Capital requirements, bank behavior and monetary policy: A theoretical analysis with an empirical application to India

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Abstract

The paper addresses the issue of monetary policy transmission through the banking sector in the presence of a bank capital regulation. A model of bank behavior is presented, which shows how a monetary policy shock affects both deposit and lending, in the short run (when equity capital is assumed to be fixed) as well as in the long run (when equity is endogenous). The analysis is extended to incorporate a salient feature of Basel II incorporating loans with differential risk weights. The findings are contrasted with those obtained under the 1988 Accord and the implications of the analysis are explored.

Key words: Basel Accord, Bank equity, Credit risk, Monetary policy

JEL Classification: G21, G28, E51

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Introduction

In recent years, a significant body of literature has emerged on the efficacy of monetary policy and the channels through which it operates. This renewed interest in monetary transmission needs to be viewed within the context of a revival of theories that stress the impact of the financial system on aggregate economic activity.

Within this broad ambit of analyzing the monetary transmission process, a relevant issue is the role played by regulation, since the banking sector is regulated in most countries (Goodhart *et al*., 1998). In particular, banks are imposed prudential requirements in the form of capital adequacy ratio, which sets an upper bound on its risk-weighted assets as percentage to equity: this regulation is expected to modify the reaction of banks to a monetary policy impulse.

The present paper seeks to examine the aforesaid question in a theoretical framework. In particular, it analyzes the transmission of a monetary policy shock, namely a change in the policy interest rate, allowing for the presence of a capital requirement constraint on the lines of the Basel Accord.

The rest of the discussion unfolds as follows. The following section reviews the relevant literature in this area. The basic framework is detailed in Section 3. Section 4 elaborates on the results under a Basel II-type setting. The concluding remarks are gathered in the final section.

II. Related Literature

Existing theory suggests a number of possible ways in which regulatory capital may alter bank lending behaviour and the efficacy of monetary policy, often with conflicting results. Models such as Chami and Cosimano (2001) and Van den Heuvel (2002) emphasize the relationship between monetary policy and bank capital, finding that the changes in monetary policy alter bank profitability, which, in turn, impinges on bank capital and lending. Alternately, under the bank lending channel hypothesis, monetary policy has a direct effect on the supply of bank loans as banks fund loans, at least in part, with reservable deposits. Van den Heuvel (2002) observes that a binding regulatory capital requirement limits the ability of capital-constrained banks to increase lending in response to an expansionary monetary policy, and thereby lower the potency of monetary policy to a certain extent. In contrast, Stein (1998) notes that bank capital might mitigate adverse selection problems. In the event of a tightening of monetary policy, capital-constrained banks are less likely to increase their issuance of reservable deposits and more likely to decrease lending, thus making monetary policy more potent. One possible explanation for these seemingly conflicting findings is that important cross-sectional differences exist in how banks respond to monetary policy shocks (Kashyap and Stein, 1994; Peek and Rosengren, 1995a; Kishan and Opiela, 2000). However, central to all these theories is the notion that monetary policy affects, either directly or indirectly, the supply of bank loans, and that the strength of this relationship can be influenced, at least in part, by regulatory capital standards.

An alternative way to address the issue of how regulatory capital standards influence bank lending and monetary policy is to examine empirical studies of the 1988 Accord. Studies such as those by Hall (1993), Haubrich and Watchel (1993), Wagster (1996), Jackson *et al*. (1999), Furfine (2000), Rime (2001) and Ghosh *et al*. (2003) suggest that banks altered the composition of their balance sheets in response to the risk-based capital standards, generally substituting high credit risk assets with assets of higher credit risk. If the composition of banks' assets has an influence on the efficacy of monetary policy, as is subsumed under the credit view of monetary policy, then asset substitution resulting from a revised Accord may impact the transmission process. Other studies, such as those by Kashyap and Stein (1994) and Thakor (1996) have demonstrated that risk-based capital standards alter the relationship between money and bank lending, with implications for the effectiveness of monetary policy. In addition, Berger and Udell (1994), Hancock and Wilcox (1994) and Peek and Rosengren (1995b) have examined what role the capital standards played in the during the credit crunch of the 1990s, often with conflicting results. While prior research is a pointer to the fact that the 1988 Accord had a significant influence on bank portfolio composition and monetary policy, existing research is limited in its applicability to the revised Accord, since some of the key elements of the revised standards differ significantly from the earlier Accord.

In a recent paper, Nachane *et al*. (2006) have explored the differential response of constrained and unconstrained banks to a monetary policy shock. Using data on Indian banks for 1993-2004, the evidence suggests that the effects of contractionary monetary policy will be significantly mitigated, the higher the proportion of unconstrained banks. The present analysis extends this analysis by developing a model which exhibits features of Basel I and Basel II.[2]

The study that comes close to the spirit of the present analysis is Kopecky and Van Hoose (hereafter KV, 2004a). In a dynamic framework, they show that the imposition of risk-based capital (RBC) requirements has fundamentally different effects on the loan market in the short and long run. For one, in the short run, with deposits fully insured, the imposition of RBC requirements leads to an increase in the market loan rate, whereas such RBC requirements weaken the impact of monetary policy on long-run equilibrium lending rate. Three features distinguish our model as compared to KV. First, in contrast to the deterministic set up in KV, we consider a stochastic framework. Second, the framework incorporates one key feature of the new Accord in terms of the differential risk weight on loans to the (non-bank) private sector.[3] Within this set up, we examine how modifications to the risk-based capital standards affect bank lending and the efficacy of monetary policy. This assumes importance is the light of remarks by recent researchers (Van den Heuvel, 2002; KV, 2004b) that very little research has addressed the issue of how Basel II would affect the monetary transmission mechanism.

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[2]See, for instance, Nachane *et al.* (2005) for a discussion of the new Accord and its implications for India.

[3]Under the earlier Accord, all loans to non-bank private sector received a uniform risk weight of 100%. By contrast, however, Basel-II acknowledges the fact that a loan to a blue-chip company might be subject to lower credit risk than that to a little-known company, which would be reflected in lower risk weights on the former.

III.A Basic Setup

Consider a bank holding loans (denoted by L) and bonds (B) on the asset side, which is funded through deposits (D) and equity (E). The following assumptions set out the rudiments of the model.

Loans: The bank is assumed to have some market power in the loan market; in fact, even when the market is competitive, banks are able to segment the loan market by keeping private the information on borrowers and building customer relationships; borrowers, therefore face significant costs if they switch from an existing banking relationship to a new one (Rajan, 1992). Thus, the bank is a price-setter in the loan market and faces a negatively-sloped demand for loans $L(r_L)$ with $L'(.)<0$ and finite elasticity $\eta_L=-L'r_L/L$.

The assumption that loans are 'information intensive' assets implies that firms are, more often than not, not able to easily substitute bank loans with alternate sources of funding. This makes firms 'bank dependent', enabling banks to apply on their loans an interest rate which is possibly higher than one prevailing in the securities market.

The other essential feature of bank loans is credit risk, which is modelled as simply as possible. Given the amount (L) of loans granted at the beginning of the period, the return to the bank at the end of the period equals $(1+r_L)*L$ with probability p.

Deposits: The bank also has some market power in the deposit market. The source of this market power might stem from the bank's ability to segment the market through spatial differentiation. Thus, the bank faces a positively sloped supply function of deposits $D(r_D)$ with $D'(.)>0$ and finite elasticity $\eta_D=D'r_D/D$.

Bonds: In addition to loans, banks also hold a marketable financial asset (Government bonds); the interest rate on these bonds (*i*) is determined in a competitive financial market, where the bank is a price-taker.

Capital requirement regulation: The banking sector is subject to a capital requirement, modeled on the lines of the Basel Accord. Under this setup, loans to private sector are subject to a uniform risk weight (while government bonds receive negligible (assumed zero, in the framework) risk weight. Thus, we may write the capital requirement as: $E \geq k_L*L$, implying that the bank cannot have an equity level lower than k_L times the volume of loans (k_L is the risk weight on loans).[4] While it is a stylized description of the Basel Accord, it captures two essential features: (i) all loans are treated in the same way, and (ii) there is an alternate asset (government bonds), which carries a negligible (market) risk weight.

Monetary Policy: We model monetary policy as modifications in the interest rate (*i*) prevailing in the bond market. This is in line with recent advancements in the literature, which observes the central banks target directly the level of interest rates (Romer, 2000). Of course, the picture is much complex than that obtained in the present framework; assets differ in their maturity profile, and central banks often set the level of short-term (overnight) interest rates and not merely one (representative) interest rate. Given the focus of the present analysis, we sidestep such complications and focuses on a single (interest rate) monetary policy indicator.

III.B Objective Function

The objective of bank management is to maximize the expected end of period income of the bank (V) given by:

$$V = p[(1+r_L)*L+(1+i)*B -(1+r_D)*D] - (1+i)*E \quad \textbf{(1)}$$

where the term in squared brackets is the (expected) return to bank equity holders, while the last term is the opportunity cost of equity: assuming risk neutrality, this is given by the riskless rate (*i*).

The budget constraint is:

$$E+D=L+B \quad \textbf{(2)}$$

which determines B as a residual B=E+D-L, which, in turn, can be substituted into the objective function (1) and upon rearrangement yields:

$$V= p[(r_L-i)*L+(i-r_D)*D] -(1-p)(1+i)*E \quad \textbf{(3)}$$

[4]Under the present dispensation k_L=0.08 under both Basel I as also Basel II, with one major exception. Under Basel I, the denominator comprised only of credit risk, whereas under Basel II, it comprises of market and operational risks, in addition to credit risk.

where the last term is the (expected) opportunity cost of equity, which is proportional to the probability of non-repayment of loan.

III.C Short-run equilibrium

A short-run equilibrium in the present setup is defined as a situation where the level of equity is fixed: following a change in *i*, the bank may react by changing its own interest rates r_D and r_L, but cannot modify the level of equity. This is typically a short run problem, since both theoretical (Stein, 1998) as well as empirical (Cornett and Tehranian, 1994) evidence is indicative of the fact that raising capital in the short-run can be costly for banks, more so, if they are constrained by risk-based capital standards.

As a result, the short run optimization problem of the bank is given as:

Max (r_L,r_D) V s.t. $E \geq k_L{*}L$

Substituting for B from the budget constraint (2), the resultant first-order conditions (FOCs) of the problem may be written as:

$r_L(1-1/\eta_L) = pi + k_L\,\lambda$ **(4)**

$r_D{*}(1+1/\eta_D) = i$ **(5)**

where λ is the Lagrangian multiplier associated with the capital requirement constraint. These conditions lead to the well-known dichotomy of the Monti-Klein bank: the equilibrium deposit and loan rates are set independently of each other, with bonds playing the role of 'buffer asset'.

The interest rate on deposits ($r_D{*}$) is set such that the marginal cost of deposits (LHS of 5) equals the marginal return on bank assets (*i*). The bank is able to earn a profit margin on its deposit taking, being higher the lower is the elasticity of the deposit supply schedule.[5]

On the loan side, we distinguish between two cases: (a) the bank is not constrained by capital regulation and (b) the bank is constrained by capital regulation.

Unconstrained bank: With λ=0, conditions (4) reads

$r^{*}_L{*}(1-1/\eta_L) = i$ **(4.1)**

[5] To see this, we re-arrange (5) to obtain: $r_D{*} = i\,[1 - 1/(1+\eta_D)]$, where $1/(1+\eta_D)$ is the "mark-down" on deposits.

where, r^*_L is the optimal loan and deposit rates. Condition (4.1) tells that the bank makes loans to the point where the marginal revenue of extending an additional unit of loan (LHS) equals the marginal cost of accepting an additional unit of deposit (RHS): in equilibrium, these are given by the return (*i*) on the alternative asset (bond). Equation (4.1) can be rewritten to yield the equilibrium loan and deposit rates according as:

$$r^*_L = i^*[(1 + (1/(\eta_L-1))] \quad \textbf{(4.2)}$$

where $1/(\eta_L-1)$ is the mark up on loans.

Constrained bank: If the optimal (unconstrained) level of bank loans $L(r_L^*)$ is larger than E/k_L, then the bank cannot actually grant such a volume of loans, since it lacks the necessary amount of equity. In that case, the loan volume and interest rates are determined by the capital constraint: $L(\overline{r_L})=E/k_L$. Condition (4) determines the value of Lagrangian multiplier:

$$\lambda=p[\overline{r_L}\ (1- 1/\eta_L) - i]/k_L$$

III.D Monetary policy effectiveness

We come to the main goal of the paper: to analyze the impact of a monetary policy intervention on the market for loans. The result is summarized in Proposition 1.

Proposition 1: *(a) In case a bank is not constrained by the equity constraint, the short-run impact of a change in the policy rate i on the loan rate is given by* $\partial r_L^*/\partial i>0$.
(b) In case a bank is not constrained by the equity constraint, the short-run impact of a change in the policy rate i on the deposit rate is given by $\partial r_D^*/\partial i>0$.
(c) In case a bank is constrained by its equity capital; a change in the policy rate has no impact on the loan rate.

Proof: From equation (4.2),

$$\partial r_L^*/\partial i=[\eta_L/(\eta_L-1)]>0 \quad \textbf{(4.3)}$$

which proves part (a) of the proposition.

From equation (4.1),

$$\partial r_D^*/\partial i=[\eta_D/(\eta_D+1)]>0 \quad \textbf{(4.4)}$$

which proves part (b) of the proposition.

In case the bank is *constrained* by the capital requirement, the equilibrium level of loan interest rate is given by $L(\overline{r_L})=E/k_L$, which is unaffected by a change in *i.* Specifically, expression (4) reveals that that the effect of the constraint is to force the bank to set its loan volume at a level that is lower than optimal: $L(\check{r}_L)< L(r_L^*)$, or equivalently, set the interest on loans at a rate higher than optimal: $\check{r}_L> r_L^*$. In other words, the bank is forced to work with a marginal revenue on loans that is higher than their marginal cost. The value of λ provides a measure of this inefficiency.

Remark 1: Proposition 1 points to a simple conclusion: In the short run, monetary policy is effective, provided that the banking system has enough equity. On the contrary, if the banking system is inadequately capitalized, so that its loan supply is constrained by the capital regulation, a monetary policy shock has limited impact on the loan market.

III.E Long-run equilibrium

In the long run, it seems reasonable to assume that banks would be able to adjust their equity level, together with their interest rates, following a change in *i*. This process leads the banking system to attain a long-run equilibrium, where E is endogenous.

In order to proceed further, we assume that the representative bank wants to keep its long-run equity-to-asset ratio at a level (weakly) above that required by regulation; in other words, the bank has an internal target for the long-run equilibrium level such that $E=\kappa_L*L$ ($\kappa_L \geq k_L$) (Berger *et al.*, 1995; Estrella, 2001). More importantly, it is assumed that the internal capital target κ_L includes a capital buffer, in that the bank can react to a monetary policy shock without being constrained by the capital regulation.

As a result, the long run optimization problem of the bank is given as:[6]

$\text{Max}\ (r_L,r_D)\ V$ s.t. $E= \kappa_L*L$

While the first order condition for deposits is unchanged, the condition for loans is altered according as:

$$p\acute{r}_L(1-1/\eta_L) = pi + \kappa_L*(1-p) *(1+i) \qquad \textbf{(5)}$$

[6]Note that we assume that the bank has an internal capital target *vis-à-vis* that on loan.

where $\acute{r}_L$ is the long-run equilibrium loan rate. According to (5), the expected marginal revenue (LHS) has to be equated to the expected marginal cost (RHS), which now comprises of two components: the expected return (p^*i) on the alternative asset (first term) and the cost of adjusting the level of equity (second term).[7] We call this second term - $\kappa_L*(1-p)*(1+i)$ – the *marginal cost of equity*, meaning that the increase of the expected opportunity cost of equity, due to an additional unit of loans.

III.F Monetary policy impact

We are now in a position to ascertain the long-run efficacy of monetary policy, defined as the impact of a change in *i* on the equilibrium loan rate and volume. The result is summarized in Proposition 2.

Proposition 2*: The long run impact of a change in the policy rate i on the loan rate is given by* $\partial\acute{r}_L^*/\partial i>0$*, with* $\partial\acute{r}_L^*/\partial i > \partial r_L^*/\partial i$.

Proof: From eq. (5)

$$\partial\acute{r}_L^*/\partial i= [\eta_L/(\eta_L-1)]*[1+ \kappa_L (1-p/p)] > 0 \quad \textbf{(6)}$$

Comparing (4.3) and (6) proves the proposition.

Remark 2: Proposition 2 suggests that, when banks are able to adjust their equity consequent upon a monetary policy shock, its reaction will have to factor into account the fact that the 'marginal cost of equity' has changed, following a change in *i*. Illustratively, suppose the central bank lowers *i* (monetary expansion). In response to this measure, in the short run, the bank lowers interest rate on loans and expands volume, only as a reaction to the reduction in *i*. In the long run, however, the bank has the freedom to choose the level of its equity base: this makes the bank take into account the fact that marginal cost of equity has declined, following a reduction in *i*. The bank is, therefore, willing to expand further the volume of loans by lowering the interest rate applied to a level beyond what is permissible in the short-run.

IV. The new regulatory framework

It is by now well recognized that ever since its inception, the 1988 Accord was subject to criticism, which was not surprising in view of the fact that the Accord had to

[7]Making an additional unit of loans induces the bank to increase its equity base by κ, increasing proportionally the expected opportunity cost of equity.

accommodate banking practices and regulatory regimes in countries with varied legal systems, business norms and institutional structures. Criticisms were mainly directed at its failure to make adequate allowance for the degree of reduction in risk exposure achievable through diversification and at its arbitrary and non-discriminatory calibration of certain credit risks. The uniform weight attributed in almost all circumstances to private borrowers, regardless of their creditworthiness, was considered an incentive to regulatory arbitrage, under which banks were tempted to exploit the opportunities afforded by the earlier Accord's classification of risk exposure to increase their holding of high-yielding, but also high-risk assets for a given level of regulatory capital. However, recurring crises over the past two decades in both the developed and developing world provided graphic evidence of the fact that, given the globalization and univeralization of banking operations, the onset of banking crises can impact the banking systems in home country as well as host countries in equal measure, through contagion effects.

In view of these factors, the Basel Committee proposed a *New Capital Adequacy Framework* in June 1999 incorporating three major elements or 'pillars': (a) *minimum capital requirements*, based on weights intended to be more closely aligned to economic risks than the 1988 Accord; (b) *supervisory review*, which set basic standards for bank supervision to minimize regulatory arbitrage; and, (c) *market discipline*, which envisages greater levels of disclosure and standards of transparency by the banking system. Ever since its publication, the Basel II has generated intense debate among policymakers and academia alike (Altman and Saunders, 2001; Danielsson *et al*. 2001; Mayer, 2001).

After several rounds of revisions to the *Consultative Paper*, the Basel Committee put forth a revised version of the 1988 Accord, with the revised standards to be applicable to large, internationally active banks in both U.S. and elsewhere (BIS, 2004; Caruana, 2004). Recognizing that the risk-based capital standards need to evolve along with changes in financial markets and improvements in risk measurement and management by banks, one of the primary purposes of the revised Accord is to align more closely regulatory capital requirements with the underlying credit risks in the activities of banks, thereby reducing distortions existing in the current Accord. As observed by the BIS (2004), '…the Committee has sought to arrive at significantly more risk-sensitive capital requirements that are conceptually sound and at the same time pay due regard to particular features of the present supervisory and accounting systems in individual member countries'.

One of the key features of the revised framework is the differential risk weight on loans to the (non-bank) private sector. Under the earlier Accord, all loans to non-bank private sector received a uniform risk weight of 100 per cent. By contrast, however, Basel-II acknowledges the fact that a loan to a blue-chip company might be subject to lower credit risk than that to a little-known company, which would be reflected in lower risk weights on the former. The question therefore arises: what implications do such features have on the transmission of monetary policy through the banking sector?

To examine this issue, we extend the present framework to include two categories of loans, each with a differential risk weight and assess its implications for monetary policy transmission. Towards this end, we make the following modification to the assumption made in the previous section.

Loans: The representative bank extends two categories of loans (L_1 and L_2), with r_1 and r_2 respectively, being the interest rate applied by the bank to the loans of type 1 and 2. Each loan gives the bank an end-of-period return of $(1+r_j)*L_j$, with probability p_j ($j=1,2$) or zero, otherwise, with $p_1>p_2$. Type 2 loans are, therefore, more risky as they have higher probability of default. The demand schedule for loan j is $L_j(r_j)$, with $L_j'(r_j)<0$ and finite elasticity defined as $\eta_j=-L_j' r_j/L_j$.

Capital requirement regulation: Type 2 loans receive a higher risk weight in the risk-weighing scheme *vis-à-vis* type 1 category; accordingly, the capital requirement regulation is $E \geq k_{L1}*L_1+ k_{L2}*L_2$, with $k_{L2}>k_{L1}$.

IV.A Loan portfolio return and bank value

The loan portfolio in our framework is $L= L_1 + L_2$. The end of period return on this portfolio is provided in table 1.[8]

Table 1: Probability of default associated with L

Return on L	Probability
$(1+r_1)*L_1+(1+r_2)*L_2$	p_1*p_2
$(1+r_1)*L_1$	$p_1*(1-p_2)$
$(1+r_2)*L_2$	$(1-p_1)*p_2$
0	$\pi=(1-p_1)*(1-p_2)$

The last row of the table denotes the 'default region', meaning that the bank is insolvent if (and only if) both categories of loans are not repaid.[9]

The (expected) end of period income of the bank (V_1) given by expression (7), i.e.,

$$V_1= p_1* p_2 [(1+r_1)*L_1 +(1+r_2)*L_2]+ p_1*(1-p_2)*[(1+r_1)*L_1]+(1-p_1)*p_2*[(1+r_2)*L_2]+ \\ (1-\pi)*[(1+i)*B - (1+r_D)*D] - (1+i)*E \quad \textbf{(7)}$$

where the first line is the expected return on the loan portfolio, whereas the second line is the expected return on bonds less than on deposits, adjusted for the opportunity cost of equity.

Given the budget constraint (2) as above, the objective function can be re-arranged and written as:

$$V_1= p_1*p_2 [(1+r_1)*L_1+(1+r_2)*L_2]+ p_1*(1-p_2)*[(1+r_1)*L_1]+(1-p_1)*p_2*[(1+r_2)*L_2] \\ - (1-\pi)*(1+i)*L+(1-\pi)*(i-r_D)*D-\pi*(1+i)*E \quad \textbf{(8)}$$

IV.B Short-run equilibrium

The short-run optimization problem of the bank is given as:

Max (r_1, r_2, r_D) V_1 s.t. $E \geq k_{L1}*L_1+k_{L2}*L_2$

The first order conditions are as follows:

$$p_1*r_1(1-1/\eta_1) = i*(1-\pi)+p_2*(1-p_1)+ k_{L1}*\lambda \quad \textbf{(9)}$$

[8]The implicit assumption is that the returns on L_1 and L_2 are statistically independent.

[9] Formally, min $\{[(1+r_1)*L_1, (1+r_2)*L_2]+ (1+i)*B\} > (1+r_D)*D > (1+i)*B$

$p_2{}^*r_2(1–1/\eta_2) = i{}^*(1-\pi)+p_1{}^*(1-p_2)+ k_{L2}{}^*\lambda$ **(10)**

$r_D(1+1/\eta_D) = i$ **(5)**

where, as earlier, λ is the Lagrangian multiplier.

On the deposit side, condition (5) is the same as earlier. On the loan side, conditions (9) and (10) replace the earlier condition (4). The crux of these conditions is summarized in Proposition 3.

Proposition 3: *(a) In case a bank is not constrained by the equity capital, the short-run impact of a change in the policy rate i on the loan rate is given by* $\partial r_j^*/\partial i>0$ *(j=1,2)*
(b) In case a bank is constrained by the equity constraint, the short-term impact of a change in the policy rate on the loan rate is given by $\partial \check{r}_z/\partial i$ (z=L_1, L_2).

Proof: (a) The first part of the proposition relies on the assumption that the bank is unconstrained by the capital requirement. Accordingly, inserting λ=0 in (11) and (12) provides the following two equations:

$p_1{}^*r_1(1–1/\eta_1) = i{}^*(1-\pi)+p_2{}^*(1-p_1)$ **(9.1)**

$p_2{}^*r_2(1–1/\eta_2) = i{}^*(1-\pi)+p_1{}^*(1-p_2)$ **(10.1)**

from which, we obtain:

$\partial r_j^*/\partial i = [\eta_j/(\eta_j–1)]^*[(1-\pi)/p_j] >0$ (j=1,2) **(11)**

(b) In this case, the bank is constrained by the capital requirement regulation. Accordingly, in this case, the equilibrium loan rates, $\check{r}_j$ together with λ are jointly (9) and (10) and the capital constraint (holding with equality). Solving (9) and (10) for λ yields the following expression:

$$\frac{p_1{}^*\check{r}_1(1–1/\eta_1) - i(1-\pi) - p_2(1-p_1)}{k_{L4}} - \frac{p_2\check{r}_2(1–1/\eta_2) - i(1-\pi) - p_1(1-p_2)}{k_{L2}} = 0 \qquad \textbf{(12)}$$

which implicitly defines $\check{r}_1$ and $\check{r}_2$ as a function of i according as g($\check{r}_1$, $\check{r}_2$; i)=0

Employing the implicit function theorem, we obtain:

$$\partial \tilde{r}_1 / \partial i = \frac{(1-\pi)(\frac{1}{k_{L1}} - \frac{1}{k_{L2}})}{\frac{p_1}{k_{L1}}(1-\frac{1}{\eta_1})} > 0 \qquad \textbf{(12.1)}$$

$$\partial \tilde{r}_2 / \partial i = \frac{(1-\pi)(\frac{1}{k_{L1}} - \frac{1}{k_{L2}})}{-\frac{p_2}{k_{L2}}(1-\frac{1}{\eta_2})} < 0 \qquad \textbf{(12.2)}$$

Remark 3: In part (b) of the proposition, the change in *i* leads to a change of opposite sign of the marginal cost of the capital requirement constraint (λ). In other words, a reduction in *i* implies an increase in λ.

Remark 4: Inserting (11) into (12.1) and (12.2), these two equations can be conveniently written as:

$$\partial \check{r}_1/\partial i = \partial r_1^*/\partial i^*[1 - (k_{L1}/k_{L2})] \qquad \textbf{(13.1)}$$

$$\partial \check{r}_2/\partial i = \partial r_2^*/\partial i^*[1 - (k_{L2}/k_{L1})] \qquad \textbf{(13.2)}$$

In particular, (13.1) reveals that $\partial \check{r}_1/\partial i < \partial r_1^*/\partial i$: the impact of monetary policy on loan interest rate of type L_1 is *lower* in the constrained case than in the unconstrained case. On the other hand, from (13.2), it is observed that $\partial \check{r}_2/\partial i > \partial r_2^*/\partial i$: the impact of monetary policy on loan interest rate of type L_2 is *higher* in the constrained case than in the unconstrained case.

Remark 5: The representative bank reacts to a change in *i* by moving the interest rate $\check{r}_2$ on the riskier borrower in the opposite direction. What this means can be explained as follows. Suppose there occurs a monetary expansion (the central bank lowers *i*). This lowers the return on bonds; the bank, therefore, would be inclined to expand loan supply. However, the capital requirement constraint bites: the marginal cost of the constraint (λ) gets larger. In order to address this situation, the bank shifts the composition of the loan portfolio towards the risky asset in order to obtain a reduction in the 'average' coefficient K.[10] This enables the bank to 'soften' the average capital requirement (footnote 10). The net effect is an increase in loan supply, but with opposite effects on the two classes of borrowers: an expansion of loan supply to type 1 borrowers, together with a contraction of loans supplied to type 2 borrowers.

The result in Proposition 3 (part b) points to a significant difference between the earlier Accord and Basel II. Under the earlier Accord, a bank that is constrained by the

[10]Define $K=k_{L1}*(L_1/L)+ k_{L2}*(L_2/L)$, so that the capital constraint $E\geq k_{L1}*L_1+ k_{L2}*L_2$ can be rewritten as (dividing and multiplying the RHS by L): $E\geq K*L$. This formulation emphasizes the fact that the 'average' capital requirement depends on the composition of the loan portfolio. Therefore, a shift towards less risky borrower (increase in L_1 and reduction in L_2) implies a reduction of K, enabling the bank to expand the (un-weighted) loan portfolio $L=L_1+ L_2$, for a given equity endowment, E.

capital requirement has limited maneuverability to respond to a monetary policy shock in the short run; monetary policy is, therefore, unable to alter the loan market equilibrium. On the contrary, under Basel II, a constrained bank has more freedom to adjust its loan portfolio pursuant upon a monetary policy shock by altering its loan composition.

Proposition 3 leaves open two issues: (a) which type of borrower is applied a higher interest rate and (b) in the unconstrained equilibrium, which type of borrower is more affected by a monetary policy impulse? These issues are addressed in the following proposition.

Proposition 4: *If $\eta_1 = \eta_2$*

(i) $r_2^* > r_1^*$ (ii) $\check{r}_2 > \check{r}_1$ and (iii) $\partial r_2^*/\partial i > \partial r_1^*/\partial i$

Proof: (i) Compare (9) and (10) assuming λ=0

(i) Compare (9 and (10), assuming λ>0

(ii) Follows from (11).

Remark 6: Proposition 4 tells that assuming the same elasticity of loan demand for the two loan categories, than (a) the riskier (type 2) borrower is applied a higher interest rate and (b) type 2 borrowers are more affected by a change in the policy rate.

IV.C Long-run equilibrium

As in the preceding case, we let the amount of equity E be endogenous. Formally, the long-run equilibrium level of E is determined as $E=\kappa_{L1}{*}L_1+\kappa_{L2}{*}L_2$, where $\kappa_{L1} \geq k_{L1}$ and $\kappa_{L2} \geq k_{L2}$ as also $\kappa_{L2} > \kappa_{L1}$: the internal targets κ_{L1} and κ_{L2} reflective of the fact that type 2 loans are relatively more risky, envisaging a higher requirement of regulatory capital.

The long run optimization problem of the bank is given as:

Max (r_1, r_2, r_D) V_1 s.t. $E= \kappa_{L1}{*}L_1+ \kappa_{L2}{*}L_2$

The first order conditions for a maximum are defined by (14) and (15) on the loan supply, while on the deposit side, it is the same as earlier (eq. 5). Explicitly writing (14) and (15) yields the following expressions:

$$p_1{*}\check{r}_1(1-1/\eta_1) = i{*}(1-\pi)+p_2{*}(1-p_1)+ \kappa_{L1}{*}\pi{*}(1+i) \qquad \textbf{(14)}$$

$$p_2{*}\check{r}_2(1-1/\eta_2) = i{*}(1-\pi)+p_1{*}(1-p_2)+ \kappa_{L2}{*}\pi{*}(1+i) \qquad \textbf{(15)}$$

The two conditions (14) and (15) enable us to state the following proposition:

Proposition 5: *The long run impact of a change in the policy rate i on the loan rate is given by* $\partial r_j^*/\partial i>0$ *with* $\partial \check{r}_j/\partial i > \partial r_j^*/\partial i$

Proof: From (14) and (15):

$$\partial \check{r}_j/\partial i = [\eta_j/(\eta_j-1)]*[1- \pi*(1-\kappa_j)]/p_j > 0 \ (j=1,2) \qquad \textbf{(16)}$$

Comparing (16) with (11) proves the result.

Remark 7: For type 1 borrower, the impact of monetary policy is stronger in the long run than in the short run.[11] For type 2 borrower, a change in i leads to a change in the opposite direction of the loan rate applied in the short run[12], while it leads to a change in the same direction in the long run.[13]

Proposition 5 highlight two points. First, in the long run equilibrium, such perverse effects of monetary policy, as the one effecting type 2 borrowers in the constrained short run equilibrium, are absent. Second, the long run impact of monetary policy on loan rate is stronger than the one prevailing in the short run unconstrained equilibrium.

As in Proposition 4, the two obvious questions of interest are: (a) which type of borrower is applied a higher interest rate and (b) in the unconstrained equilibrium, which type of borrower is more affected by a monetary policy impulse? Proposition 6 summarizes the results.

Proposition 6: *If* $\eta_1 = \eta_2$

(i) $\check{r}_2 > \check{r}_1$ *and (ii)* $\partial \check{r}_2/\partial i > \partial \check{r}_1/\partial i$

Proof: (i) Comparison of (14) and (15).
(ii) Follows from (16).

Remark 8: Following a monetary expansion (reduction in *i*), type 2 borrowers might suffer from a contraction of loan supply in the short run (the perverse effect obtained in

[11] Combine Proposition 5 with Proposition 3.
[12] Proposition 3, part (b)
[13] Proposition 5.

the short run equilibrium), while benefiting from an expansion of bank loan supply in the long run.

V. Empirical testing

The theoretical model suggests that, for a bank constrained by its equity capital, the response to a monetary contraction would be to increase loan supply to less risky borrowers, together with a possible contraction of loans to riskier borrowers (Remark 5 above). We test the empirical validity of this proposition by employing data on Indian commercial banks for 1993-2004.

Towards this end, we utilize the difference-in-differences (DiD) methodology (see Meyer, 1994) to compare the loan behavior of constrained banks, *vis-à-vis* unconstrained banks, in response to a monetary tightening. The basic premise is that a monetary contraction will engender a shift is composition of the loan portfolio towards more less risky assets and away from more risky ones, if a bank is capital constrained. The variables employed in the analysis along with their summary statistics are reported in Table 1. Of particular relevance are the two loan categories: loans to public sector (*Adv_pub*) and loans to corporate sector (*Adv_Oth*). Without loss of generality, it is presumed that loans to corporates are relatively riskier *vis-à-vis* loans to public sector, since the former entails an implicit government backing. Table 1 provides a description of the main variables.

Table 1. Variables and summary statistics

Variable	Empirical definition	Source	Mean	Std. Dev.
MYP	Dummy variable=1 if the real interest rate (RIR) in a year exceeds the median over the sample period, else zero. The RIR is computed as: [(1+ 364 day T-bill yield)/1+WPI inflation)]-1	Both the numerator and denominator are from Handbook of Statistics on Indian Economy	0.512	0.500
Constr	Dummy variable=1 if the capital ratio of a bank in a year falls short of the median value of all banks in that year, else zero. The capital ratio is defined as: (equity capital+reserves)/total assets	Statistical tables relating to banks in India (STB)	0.518	0.501
Adv_pub	Advances to the public sector/total loans (L1)	STB	0.085	0.099
Adv_Oth	Advances to corporate sector/total loans (L2)	STB	0.576	0.161
Adv_pub/Adv_Oth	L1 / L2	Computed from STB	0.184	0.266
Size	Logarithm (total asset)	STB	8.765	1.397
Liquid	(Cash in hand + balances with central bank + call money)/ total asset	Computed from STB	0.144	0.061
RoA	Net profit/total asset	Computed from STB	0.007	0.018

As a starting point, Table 2 reports comparisons of advances across the two categories of loans for constrained and unconstrained banks. The results show a clear tendency for constrained banks to exhibit greater lending to public sector and less lending to corporate sector, as compared with unconstrained ones. The differences appear to be economically important, as well. For example, the average loan extension for constrained banks to the public sector is 0.101, which far exceeds that of unconstrained banks. The difference is statistically significant at the 0.01 level.

Table 2. Univariate tests: constrained vs. unconstrained banks

Variable	Constrained	Obs.	Unconstrained	Obs.	*t*-statistic for difference
Adv_pub	0.101 (0.096)	363	0.069 (0.099)	352	4.314***
Adv_Oth	0.543 (0.141)	363	0.610 (0.174)	352	-5.691***

***, ** and * denote statistical significance at 1, 5 and 10%, respectively
Number of banks within brackets

The univariate test does not control for several factors than might systematically impact credit extension. For one, we do not control for bank size. Another possible factor is bank profitability. Bank liquidity could also be an important consideration. The pace of economic activity, in general could also be a relevant factor. We control for these factors in a multivariate regression framework as described by (17).

$$y_{i,t} = \gamma' \mathbf{w}_{i,t-1} + \alpha_1 \, MYP_t + \alpha_3 \, MYP_t {*} Cons_t + \theta_t + \alpha_i + u_{i,t} \qquad \textbf{(17)}$$

where the dependent variable $y_{i,t}$ is the ratio of loans to public sector to total loans (alternately, the ratio of corporate loans to total loans); $\mathbf{w}_{i,t}$ is a vector of sequentially exogenous bank-level variables (such as bank size, liquidity and profitability), MYP_t is a dummy variable indicating a tightening of monetary policy; *Constr* is a dummy variable that takes value one if the bank is constrained by its capital ratio; θ_t is the time dummy; α_i is bank fixed effects and u_{it} is the error term. Throughout, the *t*-statistics are computed allowing standard errors to be correlated for observations corresponding to the same bank (i.e., using clustered standard errors as described by Rogers, 1993).

The results, shown in Table 3, indicate that *liquid* and *RoA* are statistically insignificant for the whole sample. *Size*, on the other hand, has a positive coefficient and it is statistically significant. This suggests that larger banks tend to raise lending.

The regression includes *MYP,* a dummy variable that equals one in case of a monetary tightening. It has a negative and statistically insignificant coefficient in Model 1. In other words, there seems to be no economy-wide shock related to *MYP* with common effect to *all* banks.

The second regression (Model 2) adds an interaction term, *MYP*Constr,* where *Constr* is a dummy variable that equals one for capital constrained banks. If these banks respond differently to a monetary tightening, the interaction term will factor in those differences. The interaction term has a positive and statistically significant coefficient, suggesting that there is a perceptible difference in the lending activities of constrained banks owing to a monetary tightening. More specifically, the evidence indicates that constrained banks tend to raise their less risky loan portfolio driven by a monetary contraction. Since all the regressions include time fixed effects which control for the business cycle as also bank fixed effects to account for the time-dependent differences between constrained and other banks, the differences related to monetary tightening are unlikely to be due to the general differences between unconstrained and constrained banks in operating efficiency or other such factors.

Table 3: Monetary policy and bank lending - constrained vs. unconstrained banks

Variable	Model 1	Model 2	Model 3	Model 4
	Dep. Var = L1		Dep. Var = L2	
Liquid	-0.054 (0.112)	-0.064 (0.111)	0.059 (0.166)	0.068 (0.168)
RoA	0.209 (0.276)	0.207 (0.281)	0.052 (0.349)	0.049 (0.345)
Size	0.047 (0.019)***	0.046 (0.019)***	0.062 (0.029)***	0.061 (0.030)**
MYP	-0.004 (0.017)	-0.014 (0.019)	-0.021 (0.025)	-0.031 (0.026)
*MYP**Constr		0.019 (0.009)**		-0.019 (0.011)*
Bank fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Time period	1993-2004	1993-2004	1993-2004	1993-2004
Number of bank-years	715	715	715	715
p-Value of F-test	0.00	0.00	0.00	0.00
R-square	0.465	0.468	0.521	0.522

Clustered standard errors within brackets

***, ** and * denote statistical significance at 1, 5 and 10%, respectively

Models 3 and 4 repeat the earlier analysis using the riskier portfolio (*Adv_Oth*) as the dependent variable. The control variables are unaltered in sign and significance. In both Models 3 and 4, the coefficient on *MYP* is negative but statistically insignificant, suggesting that there is limited evidence of an economy-wide shock related to *MYP* with common effect to *all* banks. In Model 4 where we include the interaction term, the coefficient has a negative coefficient, and is weakly significant. In other words, constrained banks tend to lower their risky loan portfolio consequent upon a monetary contraction. Combining the evidence from Models 2 and 4, the analysis supports our theoretical postulate: an expansion of loan supply to less risky borrowers, combined with contraction of loan supply to risky borrowers by constrained banks in response to a interest rate shock.

Summing up, the results provide support to the fact that constrained banks behave differently to a monetary contraction *vis-à-vis* unconstrained ones. The results are robust after controlling for bank-specific factors and the economic environment.

VI. Concluding observations

Existing research on the Basel Accord has raised the question of how revisions to the Accord to likely to influence the efficacy of monetary policy. To explore this issue, the paper considers a basic framework to examine the efficacy of monetary policy to influence bank lending under both the earlier and the revised capital standards. The findings reveal that, in the short run, the effectiveness of monetary policy to influence bank lending differs according to whether banks are constrained by the risk-based capital standards or not. In the long run, however, when banks have fully adjusted their equity levels to incorporate the monetary policy shock, the impact of monetary policy on loan rate is stronger than the one obtaining in the short run.

The basic spirit of the model is empirically explored using data on Indian banks for 1993-2004. The analysis lends some support to the theoretical prediction that constrained banks raise lending to less risky borrowers in response to a monetary contraction, after controlling for the economic environment and bank-level factors.

Some caveats are in order at this juncture. First, the study was confined to a single bank in a static one-period setting. A more complicated set up, encompassing several banks in a multi-period horizon, might give rise to more interesting results.

Second, the institutional setting and the structure of the economy are also important factors in influencing bank behavior, which have not been explicitly incorporated in the present study. Incorporation of some of these features and their empirical examination, which would provide for a much robust framework, remains part of future research.

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