given as

$$w_t = (1 - s)k_t^{h+s} N_t^{-s} = (1 - s)k_t N_t^{-s} = (1 - s)y_t N_t^{-1} \tag{2}$$

and

$$\boldsymbol{r}_t = s k_t^{h+s-1} N_t^{1-s} = s N_t^{1-s} \equiv \boldsymbol{r} \ , \tag{3}$$

where $N_t = N = \dfrac{\boldsymbol{a}}{1 - \boldsymbol{a}}$.

2. Financial Intermediation

The existence of financial intermediation in this model is justified by the role of delegated monitoring as in Diamond (1984) and Williamson (1986). Recall that the amount of savings by each young lender is equal to w_t, whereas each borrower is intended to borrow the amount of xw_t with $x > 1$. Consequently, it needs more than one lender to finance a project. Given the nature of the standard debt contract, this implies that more than one lender have to monitor a borrower if the borrower claims bankruptcy. As in Diamond (1984), the presence of financial intermediation can economize on the costs of monitoring the borrower.[5] Competitive behaviors in financial intermediation are ensured by the assumption that any lender can establish an intermediary (or, in short, a bank) at no cost (free entry). Given this, each bank earns zero profit from its operation. In a stationary monetary equilibrium in which money and government bonds are willingly held, the return from holding money has to be equal to that from government bonds. Furthermore, to attract deposits, each bank has to offer a depositor with a safe return at least equal to the returns from holding money and government bonds. Though lending to borrowers is risky, each bank has the ability to exploit the law large numbers so to offer its depositors a safe return on risky loans. Consequently, if each bank can offer its depositors with a safe return that is at

5. Otherwise, more than one lenders have to pay monitoring costs for acquiring the same information.

least equal to the return from money, direct lending to borrowers can be precluded and all primary assets holding are intermediated.

3. Government

According to Bhattacharya *et al.* (1999), the government at time t has per lender expenditure equal to $q w_t$, where q is a constant and w_t is the wage rate. The government can finance its expenditure by issuing money and/or bonds. Denoting the time t per lender supply of bonds by B_t and per lender supply of money by M_t, the government budget constraint at t is given as

$$q w_t = [M_t - M_{t-1} + B_t - I_{t-1} B_{t-1}] / P_t \tag{4}$$

where P_t is the price level at time t, and I_{t-1} is the gross real rate of interest on government bonds. Assuming that the government wishes to keep a constant debt to money ratio of b so that at all time

$$\frac{B_t}{M_t} = b \tag{5}$$

Moreover, (4) can be rewritten as

$$q w_t = m_t - m_{t-1} \frac{P_{t-1}}{P_t} + b_t - I_{t-1} \frac{P_{t-1}}{P_t} b_{t-1}\,, \tag{6}$$

where m_t is the real balances, and b_t is the real bond (per lender) holding at time t. As stated, government bonds and money have the same rate of returns so that $I_t = 1$. Moreover, (5) implies that $b_t = b m_t$, $t \geq 1$. Denote the rate of return from holding money (the inverse of the inflation rate) between time $t-1$ and t as R_t^m (that is, $\frac{P_{t-1}}{P_t} = R_t^m$). Then (6) can be rewritten as

$$q w_t = m_t (1 + b) - m_{t-1} R_{t-1}^m (1 + b) = (1 + b)(m_t - R_{t-1}^m m_{t-1})\ . \tag{7}$$

To complete the description of the model, the government issues M_0 of money and B_0 of bonds (per lender) at the initial period. Moreover, each initial old borrowers who operates firm is endowed with k_0 units of capital.

III. Equilibrium Contracts

Since direct lending is precluded, each borrower has to contact with a bank for external funding. However, lending to borrowers is subject to adverse selection and costly state verification problems. As in Bencivenga and Smith (1993), to solve the first problem, each bank can design contracts to induce a self-selection and separate borrowers according to their type. Therefore, although the debt contract is an optimal contract in this framework, the terms of contracts (including the loan rate, loan quantity, and other conditions) are subject to the adverse selection problem. We now turn to determine the terms of the optimal contracts in financial market equilibrium.

Before proceeding, note that, to induce self-selection, one needs a situation that different types of borrowers have different opportunity cost being rejected with loans. To this end, I follow Bose and Cothren (1997) by assuming that the project of young Type l borrowers at time t can be utilized for home production without input at time $t+1$. Nonetheless, the project of Type h entrepreneurs has no such access. A project, if being implemented for capital production in t, cannot be utilized for home production in $t+1$. To allow for balanced growth, we assume that the amount of home production produced at time $t+1$ is proportional to the wage rate at the previous period; that is, vw_t with v being sufficiently small to ensure that borrowing is desirable. Given this, a Type l borrower will have no incentives to be considered as a Type h one.

The financial markets are operated in a way similar to that of B-S. In each period, after receiving deposits from lenders each bank announces a set of contracts to borrowers. The terms of equilibrium contracts at time t are defined such that there is no incentive for any bank to offer alternative contracts, taking ρ_{t+1}, the inflation rate, and other banks' offers as given.

As in B-S, the contract offered by a bank to a Type i borrower comprises a 3-tuple $\{\pi_t^i, q_t^i, R_t^i\}$, where $\pi_t^i \in [0,1]$ is the probability with which a bank offers the loan, q_t^i is the quantity of loan offered, and R_t^i is the loan rate the borrower has to pay when his project succeeds. Given this, a Type l borrower's expected payoff is

$$p_l \pi_t^l q_t^l (Q\rho_{t+1} - R_t^l) + (1-\pi_t^l) v w_t\,, \tag{8}$$

likewise, that for a Type h borrower is

$$p_h \pi_t^h q_t^h (Q\rho_{t+1} - R_t^h)\,. \tag{9}$$

To prevent a Type h borrower from pretending as a Type l one or vice verse, the contract terms have to satisfy self-selection constraints given as

$$p_h \pi_t^h q_t^h (Q\rho_{t+1} - R_t^h) \geq p_h \pi_t^l q_t^l (Q\rho_{t+1} - R_t^l) \tag{10}$$

and

$$p_l \pi_t^l q_t^l (Q\rho_{t+1} - R_t^l) + (1-\pi_t^l) v w_t \geq p_l \pi_t^h q_t^h (Q\rho_{t+1} - R_t^h) + (1-\pi_t^h) v w_t \,, \tag{11}$$

for all t.

The terms of the optimal contract is determined by the followings. First, competition will force banks to earn zero profit. Let R_t^i be the interest rate charged to a Type i borrower between time t and $t+1$ by a bank. Then, if self-selection constraints are satisfied, zero-profit is expressed as[6]

$$q_t^i [p_i R_t^i - (1-p_i)\delta] = q_t^i R_t^m, \;\; t \geq 0 \,. \tag{12}$$

From (12), the loan rate charged to a Type i borrower is given as

$$R_t^i = \frac{R_t^m + (1-p_i)\delta}{p_i}, \;\; i = h, l \,. \tag{13}$$

Second, as stated a borrower will want to implement his project at the maximal scale so that $q_t^l = q_t^h = x w_t$. Third, to ensure that borrowing is desirable, we assume that $Q\rho_{t+1} > R_t^h$.[7] Furthermore, v is assumed to be sufficiently small (smaller than $(Q\rho_{t+1} - R_t^l)$) so that the expected returns for Type h and l borrowers are increasing with π_t^h and π_t^l respectively (see (8) and (9)). Note that competition also implies that a bank offers the contract under which the expected return of the borrower is maximized. Given this, (10) should hold as equality, so

$$\frac{\pi_t^l}{\pi_t^h} = \frac{(Q\rho_{t+1} - R_t^h)}{(Q\rho_{t+1} - R_t^l)} = \frac{p_l (p_h Q\rho_{t+1} - R_t^m - (1-p_h)\delta)}{p_h (p_l Q\rho_{t+1} - R_t^m - (1-p_l)\delta)} \equiv \phi(R_t^m) \tag{14}$$

Note that $\pi_t^l < \pi_t^h$ since $R_t^l < R_t^h$; thus $\phi(R_t^m) < 1$. Using this result, one can easily verify that the self-selection of (11) is also satisfied.

IV. Equilibrium Analysis of Balanced Growth Path

Recall that the expected payoff of a Type i borrower is an increasing function of π_t^i. Thus, if there is no reserve requirement (or, it is not binding), the bank can maximize borrowers' expected payoff by setting that $\pi_t^h = 1$, and thus

6. $p_i R_t^i - (1-p_i)\delta$ is the rate of return from lending to a Type i borrower and R_t^m is the deposit rate.

7. Borrowing is desirable if the expected payoff is non-negative. This requires that $Q\rho_{t+1} > R_t^h$. Note that, from (7), $R_t^l < R_t^h$. Thus, if $Q\rho_{t+1} > R_t^h$, $Q\rho_{t+1}$ is automatically greater than R_t^l.

$$\pi_t^l = \pi_t^l\left(R_t^m\right) = \frac{p_l(p_h Q\rho_{t+1} - R_t^m - (1-p_h)\delta)}{p_h(p_l Q\rho_{t+1} - R_t^m - (1-p_l)\delta)}\,. \tag{14$'$}$$

It can be shown that $\partial\pi^l / \partial R_t^m < 0$. Therefore, an increase in the inflation rate will alleviate adverse problems and increase the probability of getting loans for Type l borrowers. Recall that the value of π_t^l lies between 0 and 1. Given this, the value of R_t^m has an upper bound (denoted as $\overline{R}^m$) given as $p_h Q\rho - (1-p_h)\delta$. Also, it is obvious that the lower bound of R_t^m (denoted as $\underline{R}^m$) is zero and in this case the value of π_t^l (denoted as $\overline{\pi}^l$) is maximized and given as

$$\overline{\pi}^l = \pi^l(R_t^m = 0) = \frac{p_l(p_h Q\rho_{t+1} - (1-p_h)\delta)}{p_h(p_l Q\rho_{t+1} - (1-p_l)\delta)}\,. \tag{14$''$}$$

To further simplify the ensuing analysis, we assume that $\overline{\pi}^l = 1$.[8] In other words, $\pi_t^l = 1$ if $R^m = 0$ and $\pi_t^l = 0$ if $R^m = \overline{R}^m = p_h Q\rho - (1-p_h)\delta$. Given the terms of equilibrium contracts, one sees that the total amount of resources used by borrowers for capital production at time t is given as

$$(1-\alpha)[\lambda + (1-\lambda)\pi_t^l]xw_t\,. \tag{15}$$

Since each old borrower operates a firm, the number of firms is ($1-\alpha$). Therefore, the per firm capital stock at time $t+1$ is given as

$$k_{t+1} = [\lambda p_h + (1-\lambda)p_l\pi_t^l]xw_t Q\,. \tag{16}$$

Given that all primary asset holdings are intermediated, the condition under which money and bond markets clear is given as

$$m_t + b_t = \frac{\alpha w_t - (1-\alpha)[\lambda + (1-\lambda)\pi_t^l]xw_t}{\alpha}\,. \tag{17}$$

It is assumed that the α is sufficiently large so that $m_t + b_t$ is non-negative.[9] Using (5), we can rewrite (17) as

8. That is, $p_l(p_h Q\rho_{t+1} - (1-p_h)\delta) = p_h(p_l Q\rho_{t+1} - (1-p_l)\delta)$.

9. Note that when $R_t^m = 0$, $\pi^l = 1$. Thus, to ensure that $m_t + b_t$ is non-negative for any given level of R_t^m, $\alpha \geq (1-\alpha)[\lambda + (1-\lambda)]x = (1-\alpha)x$. Since $x > 1$, this implies that $\alpha > 0.5$. Note that, if $\alpha = (1-\alpha)x$, $m_t + b_t = 0$.

$$m_t = \frac{M_t}{P_t} = \frac{\alpha - (1-\alpha)[\lambda + (1-\lambda)\pi_t^l]x}{(1+\beta)\alpha} w_t . \tag{18}$$

We next define a balanced-growth equilibrium as follows.

***Definition**: Given M_0, B_0, and k_0, a balanced-growth equilibrium comprises a set of non-negative sequence {$k_t, M_t, B_t, P_t, \rho_t, w_t, R_t^m, R_t^i$, and π_t^i}, $t \geq 1$, satisfying (2), (3), (7), (13), and (14). In addition, along with a balanced growth path, y_t, k_t, w_t, M_t, B_t and P_t all grow at constant rates, whereas ρ_t, R_t^m and π_t^i remain unchanged.*

1. Characterizations of Balanced Growth Equilibria

Substituting (2) into (16), we can derive the equilibrium growth rate of capital stock as[10]

$$g = g(R_t^m) = \frac{k_{t+1}}{k_t} = (1-\sigma)Q[\lambda p_h + (1-\lambda)p_l\pi_t^l]xN^{-s} . \tag{19}$$

From (1) and (2), g is also the growth rate of output. Recall that $\partial\pi^l / \partial R_t^m < 0$, implying that a decrease in R^m (an increase in the inflation rate) will reduce the amount of credit rationing and therefore raise the growth rate. However, this does not imply that infinite inflation leads to an infinite economic growth rate. To see this, recall that $\pi_t^l = \bar{\pi}^l = 1$ when the inflation rate is infinite (that is, when $R^m = 0$). Then, the growth rate under an infinite inflation rate is equal to $(1-\sigma)Q[\lambda p_h + (1-\lambda)p_l]xN^{-s}$, which obviously is not infinite.

Note from (19) that, under a balanced growth path where π^l remains unchanged, m_t is growing at the same rate as the output so that $m_t = gm_{t-1}$. Therefore, the government budget constraint can be rewritten as

$$\theta w_t = (1+\beta)m_{t-1}(g - R^m) \tag{20}$$

Note that $(1+\beta)m_{t-1}$ can be viewed as the inflation tax base and $(g - R^m)$ is the inflation tax rate. With (18) and (19) and after some manipulations, (20) becomes

$$\frac{\theta}{[1 - \frac{R^m}{g}]} = \frac{\alpha - (1-\alpha)(\lambda + (1-\lambda)\pi^l)x}{\alpha} , \tag{21}$$

10. For brevity, time subscripts are suppressed in the parameters that remain unchanged along the balanced growth path.

where $g = (1-s)Q[\,lp_h + (1-l)p_l p_t^l\,]xN^{-s}$. It is clear that the (21) determines the equilibrium value of R^m. Once R^m is derived, other variables (such as p^l, m, and g) can be obtained by substituting the equilibrium level of R^m into Equations (14′), (18), and (19). To obtain the equilibrium R^m, denote the left-hand side of (21) as $y(R^m)$ and the right-hand side as $W(R^m)$. Then the equilibrium levels of R^m can be determined by y and W. Note that $W(R^m)$ is the inflation tax base which is derived by subtracting the resources allocated to capital borrowers from total amount of deposits. To characterize the equilibrium, we first observe that $y(R^m)$ and $W(R^m)$ have the following properties (see Appendix for the proof).

Lemma 1*: (a)* $y'(R^m) > 0$ *; (b)* $y''(R^m) > 0$ *; (c)* $W'(R^m) > 0$ *; (d)* $W''(R^m) > 0$.

From Lemma 1, both $y(R^m)$ and $W(R^m)$ are strictly convex functions. Therefore, the equilibrium consequence will depend on the values of $y(R^m)$ and $W(R^m)$ when $R^m = 0$ and $R^m = \bar{R}^m$, where $\bar{R}^m$ is the upper bound of R^m. Specifically, a unique equilibrium exists if the relations of $y(0) > (<) W(0)$ and $y(\bar{R}^m) < (>) W(\bar{R}^m)$ are simultaneously held. On the other hand, multiple equilibria could arise if $y(0) > (<) W(0)$ and $y(\bar{R}^m) > (<) W(\bar{R}^m)$. From (21), it is obvious that the government spending share, q, plays an important role in determining the relationships between $y(0)$ and $W(0)$ and between $y(\bar{R}^m)$ and $W(\bar{R}^m)$. We next specify the conditions under which the unique and multiple equilibria arise.

To begin with, we define a q_1^* such that $y(0) = W(0)$ if $q = q_1^*$ and a q_2^* such that $y(\bar{R}^m) = W(\bar{R}^m)$ if $q = q_2^*$. Since $\frac{\partial y}{\partial q} > \frac{\partial W}{\partial q} = 0$, $y(0) > W(0)$, if $q > q_1^*$ and $y(\bar{R}^m) > W(\bar{R}^m)$ if $q > q_2^*$. Then we have the following lemma determining the relationship between q_2^* and q_1^*.

Lemma 2*: If* d *is relatively large, then* $q_2^* > q_1^*$.

Note that d can be viewed as the level of financial development.[11] As LDCs possess relatively less developed financial system, we will focus on the case where d is relatively large so that $q_2^* > q_1^*$. Given this, depending on the share of government deficits, we have the following three possibilities to consider: Case 1. $q > q_2^* > q_1^*$, Case 2. $q_2^* > q > q_1^*$, and Case 3. $q_2^* > q_1^* > q$. The first case is characterized with a relatively higher share of government deficits and, according to the definitions of q_1^* and q_2^*, both the relations of

11. See Di Giorgio (1999).

$\Psi(\bar{R}^m) > \Omega(\bar{R}^m)$ and $\Psi(0) > \Omega(0)$ are held. Given the convexity of $\Psi(R^m)$ and $\Omega(R^m)$, this implies that there are either multiple equilibria or none in Case 1. The locus of Ψ in Case 1 is labeled as Ψ_1 in Figure 1. As seen in the figure, the key factor ensuring the existence of two equilibria is that the slope of $\Psi(R^m)$ is sufficiently flat for a given locus of $\Omega(R^m)$. Given the functions of $\Psi(R^m)$ and $\Omega(R^m)$, this requires that θ should not be too large (of course, θ still has to be greater than θ_2^*).[12] As a consequence, a relatively large amount of government deficits may give rise to multiple equilibria of which one is characterized with a high inflation rate (denoted as high-inflation equilibrium and labeled as '*H*' in Figure 1) and the other is with a low inflation rate (low-inflation equilibrium, labeled as '*L*'. For future reference, we denote R_L^m (R_H^m) as the rate of return from holding money in the low-inflation (high-inflation) equilibrium. Note that $\partial p^l / \partial R^m < 0$; this implies that more Type *l* borrowers are credit rationed in low-inflation equilibrium than in high-inflation equilibrium. As Type *l* borrowers are more efficient in producing capital, the growth rate is lower in low-inflation equilibrium than in high-inflation equilibrium. This further implies that the inflation tax rate (given as $g - R^m$) is higher in high-inflation equilibrium than in low-inflation equilibrium. On the other hand, the inflation tax base, given as m_t, is higher in low-inflation equilibrium than in high-inflation equilibrium (see (18)). To finance a given government deficit, it can be either a higher inflation tax rate with a lower inflation tax base (high-inflation equilibrium) or a lower inflation tax rate with a higher inflation tax base (low-inflation equilibrium). This gives rise to the rationales of multiple equilibria.

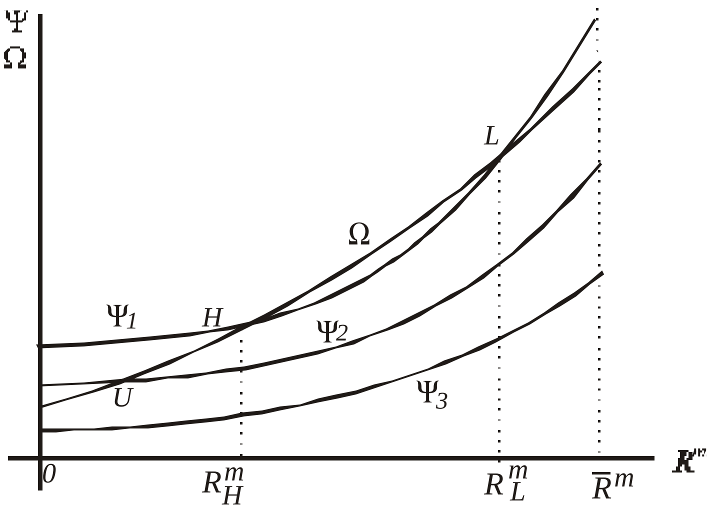

Figure 1 The Unique and Multiple Equilibria

12. If $\theta = \theta_2^*$, there are two equilibria and one of which is a corner solution.

Note that the equilibrium levels of R^m are obtained from government budget constraint specified in (21). This implies that each bank and borrower will take R^m as given. As a consequence, individual agent and financial intermediaries fail to pick high- or low-inflation equilibrium, although lenders may prefer the higher levels of R^m over the lower levels of R^m. On the other hand, the government can impose a regulatory policy on the operations of financial intermediaries and eliminate the unwanted equilibrium. We will discuss this issue in the next section.

We now turn to the next case where $q_2^* > q > q_1^*$. Obviously, both relations of $y(0) > W(0)$ and $y(\overline{R}^m) < W(\overline{R}^m)$ hold. This guarantees the existence of unique balanced growth equilibrium. The configuration of y in this case is depicted as y_2 in Figure 1 and the unique equilibrium is labeled as 'U'. Finally, if $q_2^* > q_1^* > q$, $y(0) < W(0)$ and $y(\overline{R}^m) < W(\overline{R}^m)$. Note that the slope of y is positively correlated with q. Therefore, if multiple equilibria arise in Case 1, there must be no equilibrium in Case 3 since the slope of y (labeled y_3 in Figure 1) is too flat. The following proposition summarizes the existence of equilibrium.

Proposition 1*: Suppose that d is relatively large. Then if $q > q_2^* > q_1^*$, there are two equilibria, provided that q is not too large. If $q_2^* > q > q_1^*$, there exists a unique balanced growth equilibrium. Finally, if $q_2^* > q_1^* > q$, there is no equilibrium.*

For the rest of the paper, we consider only the case where the government spending share is relatively large and multiple equilibria always arise.[13] This case raises an interesting issue of how the government regulation policy can eliminate the unwanted equilibrium and solve the problem of indeterminacy. We will discuss this issue in the next section.

2. Comparative Statics

In this subsection, we examine the effects of changing government policy on the inflation and economic growth rates when multiple equilibria arise. As the first policy, an open market operation in which the government reduces the bonds to money ratio for a given level of expenditure will have no effect on the economy's equilibrium, a standard result in overlapping generations models where money is not dominated in the rate of return. This can be derived by observing that b, government debt to money ratio, does not appear in (21).

We next discuss the result of an increase in government spending share. When q increases, y shifts up while W remains unchanged. It can be inferred from Figure 1 that the effects of an increase in q on the inflation rate and economic growth depend on the initial equilibrium. Specifically, if the initial equilibrium is the high-inflation equilibrium, an increase in q will lower the inflation rate and thus economic growth. On the other hand,

13. In fact, the characterizations of the unique equilibrium (in the case where $q_2^* > q > q_1^*$) is the same as the high-inflation equilibrium as can be inferred from Figure 1.

such increase will raise inflation and economic growth for the low-inflation equilibrium. These results may account for recent empirical findings by Bruno and Easterly (1998) who find that the initial rates of inflation play an important role in determining the relationship between inflation and economic growth.

3. Discussion

We have shown so far that multiple equilibria may arise in this framework. This result in a sense is consistent with many theoretical models;[14] nevertheless, the existence of multiple equilibria in this framework hinges on the existence of financial market imperfections.[15] To illustrate this, suppose that the information regarding entrepreneurs' type is public. In this situation, the loan rate given in (13) still holds. However, competition among banks implies that $p^h = p^l = 1$. In other words, credit rationing disappears under public information. In this case, (21) becomes

$$\frac{q}{[1-\frac{R^m}{g}]} = \frac{a-(1-a)x}{a} \qquad (22)$$

Note that both m and the growth rate (g) are independent of R^m when information is public. Clearly, y is an increasing function of R^m while W is independent of R^m. Therefore, a unique equilibrium exists if there is any equilibrium.

V. Government Regulations on Financial Intermediation: the Reserve Requirement

Section IV has demonstrated that financial market imperfections may give rise to indeterminacy of equilibrium. Economists such as Simons (1948) and Friedman (1960) argued that the source of indeterminacy is the free and unregulated financial markets.[16] This argument implies that government regulation on financial markets may be able to solve the problems of indeterminacy. Indeed, each individual will take the rate of return from money R^m as given. Then, as shown previously, either a relatively high inflation rate or a relatively low inflation rate can finance an exogenously given q. This indeterminacy may be solved if we consider the effects of government regulations on financial markets.

Financial regulations are widespread in developing countries. Many studies (as in Nichols (1974) and Bryant and Wallace (1984)) have suggested that government regulations such as reserve requirement is necessary to enhance the efficiency of using the inflation tax, especially for the countries who need to monetize deficits. In this framework, inflation has two opposite effects on the ground of welfare for each generation: An increase in the

14. See Benhabib and Farmer (1999) for a comprehensive discussion.

15. I am indebted to an anonymous referee for raising this point.

16. See Azariadis and Smith (1998) for a discussion on this point.

inflation rate will lower the payoff of lenders as the deposit rate (given as R_t^m) is equal to the inverse of the inflation rate, but it can raise the expected payoff of borrowers.[17] In consideration of all generations, an increase in the inflation rate has an additional effect: It increases the growth rate of income and thus the welfare. However, the following lemma states the conditions under which the government may prefer low-inflation equilibriumto the high-inflation one.[18]

***Lemma 3**: If Q is relatively small and the welfare of lenders carries a relatively higher weight in the social welfare, then the government may prefer low-inflation equilibrium to the high-inflation one.*

Intuitively, the magnitude of the effects of an increase in the inflation rate on the growth rate depends on the parameter Q (see Equation (19)). The assumption that Q is relatively small implies that the effect of an increase in inflation on the growth rate is sufficiently small and hence may be overwhelmed by the negative effect of the inflation rate on the welfare of lenders. Furthermore, it is assumed that the fraction of lenders, α, is sufficiently large (greater than 0.5).[19] Thus, the welfare of lenders carries a higher weight in the social welfare function.[20] These results implies that a lower inflation may be preferred by the government as it can maximize the welfare of lenders, which is the major concern of the government. We then show that a moderate level of reserve requirement allows the government to eliminate the high-inflation equilibrium and enables the government to reduce the inflation rate. Nevertheless, this result does not imply that the government can always raise the required reserve-deposit ratio and lower the inflation rate. In fact, if the required ratio is set too high, inflation will increase and such an increase reduces economic growth. In other words, Tobin effect does not hold if the reserve requirement is set too high. We now proceed with our analysis.

Denote γ_t as the reserve-deposit ratio in time t. Note that $\pi^l = \pi^h \phi(R^m)$ from (14). From this result, it is clear that $m_t = [\alpha - (1-\alpha)\pi^h x(\lambda + (1-\lambda)\phi(R^m))]w_t/[\alpha(1+\beta)]$ and the reserve-deposit ratio becomes

17. The loan rate is negatively correlated with the inflation rate. See Equation (13).

18. Owing to the length of this paper, we do not explore issues of the optimal inflation rate and thus optimal reserve requirements from the welfare aspect. In general, the effects of government regulations in financial markets on social welfare are ambiguous as the welfare of lenders and borrowers are conflicting. In this case, the closed form solution is not attainable and, to pursue the optimal reserve requirements, one has to resort to numerical experiments. To avoid this ambiguity and simplify our analysis, we simply state the conditions under which the government may prefer the low-inflation equilibrium to the high-inflation one. Then, we demonstrate how the imposition of reserve requirement enables the government to achieve this goal.

19. See footnote 9.

20. Indeed, in majority voting equilibrium the government will make its decision based on the majority's interests. Furthermore, it should be noted that only the lenders need to hold money and government bonds, through which the government collect the revenue for its deficits. This may give another reason to why the government may make its decision based on lenders' interest.

$$g_t = \frac{m_t}{w_t} = \frac{[a-(1-a)p^h(l+(1-l)f(R^m))]x}{a(1+b)}\,, \tag{23}$$

Let $\bar{g}$ be an arbitrary required ratio of reserve to deposit imposed by the government; thus $g_t \geq \bar{g}$ for all time. Recall that the optimal value of p^h is one and thus p^l is derived as in (14′) if the reserve requirement is not binding. However, if it is binding, the bank will adjust the values of p^h to meet the requirement. To illustrate this, we derive the following equation for the case where the reserve requirement is binding (that is, where $\bar{g} \geq g_t$):

$$(1-a)[l+(1-l)f(R^m)]xp^h = a-(1+b)a\bar{g} \equiv C\,, \tag{24}$$

where C is a constant. Note that when the actual reserve to deposit ratio is just equal to the required (that is, $g_t = \bar{g}$), the optimal value of p^h is still equal to one. We let $R^m_{\bar{g}}$ denote the value of R^m derived from (24) when $p^h = 1$. Since $\partial f(R^m)/\partial R^m < 0$ from (24) $R^m_{\bar{g}}$ is positively correlated with $\bar{g}$ and the reserve requirement binds if $R^m < R^m_{\bar{g}}$. Moreover, when $R^m < R^m_{\bar{g}}$, $f(R^m) < f(R^m_{\bar{g}})$; thus the value of p^h must be less than one for $R^m < R^m_{\bar{g}}$ to satisfy (24). Consequently, if the reserve requirement is binding, p^h is less than one and is a function of R^m (denoted as $p^h_{R^m}$ hereafter).

1. Equilibrium Analysis in the Presence of Reserve Requirements

With the imposition of a reserve requirement, the functions of $W(R^m)$ and $y(R^m)$ become

$$W(R^m) = \begin{cases} \dfrac{a-(1-a)[l+(1-l)f(R^m)]x}{a} & \text{if } R^m \geq R^m_{\bar{g}}, \\ (1+b)\bar{g} & \text{if } R^m < R^m_{\bar{g}} \end{cases} \tag{25}$$

and

$$y(R^m) = \begin{cases} \dfrac{q}{(1-\dfrac{R^m}{g})} & \text{if } R^m \geq R^m_{\bar{g}}, \\ \dfrac{q}{(1-\dfrac{R^m}{\bar{g}})} & \text{if } R^m < \mathrm{R}^m_{\bar{g}}, \end{cases} \tag{26}$$

where g is derived from (19) and $\bar{g}$, the rate of economic growth under a binding reserve requirement, is given as

$$\bar{g} = \bar{g}(R^m) = (1-\sigma)Q[\lambda \pi_h + (1-\lambda)\pi_l f(R^m)]x\pi^h_{R^m} N^{-\sigma} \tag{27}$$

In comparison with (19), (27) implies that $\bar{g} = g\pi^h_{R^m}$ for a given R^m. Since $\pi^h_{R^m}$ is less than one with a binding reserve requirement, $g > \bar{g}$. Consequently, for a given R^m the value of $\psi(R^m)$, the inflation rate tax base, is greater in the case where the reserve requirement is binding, except when $R^m = 0$ at which the value of $\psi(R^m)$ is the same no matter whether the reserve requirement is binding or not. Moreover, when the reserve requirement is binding, π^h can be derived from (24) as

$$\pi^h_{R^m} = \frac{\alpha - (1+\beta)\alpha\bar{g}}{(1-\alpha)[\lambda + (1-\lambda)f(R^m)]x}. \tag{28}$$

Substituting (27) and (28) into (26), one can show that $\psi'(R^m) > 0$ and $\psi''(R^m) > 0$ when the reserve requirement is binding. As a result, the locus defined by $\psi(R^m)$ with a reserve requirement (when the reserve requirement is binding and when it is not bonding) has the configuration as depicted in Figure 2. On the other hand, $\Omega(R^m)$ becomes a constant when the reserve requirement is binding. Thus, when $R^m < R^m_{\bar{g}}$, the function of $\Omega(R^m)$ has the configuration as depicted in Figure 2. Note that, in Figure 2, $\bar{\psi}$ and $\bar{\Omega}$ are the loci of ψ and Ω respectively when the reserve requirement is binding.

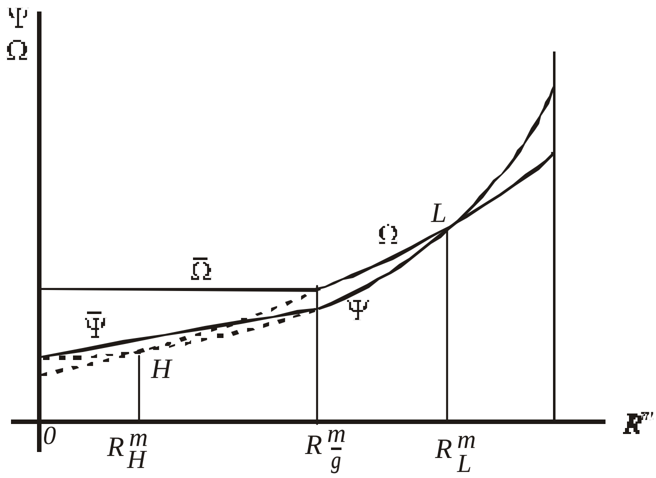

Figure 2 Effects of Reserve Reuqirement: $R^m_H < R^m_{\bar{g}} < R^m_L$

Recall that R_H^m and R_L^m are the values of R^m at the original high-inflation and low-inflation equilibrium, respectively. Therefore, we have three cases to consider regarding the required reserve-deposit ratio. The first case is characterized with a relatively low level of the reserve requirement such that $R_{\bar{g}}^m < R_H^m < R_L^m$. Obviously, the reserve requirement is not binding and has no effect. In the second case where levels of the reserve requirement are moderate so that $R_H^m < R_{\bar{g}}^m < R_L^m$, as depicted in Figure 2. As shown, the imposition of the reserve requirement will not bind; nevertheless, it eliminates the high-inflation equilibrium as shown in Figure 2. This result is consistent with that obtained by Bhattacharya *et al.* (1997). Consequently, if the government prefers the low-inflation equilibrium to the high-inflation one, a moderate level of reserve requirement is needed even though it is not binding. Finally, we consider the case where the level of reserve requirement is relatively high, that is, the case where $R_H^m < R_L^m < R_{\bar{g}}^m$. Obviously, the reserve requirement becomes fully binding and the equilibrium is located at ‘B, as shown in Figure 3. From the figure, it can be inferred that the equilibrium inflation rate in a binding reserve requirement (denoted as R_B^m) may be greater or less than R_L^m (Figure 3 is depicted under the assumption that $R_B^m > R_L^m$). Denoting g_L as the original growth rate in the low-inflation equilibrium, the condition that R_B^m is greater than R_L^m is specified in the following proposition.

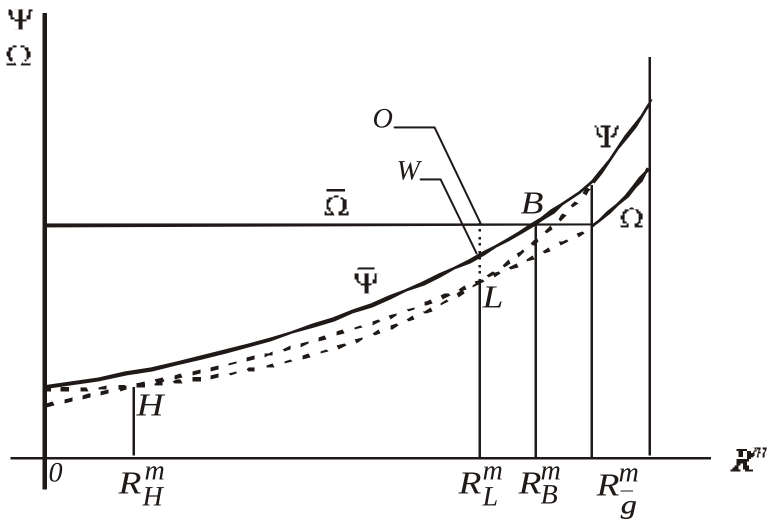

Figure 3 Effects of Reserve Requirement: $R_H^m < R_L^m < R_{\bar{g}}^m$

Proposition 2*: If* $\bar{g} < \dfrac{1-\dfrac{R_L^m}{g_L}}{(1+\boldsymbol{b})} \equiv \bar{g}^*$, $R_B^m > R_L^m$.

Proof: Denote $\overline{W}(R^m)$ and $\bar{y}(R^m)$ as the functions of $W(R^m)$ and $y(R^m)$ respectively when the reserve requirement is binding. Then, from Figure 3 it is clear that if $R_B^m > R_L^m$, $\overline{W}(R^m)$ (located at O in Figure 3)> $\bar{y}(R^m)$ (located at W). Since $W(R_L^m) = y(R_L^m)$ (located at L in Figure 3), we see that

$$\frac{W(R_L^m)}{\overline{W}(R_L^m)} < \frac{y(R_L^m)}{\bar{y}(R_L^m)}, \tag{29}$$

if $R_B^m > R_L^m$. Using the definitions of $\overline{W}(R_L^m)$, $\bar{y}(R_L^m)$, $W(R_L^m)$ and $y(R_L^m)$, (29) becomes

$$\frac{g_L(\bar{g}_L - R_L^m)}{\bar{g}_L(g_L - R_L^m)} > \frac{\boldsymbol{a} - (1-\boldsymbol{a})[\,\boldsymbol{l} + (1-\boldsymbol{l})\boldsymbol{f}(R_L^m)]x}{(1+\boldsymbol{b})\boldsymbol{a}\bar{g}}, \tag{30}$$

where g_L is derived by substituting R_L^m into (19) and, similarly, $\bar{g}_L$ is derived from (27). Using (28) to obtain $(1+\boldsymbol{b})\boldsymbol{a}\bar{g}$, we can rewrite (30) as

$$\boldsymbol{a}R_L^m(g_L - \bar{g}_L) < (1-\boldsymbol{a})[\,\boldsymbol{l} + (1-\boldsymbol{l})\boldsymbol{f}(R_L^m)]x[\bar{g}_L g_L(1-\boldsymbol{p}_{R_L^m}^h) + R_L^m(g_L\boldsymbol{p}_{R_L^m}^h - \bar{g}_L)]\,. \tag{31}$$

Note that $\bar{g}_L = \boldsymbol{p}_{R_L^m}^h g_L$ with $\boldsymbol{p}_{R_L^m}^h < 1$. The above equation can be simplified as $\boldsymbol{a}R_L^m < (1-\boldsymbol{a})\left[\boldsymbol{l} + (1-\boldsymbol{l})\boldsymbol{f}\left(R_L^m\right)\right]x\bar{g}_L$. Substituting $\bar{g}_L = \boldsymbol{p}_{R_L^m}^h g_L$ with $\boldsymbol{p}_{R_L^m}^h$ derived from (28) into this equation, we see that $R_B^m > R_L^m$, if $\dfrac{\boldsymbol{a}R_L^m}{g_L} < \boldsymbol{a} - (1+\boldsymbol{b})\boldsymbol{a}\bar{g}$, or equivalently, if

$$\bar{g} < \frac{1-\dfrac{R_L^m}{g_L}}{(1+\boldsymbol{b})} \equiv \bar{g}^*. \qquad \text{Q.E.D.} \tag{32}$$

Note that the imposition of a binding reserve requirement will increase inflation tax base and reduce the amount of resource allocated to capital borrowers. This implies that to finance a constant share of deficits the inflation tax rate (given as $(g - R^m)$) should be decreasing with an increase in $\bar{g}$. Moreover, from (28), $\boldsymbol{p}_{R_L^m}^h$ is a decreasing function of $\bar{g}$ and from (27), the growth rate is decreasing with a decrease in $\boldsymbol{p}_{R_L^m}^h$. Proposition 2 states that if $\bar{g}$ is set to be greater than $\bar{g}^*$, the growth rate decreases sharply so that the inflation tax rate, $g - R^m$, decreases even though R^m decreases (that is R_B^m is lower than R_L^m). On the other hand, if $\bar{g} < \bar{g}^*$, the growth rate is not low enough. Thus, to lower the inflation tax rate, R_B^m has to be greater than R_L^m. If the government intends to keep the inflation rate as low as possible, it is obvious that $\bar{g}^*$ is the optimal level of the reserve requirement.

Note further that, according to Proposition 2, if $\bar{g} > \bar{g}^*$, the imposition of a binding reserve requirement obviously reduces R^m and increases the equilibrium inflation rate. This will alleviate adverse selection problems as the probability of getting loans increases for Type l borrowers (see ($14'$)). As Type l borrowers are more efficient, one may suspect that this binding reserve requirement may raise economic growth. Nonetheless, since $\overline{W}(R_B^m) > W(R_L^m)$, the total amount of resources allocated to capital borrowers is smaller in equilibrium 'B' than in equilibrium 'L' (the low-inflation equilibrium). In consideration of these two effects, it can be shown that the growth rate in this case (denoted as $\bar{g}_B$) is still smaller than g_L. Note that, for a given q, $q = W(R_L^m)(1 - \frac{R_L^m}{g_L}) = \overline{W}(R_B^m)(1 - \frac{R_B^m}{\bar{g}_B})$.[21] As $\overline{W}(R_B^m) > W(R_L^m)$, $(1 - \frac{R_L^m}{g_L}) > (1 - \frac{R_B^m}{\bar{g}_B})$. Evidently, for this relation to hold, $\bar{g}_B < g_L$ because $R_B^m < R_L^m$.

2. Comparative Statics

We now consider the effects of changing government policy on equilibrium inflation. Contrast to the previous analyses, an open market operation in which the government reduces the bonds to money ratio has a real effect on the equilibrium under a binding reserve requirement. As can be seen from (25) and (26), a decrease in b will shift the locus of $\overline{W}(R^m)$ down while the locus defined by $\bar{y}(R^m)$ remains unchanged. This will obviously decrease the equilibrium level of R^m. With respect to economic growth, a decrease in b, on the one hand, increase resources allocated to capital borrowers; and on the other hand, decrease R^m so that the probability of getting loans for Type l borrowers is increased. Thus, the growth rate is increasing with a decrease in R^m.

As before, an increase in q has no effect on $W(R^m)$ but will shift the locus of $y(R^m)$ up. With a binding reserve requirement, we can infer from Figure 4 that an increase in q will always reduce the equilibrium levels of R^m and thus increase $f(R^m)$. This implies that an increase in q under a binding reserve requirement will increase the equilibrium inflation rate and economic growth.

21. Comparing equilibrium 'B' and 'L' in Figure 4 can reveals this relation.

VI. Conclusion

This paper examines the effects of government fiscal, monetary, and reserve requirement policy on the inflation rate and economic growth in an environment in which financial markets are characterized with adverse selection and costly state verification problems and financial intermediaries arise endogenously as to provide the service of delegated monitoring.

Results show that multiple equilibria arise if government deficits are relatively large. We also demonstrate that the key factor for the existence of multiple equilibria is the existence of financial market imperfections. When multiple equilibria arise, the initial condition plays an important role in determining the effects of government policy on equilibrium inflation and economic growth. In this case, Tobin effect holds. Moreover, an arbitrary reserve requirement can eliminate the high-inflation equilibrium and enable the government to reduce the inflation rate. However, if the reserve requirement is set too high, such a policy will raise the equilibrium inflation rate and reduce the economic growth. This result contradicts Tobin effect. Moreover, an open market operation in which the government reduces the bonds to money ratio will increase the equilibrium inflation rate and economic growth under a binding reserve requirement. When the reserve requirement is not binding, such a policy will have no effect.

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