THEORY OF BANK LENDING WITH MONITORING AND APPLICATION TO RURAL BANKING IN INDIA 2002-2003

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Abstract

We present a model in Costly State Verification framework that relates capital raised in a firm to profitability. We explain how optimality of investment is affected by how the aggregate funding affects the expected outcomes of the project. Although we find underinvestment, the problem does not get severe with increasing dead weight costs.

JEL Classification: G000, G290, G380
Key words: Strategic default; Underinvestment; CSV.

1. Introduction

A common feature underlying the emerging markets is the reforms governing the banks and the other financial intermediaries. E.g., in India, regulations governing the banking sector require banks and other financial institutions to operate in a more competitive framework. These regulations were carried out broadly, in two phases. It started with the *Debt Recovery Tribunal*, set up in 1993. An important question to be asked is whether emerging economies exhibit more risk taking. The answer to this question lies in finding out the likely departure from optimal investment. In other words, are emerging markets characterized by underinvestment or overinvestment.

We model a simple firm - bank relationship in a costly state verification framework (Moore 1993). Yafeh and Yosha (1996) find empirical support to the above. In these models, the lenders monitor the firm in `bad states'. Monitoring in our model is equivalent to a commitment by the lenders (the banks) to verify or audit the

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realization reported by the borrower. The lender audits the firm to prevent the later to undertake *strategic default* (Bolton and Scharfstein,1995). The basic structure of our model is as follows: The firm has a project with uncertain returns. The funds raised to undertake the project affects the probability of success. This is the main difference in our model with the other papers in the literature. In most papers, investments made by the different agents do not affect the incentives for each other to invest. However, in our model, we find that the investment by the bank and the firm, is interdependent. The total capital raised by the firm affects the probability of success. Higher is the investment made, higher is the probability that the project succeeds.

Occurrence of underinvestment with costly monitoring is common in the literature- Gale and Hellwig (1985), Mukherji and Nagarajan (1995), Biais and Casamatta (1999). In these papers, CSV framework leads to underinvestment with the standard debt contract. The reason being, with costly monitoring to encounter the moral hazard problems, the cost per unit of lending increases. Thus, credit rationing occurs, thereby reducing the aggregate investment in the project. The frameworks mentioned above differ slightly with each other. However, we obtain that costly monitoring may lead to both underinvestment as well as overinvestment. This is because, investment by the bank and the firm complement each other. In a recent paper, Mukhopadhyay (2002) reports overinvestment in a framework similar to ours. Our results relating to the capital structure problem confirms some of the existing empirical findings. A significant work has already been done explaining optimal and/or observed leverage ratios across economies.[1] Borio (1990) compares the capital structure of the G-7 countries and conclude that companies in Japan and Continental Europe are more highly levered than the Anglo-American companies. The reason behind this, he attributes, is the financial structure and systems prevailing in these countries. Similar findings are reported in Berglof (1990). The reasons again are, the financial systems prevailing in these countries.

[1] See Harris and Raviv (1991) for a literature overview on the subject.

He asserts that while financing in countries like Japan, Germany, France and Italy are `bank oriented', in USA, UK and Canada, financing is more `market oriented'. Demigurc and Levine (1996) compare the debt equity ratios across various developing and developed nations. They conclude that the more developed the stock markets, higher are the debt equity ratios. This, is despite of the fact that an improved stock market induces a firm to have more equity. They conclude, that `Firms in countries with underdeveloped stock markets first increase their debt equity ratios as their stock markets develop and subsequently lower it.' Our model corroborates the above findings.

In section 2 we propose the basic model In section 3, the equilibrium is calculated. Section 4 presents the optimality results while section 5 concludes the paper.

2. The Model

We consider a simple environment where the economy consists of only two sets of agents, an entrepreneur/ firm F and a bank B.[2] The firm owns a project that requires input today to produce output of v tomorrow. The input, X denotes the aggregate investment in the project provided by the bank and the firm. The project realization is $v = \{0, V\}$, where $0 < V < \infty$.

Capital is raised either through debt, equity or any combination of both. It is not mandatory for the firm to seek outside finance as we do not assume any funds constraint for the firm. The total investment in the project can be viewed as the fund required to purchase machinery, technology, improved human resources etc. This means that better the quality of these resources, acquired by more investments, higher is the probability that the project succeeds.

Denote X_B and X_F as the investments by the bank and the firm respectively with $X_B, X_F \geq 0$. Therefore, $X = X_B + X_F$. The

[2] The framework is similar to Mukhopadhyay (2002).

costs of raising these funds are $r(X_B) = r.X_B$ for the bank and $q(X_F) = q.X_F$ for the firm. We shall assume the following about the costs,

A.1: $q > r > 0$. The costs of raising funds for both the parties are assumed to be linear functions. Further, it is assumed that the bank can raise funds at a lower cost than the firm. This assumption is not unreasonable, given that the bank can raise funds at a low cost because of its depositors. We denote p as the probability of V occurring.[3] Let $p(X)$ be the probability of success. We assume the following about $p(X)$.

A.2: $p(X) = 1 - e^{-X}$. Therefore, the probability of success is, increasing and concave in X. The entrepreneur can finance the project in any of the following three ways. Firstly, she can finance the project entirely through equity, implying $X = X_F$. The project is successful with a probability of $p(X_F)$. In this case, the firm retains the entire cash flow. The second mode of financing is entirely by debt financing. The firm can finance the project by borrowing an amount X_B from the bank without contributing any amount herself. The bank will lend $X = X_B$ in return for a return (claim) of R from the project. The firm retains the residual $V - R$ amount. Finally, the firm may contribute X_F as equity while borrowing X_B from the bank. In this case, the project succeeds with a probability of $p(X_B + X_F)$.

There are three stages. In the first stage, the firm decides whether or not to borrow from the bank. In case, she decides not to borrow, the project is entirely equity financed. If she decides to borrow, she decides the face value of debt. In the second stage, if the firm borrows from the bank, the investment decisions by the firm and the

[3] Therefore, we shall often refer to p as the probability of success.

bank is taken. In the final stage, the actual realization takes place and the project cash flows are distributed among the firm and the bank, with debt having senior claims over equity.

Denote P_0 as the maximum profit to the firm when she does not seek outside financing. The total investment in the project in this case is denoted by X_0. Note from assumptions A.1 and A.2, $X_0 = ln\frac{V}{q}$, where ln denotes the natural logarithm. Thus,

$$P_0 = V - q - q.ln\frac{V}{q} \ldots\ldots \qquad \ldots\ldots \qquad (1)$$

An important feature of our model is that, in order to undertake the project, external funding is not compulsory. The firm will borrow from the bank only if it is more profitable than funding the project alone.

3. Equilibrium

We now consider debt financing. The bank incurs two kinds of costs. Apart from the capital cost, the bank also incurs an auditing cost. As in Moore (1993), Mukhopadhyay (2002) and others, the lenders have to incur a fixed auditing cost, q, whenever the firm defaults on her debt repayments. By incurring this cost, the lenders can observe the actual realization of the project. We implicitly assume two things. One, the auditing technology is perfect, i.e., once this cost is incurred, the lending institution knows the true realization accurately and two, the banks monitor whenever the firm defaults.[4] In the event that the firm does not default, the lenders do not audit.[5]

[4] These two assumptions together rules out *strategic defaults* as in Bolton and Scharfstein (1995). Strategic default occurs when the money available to the debtor is sufficient to pay the creditors, but is not paid.

[5] One can alternately, model the auditing choice of the bank as a stochastic variable. Modeling stochastic auditing does not alter our results.

Denote P_B, P_F as the expected profits to the bank and the firm respectively, when both parties invest in the project.

$$P_B = p(X_B + X_F).R - [1 - p(X_B + X_F)]q - r.X_B \quad (2)$$
$$P_F = p(X_B + X_F).(V - R) - q.X_F \quad (3)$$

With a probability of $p(X)$ the project succeeds and the bank gets R. With a probability of $1 - p(X)$ the project returns are zero. In order to prevent strategic default, the bank has to incur q whenever $v = 0$.

We solve stage II first where, given the choice of R by the firm, the bank and the firm chooses X_B^* and X_F^* respectively. Finally, we solve for R^* given the optimal values of X_B^* and X_F^*. The bank operates in a competitive scenario. In other words, they earn zero supernormal profits. Therefore, X_B^* satisfies,

$$p(X_B^* + X_F^*).R - [1 - p(X_B^* + X_F^*)]q - r.X_B^* = 0 \quad (4)$$

The firm chooses X_F^* to maximize profits. Therefore,

$$p'(X_B^* + X_F^*)(V - R) = q. \quad (5)$$

The explicit solutions are,

$$X_B^* = \frac{1}{r}\left[R - q\left(\frac{R+q}{V-R}\right)\right]; \; X^* = ln\left(\frac{V-R}{q}\right);$$
$$X_F^* = ln\left(\frac{V-R}{q}\right) - \frac{1}{r}\left[R - q\left(\frac{R+q}{V-R}\right)\right] \quad (6)$$

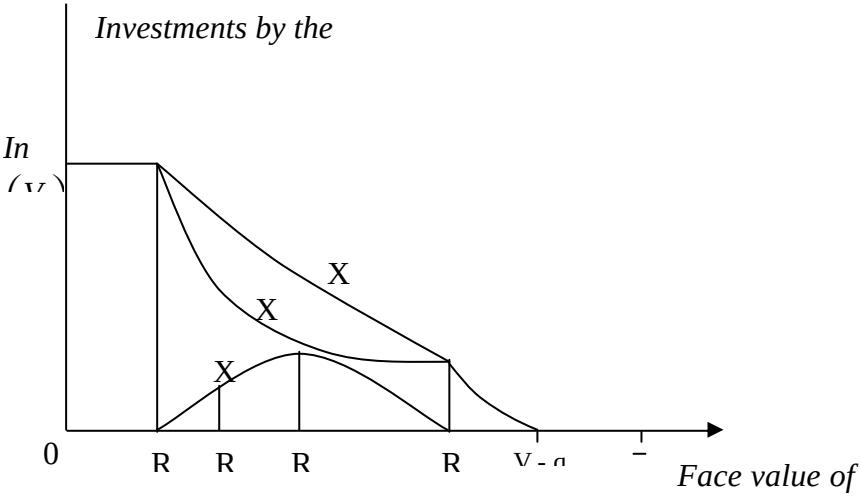
Finally, we solve stage I, where the firm chooses R^*. Denote, denote,[6]

$$R_1 \equiv \frac{V-q}{2}\left[1-\sqrt{1-\frac{4qq}{V-q}}\right], \qquad R_2 \equiv \frac{V-q}{2}\left[1+\sqrt{1-\frac{4qq}{V-q}}\right].$$

Therefore,

$$R^* = \begin{cases} V-\left(\frac{q}{2(q-r)}\right)\left\{\sqrt{\left(r^2+4(V+q)(q-r)\right)}-r\right\} & if\ R^* \in [R_1, R_2] \\ 0 & if R^* \notin [R_1, R_2] \end{cases}$$

Figure 1



[6] The expressions for R_1, R_2 is obtained by solving for R by setting $X_B^* = 0.\$I\_B = 0$ by $I_B = 0.$. Note that, if X_B^* is not positive, then the firm will not borrow from the bank.

Figure 1 plots the investment levels of the bank and the firm against the debt claims. The bank invests positive amounts in the project if and only if the debt is both bounded from below and above. The lending function of the bank is concave. The investment by the bank is highest when, $R = R^{max} = V - \sqrt{(q(V+q)}$. While it is easy to appreciate why investment by the bank, initially increases with a rise in R, the reason for its fall as R increases beyond R^{max} is not obvious. As R increases, the investment by the firm reduces. This is because, higher face value of debt reduces the residual claims of the firm.

Note, from equation (6), the aggregate investment in the project reduces as R increases. The lower aggregate investment makes the project riskier. The bank responds to this by lowering its investment.The negative relationship between the debt claims and the bank's investment is similar to the *credit rationing* results obtained in Gale and Hellwig (1985). However, the driving force behind those results were the role of monitoring costs. These costs, being dead weight in nature reduces the lenders investment. Credit rationing in our model occurs because, lower equity financing makes the project riskier. The second interesting observation pertains to the relationship between the auditing cost and the face value of debt. We observe that an increase in q decreases R^*. This happens because, *ceteris paribus*, higher auditing costs imply that the bank lower its investment. Therefore, the firm reduces *R**.

Result 1: *In equilibrium,* $R^* \leq R^{max}$.

Proof: From the expressions of R^*, R^{max} note that at $r = 0, R^* = R^{max}$. Now consider, the expression for R^*. It is straight forward to show that R^* is decreasing in r. This follows from the fact that while $\left\{\sqrt{\left(r^2 + 4(V+q)(q-r)\right)} - r\right\}$ is increasing in r, $q - r$ is decreasing in r. This completes the proof.

The above result throws up an interesting observation. With both parties being risk neutral, and with the firm having higher cost of capital than the bank, it appears that the firm should squeeze maximum investment from the bank. However, the above result indicates that the firm typically settles for a lower investment from the bank than that it could have got. This is because, lower debt increases the residual claim of the firm. The next result relates the debt level to aggregate investment in the project.

Result 2: *Ceteris paribus, the bank's investment, increases if either- (a) the monitoring cost, q decreases; or (b) the capital cost of bank, r decreases; or (c) the capital cost of the firm, q increases.*

Proof: Note that R^* decreases as either q or r increases. As $R^* \leq R^{max}$, concavity of X_B implies that an increase in R^* will lead to an increase in X_B^*. Therefore, an increase q or r which affects R^* adversely, will also affect X_B^* adversely. Part (c) can be established from the fact that an increase in q leads to an increase in R^*.

The above findings are not surprising. The negative impact of q and r on X^*_B is expected. However, part (c) of the proposition is interesting. A reduction in equity capital without accompanied by any other measure would reduce the success probability enormously. In order to prevent this from happening, the firm increases the face value of debt. In increase in debt, leads to an increase in the bank's funding.

The final result in this section relates the equilibrium aggregate investment to the various parameters.

Result 3: *Ceteris paribus, the aggregate investment, X^* increases if either- (a) the capital cost of the bank decreases, or (b) the monitoring cost of the bank increases, or (c) the capital cost of the firm decreases.*

Proof: Part (a) and (b) follow from the fact that R^* increases as, either q or r decreases. For the proof of (c), note that

$$\frac{V-R^*}{q} \equiv H(q) = \frac{\sqrt{\left(r^2+4(V+q)(q-r)\right)}-r}{2(q-r)}.$$

Denote, $G(V) \equiv (V+q)(q-r)$. Therefore,

$$Sign[H'(q)] = \left[\sqrt{\left(r^2+4G\right)}-r\right]^2 - \left[\frac{r^2}{4}+G\right] < 0.$$

Part (b) of the above result is particularly interesting. With a high q, the claim of the bank on the project is lower. This implies that the residual claim of the firm in the project is very high. A high q curtails the bank's investment but increases the firm's investment. The increase in investment by the firm is more than the bank's reduction in investment.

4. Optimal Investment and Policy Issues

With information asymmetry between the borrower and the creditor, optimality of investment becomes a crucial issue. We now investigate the *underinvestment* and the *overinvestment* problem occurring in the framework. With the bank and the firm both financing the project, the equilibrium net surplus in the system, denoted by $S^* = P_F^* + p_B^*$ is

$$S^* = p(X^*).V - q\left[1-p\left(X^*\right)\right] - \left[r.X_B^* + q.X_F^*\right] \qquad (7)$$

The net surplus is maximum when the project is funded at the least cost combination. This entails that the expected auditing cost is zero and that the entire funding is raised at the least per unit cost of r. Let Y^* denote the first best level of investment. Therefore, $Y^* = ln\left(\frac{V}{r}\right)$.

The result regarding optimal investment level is

Result 4: Under A.1 –A.2, the project will always be characterized by *underinvestment.* However, the extent of underinvestment is less if banks with higher auditing costs fund the project.

Proof: Consider, X^*. Note that, from result 3, X^* decreases as r increases. Therefeore, the maximum X^* is attained at $r \to 0$. This is given by $X^*(r=0) = ln\left(\sqrt{\frac{V+q}{q}}\right)$. From the condition that $D^{max} \geq 0$, we have, $\sqrt{\frac{V+q}{q}} \leq \frac{V}{q}$. As $q > r$, we have $\sqrt{\frac{V+q}{q}} < \frac{V}{r}$. This completes the proof.

For the second part, note that X^* is increasing in q while Y^* is independent of q.

The first best level of investment involves- (i) no monitoring activities undertaken; and (ii) the entire funds raised should be at the least unit cost, r. This is as if, the bank owns and alone funds the project. When the bank invests along with the firm, then the apart from the q, the effective cost of capital per unit is more than r. This leads to underinvestment. However, as q rises, the bank curtails its investment, the firm curtails R and therefore, she funds the project with more equity. The fall in bank financing is more than offset by the firms' contribution. Therefore, the aggregate investment exceeds the first best level. We also find that, while, lower auditing costs lead to a more severe problem of underinvestment. This observation is important. It supports the Gale Hellwig (1985) findings that costly state verification leads to underinvestment, higher auditing costs lead to overinvestment. However, it provides a rather counter intuitive but important insight to the problem. The bank curtails his investments. However, with higher per unit auditing costs, the bank attempt to avoid the expected auditing costs by reducing the probability of

default. Therefore, the percentage reduction in investment by the bank is less than the percentage increase in q. Moreover, the firm also contributes more at the margin so that for the bank, investment continues to be lucrative. This leads to an increase in overall investment.

We end the paper with the implications of these results on the optimal leverage ratio. As the investment by the bank and the firm can be solved in terms of the parameters of the model, the market value of debt equity ratio can be obtained in terms of the parameters alone. Define the market value of debt/equity as X^*_B/X^*_F.

Result 5: *The debt equity ratio decreases as (i) the auditing cost increases, or, (ii) the capital cost of the firm decreases, or, (iii) the capital cost of the bank increases.*
Proof: The proofs follow from comparing results obtained in 2 and 3. Intuitively, the results are as expected. *Ceteris paribus*, any increase in the bank's cost reduces the debt equity ratio as debt financing is increasingly substituted by equity funding. Also, an increase in the capital cost of the firm, substitutes equity by debt. The pattern leverage across economies suggests that the debt equity ratios reduce with the development of financial markets. Similar findings are also reported in Demigurc and Levine (1996. The ratios are particularly high for those markets which are still `emerging financial markets', like the Scandinavian nations, India, Pakistan and Korea, in comparison to the already developed markets like UK, US, Canada etc. The high leverage ratios in Japan and FGR are often attributed to their existing banking structure.

Harris and Raviv (1990), conjectures that the leverage ratio is negatively related to investigation cost. Our model justifies the above findings as well as supports `country wise' findings of Borio (1990) We predict, a closer bank - firm relationship would be reflected as higher leverage ratios. This is because, with banks having greater control over the firm, the auditing costs of the former will be lower inducing it to invest relatively more.

In a study by Biais and Casamatta (1999), it is established that the optimal leverage ratio decreases with a worsening of the moral hazard problem. Translated to our model, a severe moral hazard problem due to strategic under reporting, will be tackled by the bank by intensifying its monitoring activities. This in turn would mean a higher monitoring cost. We predict that the optimal leverage ratio is lower in such a case. In the most recent work of Booth et al (2001), a negative relation is established between agency cost of debt and the debt to book value ratio. They base their studies based on country wise comparisons.

We empirically test the foundation of our model- the fact that increase in investment reduces probability of default. We test the model using a cross section of rural banks operating in India.[7] We have the data for 196 such banks during 2002 and 2003. The data available are on the variables Gross NPA (NPA) and Gross Advances (GRADV). The correlation coefficient between NPA(03) and NPA(02) is 0.98 while that between GRADV (02) and GRADV(03) is 0.99. With almost perfect OLS models.

We estimate the following models:
Model I: NPA(03) = Constant + β GRADV(03)
Model II: NPA(03) = Constant + β GRADV(02)
Model III: INCPER = Constant + β INCGR.

In the above, the variable INCPER is defined as incremental change in NPA as a total percentage of Gross Advances. INCGR similarly measures incremental percentage change in Gross Advances. Therefore,

$$INCPER=\left[\left(\frac{NPA(03)}{GRADV(03)}\right)-\left(\frac{NPA(02)}{GRADV(02)}\right)\right]*100; INCGR=\left(\frac{GRADV(03)}{GRADV(02)}-1\right)*100$$

Model III has interesting implications. It relates the incremental NPA percentage to change in advances. We report the findings below.

[7] The data can be accessed from http://www.rbi.org.in/sec7/50597.doc

Table1: Empirical Results

	Model I	Model II	Model III
	NPA(03)	NPA(03)	INCPER
Explanatory Variables			
Constant	581.53 (4.74)	573.17 (4.88)	0.0017 (0.31)
GRADV(03)	0.093*** (11.81)		
GRADV(02)		0.111*** (12.59)	
INCGR			-0.001*** (-5.353)
R^2	0.41	0.45	0.13

Figures in the parantheses indicate the t-ratios. Variables with *** indicate significance at 99%.

An important policy implication from the above result comes from the empirical relationship between the relationships of gross advances and percentage NPAs (Non Performing Assets) of various banks in India. The NPA (as percentage) of gross advances goes down as the gross advances increase. We consider regional rural banks as these banks are characterized by higher average transaction costs. The findings are reported for Regional banks. With a direct relationship between probability of default and NPAs, this suggest that more investment by the bank increases the success probability. The policy implication that can be drawn from the above is, allowing banks with higher auditing costs, would not be inefficient.

5. Conclusion

In this paper, we model the creditor - borrower relationship in a costly state verification framework. In order to prevent strategic default, auditing by the bank is done only in the default states. Our model differs from those in the literature with respect to the relationship between the funds raised and the expected profitability of the project. In our model, the amount of funds raised directly influences the success probability of the project. We empirically test

the above using data of 196 regional rural banks. We establish that lower auditing costs may lead to uderinvestment while higher auditing costs may lead to overinvestment. The overinvestment result may seen paradoxical, but is explained by the fact that inefficiency in bank lending, is more than offset by an increase in equity. We also find that, while lending costs to the bank affects the debt equity ratio inversely, the capital cost of the firm affects the ratio directly.

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