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Theoretical Paradigm on Bank Capital Regulation and its Impact on Bank-Borrower Behavior

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ABSTRACT

Bank equity plays an important role in the credit allocation process of financial intermediaries. Financial institutions with higher level of equity are in better position to absorb losses and repay deposits in a timely manner. This relates to the bank capital channel of monetary policy transmission mechanism stating that banks having sound financial health could contribute significantly in transmitting monetary impulses to the real sector. Considering the important role that bank equity plays in shaping the risk taking behavior of financial intermediaries, central banks set the minimum paid-up capital requirement for banks and financial institutions. Though this regulatory requirement is aimed at ensuring the smooth financial intermediation, this could become costlier in extending loans particularly in the times of business cycle fluctuations. A higher capital requirement might also constrain the lending capacity of a bank. Given the conflicting theoretical assumptions on the role of equity capital on financial stability and economic growth, this paper develops a theoretical model examining the relationship between bank equity and its effect on bank-borrower behavior. The theoretical model recommends that higher level of bank equity might be helpful in ensuring financial stability by altering the behavior of the bank and borrower.

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I. INTRODUCTION

The global wave of financial deregulation in the last three decades fostered an interest in examining the relationship between financial development and real sector performance. While the deregulation largely shifted the ownership of the financial sector from the government to the private sector, the onus of the government regulation and supervision also increased simultaneously. This encouraged regulatory authorities to adopt the capital regulation measures.

The role of bank capital in the asset and liability management of a bank largely increased after the implementation of the risk based capital requirements of the 1988 Basel accord (Heuvel, 2009). Further, this role of bank equity has been highly recognized after the financial crisis of 2008. The financial crisis has clearly reinforced the fact that highly leveraged financial institutions create negative externalities (Admati, DeMarzo, Hellwig and Pfleiderer, 2010). Capital works as a cushion and averts possible insolvency of a bank when the value of the bank assets fall and the bank can meet its obligations as long as losses on the assets side of the balance sheet do not exceed the capital (Marcus, 1983).

Considering the risk mitigating incentive of the capital requirement, central banks around the world initiated and modified the regime of capital regulation following the Basel framework since 1988. Nevertheless, there are also counter arguments raising the concern that increased equity requirement could make the lending costlier and negatively affect the real sector performance. Thakor and Wilson (1995) argue that risk based capital regulation can promote capital rationing and constrain the credit supply resulting in the migration of growth oriented borrowers to the capital market.

The literature is divided on the role of capital requirement on financial stability. For example, Barth, Caprio and Levine (2006) state that capital regulations not necessarily exert positive impact on banking system stability. Hellmann, Murdock, and Stiglitz (2000 p. 148) write: "While it is possible to combat moral hazard with capital requirements, we find that banks must be forced to hold an inefficiently high amount of capital. It is impossible to implement any Pareto-efficient outcome using just capital requirements as the tool of prudential regulation." Helman et al recommend that deposit rate ceilings are still necessary to check banks from excessive risk taking even in the face of higher capital requirement. However, Adamti et al suggest that better capitalized banks suffer fewer distortions in lending and perform well. Diamond and Rajan (2000) argue that though the higher capital requirement reduces liquidity creation, it makes a bank able to avoid financial distress and survive more often. A debate on the impact of capital requirement on real sector also reemerged after the Bank for International Settlement pushed for a higher capital requirement in the aftermath of the financial crisis of 2008.

Given these disagreements, there is a need for further research that could more precisely investigate the effect of higher bank equity on financial stability. This paper analyzes the role of bank capital regulation in altering the behavior of the bank and borrower, which is instrumental in ensuring financial stability. The dynamic programming is used to model the behavior of borrower and bank in the presence of moral hazard, exogenous shock and monitoring effort. The remainder of this paper discusses the motivation for the bank capital channel, develops a model on the requirement for bank capital, and concludes.

II. MOTIVATION FOR THE BANK CAPITAL CHANNEL

The Modigliani-Miller theorem argues that given the perfect capital market and absence of taxes and bankruptcy costs, the capital structure of the firm does not matter in deciding the value of the firm. This idea, in banking context, suggests that a bank's lending decisions are irrelevant to its financial structure if there is a perfect capital market. When a banker does not face any difficulty in lending owing to the presence of the perfect capital market, neither the lending channel nor the capital channel are relevant for the transmission mechanism of monetary policy.[1] This capital structure irrelevance is possible only in the world of perfect competition with public information and costless contracts and negotiations. But in reality, perfect capital market does not exist.

In the real world, information is imperfect (not everyone knows what a given individual knows), behavior is opportunistic (people cannot credibly commit their future actions) and perfect competition is at best an approximation (Montiel, 2003). Asymmetric information poses challenge to perfect financial intermediation between borrowers and lenders and requires the role for specialized financial intermediaries. This information asymmetry in turn recognizes the importance of bank equity. The general understanding is that banks with sound financial health possess higher level of capital and could contribute meaningfully to the financial intermediation.

Moreover, the prudential capital requirement by the regulatory agency enforces banks to maintain a desired level of capital adequacy, which plays a catalytic role in the allocation of bank resources. In addition, the prudential capital requirement is directed at preserving the interest of small depositors who cannot monitor the behavior of banks directly due to free-rider problem on one hand and complex and opaque nature of the activities of financial intermediaries on the other.

[1] Bernanke and Blinder (1988) develop a model by modifying the IS-LM approach, which assumes convertibility of money, bonds and loans and replaces the traditional IS curve with credit and commodity (CC) curve. Their key point is that aggregate demand is affected by the availability of credit. Their seminal paper gives high importance to the credit channel of monetary policy.

The Basel Accord 1988 for the first time laid out the groundwork for prudential regulation to develop a convergence on international bank regulation. One form of prudential regulation is capital requirements (Murinde and Yaseen, 2004). Capital requirement forces banks to internalize the inefficiency of gambling or investing in high risk assets. Also this is intended to reduce gambling incentives and moral hazard by putting bank equity more at risk.

Minimum capital regulation has evolved substantially over the years, largely under the influence of the standards set internationally by the Basel Committee on Banking Supervision (Borio and Zhu, 2008). The incorporation of bank capital is motivated by two sets of considerations (Heuvel, 2009). First, it is generally agreed that bank capital is an important factor in bank asset and liability management and that its importance has likely increased since the implementation of the risk based capital requirements of the 1988 Basel Accord. The implementation of these regulations, along with other factors, has often been blamed for a perceived credit crunch immediately prior and during the 1990-91 recessions.[2] Second, the capital adequacy regulation consideration allows us to address the question what role bank lending plays in the monetary transmission in a world in which banks are increasingly able to issue nonreservable liabilities. Markov (2006) argues that the transmission of monetary policy tightening the banking sector is likely to be stronger when the level of bank capital approaches the minimum required by the regulator.

The US financial crisis of 2008 reinforced the fact that financial intermediation lies at the center of economic activities. For the smooth financial intermediation, sound health of financial intermediaries is a sine-qua-non and it is reflected in the equity of the banks. For instance, a number of US banks were asked to raise their capital due to their weak capital base and government had to intervene in the banking system to recapitalize some of these banks. The US government initially invested 245 billion dollars in US banks in the post crisis period under the Troubled Assets Relief Program-TARP (Department of Treasury, 2012).

According to the Squam Lake Report (2010), many policy makers thought that banks were not lending because they had lost too much capital.[3] Some financial economists were arguing that banks wanted to lend more but were unable to do so because they faced binding capital constraints. This binding capital constraint has become a matter of prime concern for the policy makers in the aftermath of the global financial crisis. The BIS proposed to implement BASEL III realizing that banks require higher capital adequacy in good times in order to offset the negative impact on capital in bad times. The BASEL III requires higher capital requirement for banks particularly by reassessing the requirement for core capital.

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[2] In fact, the term capital crunch has been suggested as a more apt description for the reduction in lending during this episode, in view of the role of the bank capital.

[3] The Squam Lake Report prepared by the Squam Lake Group comprising fifteen of the world's leading economists makes some important recommendations to fix the financial system in the aftermath of the recent financial crisis.

Given these discussions, the following section develops a model to examine the behavior of the bank and borrower in the face of a higher paid-up capital requirement. It is assumed that bank's behavior, in addition to the interest paid to the depositors and cost of capital, is affected by the probability of the borrower's project failure. It is therefore the cost of monitoring is also taken into account while modeling the behavior of the bank. The modeling relating to the behavior of the borrower broadly rests on the idea of moral hazard problem, which is the outcome of information asymmetry on the part of the bank.

III. MODEL

This article presents a simple model with N identical borrowers and lenders. It is assumed that banks are the lenders and firms are the borrowers. Their time horizon is infinite. Dynamic programming is used to model the behavior of borrowers and lenders in the presence of monitoring cost, possibility of borrower's project failure due to some exogenous shocks, and moral hazard problem. This is the key feature of the model presented in this article. The models developed in this reference so far directly analyze the effect of bank capital requirement on aggregate output and thus do not consider the micro factors such as moral hazard, monitoring cost and exogenous shock to the borrower's project. However, these factors are important in shaping the behavior of lenders and borrowers in the presence of capital requirement. Moreover, if these factors are not incorporated, there always remains a missing link in studying the effect of capital regulation on financial stability. Thus, the model developed in this section bridges the missing link by introducing moral hazard, monitoring costs and exogenous shock to examine the effect of bank equity on financial stability.

Modeling the Behavior of Banks

Following the standard practice in financial intermediaries, it is assumed that commercial banks' sources of financing are deposits and equity. As usual, these banks disburse loan to customers using these resources. For simplicity, banks' loan disbursement decisions are largely affected by equity requirement, which is decided by the social planner (bank regulator). The objective of the bank is to maximize profit, which is the difference between interest incomes, loan monitoring costs, interest paid to depositors, and cost of equity capital.

Both loan monitoring costs and deposit costs are expensive. Loan monitoring costs are quadratic since monitoring the behavior of borrower is costlier as the number of borrowers increases and bankers have to put additional effort to ensure the recovery of the loan in a timely manner. The deposit cost becomes expensive because of the effect of additional capital requirement. The additional capital requirement demands more resources to be mobilized and at the first sight shareholders have to supply additional capital by withdrawing their deposits. This is because other forms of financing are not readily available compared to deposits. This portfolio shift makes deposits costlier. Another reason is that dividend per share declines once the volume of equity goes up in the face of additional capital requirement. This situation forces banks to raise additional deposit for the purpose of mobilizing additional lending, which could help the bank to earn extra profit and make up the dividend shortfall. This demand for deposit also raises the deposit cost. Finally, additional capital requirement put forth by the regulator could signal that there are some structural problems in the banking industry and induce depositors to ask for higher return on their deposit.

Banks' profit is discounted over the time horizon not only by the interest rate but also by the probability that the borrower will default. The capital growth rate of a bank, which decides the amount of loan disbursement overtime, is affected by the additional equity financing and retained earnings. Also following the customary practice of banks, it is assumed that any loan collected is used for further loan disbursement. A representative commercial bank's balance sheet at the beginning of the period t is given below. The bank typically holds loans and securities on the assets side and deposits and share capital on the liabilities side. For simplicity, we assume that a bank's securities investment is negligible.

Balance Sheet of a Bank

Assets		**Liabilities**	
Loans	L(t)	Deposits	D(t)
Securities	S(t)	Capital	K(t)
Total Assets	A(t)	Total Liabilities	L(t)

Now formulate the problem of a profit maximizing bank. The bank's choice variable is loan and state variable is capital.

The objective function of a bank is:

$$\Pi = \underset{L}{Max} \int_0^{\infty} e^{-(\rho+\gamma)t} \{[rL(t) - \frac{q}{2}L^2(t) - \frac{b(1-K(t))^2}{2} - eK(t)]\}dt$$

$$s.t. \;\; \dot{K}(t) = \alpha K(t) - \delta L(t)$$

$L \geq 0$

$K \geq 0$

$b \geq 0$

$e \geq 0$

$K(0) = K0$

The terminal value assuming that optimal value for state variable (K) can be chosen optimally all the times is $\lim_{t\to\infty} \mu(t)K(t) = 0$

Where,

r = Rate of interest on loan
L = Loans granted by banks
b = Interest rate provided to depositors
K = Capital investment of owners (owners' equity)
e = Cost of capital
1-K = Portion of the deposit in the balance sheet
q = Monitoring effort per dollar of loan
γ = Possibility that the borrower's project fails
ρ = Discount factor
δ = Rate of loan loss
δL = Amount of loan loss
α = Rate of capital addition
αK = Addition to the capital stock either through the share issue or through the retained earnings
μ = Costate variable

Solve the maximization problem using the current value Hamiltonian.

$$\breve{H} = \left\{\left[\{[rL(t) - \frac{q}{2}L^2(t) - \frac{b(1-K(t))^2}{2} - eK(t)]\}\right]\right\} + \mu(\alpha K - \delta L)$$

The first order conditions with respect to control variable, state variable and costate variable using the maximum principle are:

$$\frac{\partial \breve{H}}{\partial L} = r - qL - \mu\delta = 0 \quad \text{.......... (1)}$$

$$\dot{K} = \frac{\partial \breve{H}}{\partial \mu} = \alpha K - \delta L \quad \text{.......... (2)}$$

$$\dot{\mu} = (\rho + \gamma)\mu - \frac{\partial \breve{H}}{\partial K} = (\rho + \gamma)\mu - [(b(1 - K) - e) + \mu\alpha\,] \quad \text{.......... (3)}$$

Check for *Magnasarian Sufficiency Condition (MSC).*

$H_{LL} = -q < 0, H_{LK} = 0, H_{KK} = -b < 0, and\ H_{KL} = 0$

This implies that Hessian is positive and MSC satisfies. We could also check for the arrow sufficiency condition (ASC), which requires concavity in state variable. To check for the ASC, we plug the value for L in current value Hamiltonian from (1) and find $L = \frac{(r-\mu\delta)}{q}$

$$M = \left\{\left[\{[r\frac{(r-\mu\delta)}{q} - \frac{q}{2}(r-\mu\delta/q)^2 - \frac{b\left(1-K(t)\right)^2}{2} - eK(t)]\}\right]\right\} + \mu(\alpha K\text{-}\delta\frac{(r-\mu\delta)}{q})$$

$M_K = (bK + e + \mu\alpha - b) > 0$ and M_{KK} =-b<0

This shows that ASC satisfies.

Now we need to transform the system of three differential equations into two. For this, we get the value for costate variable $\mu = \frac{(r-qL)}{\delta}$ to plug into (3).

After substituting $\mu = \frac{(r-qL)}{\delta}$, equation (3) becomes:

$$\dot{\mu} = (\rho+\gamma)\mu - \frac{\partial \check{H}}{\partial K} = \{(\rho+\lambda)\frac{(r-qL)}{\delta} - \left[(b(1-K)-e) + \frac{(r-qL)}{\delta}\alpha\right]\} \qquad \text{.......... (4)}$$

Time differentiating (1) gives us $\dot{\mu} = -\frac{q\dot{L}}{\delta}$ and substituting this into (4) gives:

$$\dot{L} == \{\left[(b(1-K)-e) + \frac{(r-qL)}{\delta}\alpha\right] - (\rho+\gamma)\frac{(r-qL)}{\delta}\}\frac{\delta}{q} \qquad \text{.......... (5)}$$

Now we have two systems of equations to solve, $\dot{K}$ and $\dot{L}$.

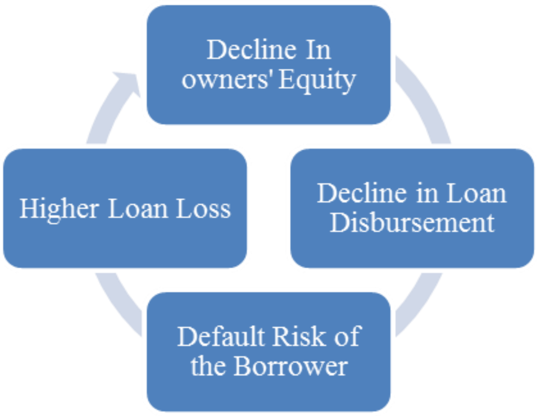
Since we are interested in the relationship between equity capital and loan loss, we develop the following propositions.

Proposition 1: An increase in loan loss of the bank results into a decline in owners' equity and constrains the lending capacity of the bank. The bad loan also reduces the amount of loan disbursement. Mathematically $\frac{\partial K}{\partial \delta} < 0$ and also $\frac{\partial L}{\partial \delta} < 0$. See appendix (I) for $\frac{\partial K}{\partial \delta} = \frac{-\{\delta[\frac{b(1-K)-e}{q}] - L(\rho+\gamma-\alpha)\}}{\alpha(\rho+\gamma-\alpha)-(\delta\frac{b\delta}{q})} < 0$ and $\frac{\partial L}{\partial \delta} = \frac{-\{\alpha[\frac{b(1-K)-e}{q}] - L\frac{b\delta}{q}\}}{\alpha(\rho+\gamma-\alpha)-(\delta\frac{b\delta}{q})} < 0$

There is a negative relationship between loan loss and owners' equity of a bank, which also constrains its lending capacity. Constrained capacity of the bank makes it unable to extend loan not only for new projects but also the existing ones are induced in a vicious cycle of bad loans. The intuition is that if a bank stops financing prior to the completion of a project, the borrower is forced to abort the project and fails to repay the debt, which increases loan loss and lowers net income of the bank subsequently lowering the owners' equity. To make it more understandable, a typical income statement is presented below:

Total Income	XXX
Less: Total Expenses	XXX
Income Before Loan Loss	**XXX**
Less: Loan Loss	XXX
Income After Loan Loss	**XXX**

In the Balance Sheet, income after loan loss adds to owners' equity. If the amount of income after loan loss is smaller than the amount of income before loan loss, there will be a positive growth in the amount of loan. And if such amount is negative, the loan stock should come down to commensurate with the standard balance sheet identity, which is: Owners' Equity+ Deposits= Loan +Securities. This relationship between loan loss and owners' equity establishes the fact that higher loan loss lowers equity and this lowers the loan growth. The lower loan growth could further induce higher loan loss given the repercussion that if a bank does not meet the financing requirement of an ongoing project, the project may discontinue operation and there should be a default risk. This may continue a vicious cycle of bad loan causing an erosion of the owners' equity in the banking business.



Proposition 2: An increase in equity financing (K) requirement induces higher monitoring effort (q). Mathematically $\frac{\partial q}{\partial K}$ >0. See appendix (II) for

$$\frac{\partial q}{\partial K} = \frac{b\delta q}{\delta[bK + e - b] + (\rho + \gamma)r - r\alpha} > 0$$

The underlying idea is that when capital requirement increases, it increases the monitoring effort as well. Higher monitoring is supportive in lowering the bad loan. Intuitively raising capital is costlier. It requires long term commitment on the part of investors. It is riskier compared to bonds and deposits. So people who are relatively risk lover go for investing in bank equity. Also generally the shareholders are the ones paid at the end of the liquidation if the firm goes into bankruptcy. These reasons should make the capital owner to take extra precaution and exert pressure on bank management to increase the monitoring effort. Thus the higher equity requirement should lower the loan loss of banks and contribute to preserve the financial stability.

Modeling the Behavior of Borrowers

It is assumed that because of the information asymmetry, borrowers enjoy borrowing from the bank and also experience moral hazard problem.[4] Once a borrower experiences moral hazard, it invites higher loan loss on the balance sheet of a bank. Borrowers are risk neutral. There are three states of the borrower:

i) Remain financed from the bank and have no moral hazard,
ii) Remain financed from the bank and have moral hazard, and
iii) No financing from the bank, loose the entrepreneurship and enter the job market.

Given these three states, there are three choices with a borrower:

i) Have no moral hazard owing to the solvency and reputational factor. This helps to continue the enterprise and remain financed for profit (Π=Y-i-m) until the enterprise fails due to some exogenous shocks.

ii) If moral hazard, there is the possibility of being caught (q) by the bank monitor. If bank finds the borrower deviating from commitment, stop financing and seize the collateral.

iii) If loses the entrepreneurship, the borrower enters the pool of the worker and gets the minimum wage (w).

In the model, no financing is the borrower disciplining device and the opportunity to remain as a worker even if the entrepreneurship is lost is the incentive for having moral hazard. The probability that the borrower will remain financed (entrepreneur) for time t is $P_1 = e^{-\lambda t}$, where λ>0 is the probability that the enterprise failure does not occur due to some exogenous factors. The expected length of a possible entrepreneur remaining unfinanced depends on the loan acquisition rate. If there are many possible clients in the borrowing pool, the loan acquisition rate will be smaller.

The possibility that a borrower deviates from pre-commitment mechanism and is caught by the bank monitor is q. The probability that a deviated borrower is still financed by the bank and remains entrepreneur for time t is $P_2 = e^{-qt}$. The borrower maximizes the expected

[4] Assumptions made here regarding a representative borrower are largely similar to the ideas, which Shapiro and Stiglitz (1984) presented in their efficiency wage model with respect to a worker.

present value of utility from profit with discount rate r, which is $U = E\int_{t=0}^{\infty} e^{-rt}\, u[Y(t), i(t), m(t)]dt$. Further, $[Y(t), i(t), m(t)]$ is Y(t) – i(t) –m(t) if the borrower gets loan and 0 if doesn't get loan. Where, Y(t) is the before interest income of the entrepreneur, i(t) is the interest payment on loan borrowed from the bank, and m(t) is the managerial effort to make committed project successful.

Now denote value for each state of the borrower:

$V_F^N = Expected\ value\ of\ a\ borrower\ with\ no\ moral\ hazard\ problem.$

$V_F^M = Expected\ value\ of\ a\ borrower\ with\ moral\ hazard\ problem.$

V_W= Expected Value of a borrower who lost entrepreneurship due to lending cut-off.

Value for a borrower having no moral hazard

The borrower having no moral hazard problem has the following value at time t:

$$V_F^N = \int_0^{\infty} \{ e^{-(\lambda+r)t} (Y - m - i) + e^{-rt}[(1 - e^{-\lambda t})V_W]\}dt$$

Where, V_F stands for the value of the borrower financed, V_F^N stands for the value of the borrower financed and having no moral hazard. Similarly, e^{-rt} is the discount factor, $e^{-\lambda t}$ is the probability that borrower remains entrepreneur, $1 - e^{-\lambda t}$ is the probability of losing entrepreneurship and V_W is the value (wage earning) of the borrower if he loses entrepreneurship. After integration (appendix II), we obtain following value for the borrower having no moral hazard:

$$V_F^N = \frac{(Y - i - m)r + V_W\lambda}{(\lambda + r)r}$$

Value for a borrower having moral hazard

$$V_F^M = \int_0^{\infty} \{ e^{-(\lambda+r+q)t} (Y - i) + e^{-rt}[(1 - e^{-(\lambda+q)t})V_W]\}dt$$

Where, V_F stands for the value of the borrower financed, V_F^M stands for the value of the borrower financed and having no moral hazard. Similar to the previous case e^{-rt} is the discount factor, $e^{-(\lambda+q)t}$ is the probability that borrower remains entrepreneur even if he has the moral hazard problem and there is no exogenous shock, $1 - e^{-(\lambda+q)t}$ is the probability of loosing entrepreneurship due to mortal hazard and some erogenous shock and V_W is the value (wage earning) of the borrower if he loses entrepreneurship and enters the job market. After integration (appendix II), we obtain following value for a borrower having moral hazard:

$$V_F^M = \frac{(Y-i)r + V_W(q+\lambda)}{(r+q+\lambda)r}$$

Condition for having no Moral Hazard

The moral hazard avoiding condition is that the value of the borrower having no moral hazard should be higher than the value of the borrower having moral hazard. Mathematically,

$V_F^N = \frac{(Y-i-m)r+V_W\lambda}{(\lambda+r)r} > V_F^M = \frac{(Y-i)r+V_W(q+\lambda)}{(r+q+\lambda)r}$ should hold. However, for this to hold there should be enough monitoring effort by the bank. This should check the moral hazard problem of the borrower.

Proposition 3: Given enough monitoring effort, the V_F^N could still be bigger than V_F^M even if the loan interest rate is higher on account of the increased capital requirement.

The monitoring effort of the bank should go up to offset the possibility of moral hazard due to a higher interest. The higher capital requirement could increase the interest rate (see appendix I). If the interest rate is above the optimal rate, it induces moral hazard and the borrower could shirk from the commitment. This delinquency on the part of the borrower should contribute to the accumulation of higher loan loss in the balance sheet of a bank. Intuitively the bank increases the monitoring effort after the increase in capital requirement since it involves a higher stake of the owners in the business. This higher monitoring should help to lower the moral hazard.

IV. CONCLUSION

This article has developed a theoretical model suggesting that bank capital requirement plays a positive role in promoting financial stability by altering the behavior of the bank and borrower. The model formulated by using dynamic programming analyzes the behavior of borrowers and banks. The analysis takes into account some of the important determinants of smooth financial intermediation such as monitoring cost, possibility of borrower's project failure due to some exogenous shocks, and moral hazard problem.

The models so far developed regarding the bank capital channel of monetary policy transmission mechanism directly analyze the effect of bank capital requirement on aggregate output and have not accounted for the micro factors such as moral hazard, monitoring cost and exogenous shocks to the borrower's project. The major contribution of this paper is to consider all these factors together in examining the role of the equity capital in promoting financial stability. The article discusses that micro factors such as moral hazard, monitoring cost and exogenous shocks are the building blocks in determining the behavior of lenders and borrowers in the presence of capital requirement. The propositions developed in this article support that an increase in loan loss of the bank results into a decline in owners' equity and constrains the lending capacity of the bank, which further reduces the amount of loan disbursement. However, a higher equity requirement induces the investors of the bank to increase monitoring and improve the quality of loan.

Further, the model suggests that borrowers enjoy borrowing from the bank and experience moral hazard due to information asymmetry. If a borrower of the bank experiences moral hazard, it invites a higher loan loss in the balance sheet of a bank. The analysis assumes that borrowers are risk neutral in their clientele relationship with the bank in three states, which are: remain financed from the bank and have no moral hazard, remain financed from the bank and have moral hazard, and no financing from the bank, loose the entrepreneurship and enter the job market. The analysis shows that even if there is moral hazard problem on the part of the borrower, the increased bank monitoring induced by a higher capital requirement helps to lower the bad loan. This is the key channel through which higher capital requirement increases financial stability.

The analysis in this paper has an important policy implication. A regulatory caveat is that capital distressed banks have a higher chance of failure due to the vicious cycle of bad loans. A bank having limited maneuver in equity management may not be able to thwart the pressure of loan loss strains in the times of adverse economic situations. In particular, these situations are the source of disruptions in smoothly operating the projects of borrowers whose failure directly affects the balance sheet of a bank. A capital stressed bank fails to extend the loan in the times of business cycle downturn, which purports the failure of a running project. Continuation of this cycle might invite systemic risk, which ultimately challenges the stability of the system as a whole.

Another issue which the paper brings into analysis and bears policy significance is that a borrower's behavior is prone to moral hazard, which requires bank monitoring. And a higher equity requirement exerts monitoring pressure on investors. In the end, this mechanism works as a disciplining device in the financial system. This paper has simply provided a theoretical basis in modeling the behavior of banks and borrowers in the presence of a higher equity requirement. Further extension of this paper requires an empirical assessment. This could be done either with some time series data or in the context of experimental economics.

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Appendix I

Solve the maximization problem using the current value Hamiltonian.

$$\breve{H} = \left\{\left[\{[rL(t) - \frac{q}{2}L^2(t) - \frac{b(1-K(t))^2}{2} - eK(t)]\}\right]\right\} + \mu(\alpha K\text{-}\delta L)$$

The first order conditions with respect to control variable, state variable and costate variable using the maximum principle are:

$$\frac{\partial \breve{H}}{\partial L} = r - qL - \mu\delta = 0 \quad \text{.......... (1)}$$

$$\dot{K} = \frac{\partial \breve{H}}{\partial \mu} = \alpha K - \delta L \quad \text{.......... (2)}$$

$$\dot{\mu} = (r+\gamma)\mu - \frac{\partial \breve{H}}{\partial K} = (\rho+\gamma)\mu - [(b(1-K) - e) + \mu\alpha] \quad \text{.......... (3)}$$

$$\dot{\mu} = (\rho+\gamma)\mu - \frac{\partial \breve{H}}{\partial K} = \{(\rho+\gamma)\frac{(r-qL)}{\delta} - \left[(b(1-K) - e) + \frac{(r-qL)}{\delta}\alpha\right]\} \quad \text{...... (4)}$$

Time differentiating (1) gives us $\dot{\mu} = -\frac{q\dot{L}}{\delta}$ and substituting this into (4) gives:

$$\dot{L} == \{\left[(b(1-K) - e) + \frac{(r-qL)}{\delta}\alpha\right] - (\rho+\gamma)\frac{(r-qL)}{\delta}\}\frac{\delta}{q} \quad \text{.......... (5)}$$

Now we have two systems of equations to solve, $\dot{K}$ and $\dot{L}$. Derive steady state comparative statistics using $\dot{K}$ and $\dot{L}$. In the steady state $\dot{K} = 0$ and $\dot{L} = 0$. Use implicit function theorem (IFT) to calculate comparative statistics.

When both $\dot{K} = 0$ and $\dot{L} = 0$ are observed in steady state,

$$F^1 = \alpha K - \delta L \quad \text{.......... (6)}$$

$$F^2 = \{\left[(b(1-K) - e) + \frac{(r-qL)}{\delta}\alpha\right] - (\rho+\gamma)\frac{(r-qL)}{\delta}\}\frac{\delta}{q} \quad \text{.......... (7)}$$

We are interested in mathematically explaining the relationship between loan loss (δ) and equity capital (K)

$$\begin{bmatrix} \frac{\partial F^1}{\partial K} & \frac{\partial F^1}{\partial L} \\ \frac{\partial F^2}{\partial K} & \frac{\partial F^2}{\partial L} \end{bmatrix} \begin{bmatrix} \frac{\partial K}{\partial \delta} \\ \frac{\partial L}{\partial \delta} \end{bmatrix} = -\begin{bmatrix} \frac{\partial F^1}{\partial \delta} \\ \frac{\partial F^2}{\partial \delta} \end{bmatrix}$$

$$\begin{bmatrix} \alpha & -\delta \\ -\frac{b\delta}{q} & (\rho+\gamma-\alpha) \end{bmatrix} \begin{bmatrix} \frac{\partial K}{\partial \delta} \\ \frac{\partial L}{\partial \delta} \end{bmatrix} = -\begin{bmatrix} -L \\ \frac{\{b(1-K)-e\}}{q} \end{bmatrix}$$

$$\frac{\partial K}{\partial \delta} = \frac{\begin{bmatrix} L & -\delta \\ -\frac{b(1-K)-e\}}{q} & (\rho+\gamma-\alpha) \end{bmatrix}}{\begin{bmatrix} \alpha & -\delta \\ -\frac{b\delta}{q} & (\rho+\gamma-\alpha) \end{bmatrix}}$$

$$\frac{\partial K}{\partial \delta} = \frac{-\{\delta[\frac{b(1-K)-e}{q}]-L(\rho+\gamma-\alpha)\}}{\alpha(\rho+\gamma-\alpha)-(\delta\frac{b\delta}{q})} < 0$$

Though the numerator is positive given the positive value of K and L exceeding all other terms, the denominator is negative since α^2 enters negatively exceeding all other values and in normal times α should be bigger than $\rho+\gamma$.

Similarly, $\frac{\partial L}{\partial \delta} = \frac{\begin{bmatrix} \alpha & L \\ -\frac{b\delta}{q} & -\frac{b(1-K)-e\}}{q} \end{bmatrix}}{\begin{bmatrix} \alpha & -\delta \\ -\frac{b\delta}{q} & (\rho+\gamma-\alpha) \end{bmatrix}}$

$$\frac{\partial L}{\partial \delta} = \frac{-\{\alpha[\frac{b(1-K)-e}{q}]-L\frac{b\delta}{q}\}}{\alpha(\rho+\gamma-\alpha)-(\delta\frac{b\delta}{q})} < 0$$

With the similar logic as in $\frac{\partial K}{\partial \delta}$, we find that there is a negative relationship between loan loss and loan disbursement.

Use (7) to find $\frac{\partial q}{\partial K}$

$$\frac{\partial q}{\partial K} = -\frac{\frac{\partial F^2}{\partial K}}{\frac{\partial F^2}{\partial q}}$$

$$\frac{\partial F^2}{\partial K} = -\frac{b\delta}{q}$$

$$\frac{\partial F^2}{\partial q} = \frac{\delta[bK+e-b]+(\rho+\gamma)r-r\alpha}{q^2}$$

$$\frac{\partial q}{\partial K} = \frac{b\delta q}{\delta[bK+e-b]+(\rho+\gamma)r-r\alpha} > 0$$

Also use (7) to find $\frac{\partial r}{\partial K}$

$$\frac{\partial r}{\partial K} = -\frac{\frac{\partial F^2}{\partial K}}{\frac{\partial F^2}{\partial r}}$$

$$\frac{\partial F^2}{\partial K} = -\frac{b\delta}{q}$$

$$\frac{\partial F^2}{\partial r} = \frac{\alpha - (\rho + \gamma)}{q}$$

$$\frac{\partial r}{\partial K} = \frac{b\delta}{(\alpha - \rho - \gamma)} > 0$$

Appendix II

Value for a borrower having no moral hazard

$$V_F^N = \int_0^\infty \{ e^{-(\lambda+r)t}(Y-m-i) + e^{-rt}[(1-e^{-\lambda t})V_W]\}dt$$

$$V_F^N = \lim_{t\to\infty}[\{-\frac{e^{-(\lambda+r)t}}{(\lambda+r)}(Y-m-i)\}_0^\infty - \{\frac{e^{-rt}}{r}V_W\}_0^\infty + \{\frac{e^{-(\lambda+r)t}}{(\lambda+r)}V_W\}_0^\infty]$$

$$V_F^N = \lim_{t\to\infty}[\{-\frac{e^{-(\lambda+r)t}}{(\lambda+r)}(Y-m-i) + \frac{e^{-(\lambda+r)t}}{(\lambda+r)}(Y-m-i)\}$$
$$-\{\frac{e^{-rt}}{r}V_W + \frac{e^{-rt}}{r}V_W\} + \{\frac{e^{-(\lambda+r)t}}{(\lambda+r)}V_W - \frac{e^{-(\lambda+r)t}}{(\lambda+r)}V_W\}]$$

$$V_F^N = [\{-\frac{e^{-(\lambda+r)\infty}}{(\lambda+r)}(Y-m-i) + \frac{e^{-(\lambda+r)o}}{(\lambda+r)}(Y-m-i)\}$$
$$-\{\frac{e^{-r\infty}}{r}V_W + \frac{e^{-ro}}{r}V_W\} + \{\frac{e^{-(\lambda+r)\infty}}{(\lambda+r)}V_W - \frac{e^{-(\lambda+r)o}}{(\lambda+r)}V_W\}]$$

$$V_F^N = [\frac{1}{(\lambda+r)}(Y-m-i) - \frac{1}{r}V_W - \frac{1}{(\lambda+r)}V_W]$$

$$V_F^N = \frac{(Y-i-m)r + V_W\lambda}{(\lambda+r)r}$$

Value for a borrower having moral hazard

$$V_F^M = \int_0^\infty \{ e^{-(\lambda+r+q)t}(Y-i) + e^{-rt}[(1-e^{-(\lambda+q)t})V_W]\}dt$$

$$V_F^N = \lim_{t\to\infty}[\{-\frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}(Y-i)\}_0^\infty - \{\frac{e^{-rt}}{r}V_W\}_0^\infty + \{\frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}V_W\}_0^\infty]$$

$$V_F^N = \lim_{t\to\infty}[\{-\frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}(Y-i) + \frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}(Y-i)\}$$
$$-\{\frac{e^{-rt}}{r}V_W + \frac{e^{-rt}}{r}V_W\} + \{\frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}V_W - \frac{e^{-(\lambda+q+r)t}}{(\lambda+q+r)}V_W\}]$$

$$V_F^N = [\{-\frac{e^{-(\lambda+q+r)\infty}}{(\lambda+q+r)}(Y-i) + \frac{e^{-(\lambda+q+r)o}}{(\lambda+q+r)}(Y-i)\} - \{\frac{e^{-r\infty}}{r}V_W + \frac{e^{-ro}}{r}V_W\} + \{\frac{e^{-(\lambda+q+r)\infty}}{(\lambda+q+r)}V_W$$
$$-\frac{e^{-(\lambda+q+r)o}}{(\lambda+q+r)}V_W\}]$$

$$V_F^N = [\frac{1}{(\lambda+q+r)}(Y-i) - \frac{1}{r}V_W - \frac{1}{(\lambda+q+r)}V_W]$$

$$V_F^M = \frac{(Y-i)r + V_W(q+\lambda)}{(r+q+\lambda)r}$$