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Keywords: Bank capital, Monetary transmission, Balance sheet channel, Non-performing assets, Public-sector banks

JEL Code: E4, E5, G2

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1 Introduction

The principal mandate of a central bank is to implement monetary policy, a crucial tool for macroeconomic management and business cycle stabilization. In some jurisdictions, central banks also oversee financial regulation, with a focus on ensuring the stability of the banking system. This dual mandate can present a potential conundrum, as the goal of maintaining financial stability may occasionally conflict with monetary policy objectives. Through an empirical study of the bank balance sheet channel of monetary transmission we explore this issue within the context of India, a large emerging economy characterized by a bank-dominated financial system.

Globally, central banks aim to achieve price stability and foster economic growth through monetary policy. For monetary policy to effectively influence inflation and output, various transmission channels must function efficiently. One such conduit is the bank balance sheet channel, or the bank lending channel, through which monetary policy impacts real economic activity by influencing the supply of credit. Evaluating the effectiveness of this channel is crucial for central bankers. The literature on the bank balance sheet channel explores whether changes in monetary policy lead to adjustments in bank credit supply and how this relationship is impacted by the strength of banks' balance sheets, as measured by capital levels. Foundational studies on this topic include Bernanke and Gertler (1987), Bemanke and Gertler (1989), Bernanke and Gertler (1995), Bernanke and Blinder (1988), and Bernanke (2007). If the bank balance sheet channel is indeed operational and significant, central banks face a dilemma: how to balance effective transmission of monetary policy with the need to maintain banking sector stability.

Understanding the role of bank capital in monetary policy transmission (MPT) is essential for grasping this dynamic. A bank's capital level directly affects its lending capacity, especially under the Basel capital adequacy framework. Other factors being equal, a bank with capital levels exceeding the regulatory minimum can extend more credit than one that meets only the minimum requirements. Consequently, banks with higher capital levels are inherently more resilient to shocks and exhibit greater stability. However, this stability may paradoxically diminish the effectiveness of monetary policy, as well-capitalized banks might continue to extend credit even when the central bank tightens monetary policy to curb credit growth.

In this paper, we aim to determine whether the Reserve Bank of India (RBI) faces a similar policy dilemma regarding the interaction between monetary policy and banking sector stability. Specifically, we explore two key questions: First, do changes in the RBI's monetary policy affect credit supply within the Indian banking sector? Second, does this effect vary according to the capital levels of the banks? While these questions have been extensively examined in developed economies, our study makes a novel contribution in two main ways: first, it fills a significant gap in the literature on emerging economies, where monetary transmission mechanisms may differ from those in developed markets due to factors such as the size and structure of the financial sector, integration with global financial markets, domestic financial market development, and regulatory frameworks (Mishra et al. 2016). Thus, it is reasonable

to question whether the transmission mechanisms observed in developed economies apply to emerging economies like India. Second, while previous research has explored the bank balance sheet channel of monetary transmission, our study is the first to situate this channel within the broader context of the central bank's policy dilemma, specifically the trade-off between ensuring financial stability and achieving effective monetary policy transmission. especially for an emerging economy.

Monetary policy actions by central banks significantly influence bank behavior. During periods of monetary tightening, when the central bank raises interest rates, a reduction in the supply of bank credit is typically anticipated. Conversely, monetary easing should result in an increase in credit supply. However, banks may exhibit considerable heterogeneity in their responses to monetary policy changes. A critical factor contributing to this variability is the capital-to-asset ratio of banks. Banks with higher capital levels are generally more inclined to extend credit and generate returns for their investors, while those with lower capital are likely to adopt a more cautious lending approach.

Our hypothesis posits that higher levels of bank capital may attenuate the impact of monetary tightening on credit growth while amplifying credit growth during monetary easing periods, thereby potentially weakening the overall effectiveness of monetary policy transmission. In other words, banks with lower capital ratios may be more effective in transmitting changes in interest rates to the broader economy. This phenomenon may be related to the external finance premium, wherein healthier and stronger banks with better access to external funding are less sensitive to changes in monetary conditions (Bernanke 2007).

Examining this topic within the context of India is particularly salient, given that the banking sector is the most important conduit for financial intermediation in the Indian economy and thus plays a pivotal role in MPT. Existing literature indicates that alternative channels of MPT exhibit relatively low effectiveness in India (Patnaik et al. 2011). Consequently, the banking sector bears a disproportionate responsibility for effective MPT, thereby amplifying the trade-off between ensuring banking sector stability and achieving desirable monetary policy outcomes.

We also explore the impact of some unique institutional features of the Indian banking system on monetary policy transmission. For example, we find that bank ownership—whether state or private—adds complexity to the MPT mechanism due to differing capital levels among these institutions. Additionally, the treatment and disclosure of bad loans as "non-performing assets (NPAs)" in bank balance sheets, including the reporting of gross and net NPAs as a percentage of total loans, significantly influence the role of bank capital in the MPT process. Our findings indicate that the level of NPAs indeed affects how bank capital impacts monetary policy transmission.

Using a panel data estimation framework, we analyze data from 18 Indian commercial banks over the period 2003 to 2018 and explore how bank capital moderates the transmission of monetary policy changes to credit growth. Specifically, we interact the short-term interest rate, represented by the weighted average call money rate, with the bank capital ratio to investigate how varying levels of capital influence MPT.

This interaction allows us to assess whether banks with higher capital ratios exhibit greater resilience to monetary policy changes, thereby transmitting a smaller impact of monetary policy tightening to credit growth compared to banks with lower capital ratios. In other words, our framework enables us to determine if banks with lower capital ratios are more responsive to monetary policy tightening thereby reducing credit supply more than their better-capitalized counterparts.

Acknowledging the crucial issue of cross-sectional dependence among banks, which are collectively exposed to monetary policy changes, we first undertake a series of diagnostic tests to address this concern. Given the interconnected nature of the banking system, the response of individual banks to monetary policy shifts is not isolated but is influenced by the broader market and regulatory environment. To assess cross-sectional dependence, we employ a battery of tests and find compelling evidence of interdependence among the banks in our sample. This result underscores the necessity of accounting for cross-sectional dependence to mitigate potential biases and ensure accurate inferences regarding the relationship between monetary policy changes and credit supply.

With evidence of cross-sectional dependence established, we proceed to assess the stationarity of our variables using panel unit root tests that account for cross-sectional dependence. These tests confirm that our variables are stationary, thereby validating the reliability of our subsequent estimations. We then estimate the panel data model, adjusting for cross-sectional dependence using an appropriate econometric method while accounting for both observed and unobserved time-varying factors. This approach allows us to examine differential monetary policy transmission across banks with varying levels of capital.

Our findings indicate that higher short-term interest rates, which represent a monetary contraction, lead to a reduction in credit growth. More importantly, the strength of bank balance sheets plays a critical role in transmitting the impact of short-term interest rate changes to bank credit supply. Banks with higher capital levels exhibit a significantly lower sensitivity to monetary policy changes compared to banks with lower capital levels. In other words, the adverse effect of higher short-term interest rates on credit supply is more pronounced for banks with lower capital ratios and is more muted for banks with higher capital ratios. As a robustness check, we separately estimate our regression model for banks categorized by high and low capital ratios. Our results reveal that banks with lower capital ratios in particular, reduce credit supply in response to rising short-term interest rates. This confirms that the bank balance sheet channel is operational in India and validates our hypothesis that bank capital—representing balance sheet strength—significantly moderates the impact of monetary policy on credit growth.

Furthermore, in sub-sample analyses, we find that the effectiveness of the bank balance sheet channel is notably higher during periods of low non-performing assets (NPA) or better asset quality. As asset quality deteriorates during high NPA phases, the effectiveness of the bank balance sheet channel diminishes. This finding adds an interesting nuance to the relationship between bank capital and monetary policy transmission. High levels of NPAs effectively erode bank capital. Hence, the higher the level of net NPAs, the lower the effective capital available to a bank which in turn makes them less resilient to monetary policy changes. This implies that the buffering effect of bank capital on credit growth diminishes during

periods of high NPAs. In contrast, in periods of low NPAs, this "notional" erosion of capital is minimal, allowing banks to better absorb monetary policy impact.

Additionally, we observe that the type of bank ownership also influences the bank balance sheet channel's effectiveness, with well-capitalized private sector banks demonstrating greater efficacy in moderating MPT compared to public sector banks that on average have lower capital ratios. This result elucidates the intricate dynamics between capital adequacy, monetary policy transmission, and banking sector-specific characteristics. They provide critical insights for refining monetary policy measures, emphasizing the need for tailored approaches that consider the distinct characteristics of different segments within the banking sector.

There is by now a considerable literature estimating the various channels of MPT in India.[1] Among the studies specifically analysing the credit channel of MPT, Bhaumik et al. (2011) look at the impact of bank ownership on this channel whereas Rakshit and Bardhan (2023) examine the impact of bank competition. However, these studies do not take into account the impact of bank balance sheet strength on credit supply. Khundrakpam (2011) examines the credit channel of MPT from 2001 to 2011 using aggregate banking sector data, whereas our study extends the analysis over a longer period and employs bank-specific data. The existing literature on India provides mixed evidence regarding monetary transmission to credit aggregates. We advance this body of work by concentrating solely on the bank balance sheet channel of MPT—assessing how monetary policy affects credit growth based on the strength of bank balance sheets, as measured by bank capital—using disaggregated data from multiple banks spanning approximately 20 years. This approach allows us to exploit cross-sectional heterogeneity among banks over time. Additionally, we explore the impact of institutional features such as bank ownership and the disclosure of non-performing assets (NPAs) in bank balance sheets, which are distinctive to the Indian context.

Our paper is further linked to a broader theoretical and empirical literature on the bank balance sheet channel and its role in MPT. Holmström and Tirole (1998) contextualize the bank balance sheet channel to the banks' net worth that serves as a buffer against financial losses and finds that any form of capital tightening disproportionately impacts the profitability of banks with weaker capitalization. Macroeconomic model frameworks that incorporate asymmetric information emphasize the crucial role of a bank's net worth in moderating macroeconomic fluctuations and influencing the transmission of monetary policy (Dimsdale 1994; Sunirand 2003). Zentefis (2020) and Markovic (2006) find that for monetary policy transmission, bank capital plays a crucial role in interest rate pass through and the channel operates through the interaction between the supply and demand sides of the credit market. Several other studies empirically explore this channel such as Jiménez et al. (2012), Abuka et al. (2015), Kishan and Opiela (2000), and Altunbaş et al. (2002). Utilizing a comprehensive dataset from Germany, Imbierowicz et al. (2021) empirically show that higher bank capital constrains corporate loan growth for weaker banks

1. See Aleem (2010), Khundrakpam (2011), Patnaik et al. (2011), Bhaumik et al. (2011), Singh (2011), Pandit and Vashisht (2011), Mohanty (2012), Sengupta (2014), Das et al. (2015) among others.

and strongly capitalized banks increase their loan growth in response to accommodative monetary policy. Acharya et al. (2020) examine the role of bank capital for monetary policy transmission for the European Monetary Union and find that banks' capital constraints impair MPT and pose a challenge to the effectiveness of the bank-lending channel and the central bank's lender of last resort function.

Building on these studies predominantly focused on developed economies, we explore the role of bank capital in mitigating the effects of monetary policy changes on credit supply within a large emerging economy, specifically across a major credit cycle spanning nearly two decades. Our research offers significant policy implications, particularly given that banking is the main channel for monetary policy transmission (MPT) in India. Our findings suggest that the RBI, in its regulatory capacity, should consider the implications of bank capital on MPT when formulating banking regulations. As well-capitalized private sector banks expand their market share, their influence on MPT will become increasingly more prominent. Therefore, careful consideration of bank capital levels is essential when assessing MPT and its broader economic impact. Additionally, our study highlights that MPT effectiveness varies with asset (loan) quality cycles, underscoring the importance of incorporating these cycles into monetary policy deliberations.

The remainder of the paper is structured as follows: Section 2 details the data sources and provides descriptive statistics. Section 23 outlines the empirical strategy and the hypotheses tested. Section 4 presents the results of the empirical analysis. Finally, Section 5 offers concluding remarks.

2 Data and descriptive statistics

We use annual data for a sample of 18 public and private sector banks in India spanning from 2002 to 2018. The bank-level and macroeconomic variables are sourced from the Reserve Bank of India's statistical database and the CEIC global database. The primary dependent variable, credit growth, is defined as the year-on-year percentage change in credit supply. The key explanatory variable, bank capital ratio (BCR), is computed as the ratio of bank capital and reserves to total assets. Control variables include the change in the credit-deposit ratio, which is the first difference of the share of total credit to total deposits at the bank level, serving as a proxy for bank liquidity. Bank size is measured by the logarithm of total assets, return on assets is the ratio of net income to total assets, and asset quality is assessed by the ratio of net non-performing assets (NPAs post restructuring and provisioning) to net advances. The macroeconomic variable used to capture monetary policy changes is the weighted average call rate (WACR), which is the primary intermediate target for the Reserve Bank of India's monetary policy and commonly used as a proxy for monetary policy stance. Additionally, we include GDP growth rate and inflation to account for domestic business cycle conditions, which may also influence bank credit growth.

Table 1: Summary Statistics: Financial accounts and macroeconomic variables

	All banks		Public sector banks		Private sector banks	
Variables	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Bank level variables						
Credit growth (%)	21.39	15.58	16.67	11.67	27.09	17.71
Bank capital ratio (%)	8.36	5.92	5.60	0.96	11.74	7.51
ΔCD ratio (%)	0.61	3.87	0.45	3.98	0.79	3.74
Size (log(assets))	14.21	1.29	14.65	1.00	13.68	1.39
Return on assets (%)	0.96	0.78	0.59	0.78	1.41	0.48
Net-NPA/Net-advances (%)	2.13	2.23	2.92	2.54	1.16	1.23
Macroeconomic variables						
WACR (%)	6.31	1.30	-	-	-	-
T-bill rate (%)	6.76	1.60	-	-	-	-
GDP growth rate (%)	6.86	1.55	-	-	-	-
Inflation (%)	6.58	3.31	-	-	-	-
Observations	294		162		132	

Note: The table presents summary statistics of bank level variables for 18 commercial banks and macroeconomic variables used in the analysis, for the period 2002 to 2018. Data is sourced from the RBI and the CEIC databases.

Table 1 presents the summary statistics for the financial accounts of the sample banks and macroeconomic variables over the period from 2002 to 2018, highlighting notable differences between public and private sector banks. During this period, the average credit growth across all banks was 21.39%, with a standard deviation of 15.58, reflecting substantial variation in credit expansion among banks. The average BCR was recorded at 8.36%, with a high standard deviation of 5.92, indicating significant disparities in capital adequacy across banks. Changes in the credit-to-deposit (CD) ratio averaged 0.61%, with a standard deviation of 3.87, pointing to relatively minor average changes but significant fluctuations for some banks. The average bank size, as measured by the logarithm of assets, stood at 14.21, while the return on assets (ROA) averaged 0.96%, suggesting moderate profitability across the sector. The net NPA to net advances ratio averaged 2.13%, with a relatively high standard deviation of 2.23, underscoring the variability in asset quality across banks.

Focusing on public sector banks, credit growth was notably lower, averaging 16.67% with a standard deviation of 11.67, compared to private sector banks, which experienced higher average credit growth of 27.09% with a larger standard deviation of 17.71. This is possibly because during the second half of the sample period, public sector banks reduced their credit growth substantially in order to deal with a balance sheet crisis which manifested in the form of high levels of NPAs on their balance sheets, predominantly coming from large infrastructure firms. On the other hand private sector banks experienced lower NPAs and have also been lending a lot more to the retail sector in India. Public sector banks also exhibited a significantly lower mean capital ratio of 5.60%, indicating tighter capital adequacy compared to their private sector counterparts, where the average capital ratio was 11.74%.

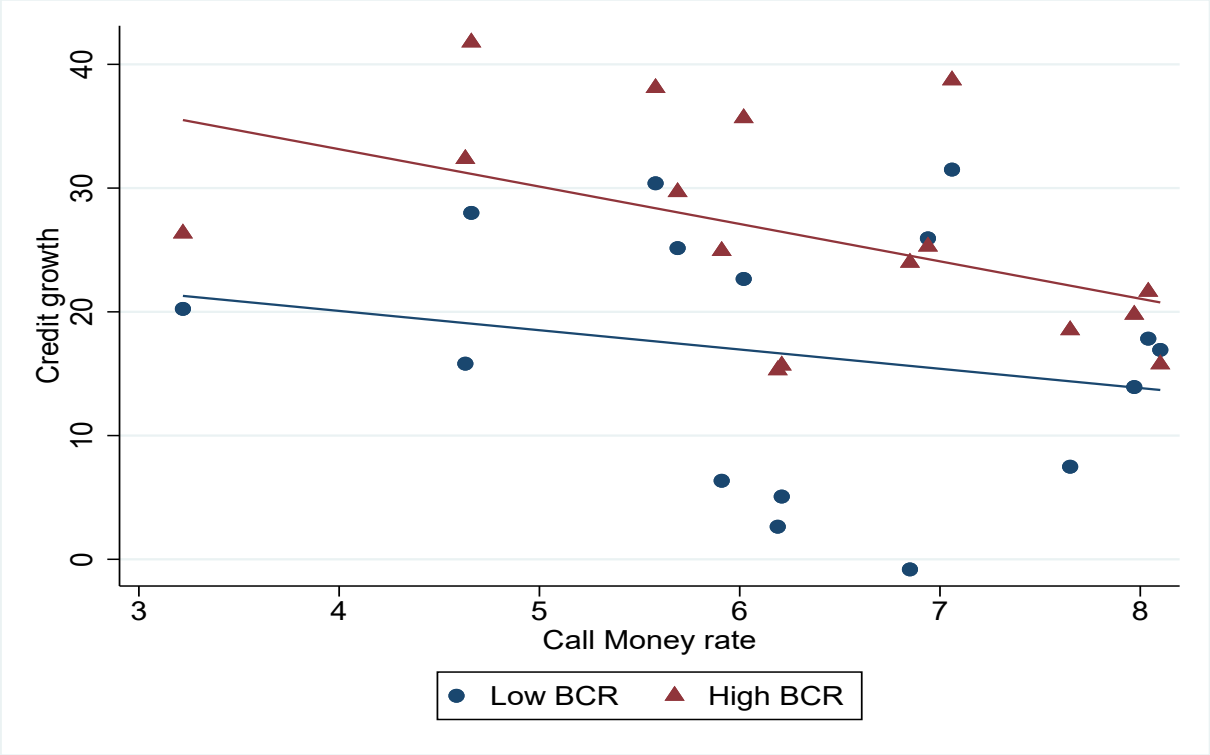
This discrepancy in capital levels between public and private sector banks reflects their differing capital-raising mechanisms. State-owned banks predominantly rely on government support for capital infusions.

During the latter part of the sample period, the government significantly increased capital allocations to public sector banks (PSBs) amidst a high NPA phase, when these banks faced substantial losses. Over three to four years, approximately Rs 4 trillion was injected into PSBs in a "just-in-time" manner, ensuring compliance with regulatory minimum capital requirements. In contrast, privately owned banks source their capital from capital markets, requiring strategic planning for issuance timing and scale. These banks typically access the capital markets intermittently, raising substantial capital in each round to support prolonged credit growth, often over four to five years. Consequently, private banks in India generally maintain higher capital levels relative to their assets compared to their government-owned counterparts.

In terms of profitability and asset quality, public sector banks had a lower average ROA of 0.59%, whereas private sector banks enjoyed a higher average ROA of 1.41%. Public sector banks also faced greater challenges with NPAs, as evidenced by a higher average net NPA to net advances ratio of 2.92%, compared to a significantly lower mean ratio of 1.16% in private sector banks. The key macroeconomic indicators, including the weighted average call rate (WACR) and the T-bill rate, which reflect the Reserve Bank of India's monetary policy stance, averaged 6.31% and 6.76% respectively. The GDP growth rate and inflation during the sample period averaged 6.86% and 6.58% respectively, providing context for the broader economic environment in which these banks operated.

Using the raw data, we analyze credit growth in relation to the weighted average call money rate for banks categorized by high and low BCR. Figure 1 shows that banks with lower BCR exhibit less credit growth compared to those with higher BCR. Specifically, as the call money rate increases—indicative of monetary policy tightening—credit growth declines across all banks. However, this decline is notably more severe for banks with lower BCR. This pattern highlights that banks with lower BCR not only extend less credit overall but also experience a more significant reduction in credit supply as the call money rate rises.

Figure 1: Monetary policy tranmission and bank capital ratio (BCR)



Note: The figure plots credit growth and weighted average call money rate for banks with low bank capital ratio (low BCR) and banks with high bank capital ratio (high BCR) for our sample dataset.

3 Empirical strategy

3.1 Estimation framework

Following the framework of monetary policy transmission studied in Jiménez et al. (2012) , we examine the the role of bank balance sheet channel by estimating the following baseline model.

$$\begin{aligned}\text{Credit growth}_{it} = \alpha_i + \beta_1 \text{MP}_{t-1} + \beta_2 \text{BCR}_{it-1} + \beta_3 \text{MP}_{t-1} \cdot \text{BCR}_{it-1} \\ + \beta_i X_{it-1} + \beta_j Z_{t-1} + \gamma_t + \epsilon_{it}\end{aligned} \tag{1}$$

The dependent variable in equation (1) refers to the growth of credit supply by banks for entity i at time t and the key explanatory variables are monetary policy lagged by one period, bank capital ratio (BCR) also lagged, and an interaction term between these two variables. We use weighed average call rate (WACR) to capture the monetary policy stance of the RBI, and the BCR as a measure of net worth the commercial banks (Das et al. 2015; Mishra et al. 2016; Jiménez et al. 2012; Bernanke et al. 1991). The interaction term ($\beta_3 \text{MP}_{t-1} \cdot \text{BCR}_{it-1}$) is the primary variable of interest in our analysis. It captures our core hypothesis that the bank capital ratio can mitigate the effects of monetary policy tightening on

credit growth. It will help assess if stronger BCR can enhance a bank's ability to absorb and cushion the effects of monetary policy changes on credit supply.

Since lending behavior across banks is likely to vary, we control for the bank level variables (X_{it-1}) that may affect bank credit supply. Following the related literature, we include key balance sheet variables that capture heterogeneity among banks (Heider et al. 2019; Gambacorta and Shin 2018). To account for the asset quality and liquidity among Indian banks, we include net NPA/net advances and credit to deposit (CD) ratio respectively (Abuka et al. 2015; Bhardwaj et al. 2022). Additionally, (Z_{t-1}) refers to macroeconomic control variables such as GDP growth and inflation (Abuka et al. 2015; Jiménez et al. 2012). We also include bank-specific fixed effects (α_i) and year fixed effects (γ_t) to control for time invariant bank heterogeneity and economy wide time varying shocks. In the case of time fixed effects, macroeconomic variables drop out but we can still estimate the coefficients on the interaction terms.

In addition to the baseline model, we examine the impact of monetary policy tightening on credit growth by dividing the sample into banks with high versus low BCR. This approach allows us to determine whether banks with lower BCR exhibit a more pronounced reduction in credit supply compared to their higher-capital counterparts, thereby highlighting the moderating role of balance sheet strength in monetary policy transmission. We also estimate a model that differentiates between two distinct phases of asset quality: the high NPA phase (2014-2018) and the low NPA phase (2002-2013), as delineated by (Sengupta and Vardhan 2017). This classification reflects the significant credit expansion prior to 2013 amidst strong economic performance, contrasted with the deterioration in asset quality and rising NPA concerns in the subsequent period. Finally, we apply the baseline model separately to public sector banks and private sector banks to investigate any differential effects of BCR on monetary policy transmission between these types of banks.

3.2 Diagnostic tests

Before proceeding with the main estimation, we address the issue of cross-sectional dependence among banks, given their simultaneous exposure to monetary policy shocks. Cross-sectional dependence is crucial in this context due to the interconnected nature of the banking sector and the uniform impact of monetary policy adjustments across institutions. Changes in interest rates affect the cost of capital, liquidity conditions, and overall economic activity, leading to correlated responses among banks. This interconnectedness implies that the behavior of individual banks is not isolated but is influenced by broader market and regulatory conditions. Consequently, neglecting cross-sectional dependence can result in biased estimates and erroneous conclusions about the true impact of monetary policy on the banking sector, as banks' responses are interrelated and shaped by a shared policy environment.

To test for this issue, we first implement a cross sectional dependence test by estimating CD-statistic (Pesaran 2021). The CD statistic is asymptotically standard normal under the null hypothesis that there is no cross-sectional dependence. We further complement the results by another cross sectional

dependence test known as Frees test (Frees 1995).

Table 2: Cross-Sectional Dependence Test Results

Cross dependence test	Statistic	P-value
Pesaran's test of cross sectional independence	4.233	0.00
Frees's test of cross sectional independence	0.453	0.01

Notes: The table reports test results for cross sectional dependence among sample banks.

As suggested by De Hoyos and Sarafidis (2006), we conduct cross sectional dependence tests and find strong evidence that we cannot reject the null hypothesis of no cross sectional dependence as shown in table 2.

Prior to our estimation, we also conduct unit root test incorporating the feature of cross-sectional dependence. According to Chudik and Pesaran (2013), standard panel unit root test may have serious drawbacks in the presence of correlation across cross sections. They can have substantial size distortions. Hence, we apply cross-sectionally augmented IPS (CIPS) which accounts for cross-sectional dependence. Table 3 shows that all bank level variables (with panel features) are stationary for lag 0 and 1.

Table 3: CIPS Unit root test with cross-sectional dependence

	Lags	Statistic	P-value
Credit-growth	0	-5.42	0.00
-	1	-2.65	0.00
Bank capital ratio	0	-2.92	0.00
-	1	-2.70	0.00
CD-ratio	0	-6.44	0.00
-	1	-4.18	0.00
Size	0	-6.69	0.00
-	1	-2.80	0.00
RoA	0	-5.69	0.00
-	1	-2.04	0.02
NPA/NADV	0	-6.94	0.00
-	1	-3.01	0.00

Note: The table presents test results for stationarity with cross sectional dependence for bank level variables used for the analysis.

Given the evidence of strong cross-sectional dependence among our sample banks, we follow Hoechle (2007) approach to estimate the above model with Driscoll and Kraay (1998) standard errors that control for cross sectional correlation and AR(1) autocorrelation (Chen et al. 2019; Yu et al. 2019; Wang and Luo 2022).

4 Empirical evidence

4.1 Baseline results

We present our baseline results in table 4, examining the the role of BCR in influencing the relationship between monetary policy tightening and credit growth. The three columns report different model specifications, with credit growth as the dependent variable.

Table 4: Monetary policy tranmission and role of bank capital ratio

	Credit growth as the dependent variable		
	(1)	(2)	(3)
L.Δ WACR	-1.095**	-1.394**	
	(0.498)	(0.554)	
L.Bank capital ratio x L.Δ WACR		0.034***	0.046**
		(0.009)	(0.016)
L.Bank capital ratio	-0.013	-0.007	-0.153
	(0.458)	(0.473)	(0.611)
L.CD ratio	-0.525	-0.529	-0.045
	(0.418)	(0.423)	(0.576)
L.Size	-9.543***	-9.530***	-20.937***
	(0.956)	(1.112)	(5.005)
L.RoA	4.422**	4.402*	5.101***
	(1.816)	(2.246)	(1.439)
L.(Net NPA/Net Advances)	-1.078	-1.090	-2.900***
	(0.747)	(0.797)	(0.627)
L.GDP growth	0.059	0.062	
	(0.418)	(0.462)	
L.Inflation	-0.424	-0.424	
	(0.277)	(0.320)	
Bank fixed effect	Yes	Yes	Yes
Time fixed effect	No	No	Yes
R-square	0.474	0.475	0.553
No of obs.	256	256	256

Notes: The table reports our baseline results where credit growth is the dependent variable. Our key explanatory variables are ΔWACR (change in weighted average call money rate) and bank capital ratio. Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances. Country level macroeconomic variables are GDP growth rate and inflation. The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

In specification (1), we find a statistically significant and negative coefficient for the weighted average call rate (Δ WACR), implying that a monetary policy tightening leads to a reduction in credit growth. Specifically, a 100 basis point increase in interest rates results in a 1.095 percentage point reduction in credit growth, highlighting how higher borrowing costs deter banks from extending credit. Interestingly, while the bank capital ratio has a coefficient of -0.013, it is not statistically significant, suggesting that the capital ratio alone does not exert a direct and meaningful influence on credit growth.

In other bank level control variables, the CD (credit-deposit) ratio has a coefficient of -0.525, which is

also not statistically significant. The coefficient for bank size is -9.543 and statistically significant at the 1 % level. This substantial negative coefficient suggests that larger banks experience lower credit growth. This make sense because, all else being equal, larger banks will show lower credit growth than smaller banks because of base effect. The return on assets (RoA) has a positive coefficient of 4.422 indicating that more profitable banks tend to raise credit supply. The net non-performing assets ratio (Net NPA/Net Advances) has a coefficient of -1.078 but is not statistically significant, potentially capturing the contractionary role of poor asset quality in credit growth. The coefficients for GDP growth (0.059) and inflation (-0.424) are both not statistically significant. The R-square value of 0.474 indicates that approximately 47.4% of the variation in credit growth is explained by the model, which is a reasonable level of explanatory power.

In specification (2), we analyze the interaction between the bank capital ratio and the weighted average call rate (WACR), which is our primary variable of interest. The standalone coefficient for WACR is -1.394, aligning with the results in specification (1) and confirming the negative relationship between higher monetary policy rates and credit growth. The positive and statistically significant coefficient of the interaction term reveals that increases in BCR mitigate the detrimental impact of monetary tightening on credit growth. Specifically, a one-percentage-point increase in BCR attenuates the negative effect of a 100 basis point rise in the WACR by 0.034 percentage points. This indicates that well-capitalized banks experience a less pronounced decline in credit growth when faced with higher WACR, compared to banks with lower capital ratios, which exhibit a more significant reduction in credit supply. The coefficients for other bank control variables remain stable across models, reaffirming the robustness of these findings.

In specification (3), we introduce time fixed effects alongside the interaction term, omitting time-varying macroeconomic variables such as the WACR, GDP growth rate, and inflation. This approach accounts for temporal macroeconomic shocks that could influence credit growth, thereby offering a more refined perspective on the interaction dynamics over time. The inclusion of time fixed effects allows us to assess the robustness of the interaction term while controlling for country-level time-varying shocks. The interaction term remains positive and statistically significant, with a higher coefficient of 0.046, emphasizing the enhanced role of bank capital in mitigating the adverse effects of monetary policy contraction on credit growth.

Additionally, among the bank-level controls, the net NPA ratio becomes significant and more negative, with a coefficient of -2.9, indicating that higher NPA ratios exert a more pronounced negative impact on credit growth when time fixed effects are included. The results from specifications (2) and (3) underscore the crucial role of BCR in moderating the effects of monetary policy tightening on credit growth. Well-capitalized banks are better equipped to sustain credit growth amidst tighter monetary policy, whereas banks with lower capital ratios experience more substantial reductions in credit supply, and hence are better able to transmit monetary policy changes.

Building on the baseline results and to deepen our understanding of the heterogeneity in bank responses, we further investigate the dynamics of monetary policy transmission by differentiating banks based on

their capital ratios. This nuanced analysis aims to elucidate how differences in capital strength among banks influence their responses to changes in monetary policy, providing a clearer picture of the varying impacts of monetary policy across banks with different capital profiles. To do this, following Di Giovanni et al. (2022), we split our sample between banks with high capital ratio and banks with low bank capital ratio[2]. We construct a similar dummy where high BCR bank has an average BCR equal to or above the median and low BCR bank has an average BCR less than the median.

Table 5: Monetary policy tranmission and role of bank capital ratio: High vs low BCR

	Credit growth as the dependent variable	
	(Bank with high BCR)	(Banks with low BCR)
L.Δ WACR	-1.175	-0.896**
	(0.965)	(0.355)
L.CD ratio	-0.364	-0.543***
	(0.719)	(0.131)
L.Size	-10.107***	-12.128***
	(1.761)	(1.800)
L.RoA	5.998*	-0.334
	(2.883)	(1.243)
L.(Net NPA/Net Advances)	-2.718	-0.838
	(2.146)	(0.581)
L.GDP growth	-0.450	0.658*
	(0.727)	(0.328)
L.Inflation	-0.929*	0.309
	(0.524)	(0.346)
Bank fixed effect	Yes	Yes
Time fixed effect	No	No
R-square	0.412	0.693
No of obs.	131	125

Notes: The table reports our baseline results where credit growth is dependent variable and the sample is split between banks with a high capital ratio and banks with a low capital ratio. Our key explanatory variables are ΔWACR (change in weighted average call money rate). Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances. Country level macroeconomic variables are GDP growth rate and inflation. The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

Table 5 contrasts the effects of a contractionary monetary policy on credit growth between banks with high versus low bank capital ratios. The results indicate a significant divergence between the two groups. For banks with high BCR, the coefficient for WACR is statistically insignificant, suggesting that these banks are less impacted by monetary policy tightening. In contrast, banks with low capital ratios show a significantly negative coefficient for the WACR, reflecting their heightened sensitivity to monetary tightening, which consequently restricts their credit supply. This differential response highlights the crucial role of capital buffers in mitigating the adverse effects of tighter monetary policy on credit supply. These findings reinforce our baseline conclusion that well-capitalized banks exhibit greater resilience to

2. Di Giovanni et al. (2022), in their analysis, construct a time-invariant dummy variable that splits banks into low and high non-core groups based on their average non-core ratio compared to the overall sample's median. A low non-core bank has an average non-core ratio below the sample median, while a high non-core bank has an average non-core ratio equal to or above the median.

policy shifts, whereas banks with lower capital ratios are more vulnerable to contractionary measures and the associated increase in bank borrowing costs.

4.2 Extensions and sub-sample analyses

In this part of our analysis, we examine the dynamics across different time periods and cross-sectional groups within the sample. Specifically, we analyze two distinct phases in the Indian banking sector: the low NPA phase (2002-2013), characterized by a credit boom, and the high NPA phase (2014-2018), marked by a credit bust. Further, we examine if the role of bank capital ratio in moderating MPT differs between public sector banks and private sector banks, given their varying levels of capital as discussed in Section 2.

4.2.1 *High NPA phase vs. low NPA phase*

Shifting our focus from the entire sample period to distinct phases of bank lending offers a nuanced view of the Indian banking sector's dynamics. By segmenting the sample into these sub-periods, we seek to capture how variations in banks' asset quality conditions influence the effectiveness of MPT.

The first column in the table 6 presents the estimation results for the low NPA period (2002-13) and the second columns refers to the results from the high NPA phase (2014-18). During the low NPA phase, our findings reveal a statistically significant and positive relationship between credit growth and the interaction of BCR with changes in WACR. Consistent with our baseline results, this indicates that well-capitalized banks are less likely to reduce credit supply in response to monetary tightening when the sector is in a relatively healthy state. However, in the high NPA phase, this relationship shifts notably. The interaction term between BCR and WACR becomes negative and weakly significant. This suggests that even well-capitalized banks tend to transmit the negative effects of interest rate increases on credit growth when the banking sector is under stress. In essence, the ability of bank capital to buffer the impact of monetary policy shocks on credit growth diminishes during periods marked by high NPAs.

Table 6: Monetary policy transmission: low NPA and high NPA phase

	Credit growth as the dependent variable	
	Low NPA phase (2002-13)	High NPA phase (2014-18)
L.Bank capital ratio x L.Δ WACR	0.031**	-0.387*
	(0.013)	(0.171)
L.Bank capital ratio	-1.057***	1.538
	(0.182)	(1.511)
L.CD ratio	0.581**	-0.787
	(0.203)	(0.577)
L.Size	-32.462***	-31.081**
	(4.394)	(8.926)
L.RoA	4.644***	-0.996
	(1.163)	(3.172)
L.(Net NPA/Net Advances)	-3.520***	-2.235*
	(0.963)	(0.811)
Bank fixed effect	Yes	Yes
Time fixed effect	Yes	Yes
R-square	0.541	0.232
No of obs.	168	88

Notes: The table reports our results where credit growth is dependent variable and the sample is split between high and low NPA phases. Our key explanatory variables are ΔWACR (change in weighted average call money rate) and bank capital ratio. Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances.The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

Several factors likely contribute to these distinct outcomes across the two periods. In a low NPA environment, an increase in bank capital typically signals stronger financial health and resilience. This robust capital base enables banks to absorb potential losses and the risks associated with lending, thereby fostering confidence among the lenders to extend credit. When the policy rate (WACR) rises, well-capitalized banks remain inclined to absorb the shock, moderating its contractionary impact on credit supply, similar to our baseline result.

In contrast, the dynamics change significantly in a high NPA environment. Elevated NPA levels indicate heightened credit risk and potential strains on bank balance sheets. Faced with such challenges, banks may prioritize risk management and reduce credit supply in response to a contractionary monetary policy. Rather than using their capital buffers to moderate credit reduction, banks might adopt more cautious lending strategies, tightening credit standards to avoid further asset quality deterioration. Thus, during periods of high NPAs, the capacity of the BCR to influence credit growth in response to monetary policy shocks becomes constrained, reflecting the overriding influence of asset quality concerns and heightened risk aversion among banks.

These results highlight the crucial link between bank capitalization and monetary policy transmission. High levels of NPAs deplete available bank capital. As net NPAs increase, the effective capital of banks decreases, making them less resilient to monetary policy changes. During high NPA periods, banks' effective capitalization appears lower than their reported capital levels, weakening their ability to sustain

credit growth. Conversely, in periods of low NPAs, this "notional" erosion of capital is minimal, allowing banks to better absorb monetary policy impacts.

4.2.2 *Public sector banks vs private sector banks*

We further examine how MPT affects credit growth differently for public sector banks (PSBs) versus private sector banks. This ownership distinction is crucial in the context of capital. While both PSBs and private banks are subject to the same capital adequacy norms, the methods by which they raise capital differ significantly. As discussed in Section 2 PSBs typically have lower capital levels compared to private sector banks. This is because PSBs rely on government capital injections, which typically occur on a need-based basis. For instance, the government often does substantial capital infusions into PSBs during periods of significant losses, as observed during the 2014-2018 period. So at any give point of time the PSBs may hold lower capital. In contrast, privately owned banks rely on capital markets for their funding requirements and typically engage in episodic capital raising. They secure substantial amounts of capital during each round to sustain their credit growth over extended periods. Consequently, these banks typically hold higher levels of capital on their balance sheets compared to PSBs.

To elucidate how this disparity in capital levels influences the bank balance sheet channel of MPT, we divide the sample into PSBs and private banks and specifically focus on the interaction between BCR and ΔWACR. Our findings indicate that for PSBs, the interaction term has a positive but statistically insignificant coefficient. This suggests that the bank capital channel is less effective in moderating the impact of monetary policy changes on credit growth for PSBs.

Table 7: Monetary policy tranmission and role of bank capital ratio: Public vs private sector banks

	Credit growth as the dependent variable	
	Public sector banks	Private sector banks
L.Bank capital ratio x L.Δ WACR	0.060	0.063**
	(0.114)	(0.029)
L.Bank capital ratio	-1.187**	-0.530
	(0.422)	(0.669)
L.CD ratio	0.447**	0.243
	(0.171)	(0.798)
L.Size	-20.315***	-21.847***
	(6.094)	(2.758)
L.RoA	2.645	6.671***
	(2.698)	(1.075)
L.(Net NPA/Net Advances)	-2.601***	-6.230***
	(0.477)	(2.012)
Bank fixed effect	Yes	Yes
Time fixed effect	Yes	Yes
R-square	0.784	0.523
No of obs.	140	116

Notes: The table reports our baseline results where credit growth is dependent variable and the sample is split between public-sector and privately owned banks. Our key explanatory variables are ΔWACR (change in weighted average call money rate) and bank capital ratio. Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances. The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

In contrast, for private sector banks, the coefficient of the interaction term between BCR and WACR is positive and statistically significant. This indicates that BCR plays a substantial role in moderating MPT within private sector banks. Specifically, private sector banks with stronger capital bases are better positioned to mitigate credit reduction in response to interest rate hikes, effectively leveraging their capital buffers. These findings highlight the complex relationship between capital adequacy, monetary policy transmission, and sector-specific characteristics, offering valuable insights for enhancing the effectiveness of monetary policy measures tailored to different segments of the banking sector.

4.3 Robustness and sensitivity tests

In this section, we assess the robustness of our findings by implementing two key modifications. First, we substitute the weighted average call money rate (WACR) with the 91-day Treasury Bill rate as an alternative measure of monetary policy stance and re-estimate the baseline model. Second, we apply the dynamic panel system GMM (Generalized Method of Moments) approach, replacing the panel fixed effects model, and evaluate the sensitivity of our results to different estimation methods. Both modifications confirm the robustness of our results.

4.3.1 *Treasury bill rate (T-bill) for monetary policy stance*

Table 8: Monetary policy tranmission with Tbill rate

	Credit growth as the dependent variable		
	(1)	(2)	(3)
L.Δ Tbill-rate	-0.765**	-0.639	
	(0.291)	(1.153)	
L.Bank capital ratio x L.Δ Tbill-rate	0.040***	0.044***	0.051**
	(0.012)	(0.012)	(0.023)
L.Bank capital ratio	-0.019	0.078	-0.097
	(0.418)	(0.340)	(0.622)
L.CD ratio	-0.553	-0.545	-0.040
	(0.408)	(0.397)	(0.582)
L.Size	-9.997***	-10.093***	-20.902***
	(0.754)	(1.385)	(3.460)
L.RoA	5.183***	4.862***	4.954***
	(1.450)	(1.481)	(1.101)
L.(Net NPA/Net Advances)	-0.539	-0.838	-2.927***
	(0.640)	(0.673)	(0.513)
L.GDP growth		-0.190	
		(0.769)	
L.Inflation		-0.230	
		(0.386)	
Bank fixed effect	Yes	Yes	Yes
Time fixed effect	No	No	Yes
R-square	0.463	0.466	0.554
No of obs.	256	256	256

Notes: The table reports our estimation results where credit growth is dependent variable and our key explanatory variables are ΔT-bill rate (change in 90 days treasury bill rate) and bank capital ratio. Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances. Country level macroeconomic variables are GDP growth rate and inflation. The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

Our robustness check, detailed in Table 8, reveals similar results when substituting WACR with the 91-day Treasury bill rate. The interaction term BCR and changes in the T-bill rate remains consistently positive and statistically significant across all three model specifications. These findings reinforce the robustness and reliability of the baseline model's results.

4.3.2 *Alternative estimation approach: Dynamic panel GMM estimation*

Table 9: Dynamic panel GMM: MP tranmission

	Credit growth as the dependent variable	
	(1)	(2)
L.Credit growth	0.306***	0.300**
	(0.091)	(0.122)
L.Δ WACR	-1.681**	
	(0.635)	
L.Bank capital ratio x L.Δ WACR	0.117**	0.160**
	(0.053)	(0.073)
L.Bank capital ratio	0.312	-0.677
	(0.446)	(0.403)
L.CD ratio	0.084	0.367
	(1.392)	(1.356)
L.Size	-8.127***	-2.781
	(1.669)	(1.690)
L.RoA	10.908*	6.198
	(5.860)	(5.680)
L.(Net NPA/Net Advances)	1.564	-0.670
	(1.088)	(1.915)
L.GDP growth	-0.439	
	(0.573)	
L.Inflation	-0.176	
	(0.246)	
Bank fixed effect	Yes	Yes
Time fixed effect	No	Yes
No of obs.	256	256
P value Hansen J statistic	0.975	1.000
P value Sargan statistic	0.382	0.250
p value of AR(1)	0.004	0.006
p value of AR(2)	0.202	0.244

Notes: The table reports our results where credit growth is dependent variable and dynamic panel GMM method is used for the estimation. Our key explanatory variables are ΔWACR (change in weighted average call money rate) and bank capital ratio. Bank level control variables include CD ratio (credit to deposit ratio), size as logarithm of assets, RoA as return to assets and the ratio of net NPA to net advances. Country level macroeconomic variables are GDP growth rate and inflation. The sample includes 18 banks for the sample period of 2002-2018. Standard errors are in parentheses. *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively

Table 9 presents results from a dynamic panel Generalized Method of Moments (GMM) model, which validates the findings from our baseline analysis. The Hansen J statistic, Sargan statistic, and the AR(1) and AR(2) tests confirm the validity of the model specification and the appropriateness of the instruments used, reinforcing the reliability of the GMM approach in capturing MPT dynamics. The interaction term between BCR and ΔWACR continues to show that banks with higher capital levels are better positioned to moderate their lending activities in response to monetary policy changes. In contrast, banks with lower capital are more susceptible to monetary tightening, resulting in a more pronounced reduction in credit supply.

5 Concluding remarks

In this paper we explore the pivotal role of bank capital in the transmission of monetary policy changes and the resultant policy dilemma faced by central banks. We focus on the Indian banking sector, which is a dominant channel of financial intermediation in the economy and plays a critical role in monetary policy transmission. The effectiveness of alternative transmission channels in India is relatively limited, thus placing a disproportionate burden on the banking sector to transmit monetary policy changes.

Our analysis reveals that bank capital significantly influences the transmission of monetary policy. Higher short-term interest rates, indicative of monetary contraction, lead to reduced credit growth. More importantly, we find that banks with higher capital levels are less affected by changes in monetary policy compared to banks with lower capital ratios. This suggests that the negative impact of increased interest rates on credit supply is more pronounced in banks with lower capital ratios.

To ensure robustness, we conduct separate regressions for banks with high and low capital ratios. The results confirm that banks with lower capital ratios contract credit supply more sharply in response to monetary tightening. This finding underscores the operational significance of the bank balance sheet channel in India and confirms that bank capital—serving as a proxy for balance sheet strength—moderates the effect of monetary policy on credit growth.

Further, our sub-sample analyses indicate that the effectiveness of the bank balance sheet channel is notably higher during periods of low non-performing assets (NPA), with a weakening effect during high NPA phases. Additionally, the ownership structure of banks affects the channel's effectiveness, with private sector banks showing greater efficiency in moderating monetary policy transmission compared to their public sector counterparts.

In summary, our findings highlight a central bank's dilemma: while strong bank capital can buffer the impact of monetary policy on credit supply, it also complicates the task of ensuring effective monetary policy transmission. This dual role of bank capital necessitates careful consideration by central banks in their policy formulation and implementation strategies.

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