Does Monetary Tightening Improve Banking Stability? The Role of Bank Cost Efficiency *

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Abstract

We examine how monetary tightening affects bank stability, and whether the response varies with bank cost efficiency. Using annual data for 3,903 banks in 95 countries over 1996–2024, we measure efficiency with a stochastic metafrontier and identify policy shocks using Taylor-rule deviations (and, in IV, central bank independence). Fixed-effects estimates and local projections show that a one-standard-deviation tightening initially raises Z-scores and reduces non-performing loan growth, but stability weakens at medium horizons as borrower distress builds up. This medium-run deterioration is notably smoother for high-efficiency banks, consistent with stronger risk control. Tightening also compresses net interest margins—most persistently for efficient banks—while credit growth responses are heterogeneous. A parsimonious efficiency-augmented New Keynesian DSGE model with fast risk management and slow distress dynamics reproduces the sign reversal and the cross-bank smoothing pattern.

Keywords: Monetary policy; bank stability; risk-taking channel; local projections; stochastic metafrontier

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"The 2007–2009 global financial crisis demonstrated that severe financial instability is not an historical curiosity or something that can happen only in emerging markets. It can happen in, and do terrible damage to, even the most advanced economies and the most sophisticated financial systems."

— — Ben S. Bernanke [Chair of the Federal Reserve, 2006–2014], Bernanke (2022).

1 Introduction

A central lesson of the past two decades is that monetary policy and financial stability are jointly determined, even when institutional mandates treat them as separate objectives. In the wake of the global financial crisis (GFC) and subsequent episodes of unconventional policy, economists and policymakers have increasingly argued that central banks cannot ignore the financial stability consequences of interest-rate decisions, consistent with calls to prioritise financial stability as a core policy goal (Yellen, 2014) and with the broader notion of a twin objective of monetary and financial stability (Oosterloo and De Haan, 2004). Yet, achieving this twin objective has largely remained elusive (Borio and Crockett, 2000; Borio, 2005), reflecting both conceptual tensions and empirical disagreements about how monetary policy decisions transmit through bank balance sheets, borrower risk, and the accumulation of vulnerabilities.

The empirical question is therefore direct: does monetary tightening (or easing) improve banking stability, and over what horizons? Indeed, a prominent line of assertion by some economists (Rajan, 2006; Taylor et al., 2010; Altunbas, Gambacorta, and Marques-Ibanez, 2014) suggests that accommodative policy in the aftermath of the dot-com bubble bust may have contributed to the build-up of vulnerabilities preceding the GFC, while others (Bernanke, 2010; Svensson, 2010) disagree with this interpretation and instead emphasise regulatory and supervisory failures. Yet, existing empirical evidence does not deliver a consensus. Some studies find that tighter (looser) policy strengthens (weakens) banking stability by restraining (encouraging) risk-taking (Jiménez et al., 2014; Lamers et al., 2019); others document destabilising effects through higher debt-service burdens, weaker borrower cash flows, and rising credit losses (De Graeve, Kick, and Koetter, 2008; Altunbas, Gambacorta, and Marques-Ibanez, 2014). Crucially, the sign and timing of these effects appear to vary across institutional settings, financial structures, and horizons.

For example, Lamers et al. (2019) report that expansionary monetary policy is associated with improved bank stability in the euro area, but reduces stability in the U.S., using market-based measures such as long-run marginal expected shortfall (LRMES) in a fixed-effects framework. In contrast, De Graeve, Kick, and Koetter (2008) finds that unexpected monetary tightening increases bank distress in Germany, with material heterogeneity in terms of bank characteristics, and estimates a VAR for distress responses. Importantly, even where bank heterogeneity is explicitly studied — typically along dimensions such as capitalisation, liquidity, or funding structure — the role of *cost efficiency* as a fundamental determinant that governs banks' risk-control capacity, loss absorption, and the smoothness of medium-run stability dynamics has received limited direct attention. Consequently, these existing results diverge for three related reasons: (i) context and external validity (with a disproportionate focus on the U.S. and Europe), (ii) the measurement of "stability" (market-based systemic-risk indicators versus accounting- and balance-sheet-based solvency and asset-quality metrics), and (iii) identification and dynamics (static panel designs versus impulse-response approaches that trace horizon-by-horizon transmission).

Against this backdrop, we make two testable predictions primarily. First, we test whether monetary tightening can increase (or decrease) stability and whether this effect is horizon-dependent. Second, we also introduce and test an *efficiency channel* to understand whether the monetary policy-stability relationship is systematically dependent on the level of cost efficiency of banks. To assess these predictions empirically, the paper assembles a global panel of roughly 90 countries and nearly 4,000 banks, which enables a unified assessment of monetary policy transmission to bank stability across diverse banking systems. We also utilise balance sheet-based measures — Z-score and non-performing loans (NPLs) — of banking stability, which have been extensively used in the banking stability literature (Uhde and Heimeshoff, 2009; Houston et al., 2010; Demirgüç-Kunt and Huizinga, 2010; Carretta et al., 2015). While market-based risk measures (typically constructed from equity returns and market valuations) are informative when available, they are inherently limited to publicly traded (and sufficiently liquid) institutions and therefore offer incomplete coverage in global bank panels that include privately held banks and many emerging-market institutions (Acharya, Engle, and Richardson, 2012; Brownlees and Engle, 2017). We also estimate the model using various techniques, including fixed effects regression (FE), local projections (LP), and instrumental variables (IV) approach, to provide robustness to our results.

Overall, we find that monetary tightening improves banking stability. This is consistent across most regions (except for Europe & Central Asia), income groups, especially for high income, low income and lower middle income countries – and for developed and developing countries. Moreover, the results show a systematic horizon dependence: a contractionary monetary policy innovation raises bank stability on impact and at short horizons, but this stabilisation is followed by a deterioration at medium horizons. We provide three key complementary channels to support the interpretation. First, the medium-run decline is systematically smoother for more cost-efficient banks, where cost efficiency is interpreted as a shifter of operating technology and managerial capability linked to monitoring, screening, and loss-mitigation capacity (Berger and Humphrey, 1997; Berger and DeYoung, 1997). Second, intermediation margins (net interest margins) compress on impact and recover more slowly among high-efficiency banks. Lastly, credit growth declines with meaningful heterogeneity across efficiency groups. Taken together, the evidence suggests an adjustment margin beyond pass-through to intermediation margins: operational and risk-control capacity shapes how monetary tightening propagates into realised asset quality stress.

The analysis builds on, and contributes to, a broad literature showing that policy rates shape bank lending and risk-taking through bank funding conditions, intermediation constraints, and the broader macro-financial environment in which borrower creditworthiness evolves (Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Gertler and Kiyotaki, 2010; Borio and Zhu, 2012; Jiménez et al., 2014). Rather than imposing a priori that monetary policy is stabilising or destabilising, the empirical results emphasise that both forces can coexist over different horizons; perhaps, this may explain the divergent views in the literature. The key novelty is that we document this horizon dependence within a single empirical design and show that bank cost efficiency is a first-order determinant of the medium-run dynamics even when the response of bank margins moves in the opposite direction.

The paper makes three important contributions. First, it establishes horizon-dependent sign reversal in the response of bank stability to monetary tightening in a large cross-country banking panel, and shows that the subsequent decline is not uniform across banks: cost efficiency robustly predicts the extent of smoothing. Second, it clarifies the relevant channels by jointly tracing stability, net interest margins, and credit growth across efficiency groups, which distinguishes a margin-based mechanism from a loss-mitigation mechanism. Third, it develops an Efficiency-Augmented Banking DSGE (EAB-DSGE) framework that mirrors the empirical findings. The model is a standard New Keynesian core (Woodford and Walsh, 2005; Galí, 2015) which is augmented with a banking block in which: i) a persistent borrower-distress state gradually raises default risk after tightening, and ii) bank risk-management effort which responds on impact, with its effectiveness and cost governed by bank efficiency. The interaction of a slow loss channel and a fast risk-management channel reproduces the sign reversal and efficiency-conditioned smoothing observed in the data, providing a coherent mapping from monetary shocks to stability dynamics.

Finally, the results have direct policy implications, especially for central banks and monetary authorities. If tightening delivers short-run stabilisation but induces delayed fragility through borrower distress, then policy assessments based on near-term indicators may understate risks during tightening cycles. Moreover, the distribution of bank efficiency is not merely a micro-level feature: it conditions aggregate resilience by shaping the time profile of stability and the cross-sectional propagation of monetary policy. This places operational efficiency and risk-management capacity as central state variables for macroprudential monitoring when monetary policy shifts, particularly in global tightening episodes where vulnerabilities can accumulate even as measured stability improves initially.

The remainder of the study is organised as follows. Section 2 provides a brief review of related literature. Section 3 describes the data used in the study, while Section 4 presents the methods used in analysing the data. In Section 5, we present and discuss the empirical results. Section 7 presents the supporting DSGE model, calibrated to the empirical results, which explains the channels of monetary tightening and their impact on banking stability. Section 8 concludes the study and discusses the policy implications of the findings.

2 Related Literature

A rich literature studies the determinants of banking stability, spanning both bank-level fundamentals (e.g., capitalisation, funding structure, governance, and operational performance) and macro-financial conditions (notably the monetary policy stance). This paper sits at the intersection of two strands: i) how monetary policy decisions transmit to bank stability over different horizons, and ii) how *cost efficiency* conditions that transmission. We review these strands to motivate the empirical design and to clarify the gaps the study addresses.

A substantial empirical literature investigates whether monetary policy influences bank stability and through which mechanisms. A central framework is the *risk-taking channel*: prolonged accommodation can compress intermediation margins, raise incentives to reach for yield, and soften screening/monitoring—thereby increasing the risk content of bank balance sheets even when contemporaneous measured performance looks benign (Rajan, 2006; Jiménez et al., 2014). Related arguments emphasise that easy financial conditions can inflate asset prices and collateral values, reducing measured risk and relaxing constraints in a way that may later unwind sharply (Bernanke, Gertler, and Gilchrist, 1996; Matsuyama, 2007).

Micro-evidence strongly supports the existence of a risk-taking channel, but its implications for stability are not uniform across settings. Using Spanish credit-register data, Jiménez et al. (2014) show that lower policy rates induce banks—especially those with weaker buffers—to expand credit to ex ante riskier borrowers, and that these loans default more subsequently, consistent with a shift in the composition of credit risk rather than only the volume. Complementary evidence from a dollarised financial system is provided by Ioannidou, Ongena, and

Peydró (2015), who exploit the pass-through of U.S. monetary policy to Bolivian banks and document greater risk-taking and softer pricing when U.S. rates fall. At the macro-finance interface, Maddaloni and Peydró (2011) utilise bank lending survey information for the U.S. and the euro area, demonstrating that low short-term rates (monetary policy) are associated with a measurable softening of lending standards—an effect that interacts with securitisation and supervisory environments. Taken together, these results rationalise why monetary accommodation can be associated with increased risk-taking; however, they do not deliver a consensus prediction for stability once one accounts for countervailing forces (e.g., recapitalisation through higher borrower cash flows, valuation effects, and policy backstops), differences in banking structure, and the horizon at which stability is measured.

Importantly, the lack of consensus is not confined to North America and Europe. Beyond these regions, Chen et al. (2017), for instance, analyse over 1000 banks across 29 emerging market economies and reports that an easing of monetary policy increases bank risk (measured by indicators like the loan-loss-provision ratio or Z-score). Moreover, some key bank-specific characteristics have been identified in the previous studies to explain these relationships. For instance, De Graeve, Kick, and Koetter (2008) find that these results are dependent on bank size and capitalisation. They find that bank distress responses to monetary policy tightening are largest for small and low-capitalised banks. This is consistent with Kishan and Opiela (2000) who also show the importance of bank size and capitalisation for monetary transmission. Among these characteristics, bank efficiency has not received the necessary attention in this transmission mechanism. This gap is central to our contribution: we study not only whether stability rises or falls after a policy shock, but also whether the *time profile* of stability responses differs systematically by bank efficiency.

Consequently, we review a second strand of literature that examines whether bank efficiency predicts risk and stability. Seminal contributions argue that efficiency contains information about managerial quality and internal controls and therefore should forecast asset quality and risk outcomes. According to the "bad management" hypothesis, cost-inefficient banks are more likely to exhibit weaker monitoring and inferior credit processes, which can lead to problem loans and subsequent instability (Berger and DeYoung, 1997; Kwan and Eisenbeis, 1997). Subsequent evidence for European banking systems similarly links operational performance to risk outcomes, often finding that more efficient banks display lower risk or superior resilience, though results depend on sample composition, period, and risk proxies (Williams, 2004; Fiordelisi, Marques-Ibanez, and Molyneux, 2011). At the same time, the evidence is not unidirectional: some studies argue that lower efficiency can coincide with greater stability if it reflects conservative business models or higher capital buffers, implying that the mapping between efficiency and risk may be mediated by balance-sheet structure and strategic choices (Altunbas et al., 2007). This mixed evidence motivates treating efficiency as an economically meaningful shifter—rather than assuming it is mechanically stabilising in all contexts.

Two limitations of the existing efficiency–stability literature are particularly salient for the present study. First, much of the evidence focuses on *level* relationships (e.g., whether efficiency predicts average risk) rather than on *dynamic* responses to macro-financial shocks. Second, even when monetary policy is part of the conditioning information set, efficiency is rarely modelled as a *channel* that governs banks' adjustment of screening, monitoring, provisioning, and loss absorption—precisely the mechanisms through which policy can generate horizon-dependent effects on stability. Our empirical design targets this channel directly by interacting monetary policy shocks with efficiency groups and by tracing impulse responses across horizons. Moreover, our DSGE framework formalises this economic logic: a fast, efficiency-conditioned risk-management response can stabilise banks on impact, while a slower borrower-distress channel can dominate at medium horizons, generating sign reversal with smoother deterioration among more efficient banks.

In sum, prior research establishes plausible channels through which monetary policy affects bank risk-taking and lending standards, and a separate body of work links efficiency to risk and stability. However, the literature remains divided on whether monetary tightening stabilises or destabilises banks once horizons, institutional settings, and risk measures are taken seriously, and it offers limited direct evidence on cost efficiency as a conditioning channel for the dynamic stability response. This paper addresses these gaps.

3 Data

We obtain bank-level data from the Osiris database, covering 7,386 listed and unlisted commercial banks across 143 countries over 1996–2024. To ensure reliable frontier estimation in the first-stage efficiency analysis, we exclude countries with fewer than five banks, leaving 7,318 banks in 106 countries for the stochastic metafrontier estimation of cost efficiency. We then proceed to the second stage, where we estimate the effects of monetary policy on bank stability while conditioning on the cost-efficiency measures obtained from the first stage. Owing to data availability for bank-level and macroeconomic controls, the baseline regression sample comprises 3,903 banks across 95 countries.[1] We additionally obtain data on central bank independence from Garriga (2016) and country-level monetary policy stance measures from Müller et al. (2025). Macroeconomic controls are sourced from the World Bank's World Development Indicators (WDI). All bank-level variables are winsorised at the 1st and 99th

[1]The countries and number of banks are listed in Table A1 under Appendix A.

percentiles following standard practice (Carretta et al., 2015; Beck, De Jonghe, and Schepens, 2013; Husted, Rogers, and Sun, 2020; Adelino et al., 2023).

We discuss the key variables used in our main specification, which examines the impact of monetary policy on banking stability.[2] Following the literature (Roy, 1952; Uhde and Heimeshoff, 2009), we use Z-score as our main measure of banking stability, which measures a bank's distance to insolvency. Our monetary policy variable is constructed using the Taylor-type rule (Taylor, 1993) as used in the literature (Lamers et al., 2019).

We also employ some key bank-specific variables following the literature. First, our key variable of interest is cost efficiency. We employ the stochastic metafrontier technique proposed by Huang, Huang, and Liu (2014), which is discussed in sections 4.1 and 4.2. This is used to estimate the cost efficiency of each bank. Following the extant literature as discussed earlier Berger and Humphrey (1997); Fiordelisi, Marques-Ibanez, and Molyneux (2011), we expect a positive relationship between cost efficiency and stability. This implies that cost-efficient banks reflect good management, hence exhibit better monitoring and credit processes and will therefore have less risk and be more stable. This underpins our argument that these banks typically enjoy the *efficiency buffer* in the face of policy tightening. We also note that in rare cases, as found by (Altunbas et al., 2007), inefficient banks may be more stable, especially when they are highly capitalised, reflecting a conservative business model with the advantage of higher capital buffers.

Second, we include a measure of bank liquidity as a control variable (Bank liquidity). This is the ratio of liquid assets to total assets. We measure bank size as the log of total assets (Size). The empirical results are ambiguous as to the relationship between bank size and stability. From one perspective, larger banks are perceived as more stable due to their diversification and capital buffers, as well as their ability to enter other markets (Uhde and Heimeshoff, 2009). On the other hand, larger banks can face the moral hazard problem where they tend to take on more risk. This exposure to higher risk can make these banks unstable. We therefore expect either a positive or a negative relationship between bank size and stability.

We also control for the asset structure of banks, measured as the ratio of fixed assets to total assets (Asset Structure). At the industry/country level, we control for bank concentration, which is the assets of the three largest banks (Bank Concentration). The literature provides evidence of both concentration-stability and concentration-fragility views. In the concentration-stability view, banks in monopolistic banking markets dominated by a few large banks can enjoy higher profits and thus improve their stability. The concentration-fragility view also

[2] Details of the variables used in the stochastic metafrontier estimations are well discussed under Section 4.2. Other details on the construction of Z-score and our monetary policy variables are also discussed under Section 4.3.

emphasises the too-big-to-fail argument where larger banks take on more risk, and this risky behaviour is exacerbated by their knowledge that governments normally would bail them out in case of distress (Mishkin, 2016). We therefore expect either a positive or a negative relationship between bank concentration and stability.

3.1 Summary Statistics

Table 1 summarises the main variables used in the two-stage design and provides a first-pass characterisation of the data's scale and heterogeneity. The stochastic metafrontier variables block indicates a large estimation sample for frontier recovery (49,859 bank-year observations), with substantial dispersion in both total costs and output: the mean log total cost is 17.36 (s.d. 3.61) and the mean log gross loans is 15.92 (s.d. 3.66). Input-price ratios also vary meaningfully across banks and countries, consistent with heterogeneous funding and operating environments; in particular, the dispersion in the relative price of borrowed funds (mean 0.20, s.d. 1.45) suggests material cross-sectional and intertemporal shifts in funding conditions that are central to cost-technology estimation. The macro environment is equally heterogeneous: GDP per capita growth averages 1.95 (s.d. 3.49), while inflation is volatile—mean 4.43 with a very large s.d. of 10.81 using CPI (and similarly 4.63 with s.d. 12.43 using the GDP deflator)—which motivates controlling for macro conditions directly in the frontier estimation and in the second-stage stability regressions.

The *efficiency scores* block reveals economically meaningful gaps between country-frontier and metafrontier performance. Average country-frontier cost efficiency is 0.68 (s.d. 0.21), implying that, relative to the best-practice bank within each country technology, the typical bank could reduce costs by roughly one-third for a given output and input prices. By contrast, global metafrontier efficiency averages 0.45 (s.d. 0.18), indicating that once all banks are evaluated against a common best-practice global technology set, the implied cost gap is substantially larger. The intermediate metafrontier benchmarks (regional mean 0.53, development status 0.47, income dynamics 0.49, ECB group 0.46) sit between these two extremes, consistent with persistent cross-country technology differences and the relevance of grouping-based technology sets. This implies that the large dispersion in efficiency may suggest heterogeneous adjustment of banks to monetary policy shocks, with more cost-efficient banks plausibly better positioned to absorb sustained tightening through smoother funding-cost pass-through and more resilient margins.

Competition measures corroborate substantial variation in market power: the Lerner index is 0.52 (s.d. 0.25) at the country benchmark and higher at the global benchmark (0.67, s.d. 0.21), suggesting that market power appears stronger when evaluated against the global metafrontier—consistent with the idea that technological gaps can translate into pricing power differentials. Finally, the key second-stage variables show wide dispersion in stability and meaningful time-series variation in policy. The Z-score averages 26.47 with a large s.d. of 23.65, pointing to pronounced heterogeneity in distance-to-default across banks and over time. Monetary policy stance measures are standardised (means near zero and s.d. around one), which facilitates interpretation of dynamic responses: a one-standard-deviation tightening can be mapped directly into the impulse responses of banking stability. The remaining controls exhibit substantial cross-sectional spread — e.g., liquidity ratios average 35.61 (s.d. 44.40) and concentration (CR3) averages 42.69 (s.d. 19.72) — underscoring that both bank balance-sheet structure and market structure vary sharply across the sample.

Table 1: Summary statistics across blocks

Variable	**Symbol**	**Obs**	**Mean**	**Std. Dev.**
Panel A: Stochastic metafrontier variables				
Total cost (log)	lcost	49,859	17.36	3.61
Output: Gross Loans (log)	ly1	49,859	15.92	3.66
Price of Capital Input scaled by price of labour (log)	lx2: ln(w2/w1)	49,859	3.9773	1.413
Price of borrowed funds scaled by price of labour (log)	lx3: ln(w2/w1)	49,859	0.20	1.451
GDP per capita growth	GDP p.c. growth	49,859	1.95	3.49
Inflation (CPI) (%)	Inflation	49,859	4.4279	10.8084
Inflation (GDP deflator) (%)	Inflation	49,859	4.633	12.43
Panel B: Efficiency scores				
Cost efficiency (Country frontier)	$\hat{CE}^j$	44,652	0.68	0.21
Cost efficiency (Global metafrontier)	$M\hat{C}E$:(CostEff)-Global	44,652	0.45	0.18
Cost efficiency (Regional metafrontier)	$M\hat{C}E$:(CostEff)-Regional	44,652	0.53	0.22
Cost efficiency (Development-status metafrontier)	$M\hat{C}E$:(CostEff)-Devstat	44,652	0.47	0.19
Cost efficiency (Income-dynamics metafrontier)	$M\hat{C}E$:(CostEff)-IncGrp	44,652	0.49	0.19
Cost efficiency (ECB group metafrontier)	$M\hat{C}E$:(CostEff)-ECBM	44,652	0.46	0.19
Panel C: Competition (Lerner index)				
Lerner index (Country frontier)	$\widehat{L}_{it}^{(g)}$	40,562	0.52	0.25
Lerner index (Global metafrontier)	$\widehat{L}_{it}^{M}$	40,562	0.67	0.21
Panel D: Other variables				
Monetary policy stance (official, standardised)	Policy_j^z	44,269	-0.004	0.96
Monetary policy stance (hybrid, standardised)	Policy_j^z	44,269	-0.003	0.95
Bank stability: (Z-score)	Z-score	44,652	26.47	23.65
Bank stability: NPL growth (log change)	$\Delta\ln(\text{NPL})$	39,227	0.13	1.14
Bank stability: NPL growth minus loan growth	$\Delta\log(\text{NPL})-\Delta\ell$	39,177	-12.12	3.71
Real GDP (constant 2015, USD billions)	Real GDP	44,652	6866.95	7735.67
Liquidity ratio (%)	Bank Liquidity	44,652	35.61	44.40
Bank size (log of assets)	Size	44,652	16.65	3.56
Asset structure (%)	Asset Structure	44,652	1.72	3.72
Bank concentration (%)	Bank concentration	44,533	42.69	19.72
GDP growth (%)	GDP growth	44,652	2.92	3.20
Inflation (CPI) (%)	Inflation	44,652	3.79	5.11
Institutional Quality	Quality	42,760	0.59	0.85
Net interest margin (%)	NIM	44,649	3.8290	3.6209
Loan growth (log change)	$\Delta\ell$	40,569	12.13	3.59
Loans-to-assets ratio (%)	Loans/TA	44,595	59.52	20.29
Macroprudential: Liquidity	Liquidity	43,816	0.20	0.68
Macroprudential: FX-related limit (LFX)	LFX	43,816	0.02	0.24
Macroprudential: Loan-to-value limit (LTV)	LTV	43,816	0.02	0.40
IV: Central bank independence	CBI	44,188	0.52	0.18

4 Empirical Strategies

The methods used in estimating the bank efficiency scores are discussed here. We then proceed to specify our main model, which shows the impact of monetary policy on banking stability, also accounting for the role of bank efficiency.

4.1 Estimating bank efficiency – Stochastic Metafrontier (SMF) approach

In this paper, the bank efficiency scores are estimated using the stochastic meta-frontier (SMF) cost function approach of Huang, Huang, and Liu (2014). While Huang, Huang, and Liu (2014) developed this approach to estimate technical efficiency from a production function, we apply this methodology to a cost function in a similar way as Dwumfour, Oteng-Abayie, and Mensah (2022).[3] The advantage of the SMF approach is that it enables the estimation of comparable cost functions for each country. We first estimate the country-specific cost frontier using the Stochastic Frontier (*SF*) and then move on to estimate the metafrontier cost function. In summarising the SMF, suppose that country *j*, its *SF* of the *i*th decision making unit (*DMU*) in this case bank, in the *t*th period is modelled as:

$$C_{jit} = f_t^j\left(\mathbf{X}_{jit}\right)e^{V_{jit}+U_{jit}}, \quad j = 1,2, \ldots, J: i = 1,2, \ldots, N_j; t = 1,2, \ldots, T \tag{1}$$

where C_{jit} is the scalar cost and $\mathbf{X}_{jit}$ is the vector of output Y and input prices of the *i*th bank in country *j*, for the period *t*. The subscript *t* and superscript *j* of the function, $f_t^j(.)$ of the cost frontier indicate that the technologies for the various individual groups may differ at different times. The standard *SF* approach denotes V_{jit} as the statistical noise, while U_{jit} is the term for the cost inefficiency. V_{jit}s are assumed to be $N(0, \sigma_v^{j2})$ and are independent of the $U_{jit}s$ which follow a truncated-normal distribution as $N\left(\mu^j\left(Z_{jit}\right), \sigma_u^{j2}\left(Z_{jit}\right)\right)$. Here, the truncation is done at zero and with a mode of $\mu^j\left(Z_{jit}\right)$ where the $Z_{jit}s$ are identified exogenous variables. Here, the cost efficiency (*CE*) of the bank for the country frontier in this function will be:

$$CE_{it}^j = \frac{f_t^j\left(\mathbf{X}_{jit}\right)e^{V_{jit}}}{C_{jit}} = e^{-U_{jit}} \tag{2}$$

The environmental variables Z_{jit} are exogenous to the banks, even though they are related to the *CE* of the banks in their specific countries.

Here, the meta-frontier cost function that is common to all the countries in period t is defined as $f_t^M\left(\mathbf{X}_{jit}\right)$. This function is the same for all groups $j = 1,2,\ldots,J$. The meta-frontier envelopes the individual country-specific frontiers and can be represented as:

$$f_t^j\left(\mathbf{X}_{jit}\right) = f_t^M\left(\mathbf{X}_{jit}\right)e^{U_{jit}^M}, \forall j,i,t \tag{3}$$

where $U_{jit}^M \geq 0$. This implies that $f_t^j(.) \geq f_t^M(.)$ and thus the ratio of the meta cost frontier to the *jth* group's cost frontier is defined as the technological gap ratio (*TGR*), which is repre-

[3]See Dwumfour, Oteng-Abayie, and Mensah (2022) for a complete derivation of the cost efficiency following the approach of Huang, Huang, and Liu (2014).

sented as:

$$TGR^{j}_{It} = \frac{f^{M}_{t}\left(\mathbf{X}_{jit}\right)}{f^{j}_{t}\left(\mathbf{X}_{jit}\right)} = e^{-U^{M}_{jit}} \leq 1. \tag{4}$$

The fact that each group or country is exposed to certain unique environmental characteristics – both economic and non-economic – accounts for the technological gap. This makes the technological gap component, U^{M}_{jit}, country-, bank-, and time-specific. Given the observed outputs and inputs, this ratio measures the ratio of the potential minimum cost available at the metafrontier level to the cost function at the country level. The meta-frontier of bank *i* in country *j* at time *t*, $f^{M}_{t}\left(\mathbf{X}_{jit}\right)$ can therefore be expressed as:

$$MCE_{jit} \equiv \frac{f^{M}_{t}\left(\mathbf{X}_{jit}\right) e^{V_{jit}}}{C_{jit}} = TGR^{j}_{it} \times CE^{j}_{it} \tag{5}$$

where MCE_{jit} is therefore the cost efficiency of the bank with respect to the meta cost frontier, $f^{M}_{t}(.)$, as opposed to the bank's cost efficiency, CE^{j}_{it}, with respect to the group-*j* (country) production technology $f^{j}_{t}(.)$. The estimated empirical panel framework is hence expressed as follows:

$$M\hat{C}E_{jit} \equiv T\hat{G}R^{j}_{it} \times C\hat{E}_{it}{}^{j} \tag{6}$$

where $M\hat{C}E_{jit}$ is the meta cost efficiency of bank *i* in country *j* at time *t*.

4.2 Empirical specification of SMF model

The study employs a two-step approach to estimate the cost efficiency scores based on the *SMF*. First, bank cost efficiency scores are estimated at the country level, thus using the country-specific frontier. Then, the second step is to estimate the final bank cost efficiency scores using the global cost frontier, which is referred to as the metafrontier.[4] The translog cost function is based on the bank intermediation approach, which has been used widely in the literature (Sealey Jr and Lindley, 1977; Hughes and Mester, 1993; Shamshur and Weill, 2019; Dwumfour, Oteng-Abayie, and Mensah, 2022). In this approach, banks are modelled to take deposits, convert them to loans using capital and labour. Hence, in the cost function, we use loans as the

[4]We also estimate efficiency scores using different metafrontier based on the regional classification, the income groups based on the World Bank classification, development status (developed *vs* developing) as well as comparing euro area countries under the (ECB *vs* non-ECB members).

output. The translog cost function is therefore given by:

$$\begin{aligned}\ln\left(\frac{TC_{it}}{w_{1it}}\right) &= \alpha_0 + \beta_y \ln Y_{it} + \sum_{m=2}^{3}\beta_m \ln\left(\frac{w_{mit}}{w_{1it}}\right) \\ &+ \frac{1}{2}\gamma_{yy}(\ln Y_{it})^2 + \sum_{m=2}^{3}\gamma_{ym}\ln Y_{it}\ln\left(\frac{w_{mit}}{w_{1it}}\right) \\ &+ \frac{1}{2}\sum_{m=2}^{3}\sum_{n=2}^{3}\gamma_{mn}\ln\left(\frac{w_{mit}}{w_{1it}}\right)\ln\left(\frac{w_{nit}}{w_{1it}}\right) + v_{it} + u_{it}.\end{aligned} \tag{7}$$

where TC_{it} is total operating cost of bank i at time t; Y_{it} stands for output (total gross loans); $w_{1it}, w_{2it}, w_{3it}$ represent input prices of labour, physical capital, and borrowed funds; v_{it} denotes random error term *i.i.d.* with $v_{it} \sim N(0, \sigma_v^2)$, independent of regressors; u_{it} is non-negative cost inefficiency term $u_{it} \sim N\big(\mu(Z_{it}),\ \sigma_u^2(Z_{it})\big)$ with $u_{it} \perp\!\!\!\perp v_{it}$; and $m, n \in \{2,3\}$ index the normalised input prices.

We define the input prices based on previous studies (Hasan and Marton, 2003; Fries and Taci, 2005; Davies and Tracey, 2014; Shamshur and Weill, 2019; Dwumfour, Oteng-Abayie, and Mensah, 2022). The price of labour (w_{1it}) is the ratio of staff expenses to total assets. The price of physical capital (w_{2it}) is the ratio of non-interest expenses to fixed assets. The price of borrowed funds (w_{3it}) is defined as the ratio of interest expense to total assets.

Equation (7) is estimated for each country *j*. Following Berger and Mester (1997), Dietsch and Lozano-Vivas (2000) and Dwumfour, Oteng-Abayie, and Mensah (2022), the study includes some bank-, and country-specific environmental variables that may account for technological differences among the banks. Hence, the study follows the approach of Battese and Coelli (1995) which allows for the inclusion of environmental variables such that the truncation of the distribution of the inefficiency term is of the form $N\left(\mu_{it},\ \sigma^2\right)$ where $\mu_{it} = z_{it}\delta$, with the z_{it} representing the environmental variables and the vector of unobserved scalar parameters are represented by δ. The bank-specific environmental variables included in the country-level frontier estimations are bank profitability (measured by return on average assets) and the equity ratio. Again, as noted by Fries and Taci (2005), it is essential to incorporate country-level environmental variables to account for heterogeneity in cross-country technology efficiencies and variations in service quality. Failing to account for these would assume that bank efficiency is purely driven by managerial decisions on the composition and scale of inputs. Hence, in the Metafrontier analysis, we include GDP per capita growth and inflation.[5]

[5] The *predict bc* option of the *sfpanel STATA* package is used to generate the efficiency scores (both $C\hat{E}_{it}^{\,j}$ and $M\hat{CE}_{jit}$). This option estimates the cost efficiency scores following Battese and Coelli (1988) via $E\ \{exp(\varepsilon)\}$.

4.3 Model specification: monetary policy on bank stability

We estimate the impact of monetary policy on banking stability following Equation (8) below:[6]

$$ZScore_{i,j,t} = \alpha_i + \mu_j + \delta_t + \alpha_1 Policy^{z}_{j,t-1} + \alpha_2 \text{CostEff}_{i,j,t} + \gamma \mathbf{X}^{bank}_{i,j,t} + \phi \mathbf{X}^{country}_{j,t} + \varepsilon_{i,j,t} \quad (8)$$

where *i,j,t* represents bank i in country j at time t. $Policy^{z}_{j,t-1}$, the monetary policy stance variable for country j at time $t-1$ which we discuss later under this section. The equation models the Z-score for bank i in country j at time t, denoted as $ZScore_{i,j,t}$, which serves as the dependent variable measuring a bank's distance to insolvency or financial stability which is widely used in the banking stability literature (Roy, 1952; Uhde and Heimeshoff, 2009; Houston et al., 2010; Demirgüç-Kunt and Huizinga, 2010; Carretta et al., 2015). This is calculated as follows:

$$Z_{i,j,t} = \frac{ROAA_{i,j,t} + \frac{E_{i,j,t}}{A_{i,j,t}}}{\sigma(ROAA)_{i,j}} \quad (9)$$

where $ROAA_{i,j,t}$ is the return on average assets for bank i in country j at time t, $E_{i,j,t}$ is equity, $A_{i,j,t}$ is total assets, and $\sigma(ROAA)_{i,j}$ is the standard deviation of *ROAA* for bank i in country j.[7] A higher Z-score denotes lower default probability.

Again, the right-hand side includes α_i, the bank-specific fixed effect capturing time-invariant heterogeneity across individual banks; μ_j is the country-specific fixed effect that accounts for time-invariant country differences and δ_t is the time-specific fixed effect capturing common shocks across all entities at time t. α_1, the coefficient estimating the impact of the policy change on the Z-score. α_2, the coefficient quantifying the effect of cost efficiency on bank Z-score; $\text{CostEff}_{i,j,t}$ is the cost efficiency measure for bank i in country j at time t (derived from stochastic metafrontier frontier analysis). It quantifies how changes in bank cost efficiency affect their stability. Higher values of CostEff indicate better efficiency in minimising costs for a given level of output or loans. γ, a vector of coefficients for bank-level controls, $\mathbf{X}^{bank}_{i,j,t}$. These are bank-specific covariates, including bank size, liquidity and asset structure, as used in the literature (Dwumfour, Oteng-Abayie, and Mensah, 2022). ϕ is a vector of coefficients for country-level controls, $\mathbf{X}^{country}_{j,t}$. Also following the literature (Dwumfour, Oteng-Abayie, and Mensah, 2022), we include a measure of bank asset concentration ratio based on the top 3 banks. The country controls also include macroeconomic factors, such as GDP growth and inflation, which vary by country and over time. $\varepsilon_{i,j,t}$, the idiosyncratic error term representing unobserved random shocks.

[6] We also include one lag of all controls in order to mitigate any possibility of endogeneity.

[7] We also use 3-year rolling standard deviation of ROAA as robustness. The results shown in Appendix E remain robust.

4.3.1 Measurement of monetary policy stance

We construct our monetary policy stance indicator, $Policy_{j,t-1}$, at the country–year level and merge them into the bank-level panel. This is standardised within countries so that regression coefficients reflect the effect of a one-standard-deviation monetary tightening. Following the banking and monetary transmission literature (Altunbas, Gambacorta, and Marques-Ibanez, 2014; Jiménez et al., 2014; Altunbas, Binici, and Gambacorta, 2018; Lim, Hagendorff, and Armitage, 2023), we employ the one-year lag of our policy measure to address reverse causality and to account for the delayed transmission of monetary policy to bank risk-taking and financial stability. Higher values of the monetary policy indicator correspond to a tighter policy stance. We describe the construction of our policy measure based on the Taylor rule below:

Taylor-Rule deviations. To proxy for discretionary deviations from systematic monetary policy, we calculate deviations of the observed policy rate from a benchmark Taylor-type rule (Taylor, 1993). Given the annual frequency of the data and the broad cross-country coverage, we adopt coefficients of 0.5 on both the inflation gap and the output gap, which is standard in annual cross-country banking studies (Clarida, Gali, and Gertler, 2000; Altunbas, Binici, and Gambacorta, 2018).

Output gap. The output gap is estimated country-by-country using the Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997) applied to the logarithm of real GDP with smoothing parameter $\lambda = 6.25$ as suggested by Ravn and Uhlig (2002):

$$y_{j,t} = 100 \times \left(\ln Y_{j,t} - \ln Y^*_{j,t}\right), \tag{10}$$

where $Y^*_{j,t}$ denotes HP-filtered potential output. Positive values indicate that actual output exceeds potential.

Inflation gap. The inflation gap is defined as:

$$\pi^{\text{gap}}_{j,t} = \begin{cases} \pi_{j,t} - \pi^*_j, & \text{if country } j \text{ operates an inflation-targeting regime,} \\ \pi_{j,t} - \tilde{\pi}_{j,t}, & \text{otherwise,} \end{cases} \tag{11}$$

where $\pi_{j,t}$ is annual CPI inflation, π^*_j is the official midpoint inflation target, and $\tilde{\pi}_{j,t}$ is the HP-filtered inflation trend ($\lambda = 6.25$) for non-inflation-targeting countries (Altunbas, Binici, and Gambacorta, 2018; Lim, Hagendorff, and Armitage, 2023). For non-targeting regimes, the inflation gap captures cyclical deviations of inflation from its medium-run trend.

Time-varying neutral real rate. A country-specific time-varying neutral real rate $r^*_{j,t}$ is proxied by applying the HP filter ($\lambda = 6.25$) to the ex-post real policy rate:

$$r^*_{j,t} = \text{HP}\big(i_{j,t} - \pi_{j,t}\big), \tag{12}$$

which serves as a reduced-form proxy for medium-run neutral monetary conditions (Lim, Hagendorff, and Armitage, 2023).

Taylor rule and monetary policy measure. The implied neutral nominal policy rate is given by:

$$i^*_{j,t} = r^*_{j,t} + \pi_{j,t} + 0.5\,\pi^{\text{gap}}_{j,t} + 0.5\,y_{j,t}. \tag{13}$$

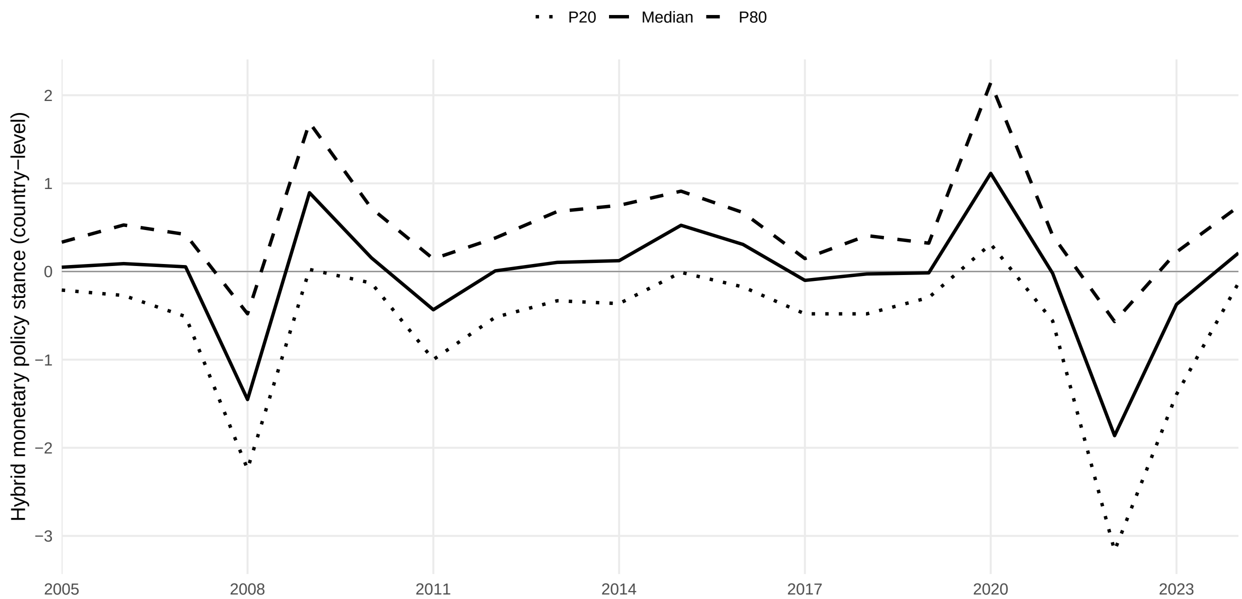
Our headline monetary policy stance indicator is the deviation of the observed policy rate from this benchmark:

$$\text{Policy}_{j,t} \equiv i_{j,t} - i^*_{j,t}. \tag{14}$$

This deviation is standardised within countries to obtain $\text{Policy}^{z}_{j,t}$, and the one-year lag $\text{Policy}^{z}_{j,t-1}$ is used in our regressions. We also use Taylor-rule deviation, using only official inflation targets (with the inflation gap set to zero for non-targeting countries), as an alternative to provide further robustness.

Figure 1 summarises the cross-country distribution of our hybrid monetary-policy stance — the first quintile (P20), median, and the last quintile (P80) — which highlights both major global episodes and dispersion in policy settings. The series exhibits pronounced accommodation around downturns, with a sharp easing during the early-2000s slowdown and a deep, broad-based policy response during the Global Financial Crisis (GFC), where the lower tail (P20) falls substantially below the median, indicating that a non-trivial subset of countries adopted exceptionally expansionary stances. The subsequent rebound and oscillation through the 2010s are consistent with gradual normalisation and intermittent renewed accommodation, with the upper tail (P80) remaining persistently above the median during several years—suggestive of heterogeneous normalisation speeds across countries. The COVID-19 episode is characterised by an abrupt, outsized surge in accommodation at the top of the distribution (P80 spiking well above the median), followed by a rapid reversal into a markedly restrictive phase in 2021–2022, with the lower tail dropping sharply and the dispersion widening; this pattern is consistent with a synchronized global pivot from pandemic-era support toward disinflationary tightening, while the cross-sectional spread indicates substantial heterogeneity in timing and intensity across countries.

Figure 1: Monetary policy stance, hybrid Taylor rule



Note: The figure reports the median, the first quintile (P20), and the last quintile (P80) of the monetary policy stance measures estimated following Equation (14). The monetary policy stance measure is given by the difference between the the observed policy rate and the neutral policy rate, calculated using the HP filter with a smoothing parameter $\lambda = 6.25$.

4.4 Monetary policy, cost efficiency, and bank Stability

To examine whether the transmission of monetary policy to bank stability depends on banks' cost efficiency, we embed the interaction between the monetary policy stance and cost efficiency within a local projection (LP) framework. For each forecast horizon $h = 0, 1, \ldots, H$, we estimate:

$$\begin{aligned} ZScore_{i,j,t+h} = \alpha_i + \mu_j + \delta_t + \beta_{1,h}\,\text{Policy}^z_{j,t-1} + \beta_{2,h}\,\text{CostEff}_{i,j,t} \\ + \beta_{3,h}\big(\text{Policy}^z_{j,t-1} \times \text{CostEff}_{i,j,t}\big) + \gamma'_h \mathbf{X}^{bank}_{i,j,t} + \phi'_h \mathbf{X}^{country}_{j,t} + \varepsilon_{i,j,t+h}. \end{aligned} \tag{15}$$

Rather than interpreting the horizon-specific coefficients in isolation, inference is based on the impulse response functions implied by Equation (15). Specifically, the dynamic response of bank stability to a one-standard-deviation monetary policy tightening at horizon h, conditional on a given level of cost efficiency, is:

$$\text{IRF}_h(\text{CostEff}) = \beta_{1,h} + \beta_{3,h}\,\text{CostEff}. \tag{16}$$

We evaluate these IRFs at selected percentiles of the cost-efficiency distribution (25th, 50th, and 75th percentiles) and trace their evolution over the forecast horizon. This approach allows us to assess how both the magnitude and the smoothness of the response of bank stability to monetary policy shocks vary systematically with efficiency, without imposing dynamic restrictions on the underlying adjustment process.

A more positive IRF at higher cost-efficiency percentiles indicates that efficient banks exhibit greater resilience to monetary tightening, consistent with stronger buffers, superior screening, or enhanced pricing capacity. Conversely, a more negative IRF among high-efficiency banks is consistent with re-optimisation or risk-taking channels, whereby efficient institutions adjust balance sheets more aggressively following policy shocks.

In the baseline specification, we do not condition on lagged bank stability, allowing the LPs to capture the full dynamic response of Z-score to the monetary shock. As a robustness check, we augment the specification with a lagged Z-score.

5 Empirical Results

Here, we discuss the results of the stochastic metafrontier analysis, based on Equation (7), and the efficiency scores generated using Equation (6). We then proceed to discuss our main results, which examine the impact of monetary policy on banking stability, with a focus on the role of bank efficiency. In this analysis, we also examine potential heterogeneities in our findings based on subsamples of our data. Specifically, we examine differences in regions based on the World Bank classifications. These are East & Asia and Pacific (EAP), Europe & Central Asia (ECA), Latin America & Caribbean (LAC), Middle East & North Africa (MENA), North America (NA), South Asia (SA) and Sub-Saharan Africa (SSA). The second grouping is based on the income groups as classified by the World Bank. These are High-Income Countries (HIC), Low-Income Countries (LIC), Lower-Middle-Income Countries (LMIC), and Upper-Middle-Income Countries (UMIC). We also categorise countries based on their development status, specifically as developed and developing countries. Lastly, given that banks under the European Central Bank (ECB) are the the only monetary Union with common currency in our sample,[8] we group the countries into ECB members and non-ECB members, given the potential dynamics of operating under a monetary union.

[8] The only other monetary bloc to be considered in our sample is the West African Economic and Monetary Union (WAEMU/UEMOA), a monetary bloc where member nations share the West African CFA Franc (XOF) as a common currency, managed by the regional central bank (BCEAO). However, our sample only has one of the member countries, Côte d'Ivoire; hence, we do not have a separate group for this bloc.

5.1 Results of stochastic metafrontier analysis

We first discuss the results from the stochastic metafrontier (SMF) analysis. The results include those related to the global frontier and the income group, as well as the regional, development status and ECB member countries sub-frontier group analysis. The results of the main global and the income group results are shown in Table 2 while the results of the other sub-groups are reported in Tables B1 to B3 in Appendix B.

The global SMF estimates in Table 2 indicate a well-behaved translog cost structure with strong statistical significance. The output elasticity component is dominated by the positive and highly significant coefficient on ln(Loans), suggesting that higher loan output is associated with higher total cost, as expected in a cost frontier setting. The first-order price effects also conform to economic intuition under the normalisation by $w1$: ln($w2/w1$) enters positively while ln($w3/w1$) enters negatively, consistent with relative-price substitutions embedded in the translog specification. The interaction and squared terms further support the notion of curvature and flexibility, indicating that marginal cost responses vary with output scale and input price configurations, rather than remaining constant.

On the inefficiency side, the μ-equation shows that GDP p.c. growth is associated with lower cost inefficiency (negative and significant), consistent with the view that stronger macroeconomic performance improves banking sector efficiency through demand expansion, balance-sheet strength, and scale economies. Inflation appears to be positively associated with cost inefficiency at the global level, which is plausible given the operational and pricing frictions that inflation can introduce into intermediation and cost management.

Turning to the group-level results, the income splits indicate meaningful heterogeneity in technology and the macro-inefficiency relationship. In particular, the effect of GDP p.c. growth is strongly negative in all four income groups, with particularly large magnitudes for LICs, indicating that macroeconomic improvements may translate into larger efficiency gains where structural constraints are more binding. The Usigma and Vsigma estimates are also uniformly significant in income groups, suggesting that the decomposition of the composite error into inefficiency and noise is empirically relevant across the samples, thereby supporting the appropriateness of the SMF framework over a pooled homogeneous-technology alternative.

Table 2: Stochastic metafrontier results – global and income groups

	Global	HIC	LIC	LIMC	UMIC
Frontier					
ln(Loans)	0.794***	0.771***	0.721***	0.862***	0.803***
	(0.003)	(0.004)	(0.011)	(0.009)	(0.015)
ln(w2/w1)	0.062***	0.011	0.508***	0.150***	0.166***
	(0.007)	(0.007)	(0.043)	(0.019)	(0.024)
ln(w3/w1)	-0.025***	0.010	-0.281***	-0.188***	-0.115***
	(0.006)	(0.007)	(0.038)	(0.024)	(0.029)
ln(Loans) × ln(w2/w1)	0.000	0.005***	-0.026***	-0.007***	-0.007***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
ln(Loans) × ln(w3/w1)	-0.001***	-0.000	0.005***	0.004***	0.000
	(0.000)	(0.000)	(0.002)	(0.001)	(0.002)
ln(w2/w1) × ln(w3/w1)	0.007***	-0.002***	0.023***	0.014***	0.036***
	(0.001)	(0.001)	(0.006)	(0.002)	(0.003)
$0.5[\ln(\text{Loans})]^2$	0.012***	0.012***	0.024***	0.008***	0.011***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
$0.5[\ln(w2/w1)]^2$	0.000	-0.009***	-0.009	0.009***	-0.005**
	(0.001)	(0.001)	(0.008)	(0.002)	(0.002)
$0.5[\ln(w3/w1)]^2$	0.002***	0.005***	0.028***	-0.023***	0.037***
	(0.001)	(0.001)	(0.007)	(0.003)	(0.003)
Constant	1.889***	2.207***	1.442***	1.536***	1.949***
	(0.034)	(0.038)	(0.145)	(0.099)	(0.145)
Mu					
GDP p.c. growth	-0.071***	-0.070***	-0.435***	-0.066***	-0.076***
	(0.002)	(0.005)	(0.027)	(0.003)	(0.005)
Inflation	0.002***	-0.593***	0.032***	0.002***	-0.021***
	(0.000)	(0.026)	(0.005)	(0.000)	(0.004)
Usigma					
Constant	-0.408***	-0.138***	-0.480***	-0.405***	-0.112***
	(0.008)	(0.024)	(0.071)	(0.022)	(0.028)
Vsigma					
Constant	-4.321***	-4.750***	-3.786***	-3.258***	-2.890***
	(0.021)	(0.022)	(0.099)	(0.046)	(0.049)
Observations	49,859	29,744	1,779	9,922	8,136
Log Likelihood	-28640.004	-8945.604	-459.696	-6523.118	-6325.623
Wald χ^2	7886434.96	5436008.99	578517.87	627949.26	436108.16

Note: Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Turing to the other group-level results presented in Tables B1 to B3 in Appendix B reinforce this pattern. For instance, the regional SMF results presented in Table B2 reinforce the argument that banks operate under heterogeneous technologies across geographic clusters. The results imply differences in cost structures and the way input-price pressures translate into total cost. For example, the differences in the output coefficients and the interaction terms involving ln(Loans) and input prices signal meaningful cross-regional differences in scale and substitution patterns. The μ-equation also exhibits notable heterogeneity: GDP p.c. growth remains predominantly efficiency-enhancing across regions (negative coefficients in most cases), while the inflation effect is more mixed in sign and magnitude. The ECB split further suggests that the cost structure and macro-inefficiency channel differ materially between ECB and non-ECB systems, which is consistent with differing regulatory, monetary, and competitive environments.

Table 3: Likelihood ratio tests (Kodde–Palm critical values)

Item	**N**	**LL_U**	**LL_R**	**LR_stat**	**KP10**	**KP5**	**KP1**	**Reject–10%**	**Reject–5%**	**Reject–1%**	**p_KP**
Global	49,859	-2.86e+04	-4.20e+04	26626.154	1.642	2.706	5.412	1	1	1	0.000
East Asia & Pacific	6,872	-4468.153	-4992.373	1048.440	1.642	2.706	5.412	1	1	1	0.000
Europe & Central Asia	12,392	-7557.901	-9083.080	3050.357	1.642	2.706	5.412	1	1	1	0.000
Latin America & Caribbean	2,826	-1678.136	-2026.449	696.626	1.642	2.706	5.412	1	1	1	0.000
Middle East & North Africa	4,026	-3826.647	-4239.617	825.941	1.642	2.706	5.412	1	1	1	0.000
North America	16,756	33800.153	32592.898	2414.510	1.642	2.706	5.412	1	1	1	0.000
South Asia	5,414	-807.326	-1872.228	2129.804	1.642	2.706	5.412	1	1	1	0.000
Sub-Saharan Africa	1,806	-1348.248	-1560.066	423.636	1.642	2.706	5.412	1	1	1	0.000
High Income	29,744	-8945.604	-1.89e+04	19906.875	1.642	2.706	5.412	1	1	1	0.000
Low Income	1,779	-459.696	-983.758	1048.124	1.642	2.706	5.412	1	1	1	0.000
Lower Middle	9,922	-6523.118	-7963.633	2881.031	1.642	2.706	5.412	1	1	1	0.000
Upper Middle	8,414	-6514.501	-7634.378	2239.754	1.642	2.706	5.412	1	1	1	0.000
Developed	30,243	-9009.575	-1.63e+04	14594.386	1.642	2.706	5.412	1	1	1	0.000
Developing	19,616	-1.57e+04	-2.01e+04	8806.766	1.642	2.706	5.412	1	1	1	0.000
Non-ECB	44,921	-2.40e+04	-3.69e+04	25815.727	1.642	2.706	5.412	1	1	1	0.000
ECB	4,938	-2782.731	-3592.649	1619.836	1.642	2.706	5.412	1	1	1	0.000

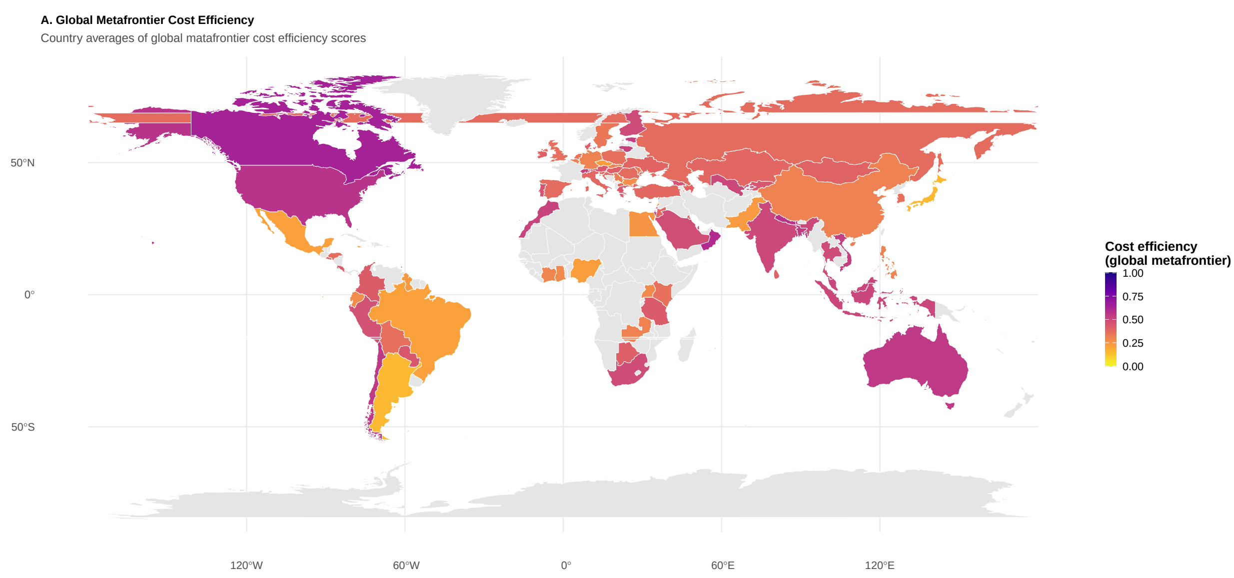
Reject: 1 to reject null and 0 fail to reject.

The LR test results in Table 3 with Kodde–Palm critical values provide a formal complement to the coefficient-based narrative. Across the global sample and each classification group (regions, income groups, development status, and ECB membership), the reported LR_stat values are substantially larger than the relevant KP critical thresholds at 10%, 5%, and 1%. This implies a strong rejection of the null of no cost inefficiency across all panels, confirming that the one-sided inefficiency component is empirically non-trivial. More importantly for the paper's organising theme, the consistent rejections across panels support the interpretation that technology (and thus the attainable cost frontier) differs meaningfully across banks from different countries, regions, income groups and development status, validating the use of a stochastic metafrontier approach to summarise within-country efficiency and between-group technology gaps in a single coherent framework. Overall, these results highlight the technological and environmental heterogeneities that drive metafrontier gaps.

5.1.1 Efficiency scores

We move to discuss the cost efficiency scores generated following Equation (7). We present the map of efficiency scores to illustrate the differences between countries and regions in terms of efficiency, as well as the coverage of our dataset. These are shown in Figures 2 and 3. Figure 2 indicates a clear clustering by level of financial development and institutional capacity. High efficiency tends to be concentrated in advanced and well-supervised banking systems (e.g., North America, Northern/Western Europe, and high-income Asia such as Singapore), consistent with stronger managerial practices, tighter cost discipline, and deeper financial infrastructures that support scale and process standardisation. By contrast, lower efficiency values are more prevalent in parts of Latin America and Sub-Saharan Africa, as well as in several emerging/frontier systems, reflecting greater operational frictions (e.g., higher overheads, weaker intermediation technology, and more volatile macro-financial environments). The dispersion is economically meaningful, as the cross-country range is wide (from roughly 0.17 to 0.60), which motivates our use of a metafrontier approach to ensure that the cross-country efficiency signal captures managerial/operational performance net of technology heterogeneity, rather than simply reflecting differences in country-specific banking technologies.

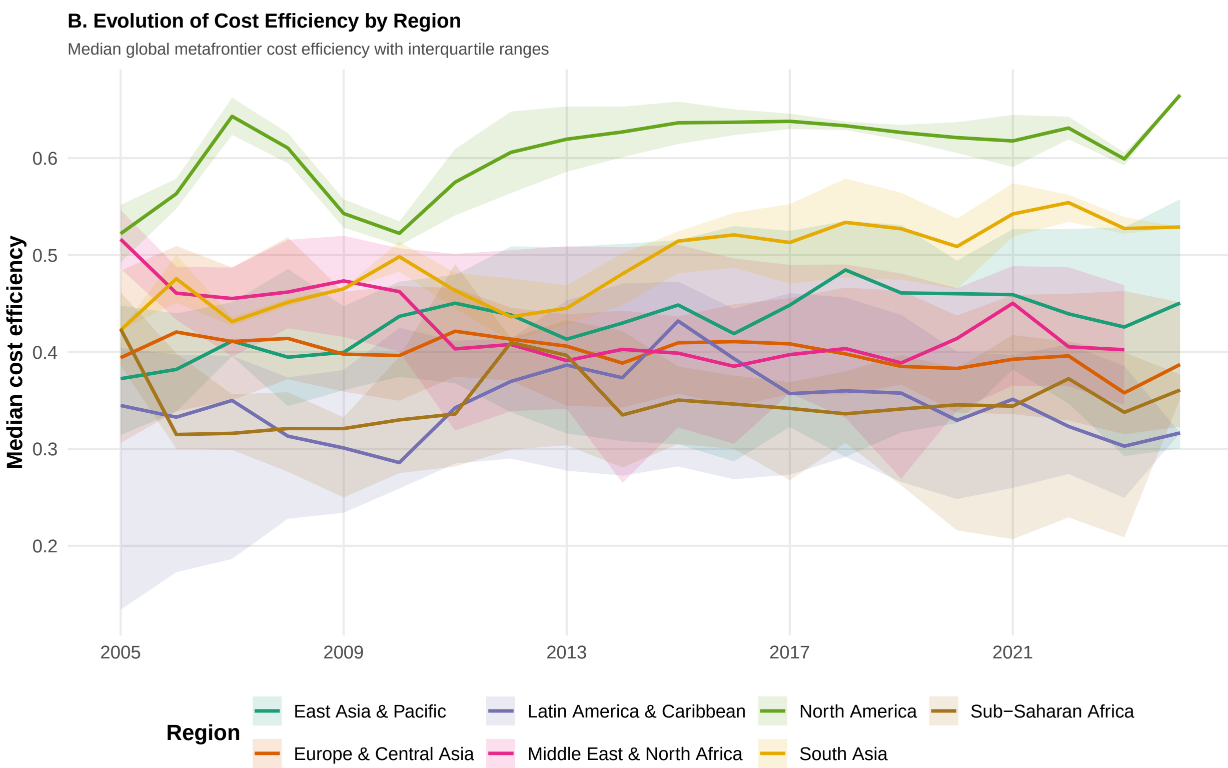
Figure 2: Global metafrontier cost efficiency scores



Note: Grey areas represent missing data.

The trend of regional medians of metafrontier cost efficiency in Figure 3, reveal level-and-trend heterogeneity across the global banking landscape. North America consistently exhibit the highest median efficiency levels (typically around 0.5–0.65), followed by South Asia. East Asia & Pacific and Europe & Central Asia occupy an intermediate range (roughly 0.38–0.48 over most years). By contrast, Latin America & the Caribbean and Sub-Saharan Africa tend to post lower medians (often around 0.30–0.37), indicating systematically larger cost inefficiencies relative to the global best-practice technology. Importantly, aside North America and South Asia where cost efficiency has seen some gradual upward drift consistent with longer-run diffusion of managerial practices and intermediation technologies, while the other regions have seen relatively stable cost efficiency over the period showing persistent cross-region gaps.

Figure 3: Trend of median metafrontier cost efficiency by region



5.2 Monetary policy on banking stability

Table 4 presents the core empirical result of the paper: monetary tightening is associated with higher bank stability, measured by the Z-score, after absorbing a rich set of bank fixed effects, country fixed effects, and common time shocks. Across both measures of policy stance — the hybrid and the official indicator — the estimated coefficient on $\text{Policy}^{z}_{j,t-1}$ is positive and highly statistically significant. This pattern is robust to alternative timing conventions: the contemporaneous specification (Models 1 and 3) and the fully lagged specification (Models 2 and 4) deliver qualitatively identical conclusions, with the lagged models yielding somewhat larger point estimates. Quantitatively, this effect is consequential. For instance, a one standard deviation increase in the policy stance (0.95) leads to a 0.14 (Model 1) increase in Z-score. The baseline evidence, therefore, supports the first pillar of our central hypothesis: at least over the average policy cycle in the sample, tightening shocks tend to strengthen bank stability rather than weaken it.

The role of cost efficiency emerges as the second pillar of the paper's narrative. The coefficient of cost-efficiency is positive and statistically significant in both the contemporaneous and lagged specifications. This suggests that more efficient banks are systematically more stable, consistent with an interpretation of efficiency based on "operational discipline" or "risk management capacity" as discussed earlier (Berger and DeYoung, 1997). When all predictors are lagged (Models 2 and 4), the cost-efficiency coefficient attenuates but remains statistically significant, which is informative. Cost efficiency is typically persistent, may be partially absorbed by bank fixed effects, and its marginal contribution is more difficult to isolate when measured in the presence of noise and dynamics. This motivates the paper's emphasis on dynamic responses and heterogeneity: efficiency is not only a level shifter of stability, but also a conditioning state that shapes how stability responds over time to a common monetary tightening shock—an implication that the subsequent local-projection IRFs are designed to quantify.

The results of the remaining covariates are consistent with literature. Liquidity and asset structure are positively related to stability, consistent with balance-sheet resilience and portfolio composition buffering shocks. In contrast, larger banks display lower stability in this specification, which is consistent with greater risk-taking capacity (moral hazard problem), complexity, or thinner capital buffers once fixed effects are controlled for (Uhde and Heimeshoff, 2009). On the macro side, stronger GDP growth and higher institutional quality are robustly stabilising, while inflation is stabilising only in the contemporaneous models and becomes insignificant under lags, consistent with inflation capturing short-run nominal effects that are less predictive once dynamics are accounted for. Taken together, these results motivate the paper's organising proposition: monetary tightening can be stabilising on impact, but the durability and distribution of this effect depend on bank-level capacity—proxied by cost efficiency—which we examine directly in the dynamic, state-contingent local-projection analysis that we discuss subsequently.

Table 4: Impact of monetary policy on banking stability

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	0.1391***	0.1159***	0.1736***	0.1544***
	(0.0389)	(0.0374)	(0.0395)	(0.0381)
Cost efficiency	4.301***	2.621***	4.297***	2.610***
	(0.8219)	(0.7868)	(0.8221)	(0.7872)
Bank liquidity	0.0298***	0.0161***	0.0298***	0.0161***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.754***	-1.855***	-2.752***	-1.852***
	(0.1980)	(0.1781)	(0.1981)	(0.1781)
Asset structure	0.1087***	0.0576	0.1089***	0.0575
	(0.0405)	(0.0384)	(0.0404)	(0.0383)
Bank Concentration	0.0272**	0.0440***	0.0275**	0.0444***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0413***	0.0352**	0.0382**	0.0325**
	(0.0153)	(0.0142)	(0.0154)	(0.0142)
Inflation (CPI)	0.0362***	0.0089	0.0357***	0.0086
	(0.0116)	(0.0109)	(0.0116)	(0.0109)
Institutional Quality	2.912***	3.246***	2.849***	3.175***
	(0.7138)	(0.7253)	(0.7125)	(0.7240)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Clustered (bank level) standard errors in parentheses.

Lag 1 of all predictors in Models (2) and (4).

****p<0.01, **p<0.05, *p<0.1.*

5.3 Robustness: sub-sample/group analysis

We assess the external validity of our baseline results by allowing the effect of monetary tightening on bank stability to vary systematically across economic and institutional environments. Specifically, we estimate heterogeneous policy effects across the World Bank regions (EAP, ECA, LAC, MENA, NA, SA, and SSA), across income groups (HIC, UMIC, LMIC, LIC), across development status (developed versus developing), and across monetary union membership (ECB versus non-ECB). These splits are informative because the transmission of policy to bank balance sheets depends on the maturity and structure of financial systems, the prevalence of variable-rate credit, the depth of capital markets, the regulatory regime, and the degree to which policy shocks are amplified by macroeconomic conditions. The corresponding estimates are reported in Tables C1–C4 in Appendix C, and the patterns are robust to also using the group-specific metafrontier cost efficiency measures.[9]

Across most regions, monetary tightening is associated with higher bank stability, with the strongest effects in North America, Sub-Saharan Africa, the Middle East & North Africa, Latin America & the Caribbean and a smaller but still positive effect in East Asia & the Pacific, consistent with tighter conditions improving portfolio risk through stricter underwriting and a more conservative balance-sheet stance. The main exception is Europe & Central Asia (ECA), where the estimated effect is negative. The ECA result is plausible if the dominant transmission margin is asset-quality and valuation losses rather than improved risk selection: sharp rate increases can raise debt-service burdens for leveraged borrowers, elevate defaults among marginal firms and households, and generate mark-to-market losses on securities holdings, while competitive banking structures and exposure to slow-repricing (often fixed-rate) assets can compress profitability and slow internal capital generation in the short run. Moreover, institutional features—such as tight capital and liquidity requirements and the joint operation of macroprudential and monetary tightening—can weaken the mapping from policy rates to measured stability, and region-specific macro shocks (including energy and geopolitical disturbances) may coincide with tightening and amplify borrower distress. Taken together, the ECA evidence indicates that the net stability effect of tighter policy is regime-dependent: it is positive when tighter conditions primarily reduce risk-taking, but can turn negative when valuation and credit-loss channels dominate.

The income-group and development-status splits reinforce the baseline conclusion that monetary tightening is, on average, stabilising, while clarifying where the stabilisation is most pronounced. The positive effect is present across all income groups and appears strongest in low-income countries, with a similarly larger effect in developing economies relative to de-

[9] Tables D1 to D8 in Appendix D.

veloped ones. A plausible interpretation is that in lower-income and developing settings, periods of accommodative policy may be more closely associated with rapid credit expansion, weaker screening, and higher marginal borrower risk; tightening, therefore, delivers larger improvements in portfolio quality and risk discipline. At the same time, the ECB split highlights that policy effects are not uniform across monetary regimes: we find significant stabilising effects in non-ECB countries but no statistically meaningful effect for ECB members as a group. This pattern is consistent with the notion that in monetary unions, country-level bank outcomes depend not only on the common policy rate but also on cross-country differences in financial structure, sovereign-bank linkages, and the interaction of common monetary policy with heterogeneous macro conditions; aggregation across member states can therefore attenuate average effects. Across all subsamples, cost efficiency remains positively associated with stability, underscoring that the efficiency-stability nexus is not a sample-specific artefact but rather a pervasive margin shaping banks' resilience. Overall, the subgroup evidence supports the central theme of the paper — tightening is typically stabilising, and efficiency strengthens resilience — while also emphasising that the sign and magnitude of policy effects are state– and structure–dependent, with ECA representing an empirically and economically coherent regime in which valuation and borrower-solvency channels can dominate.

5.4 Monetary policy on banking stability (interaction with cost efficiency)

We next evaluate whether the stabilising effect of monetary tightening is systematically heterogeneous across banks with different levels of cost efficiency. The central empirical object is the interaction between the policy stance and bank-level cost efficiency. In line with our conceptual framework, this interaction is intended to capture an *efficiency-buffer* mechanism: conditional on the same monetary policy shock, more cost-efficient banks should be able to preserve stability more effectively because they manage risk and operating costs better, adjust balance-sheet policies with less disruption, and face a lower marginal cost of screening, monitoring, and internal control.

An essential point for interpretation is that the interaction term captures how this marginal policy effect changes with efficiency. A positive interaction is consistent with efficiency, amplifying the stabilising component of tightening and/or attenuating its destabilising component when tightening becomes prolonged. Importantly, in our empirical strategy, we capture non-linearity by emphasising a dynamic response: the impulse response of stability can rise initially and subsequently decline over the horizon, even when the contemporaneous regression is locally linear. In this sense, the interaction is interpreted through the entire IRF path rather than through a static curvature restriction in the policy variable.

Our local-projection IRFs shown in Figure 4 directly operationalise this logic. The left panel (i) follows Equation (15) while the right panel (ii) follows the same equation but includes one lag of the dependent variable (Z-score). From Panel (i), conditioning on cost efficiency (at the 25th, 50th, and 75th percentiles), we find that a tightening shock increases stability on impact and in the short run, but the response begins to weaken and eventually turns negative as the horizon extends. Crucially, the decline in stability is markedly smoother for high-efficiency banks (cost efficiency at 75th percentile): the post-peak deterioration is less steep, and the adjustment path is less volatile relative to low-efficiency banks (cost efficiency at 75th percentile). These results are similar in Panel (ii), where it takes after 4 years for stability to reach the negative territory for high cost-efficient banks, compared to 3 years for low cost-efficient banks. This is precisely the pattern predicted by the efficiency-buffer hypothesis: more efficient institutions do not merely start from higher stability; they also exhibit greater resilience as the tightening episode persists. In economic terms, efficiency appears to shift the effective "turning point" of the stability response outward and dampen the sensitivity of stability to prolonged policy restraint, consistent with superior risk governance and operational flexibility rather than simple margin expansion.

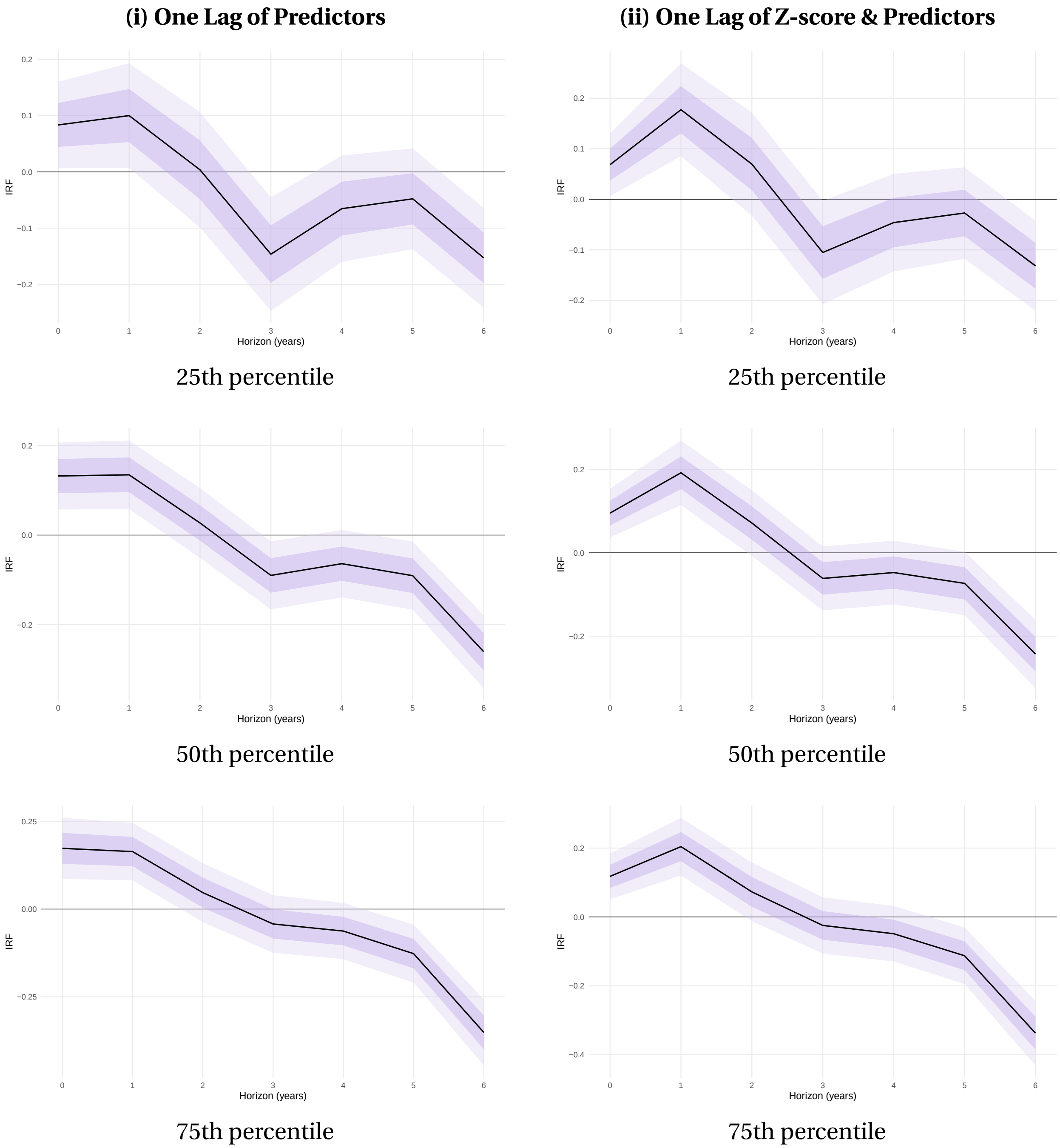
5.5 Robustness: controlling for macroprudential policies

To strengthen the identification of monetary policy effects on banking stability and to further mitigate potential omitted variable bias, we control for time-varying macroprudential policies. Macroprudential tools are frequently deployed in conjunction with monetary policy to address financial stability risks; hence, it is important for us to control for these tools.

We draw on the updated iMaPP database of Alam et al. (2025), which provides detailed monthly policy action indicators for 17 macroprudential instruments across a broad set of advanced and emerging market economies. Each tightening action is coded as +1, each loosening as −1, and no change or neutral actions as 0, while the sum of these actions gives the cumulative policy decision. Following Alam et al. (2025), we aggregate these monthly indicators to the annual frequency by summing actions within each year, yielding net cumulative annual tightening (positive values) or loosening (negative values).

Our preferred macroprudential controls are: i) *Liquidity requirements (Liquidity)*: This index captures measures aimed at mitigating systemic liquidity and funding risks, including liquidity coverage ratios, net stable funding ratios, liquid asset ratios, core funding ratios, and non-currency-specific external debt restrictions. ii) *Limits on foreign exchange positions (LFX)*: This index includes limits on net or gross open foreign exchange positions, FX exposures, FX funding restrictions, and currency mismatch regulations.

Figure 4: Local projections responses of banking stability (Z-score), conditional on bank cost efficiency



Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of Z-score and predictors.

These two instruments are selected because Alam et al. (2025) and Cerutti, Claessens, and

Laeven (2017) identify liquidity requirements as the most frequently used macroprudential tool in advanced economies and limits on foreign exchange positions as the predominant instrument in emerging market and developing economies (EMDEs). Given the global scope of our sample, which includes both advanced and emerging markets, these controls are particularly relevant for capturing the dominant macroprudential responses in each country group.

As a further robustness check, we alternatively replace LFX with limits on loan-to-value ratios (LTV), which cover caps on residential and commercial mortgages as well as other secured loans (including "speed limits" on high-LTV lending). LTV restrictions are among the most targeted borrower-based instruments, providing an additional dimension of macroprudential tightening that operates through credit demand rather than bank liquidity or currency risk.

By including these macroprudential indices (entered contemporaneously and lagged where appropriate), we isolate the effects of monetary policy from concurrent regulatory actions aimed at financial stability. The results, reported in Tables 5 and 6, confirm that our baseline findings on the impact of monetary policy tightening on bank stability remain robust and, if anything, are strengthened (coefficients of the monetary policy variables increased slightly) after accounting for these key macroprudential policy dimensions.

The results from our LP regressions following the interactions between monetary policy and cost efficiency are also presented in Figure 5. The results are consistent with our earlier findings on the *efficiency buffer*, where high-cost-efficient banks exhibit a smoother stability response to monetary policy shocks over the horizon.

Figure 6 plots local-projection impulse responses of bank stability (Z-score) to a one-standard-deviation monetary tightening shock, conditional on bank cost efficiency (25th, 50th, and 75th percentiles), while controlling for macroprudential policies that operate through liquidity requirements and loan-to-value (LTV) limits. Three findings stand out. First, the qualitative pattern of short-run stabilisation followed by medium-run deterioration remains intact after conditioning on LTV policy. Across all efficiency percentiles and in both columns, a tightening shock raises Z-score on impact and over short horizons, but this initial improvement steadily unwinds as the horizon extends, with the response eventually turning negative at medium horizons. This persistence of sign reversal under LTV controls strengthens the interpretation that the medium-run decline is not an artefact of omitted borrower-based macroprudential tightening, but rather reflects the delayed propagation of tighter monetary conditions into realised asset-quality stress.

Table 5: Impact of monetary policy on banking stability controlling for macroprudential policies (Liquidity and LFX) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	0.1367***	0.1057***	0.1724***	0.1435***
	(0.0400)	(0.0382)	(0.0406)	(0.0391)
Cost efficiency	4.239***	2.549***	4.236***	2.540***
	(0.8304)	(0.7940)	(0.8306)	(0.7944)
Bank liquidity	0.0300***	0.0164***	0.0299***	0.0164***
	(0.0030)	(0.0023)	(0.0030)	(0.0023)
Size	-2.768***	-1.863***	-2.766***	-1.861***
	(0.2016)	(0.1806)	(0.2016)	(0.1807)
Asset structure	0.1120***	0.0591	0.1121***	0.0591
	(0.0417)	(0.0393)	(0.0417)	(0.0393)
Bank Concentration	0.0251**	0.0418***	0.0254**	0.0421***
	(0.0110)	(0.0122)	(0.0110)	(0.0122)
GDP growth	0.0414**	0.0445***	0.0380**	0.0416***
	(0.0171)	(0.0154)	(0.0172)	(0.0155)
Inflation (CPI)	0.0311**	0.0043	0.0307**	0.0041
	(0.0126)	(0.0119)	(0.0126)	(0.0119)
Institutional Quality	2.656***	3.118***	2.588***	3.048***
	(0.7361)	(0.7488)	(0.7348)	(0.7475)
Macroprudential: Liquidity	-0.1781***	-0.1978***	-0.1755***	-0.1948***
	(0.0457)	(0.0449)	(0.0457)	(0.0449)
Macroprudential: LFX	0.2998***	0.3066***	0.2954***	0.3031***
	(0.1083)	(0.1081)	(0.1083)	(0.1080)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,690	38,426	41,690	38,426
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4). LFX: Limits on FX positions.
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table 6: Impact of monetary policy on banking stability controlling for macroprudential policies (Liquidity and LTV) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	0.1243***	0.0942**	0.1612***	0.1332***
	(0.0399)	(0.0379)	(0.0405)	(0.0388)
Cost efficiency	4.302***	2.601***	4.298***	2.590***
	(0.8307)	(0.7938)	(0.8309)	(0.7943)
Bank liquidity	0.0300***	0.0163***	0.0300***	0.0163***
	(0.0030)	(0.0023)	(0.0030)	(0.0023)
Size	-2.773***	-1.870***	-2.772***	-1.868***
	(0.2014)	(0.1805)	(0.2014)	(0.1806)
Asset structure	0.1121***	0.0584	0.1123***	0.0584
	(0.0416)	(0.0391)	(0.0416)	(0.0390)
Bank Concentration	0.0246**	0.0413***	0.0250**	0.0416***
	(0.0110)	(0.0122)	(0.0110)	(0.0122)
GDP growth	0.0530***	0.0553***	0.0493***	0.0521***
	(0.0167)	(0.0151)	(0.0168)	(0.0152)
Inflation (CPI)	0.0367***	0.0100	0.0362***	0.0096
	(0.0125)	(0.0118)	(0.0125)	(0.0118)
Institutional Quality	2.634***	3.099***	2.567***	3.029***
	(0.7337)	(0.7471)	(0.7325)	(0.7460)
Macroprudential: Liquidity	-0.1926***	-0.2117***	-0.1897***	-0.2083***
	(0.0451)	(0.0447)	(0.0452)	(0.0447)
Macroprudential: LTV	-0.2578***	-0.2532***	-0.2508***	-0.2461***
	(0.0922)	(0.0852)	(0.0922)	(0.0852)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,690	38,426	41,690	38,426
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4). LTV: Limits on Loan-to-Value Ratio
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Second, the *efficiency-buffer mechanism* continues to be clearly visible. The post-peak decline is systematically smoother for banks at the 75th percentile of cost efficiency than for those at the 25th percentile: high-efficiency banks exhibit a less steep deterioration and a more gradual transition toward negative territory. Put differently, conditioning on LTV restrictions does not eliminate cross-bank heterogeneity in the stability path; instead, it reinforces the idea that operational and risk-control capacity governs how quickly (and how sharply) the delayed fragility component dominates the initial stabilisation effect.

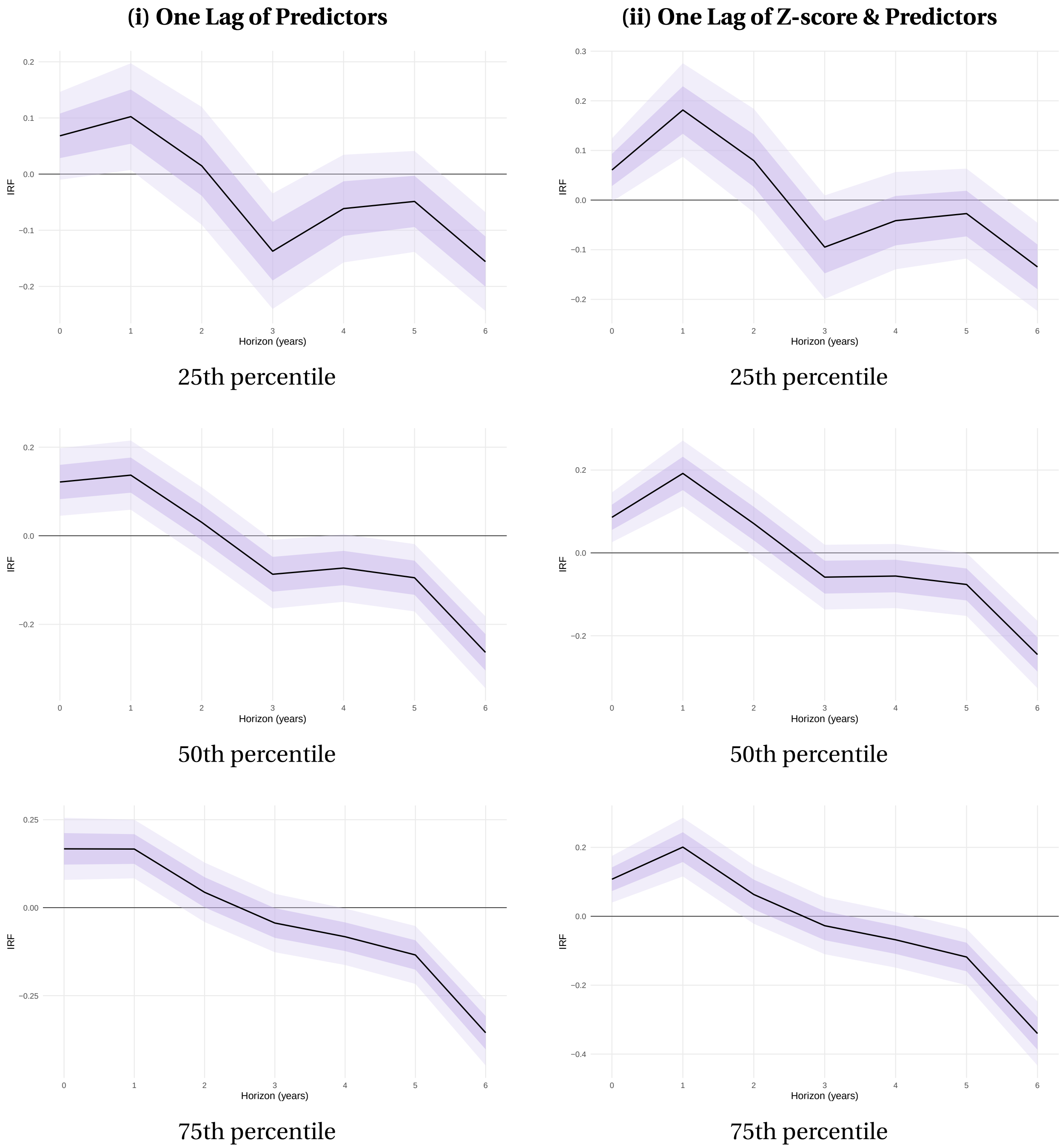
Third, the comparison across columns (i) and (ii) indicates that the main message is robust to dynamics in the dependent variable. Adding lagged Z-score (column (ii)) changes the shape of the IRFs mechanically—by absorbing persistence in stability—but the core ordering across efficiency groups and the horizon-dependent weakening of the tightening effect remain. Overall, Figure 6 therefore corroborates the central narrative: monetary tightening tends to strengthen measured bank stability in the near term, yet this benefit is not durable, and cost efficiency materially dampens the medium-run deterioration even after accounting for borrower-side macroprudential policy via LTV limits.

5.6 Channel analysis: banking intermediation channel (bank spread)

This section examines the mechanisms by which monetary policy shocks affect bank stability and how this transmission varies with cost efficiency. We focus on the banking spread — measured by net interest margin (NIM) — as the primary channel, because it directly captures the repricing wedge between interest income on assets and interest expense on liabilities following tightening episodes. Complementary channels are analysed in sections 6 and F in Appendix E: we document: i) the response of credit growth and ii) portfolio-adjustment behaviour (loan share reallocation), which provide additional evidence on banks' balance-sheet management but are not treated as the main organising mechanism in the baseline discussion.

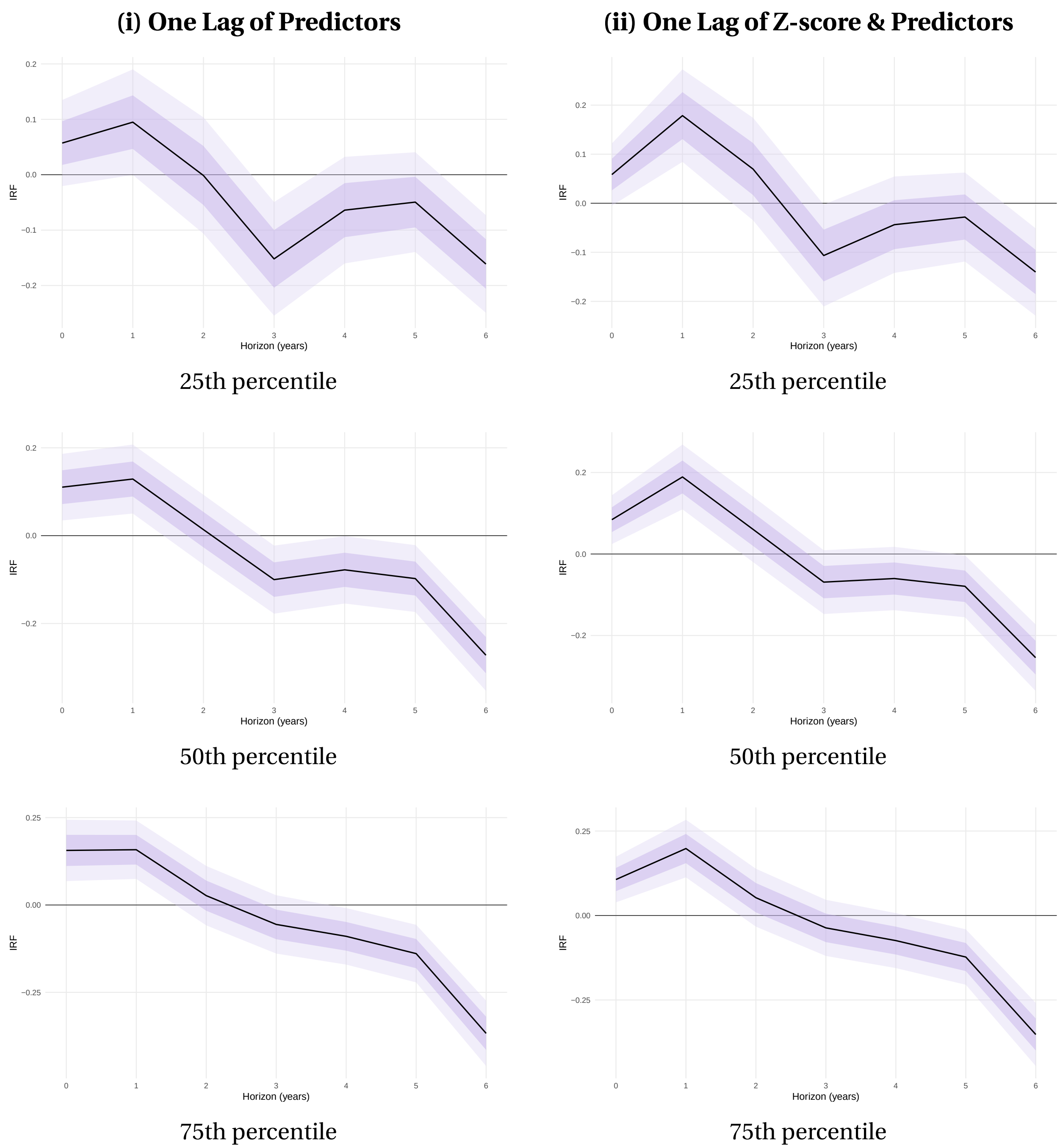
We begin by estimating reduced-form regressions of NIM on the monetary policy stance measure and the bank-level and macro controls, as defined in Equation (8). We then implement local projections following Equation (15) to trace the dynamic response of NIM to a policy tightening, conditional on cost-efficiency percentiles. The regression evidence in Tables 7–9 indicates that tightening compresses bank spreads on average, with the magnitude generally becoming more negative once macroprudential controls are included.

Figure 5: Local Projections responses of banking stability (Z-score), controlling for macroprudential policies (Liquidity and LFX)



Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LFX). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of Z-score and predictors.

Figure 6: Local projections responses of banking stability (Z-score), controlling for macroprudential policies (Liquidity and LTV)



Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LTV). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of Z-score and predictors.

The LP evidence in Figures 7–9 shows that at short horizons ($h = 0$–3) the NIM response is negative across the 25th, 50th, and 75th percentiles of cost efficiency, consistent with asymmetric repricing: funding costs (particularly wholesale and rate-sensitive deposits) adjust rapidly, while loan yields and securities returns reprice more sluggishly due to fixed-rate exposures, contractual rigidities, interest-rate caps, and competitive constraints.

These results suggest that conditioning the stability response to policy shocks on cost efficiency reveals a systematic pattern of heterogeneity. Although differences are not always statistically significant, lower-efficiency banks exhibit a faster and smoother NIM reversal relative to higher-efficiency banks, while high-efficiency banks experience a more persistent NIM compression (lasting up to roughly three years) before recovering. Our interpretation is that, conditional on a common country-level policy shock, less efficient banks restore margins more quickly through stronger pass-through and strategic repricing (e.g., faster loan-rate adjustment, wider spreads, reallocation toward higher-yield assets, or a funding mix that reprices differently). By contrast, high-efficiency banks display a more muted NIM recovery, consistent with greater competitive discipline, a liability structure that transmits tightening more strongly into interest expense, and/or an active choice to prioritise asset quality over yield chasing (Rajan, 2006). Importantly, this pattern aligns with our core stability results: efficient banks remain more stable despite weaker NIM recovery. Consequently, the heterogeneous stability responses to tightening are unlikely to be driven by differential margin buffers. This evidence supports the risk-management and operational discipline (screening and monitoring quality, provisioning practices, and cost control) interpretation of cost efficiency: efficient banks attenuate the translation of tightening into credit losses (and thus into Z-score deterioration), consistent with their lower marginal cost of monitoring and superior underwriting/portfolio discipline.

6 Complementary Channel: Credit Growth

As complementary evidence on balance-sheet adjustment, we examine the credit-growth response to monetary tightening, conditioning on bank cost efficiency. Credit growth captures the lending margin through which policy shocks propagate to bank balance sheets—via shifts in loan supply, funding conditions, and internal constraints. We estimate local projections in which the dependent variable is bank credit growth (log changes, $\Delta\ell$), and the key regressor is the monetary policy stance shock interacted with cost efficiency, controlling for the same bank-level and macro covariates as in Equation (15). Figures 10–12 report impulse responses evaluated at the 25th, 50th, and 75th percentiles of the efficiency distribution.

Table 7: Channel analysis: impact of monetary policy on banking spread (NIM) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	-0.0368***	-0.0344***	-0.0369***	-0.0364***
	(0.0135)	(0.0133)	(0.0131)	(0.0130)
Cost efficiency	1.516***	0.8358***	1.518***	0.8383***
	(0.3309)	(0.2908)	(0.3309)	(0.2908)
Bank liquidity	-0.0012	-0.0016	-0.0012	-0.0016
	(0.0010)	(0.0011)	(0.0010)	(0.0011)
Size	-0.1155*	-0.3321***	-0.1158*	-0.3325***
	(0.0701)	(0.0643)	(0.0701)	(0.0643)
Asset structure	-0.0551	-0.0665	-0.0551	-0.0665
	(0.0516)	(0.0450)	(0.0516)	(0.0450)
Bank Concentration	-0.0021	-0.0014	-0.0021	-0.0014
	(0.0032)	(0.0033)	(0.0032)	(0.0033)
GDP growth	0.0110**	0.0088*	0.0112**	0.0090*
	(0.0054)	(0.0049)	(0.0055)	(0.0049)
Inflation (CPI)	0.0564***	0.0525***	0.0565***	0.0526***
	(0.0097)	(0.0089)	(0.0097)	(0.0089)
Institutional Quality	-0.3016	-0.1815	-0.2962	-0.1733
	(0.2068)	(0.2049)	(0.2068)	(0.2048)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,516	39,168	42,516	39,168
R^2	0.84	0.85	0.84	0.85

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table 8: Channel analysis: impact of monetary policy on banking spread (NIM), controlling for macroprudential policies (Liquidity and LFX) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	-0.0442***	-0.0460***	-0.0443***	-0.0473***
	(0.0138)	(0.0136)	(0.0134)	(0.0133)
Cost efficiency	1.519***	0.8384***	1.521***	0.8415***
	(0.3351)	(0.2947)	(0.3350)	(0.2947)
Bank liquidity	-0.0013	-0.0016	-0.0013	-0.0016
	(0.0010)	(0.0011)	(0.0010)	(0.0011)
Size	-0.1306*	-0.3400***	-0.1308*	-0.3405***
	(0.0709)	(0.0651)	(0.0708)	(0.0650)
Asset structure	-0.0576	-0.0702	-0.0576	-0.0702
	(0.0521)	(0.0458)	(0.0521)	(0.0458)
Bank Concentration	-0.0030	-0.0024	-0.0031	-0.0025
	(0.0032)	(0.0033)	(0.0032)	(0.0033)
GDP growth	0.0138**	0.0135**	0.0140**	0.0138***
	(0.0061)	(0.0053)	(0.0061)	(0.0053)
Inflation (CPI)	0.0556***	0.0517***	0.0556***	0.0518***
	(0.0107)	(0.0097)	(0.0107)	(0.0097)
Institutional Quality	-0.3830*	-0.2655	-0.3761*	-0.2560
	(0.2141)	(0.2121)	(0.2140)	(0.2120)
Macroprudential: Liquidity	-0.0517***	-0.0687***	-0.0520***	-0.0690***
	(0.0178)	(0.0183)	(0.0178)	(0.0183)
Macroprudential: LFX	-0.0246	-0.0463	-0.0232	-0.0448
	(0.0398)	(0.0388)	(0.0398)	(0.0388)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,687	38,424	41,687	38,424
R^2	0.84	0.85	0.84	0.85

Note: Lag 1 of all predictors in Models (2) and (4). LFX: Limits on FX

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table 9: Channel analysis: impact of monetary policy on banking spread (NIM) , controlling for macroprudential policies (Liquidity and LTV) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	-0.0445***	-0.0453***	-0.0447***	-0.0468***
	(0.0137)	(0.0135)	(0.0133)	(0.0132)
Cost efficiency	1.519***	0.8332***	1.521***	0.8364***
	(0.3353)	(0.2946)	(0.3353)	(0.2946)
Bank liquidity	-0.0013	-0.0016	-0.0013	-0.0016
	(0.0010)	(0.0011)	(0.0010)	(0.0011)
Size	-0.1307*	-0.3395***	-0.1309*	-0.3400***
	(0.0708)	(0.0650)	(0.0708)	(0.0650)
Asset structure	-0.0576	-0.0702	-0.0576	-0.0701
	(0.0521)	(0.0458)	(0.0521)	(0.0458)
Bank Concentration	-0.0030	-0.0024	-0.0031	-0.0024
	(0.0032)	(0.0033)	(0.0032)	(0.0033)
GDP growth	0.0139**	0.0128**	0.0141**	0.0130**
	(0.0062)	(0.0054)	(0.0063)	(0.0055)
Inflation (CPI)	0.0559***	0.0515***	0.0559***	0.0516***
	(0.0108)	(0.0098)	(0.0108)	(0.0098)
Institutional Quality	-0.3811*	-0.2614	-0.3741*	-0.2519
	(0.2143)	(0.2123)	(0.2142)	(0.2122)
Macroprudential: Liquidity	-0.0516***	-0.0675***	-0.0519***	-0.0679***
	(0.0180)	(0.0185)	(0.0180)	(0.0185)
Macroprudential: LTV	-0.0086	0.0122	-0.0092	0.0113
	(0.0258)	(0.0256)	(0.0258)	(0.0256)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,687	38,424	41,687	38,424
R^2	0.84	0.85	0.84	0.85

Note: Lag 1 of all predictors in Models (2) and (4). LTV: Limits on Loan-to-Value Ratio
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

The impact responses are heterogeneous across cost-efficiency percentiles. In baseline specifications without macroprudential controls, credit growth increases on impact for low-efficiency banks ($P25$) but contracts for high-efficiency banks ($p75$). Quantitatively, the impact response is positive for $P25$ (e.g., $I\hat{R}F^{P25}_{\Delta\ell}(0) \approx 0.007$), while it is negative for $P75$ (e.g., $I\hat{R}F^{P75}_{\Delta\ell}(0) \approx -0.015$), with the median group also contracting (e.g., $I\hat{R}F^{P50}_{\Delta\ell}(0) \approx -0.005$). This divergence is consistent with different adjustment speeds: less efficient banks may initially sustain lending to preserve income when funding conditions tighten (e.g., delayed repricing, relationship-lending rigidities, or slower internal constraint adjustment), whereas more efficient banks appear to react more promptly by tightening underwriting and contracting credit growth, consistent with faster balance-sheet discipline.

Beyond impact, the dynamics are not monotone, which helps anticipate the asset-quality evidence discussed next. At short horizons, the contraction among high-efficiency banks is not persistent—for example, $P75$ credit growth turns slightly positive at $h = 1$ (≈ 0.002) and is near zero around $h = 4$–5, whereas low-efficiency banks display a clearer medium-run contraction (e.g., $P25$ falls to ≈ -0.017 at $h = 2$ and to ≈ -0.030 by $h = 6$). The key takeaway is that cost efficiency maps into the timing and smoothness of lending adjustment: high-efficiency banks exhibit a more front-loaded response (initial contraction and earlier stabilisation), while low-efficiency banks display a more inertial profile with slower correction and a more persistent medium-run decline.

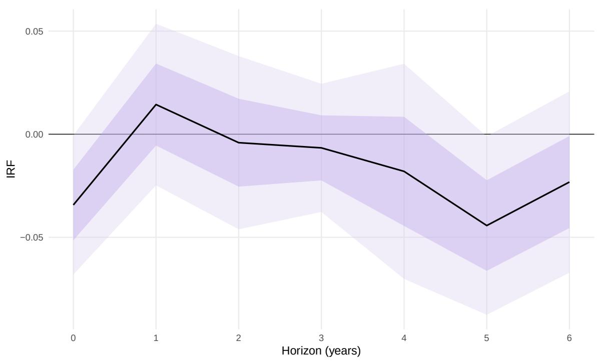
These credit-growth patterns complement the main stability findings. They indicate that the "efficiency buffer" operates partly through differential adjustment frictions in loan supply — with more efficient banks moving earlier to contain balance-sheet risk — even though our core interpretation emphasises risk-management discipline as the primary stabilising force on impact. This sequencing is important for interpreting the subsequent NPL dynamics: early credit restraint and tighter standards can coincide with near-term improvements in measured stability, while delayed borrower stress and loan-loss realisations can still emerge at medium horizons even when lending growth has already adjusted.

6.1 Robustness: using NPL as a measure of stability

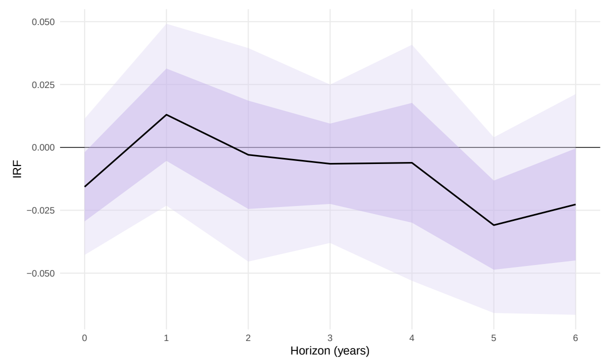
While the primary stability outcome in the paper is Z-score, it is useful to complement it with a direct measure of asset quality based on nonperforming loans (NPLs). NPLs are more tightly linked to realised borrower distress and loan performance. Examining NPL dynamics alongside the Z-score helps distinguish a "buffer/margins" channel (which can mechanically support composite stability measures in the short run) from a "credit-loss" channel (which may emerge with a delay as repayment stress materialises). This distinction is particularly relevant in tightening cycles, where the earlier results indicate horizon-dependent sign reversals in stability and heterogeneity in terms of cost efficiency.

Figure 7: Local projections responses of net interest margin (NIM) to monetary policy shock

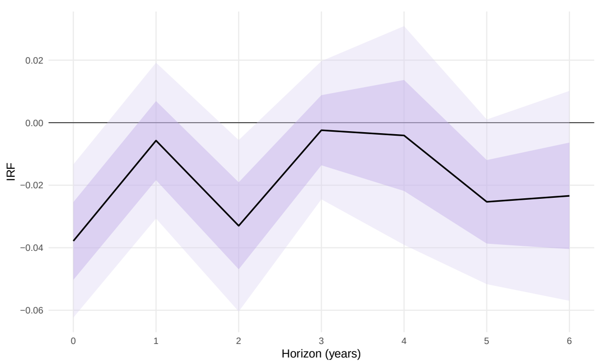
(i) One Lag of Predictors | **(ii) One Lag of NIM & Predictors**



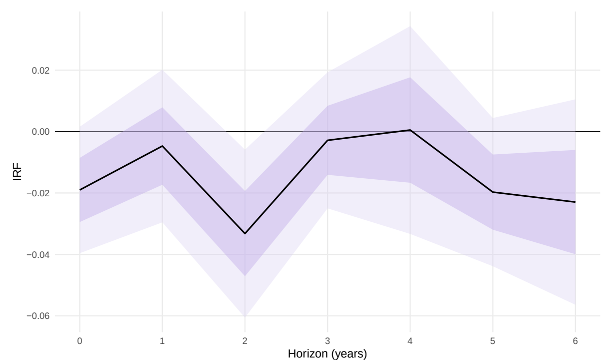
25th percentile



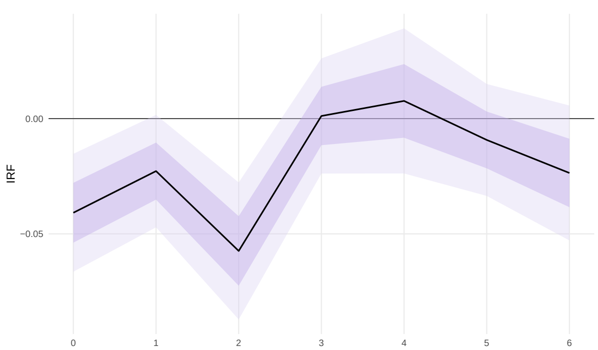
25th percentile



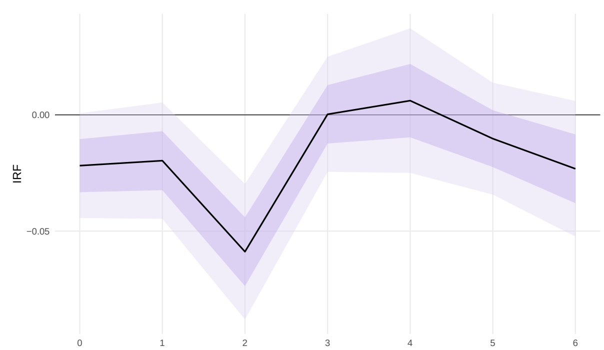
50th percentile



50th percentile



75th percentile

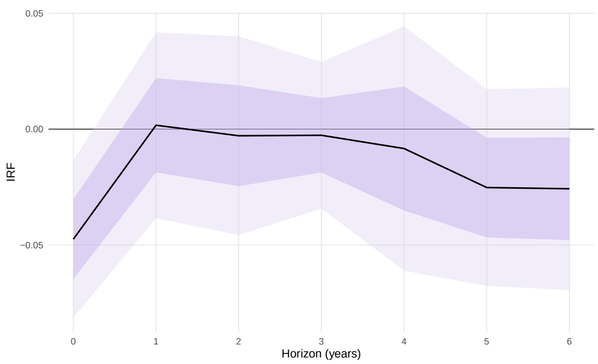


75th percentile

Note: The figure plots local projections responses of net interest margin (NIM) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of NIM and predictors.

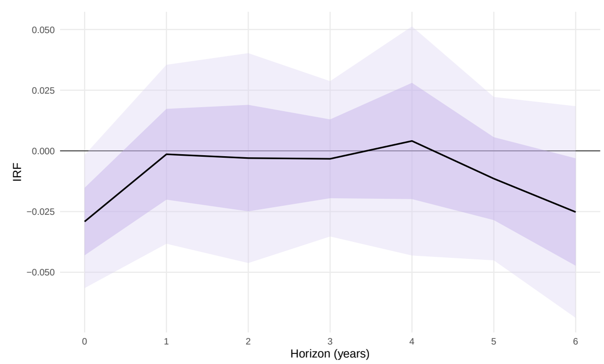
Figure 8: Local projections responses of net interest margin (NIM) to monetary policy shock, controlling for macroprudential policies (Liquidity and LFX)

(i) One Lag of Predictors

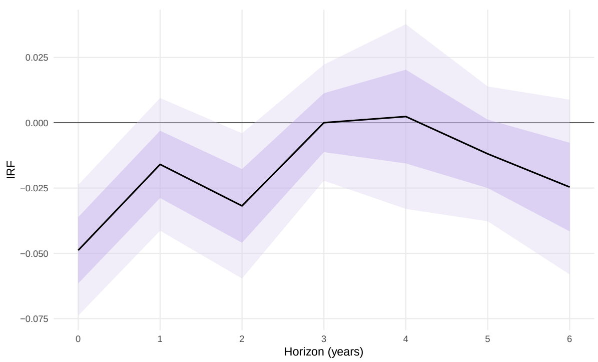


25th percentile

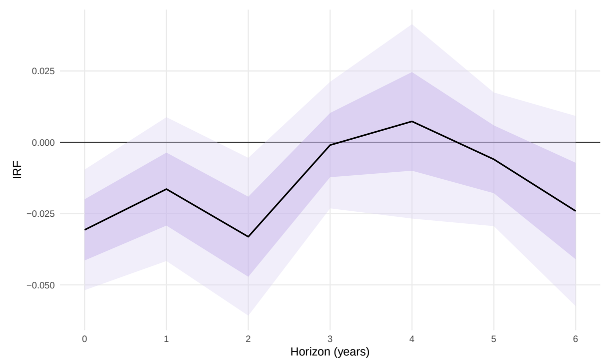
(ii) One Lag of NIM & Predictors



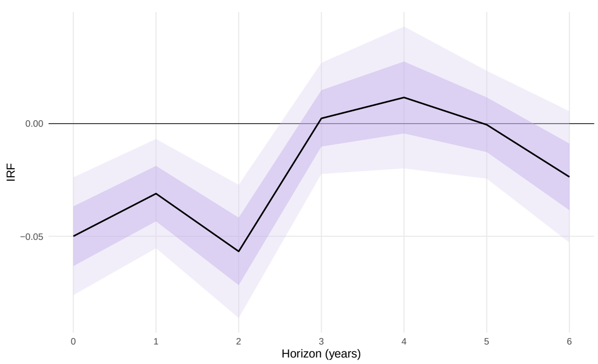
25th percentile



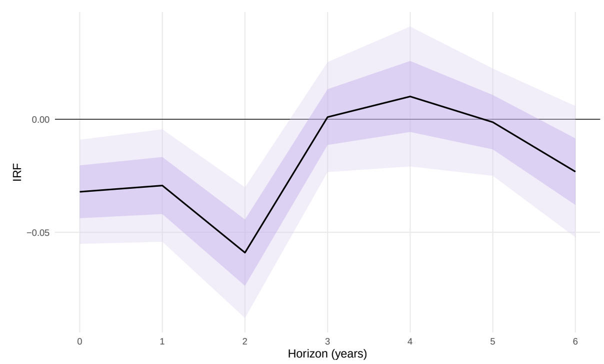
50th percentile



50th percentile



75th percentile

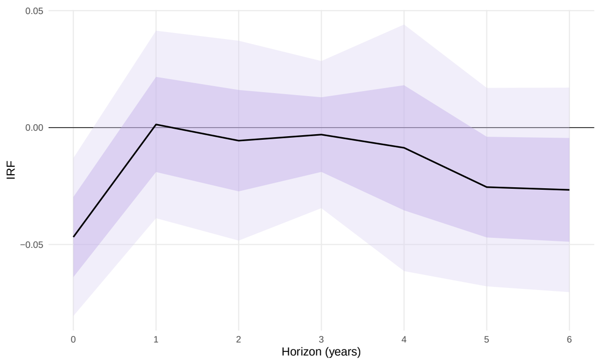


75th percentile

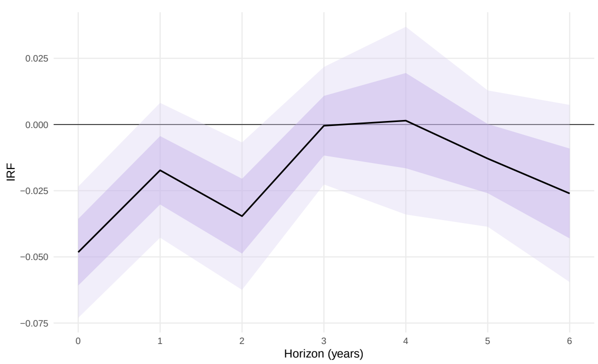
Note: The figure plots local projections responses of net interest margin (NIM) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LFX). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of NIM and predictors.

Figure 9: Local projections responses of net interest margin (NIM) to monetary policy shock, controlling for macroprudential policies (Liquidity and LTV)

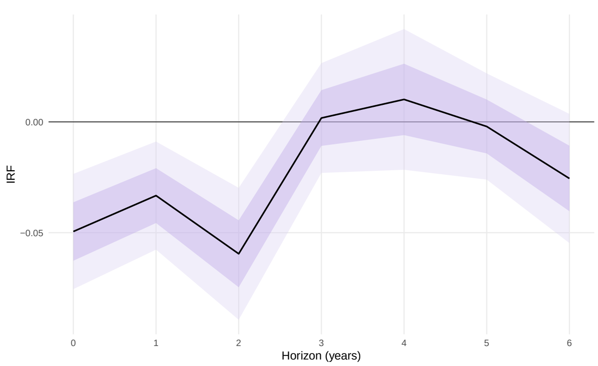
(i) One Lag of Predictors



25th percentile

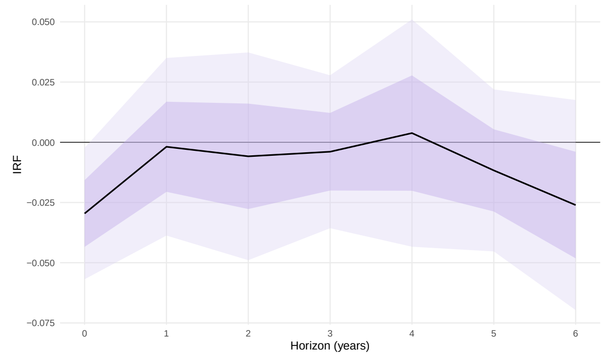


50th percentile

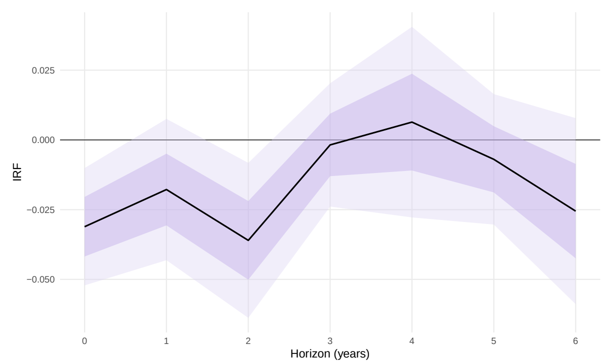


75th percentile

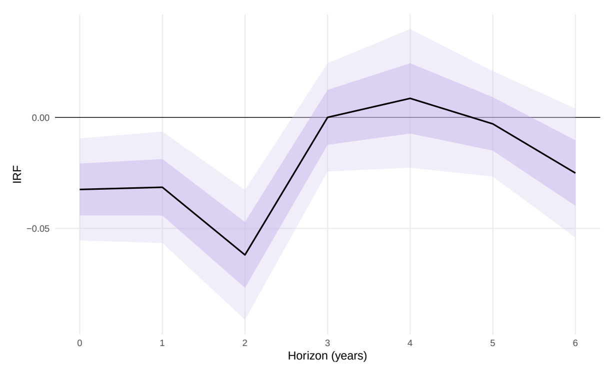
(ii) One Lag of NIM & Predictors



25th percentile



50th percentile



75th percentile

Note: The figure plots local projections responses of net interest margin (NIM) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LTV). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of NIM and predictors.

Let $\Delta \ln \mathrm{NPL}_k(h)$ denote the local-projection impulse response of log NPL growth at horizon h for efficiency group $k \in \{25, 50, 75\}$, and let $\Delta \ln \mathrm{L}_k(h)$ (also denoted as $\Delta \ell_k$) denote the corresponding impulse response of log loan growth. We follow Equation (15) and (16) but use these measures as the outcome variables. Because the NPL ratio is NPL/Loans, the log-change identity implies:

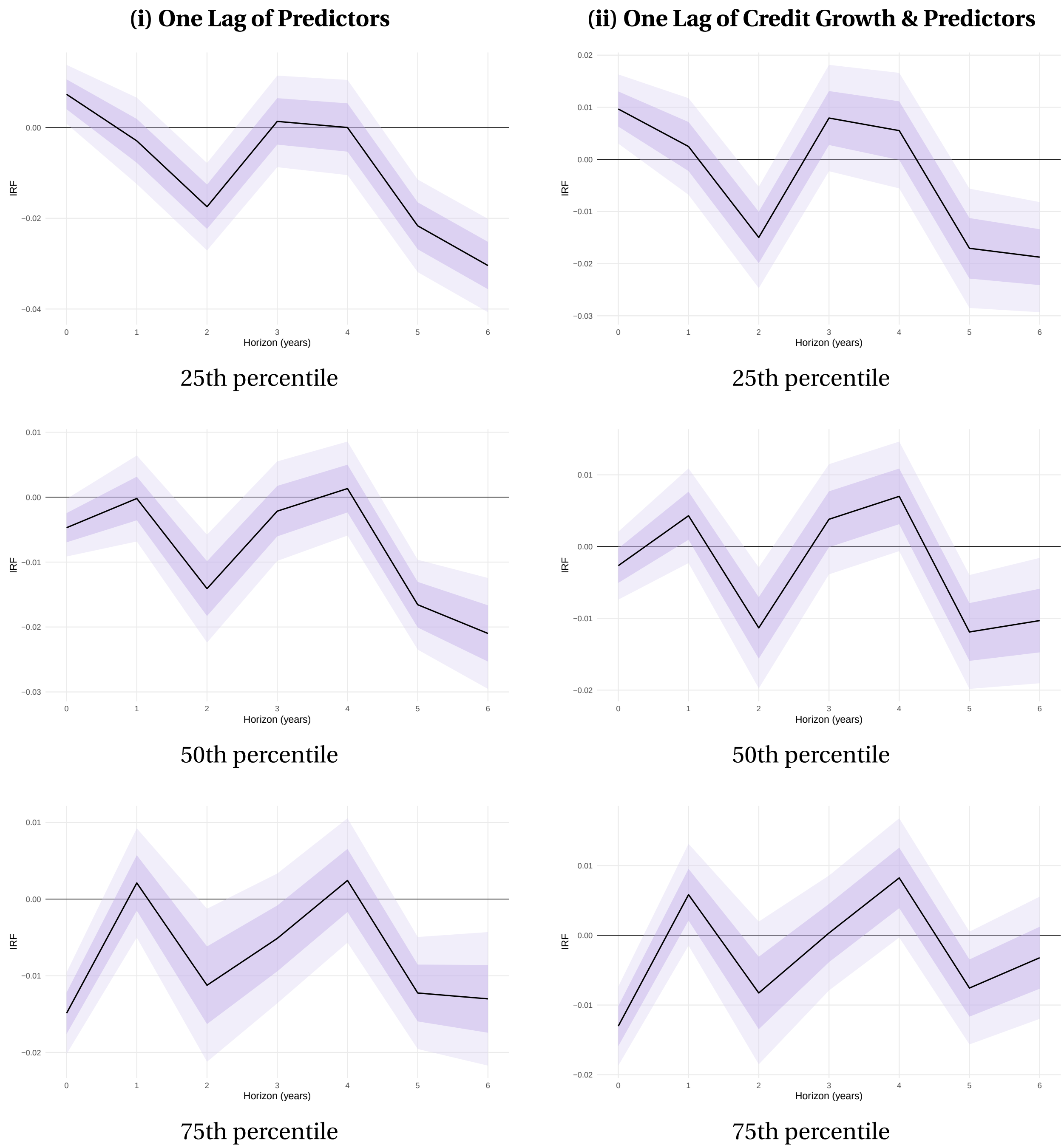
$$\Delta \ln \left(\frac{\mathrm{NPL}}{\mathrm{L}} \right)_k (h) = \Delta \ln \mathrm{NPL}_k(h) - \Delta \ln \mathrm{L}_k(h). \tag{17}$$

Accordingly, we report: i) NPL growth, $\Delta \ln \mathrm{NPL}_k(h)$, and ii) the difference object, $\Delta \ln \mathrm{NPL}_k(h) - \Delta \ln \mathrm{L}_k(h)$, which is a good measure of NPL-ratio growth that nets out denominator movements and avoids the mechanical ambiguity of ratio levels when both numerator and denominator move contemporaneously.

The results are shown in Figures 13 and 14. The local-projection evidence reveals a clear two-phase pattern. First, at short horizons ($h = 0, 1$), a contractionary monetary policy innovation reduces NPL growth across the distribution, with the effect particularly pronounced for the median and high-efficiency groups (e.g., $\Delta \ln \mathrm{NPL}_{P50}(0) \approx -0.027$ and $\Delta \ln \mathrm{NPL}_{P75}(0) \approx -0.039$, Panel (i) Figure 13). Over the same horizons, loan growth is already weak or negative for $P50$ and $P75$ (and close to zero for $P25$) as we discussed earlier. Consistent with Equation (17), the implied NPL-ratio growth is therefore negative at impact and at $h = 1$ for all groups, indicating an initial improvement in asset-quality dynamics in ratio terms.

Second, at medium horizons ($h = 2, 3$), NPL growth turns sharply positive and is precisely estimated across all percentiles (e.g., $\Delta \ln \mathrm{NPL}_{P50}(2) \approx 0.042$ and $\Delta \ln \mathrm{NPL}_{P75}(2) \approx 0.053$), while loan growth remains subdued and typically negative around the same period as noted earlier. The difference measure (ratio-growth measure) consequently rises strongly and significantly at $h = 2$–3 for each group, implying that NPLs begin to grow faster than loans. This medium-run deterioration is economically important: because the ratio-growth measure controls for the denominator, it indicates that the subsequent worsening is not merely a mechanical consequence of slower credit expansion, but reflects a genuine increase in the intensity of problem-loan accumulation relative to the loan book. At longer horizons ($h \geq 4$), the responses display partial reversals and oscillations, which are consistent with a combination of loan-loss recognition and resolution (charge-offs and write-downs), balance-sheet repair, and intertemporal re-optimisation of lending following the initial tightening episode.

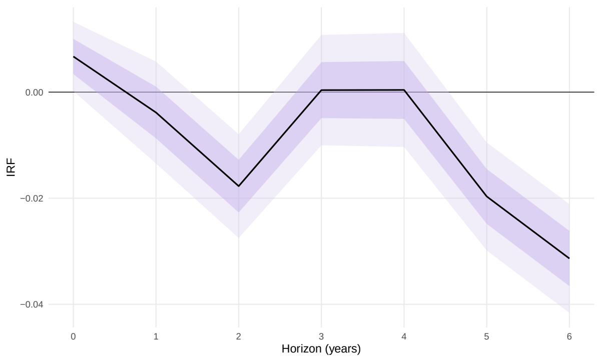
Figure 10: Local projections responses of credit growth to monetary policy shock



Note: The figure plots local projections responses of credit growth to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

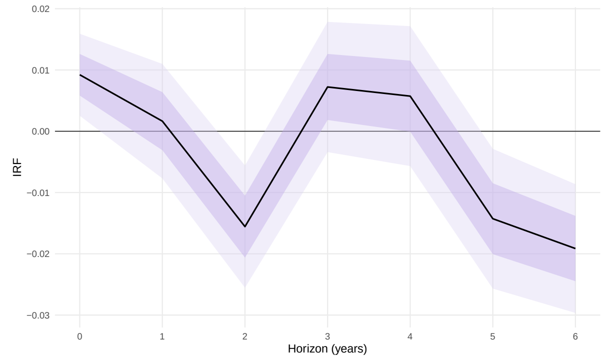
Figure 11: Local projections responses of credit growth to monetary policy shock, controlling for macroprudential policies (Liquidity and LFX)

(i) One Lag of Predictors

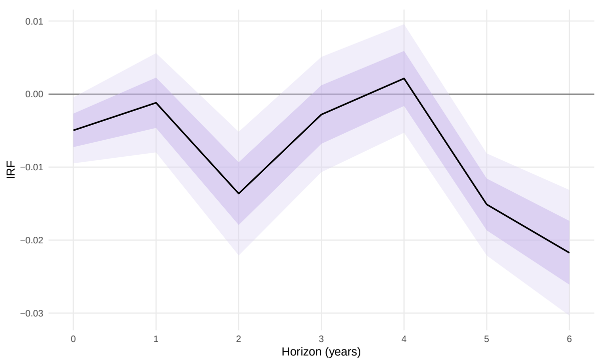


25th percentile

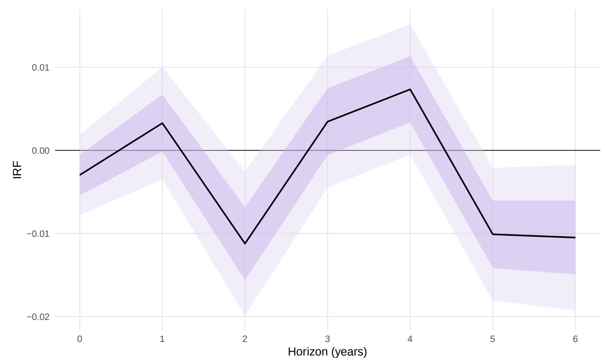
(ii) One Lag of Credit Growth & Predictors



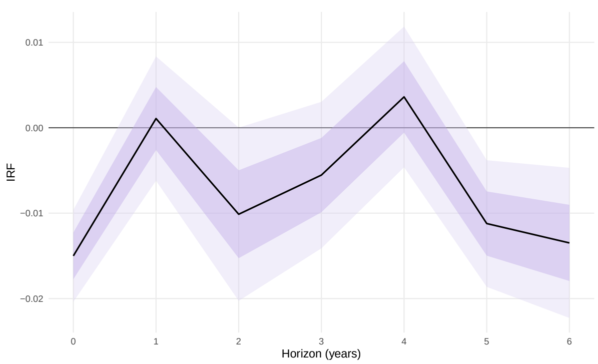
25th percentile



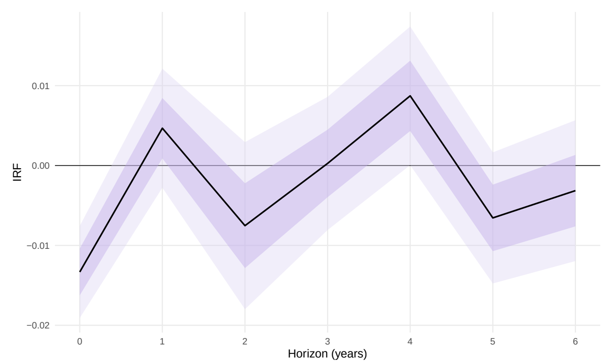
50th percentile



50th percentile



75th percentile

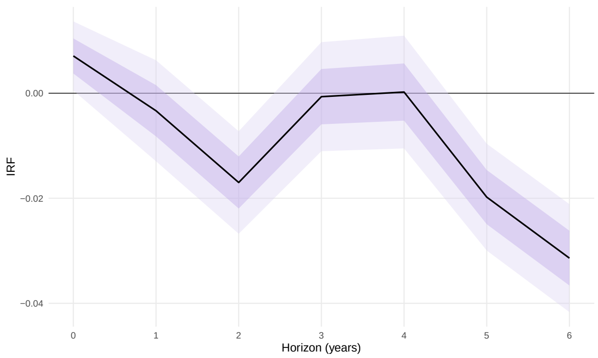


75th percentile

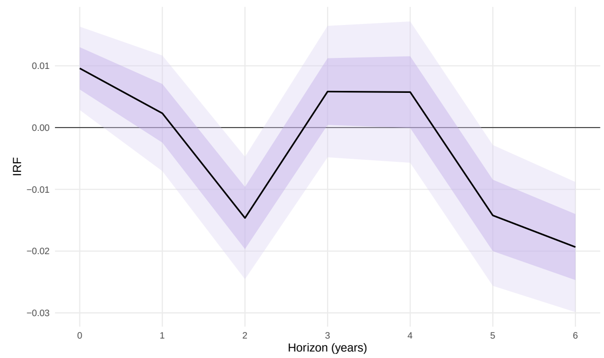
Note: The figure plots local projections responses of credit growth to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LFX). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

Figure 12: Local projections responses of credit growth to mnetary policy shock, controlling for macroprudential policies (Liquidity and LTV)

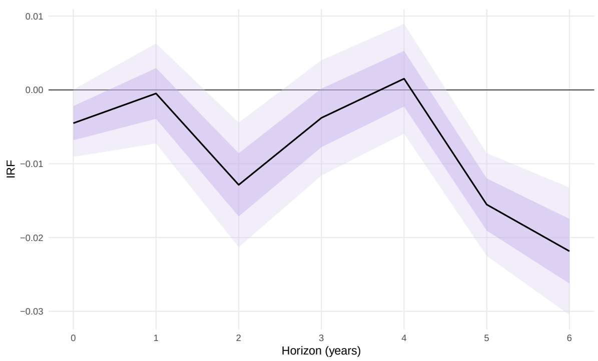
(i) One Lag of Predictors | **(ii) One Lag of Credit Growth & Predictors**



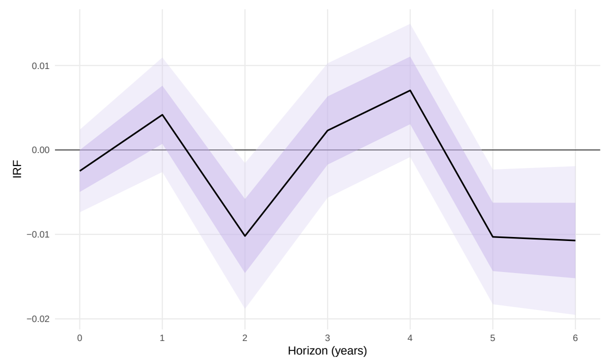
25th percentile



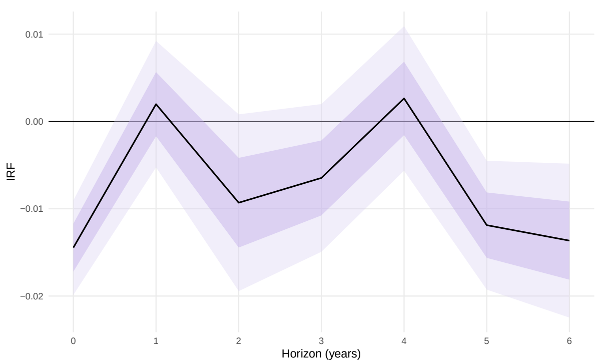
25th percentile



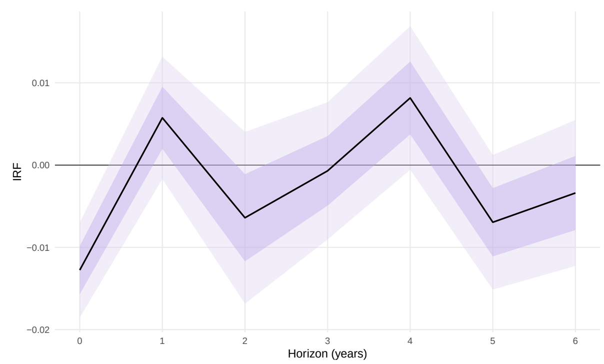
50th percentile



50th percentile



75th percentile



75th percentile

Note: The figure plots local projections responses of credit growth to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LTV). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

Taken together, the Z-score and NPL results align with a fast-versus-slow propagation mechanism. Tightening can improve measured stability (Z-score) and reduce NPL growth initially — consistent with an immediate risk-management/underwriting response and reduced risk-taking — but borrower repayment stress and credit-loss realisations materialise with a delay, raising NPL accumulation (and NPL-ratio growth) at medium horizons. This two-speed dynamics provides an empirical bridge to the DSGE mechanism developed later: a fast risk-management channel that improves near-term measured stability, and a slow borrower-distress channel that generates delayed deterioration in asset quality and, ultimately, in stability.

6.2 Monetary policy-stability nexus: competition heterogeneity

We go further to test another important market condition, banking competition, that can influence the impact of monetary policy on banking stability. We derive bank-level marginal costs and Lerner indices using a two-step stochastic metafrontier framework consisting of: i) country-specific cost frontiers that allow for heterogeneous technologies across banking systems, and ii) a stochastic metafrontier estimated on the fitted systematic component from the country frontiers. This structure enables us to benchmark market power within each country against a global best-practice technology set, thereby separating variation in inferred markups driven by local competitive conditions from variation attributable to cross-country technology gaps.

The starting point is the normalised translog cost function,

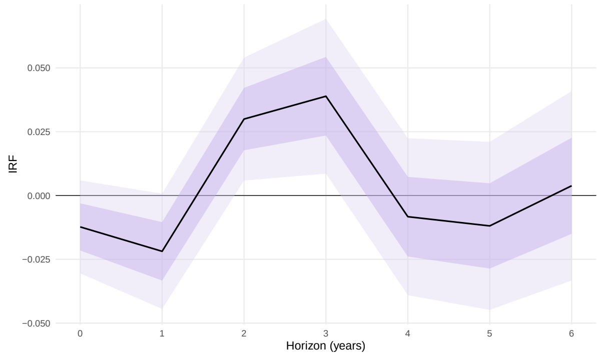
$$\ln\left(\frac{TC_{it}}{w_{1it}}\right) = g\left(\ln Y_{it}, \ln\frac{w_{2it}}{w_{1it}}, \ln\frac{w_{3it}}{w_{1it}}\right) + v_{it} + u_{it}, \tag{18}$$

where all variables are as defined earlier in subsection 4.2. The function $g(\cdot)$ is a flexible translog representation of the underlying technology. Let $\widehat{g}_{it}$ denote the fitted deterministic component of the estimated frontier.

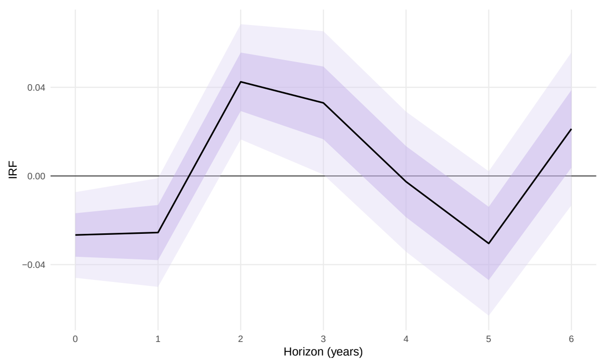
$$\begin{aligned} \widehat{g}_{it} = {} & \widehat{\alpha}_0 + \widehat{\beta}_y \ln Y_{it} + \sum_{m=2}^{3} \widehat{\beta}_m \ln\left(\frac{w_{mit}}{w_{1it}}\right) \\ & + \frac{1}{2}\widehat{\gamma}_{yy}\left(\ln Y_{it}\right)^2 + \sum_{m=2}^{3} \widehat{\gamma}_{ym} \ln Y_{it} \ln\left(\frac{w_{mit}}{w_{1it}}\right) \\ & + \frac{1}{2}\sum_{m=2}^{3}\sum_{n=2}^{3} \widehat{\gamma}_{mn} \ln\left(\frac{w_{mit}}{w_{1it}}\right) \ln\left(\frac{w_{nit}}{w_{1it}}\right). \end{aligned} \tag{19}$$

Figure 13: Local projections responses of NPL growth to monetary policy shock

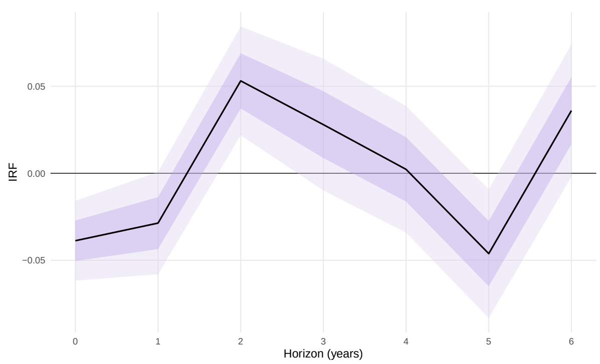
(i) One Lag of Predictors



25th percentile

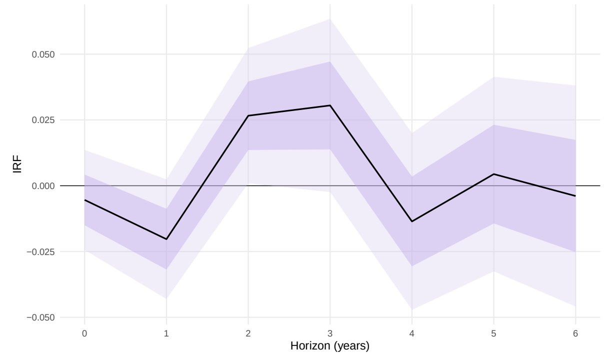


50th percentile

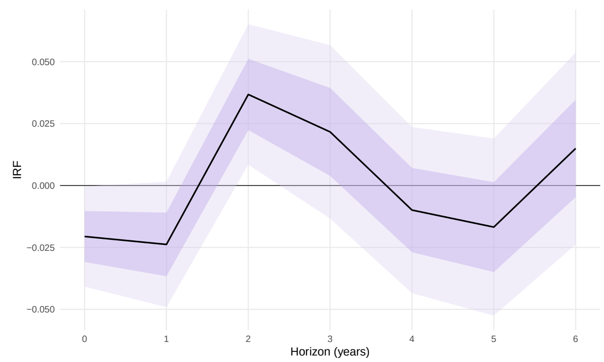


75th percentile

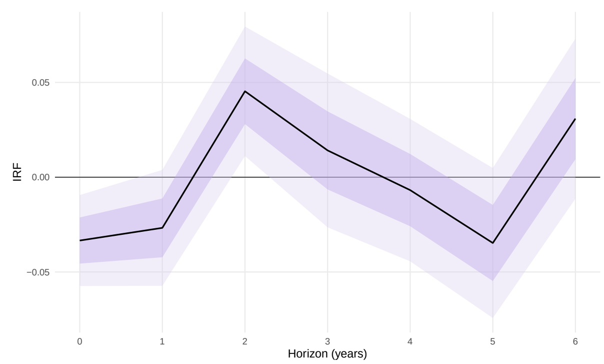
(ii) One Lag of NPL Growth & Predictors



25th percentile



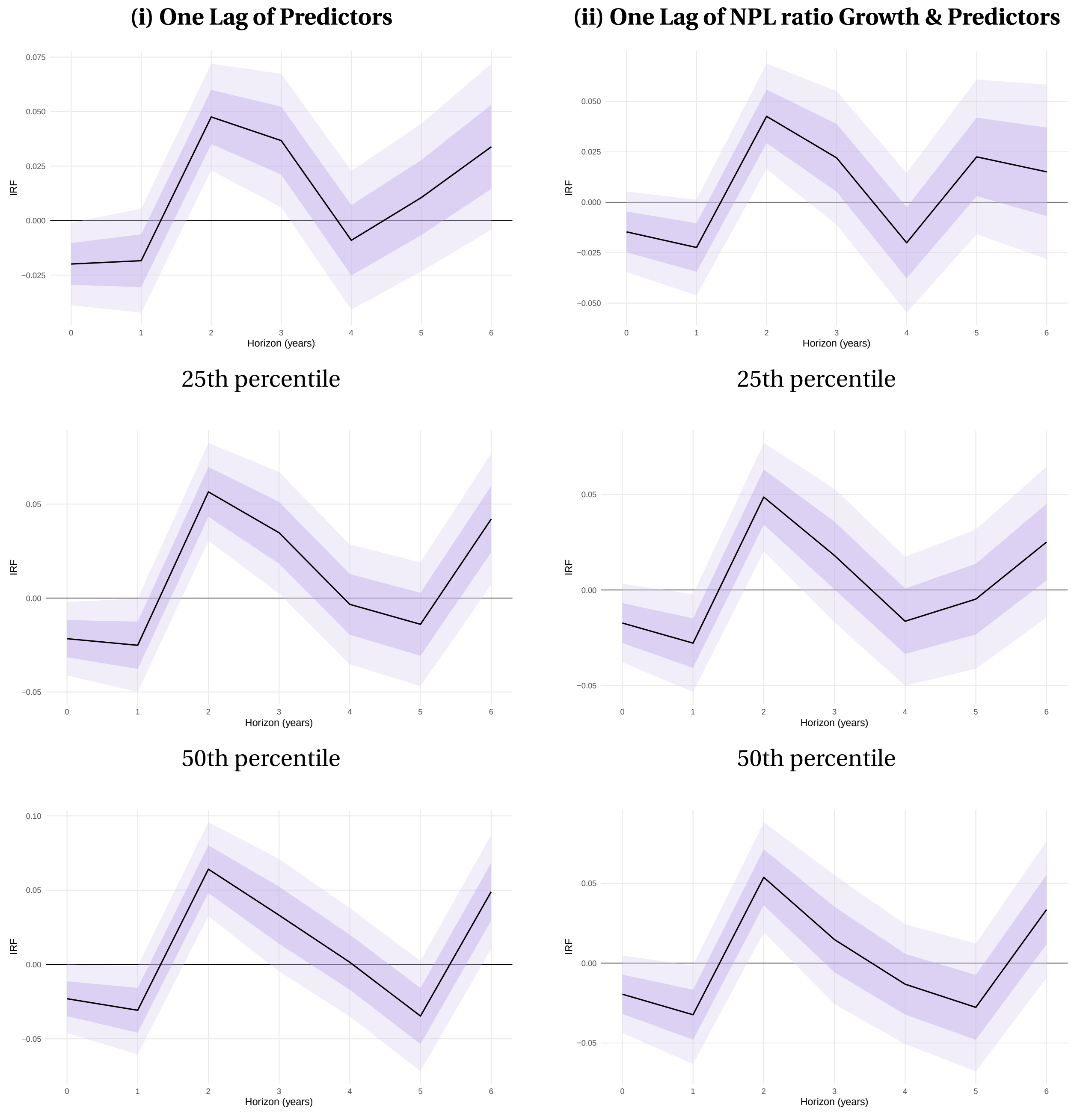
50th percentile



75th percentile

Note: The figure plots local projections responses of NPL growth to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

Figure 14: Local projections responses of NPL ratio growth to monetary policy shock



Note: The figure plots local projections responses of NPL ratio growth to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

Using this fitted component, the predicted total cost (in levels) is recovered as:

$$\hat{TC}_{it} = w_{1it} \exp\big(\widehat{g}_{it}\big). \tag{20}$$

Group-specific (country) frontiers. To allow for heterogeneity in banking technologies across countries, we estimate frontiers separately for each country $g \in \{1, \ldots, G\}$ using the same functional form as in Equation (18). Let $\widehat{g}_{it}^{(g)}$ denote the fitted component for country g, and $\hat{TC}_{it}^{(g)}$ is the implied predicted cost. The corresponding marginal cost is:

$$\hat{MC}_{it}^{(g)} = \frac{\hat{TC}_{it}^{(g)}}{Y_{it}} \, \widehat{\varepsilon}_{CY,it}^{(g)}, \tag{21}$$

and the country (group) Lerner index is:

$$\widehat{L}_{it}^{(g)} = 1 - \frac{\hat{MC}_{it}^{(g)}}{P_{it}}. \tag{22}$$

Metafrontier estimation. The metafrontier provides a global envelope of the country frontiers, capturing the best-practice technology available internationally. Following the stochastic metafrontier approach, we estimate the metafrontier using the fitted systematic component obtained from each country's frontier:

$$\text{pred}_{it} \equiv \widehat{g}_{it}^{(g)}.$$

Thus, the metafrontier model is:

$$\text{pred}_{it} = g^M\big(\ln Y_{it}, \ln \tfrac{w_{2it}}{w_{1it}}, \ln \tfrac{w_{3it}}{w_{1it}}\big) + v_{it}^M + u_{it}^M, \tag{23}$$

where $g^M(\cdot)$ is again specified as a translog function. Let $\widehat{g}_{it}^M$ denote the fitted metafrontier component. The implied metafrontier predicted total cost is:

$$\hat{TC}_{it}^M = w_{1it} \exp\big(\widehat{g}_{it}^M\big). \tag{24}$$

Marginal cost relative to the metafrontier is:

$$\hat{MC}_{it}^M = \frac{\hat{TC}_{it}^M}{Y_{it}} \, \widehat{\varepsilon}_{CY,it}^M, \tag{25}$$

and the meta-Lerner index is:

$$\widehat{L}_{it}^{M} = 1 - \frac{\hat{MC}_{it}^{M}}{P_{it}}. \tag{26}$$

This measure reflects market power after controlling for cross-country technological differences. Whereas $\widehat{L}_{it}^{(g)}$ captures pricing power relative to a bank's local technology, $\widehat{L}_{it}^{M}$ reflects pricing power relative to the global best-practice technology. The difference,

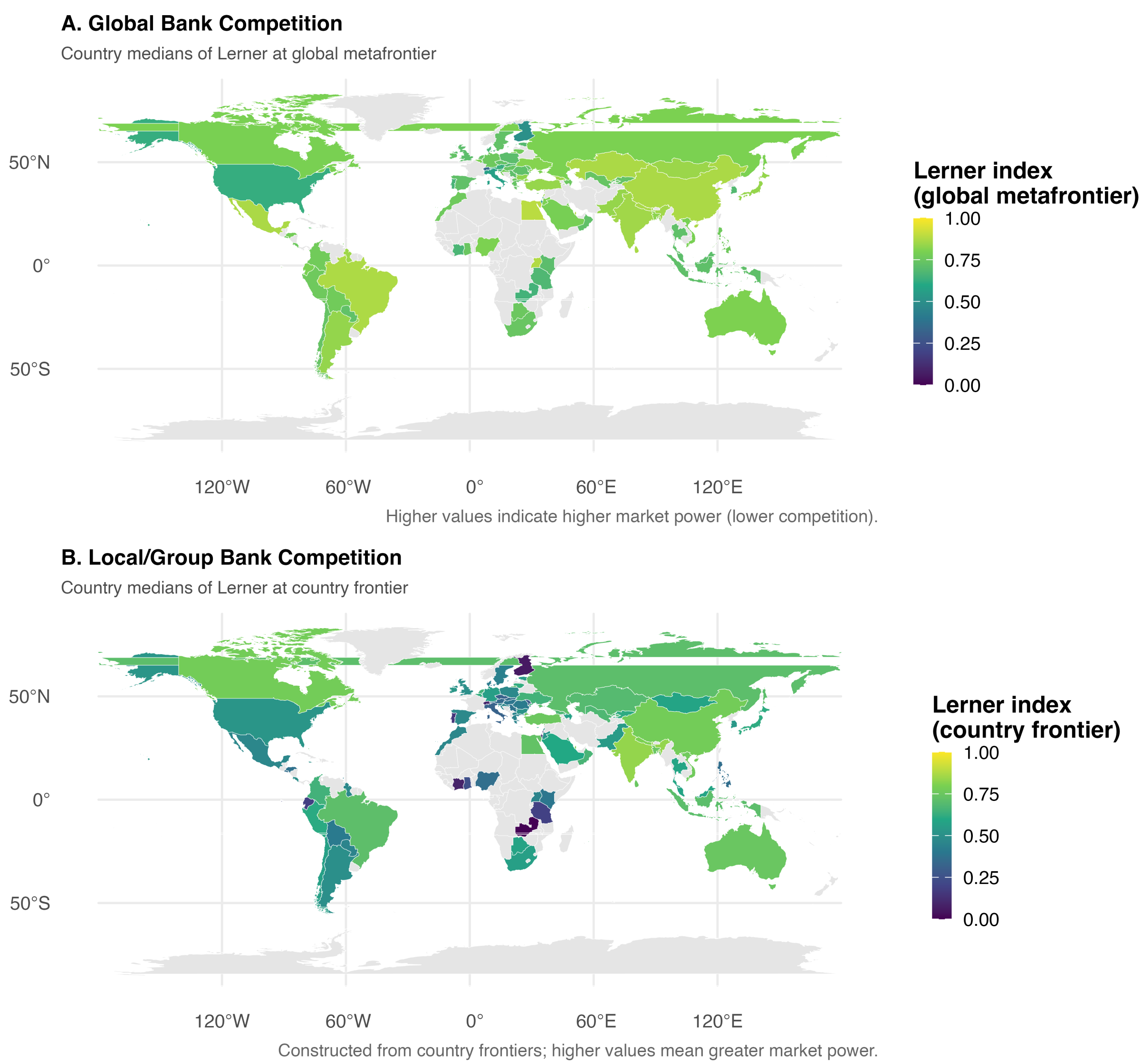
$$\widehat{L}_{it}^{(g)} - \widehat{L}_{it}^{M}, \tag{27}$$

therefore provides a technology-adjusted diagnostic of market power. A large positive gap suggests that apparent markups under the country benchmark may be inflated by cross-country technology differences, whereas a small gap indicates that inferred pricing power is broadly robust to benchmarking against the global best-practice technology set.

The two Lerner indices provide complementary measures of market power under distinct technological benchmarks. The country-specific Lerner index $\widehat{L}_{it}^{(g)}$ measures pricing power relative to each country's own cost technology and therefore summarises local competitive conduct conditional on the prevailing domestic production possibilities. The meta-Lerner index $\widehat{L}_{it}^{M}$, by contrast, re-evaluates the same bank against the global best-practice technology set embodied in the metafrontier and therefore nets out cross-country technological heterogeneity. Empirically, the summary statistics show $\widehat{L}_{it}^{M}$ exceeding $\widehat{L}_{it}^{(g)}$ on average, implying $\widehat{L}_{it}^{(g)} - \widehat{L}_{it}^{M} < 0$. This ordering is informative: it indicates that once marginal costs are disciplined by the global frontier (which is typically lower than domestic frontiers), implied markups are larger. Put differently, part of the "comfort" of moderate local markups reflects the fact that domestic technologies (and thus domestic cost levels) are below best practice; benchmarking to the global frontier reveals that prices are high relative to what would prevail under best-practice cost efficiency.

The patterns in Figure 15 are characterised by a systematic wedge between the two benchmarks: for most countries in the map, the metafrontier Lerner ($\widehat{L}^{M}$) exceeds the country-frontier Lerner ($\widehat{L}^{(g)}$), implying that pricing power is larger when marginal costs are evaluated against the global best-practice technology. Interpreted through the cost-technology lens, this indicates that local marginal costs (embedded in $\widehat{L}^{(g)}$) are typically higher than the counterfactual best-practice costs used in $\widehat{L}^{M}$, so the implied markup relative to the global benchmark is mechanically larger. Regionally, several emerging and smaller banking systems exhibit particularly high $\widehat{L}^{M}$ (often alongside moderate or high $\widehat{L}^{(g)}$), consistent with the joint presence of meaningful market power and non-trivial technology gaps; in contrast, a subset of advanced systems display comparatively lower Lerner values (especially under the country benchmark), consistent with tighter competitive constraints, while still showing a positive wedge under the global benchmark. Overall, the maps jointly suggest that cross-country comparisons of competition are sensitive to technology benchmarking, and that the metafrontier-based Lerner index provides a more technology-adjusted measure of pricing power, which is especially informative in countries where cost technologies differ materially from the global best-practice frontier.

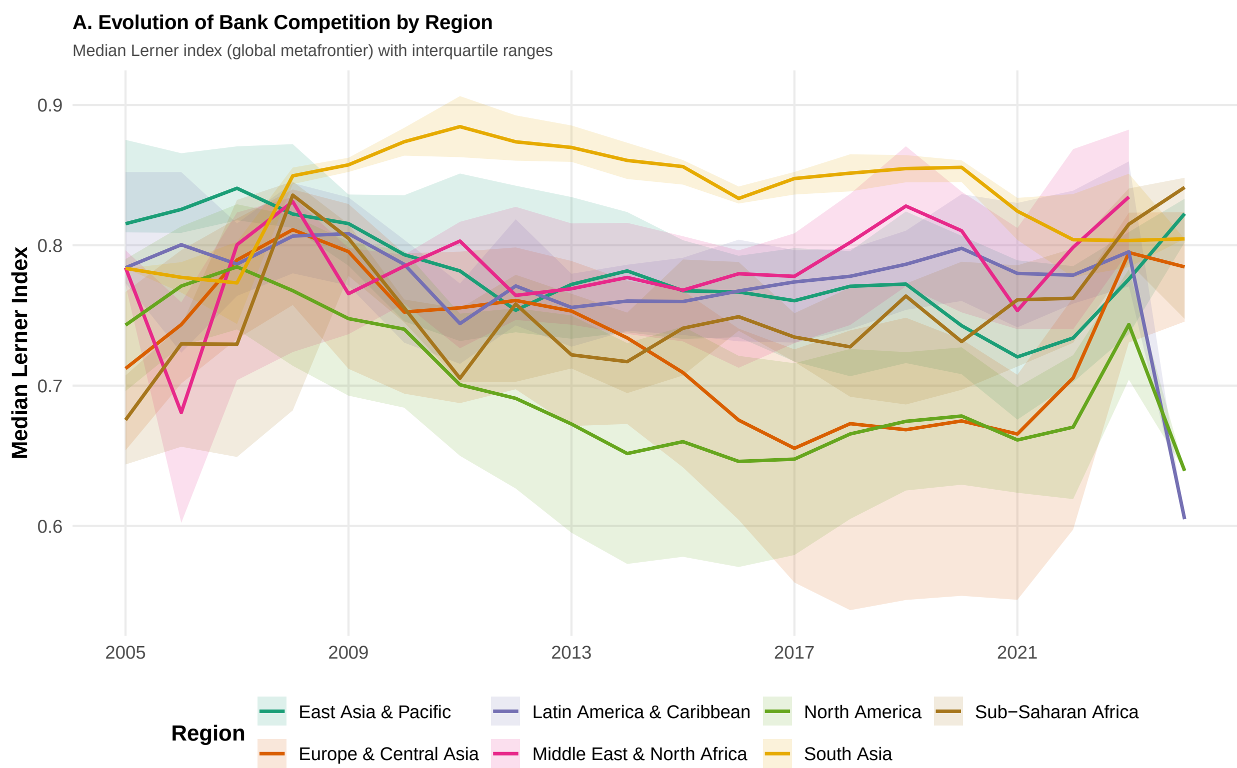
Figure 15: Global metafrontier Lerner index



Note: Grey areas represent missing data.

The regional median meta-Lerner index, $\widehat{L}^M$, shown in Figure 16 is uniformly high and typically exceeds the country-frontier median, indicating that benchmarking marginal costs against the global best-practice technology systematically implies higher markups than benchmarking against local technologies. The levels are especially elevated in South Asia and East Asia & Pacific (with $\widehat{L}^M$ commonly around 0.75–0.87), while Europe & Central Asia and North America tend to sit at comparatively lower (though still sizable) medians (roughly 0.65–0.79). Sub-Saharan Africa exhibits a marked upward trend in $\widehat{L}^M$ during the post-2020 period, consistent with rising implied market power under the global benchmark, or equivalently, an expansion in the technology-adjustment component embedded in the metafrontier comparison. Taken together with the cost-efficiency patterns, the Lerner evidence suggests that cross-region comparisons of competitive conduct are tightly intertwined with technology benchmarking: where typical banks are further from the global best-practice cost frontier, the implied markup relative to that frontier is mechanically larger, reinforcing the case for reporting both $\widehat{L}^{(g)}$ and $\widehat{L}^M$ to separate local competitive conditions from technology-adjusted market power.

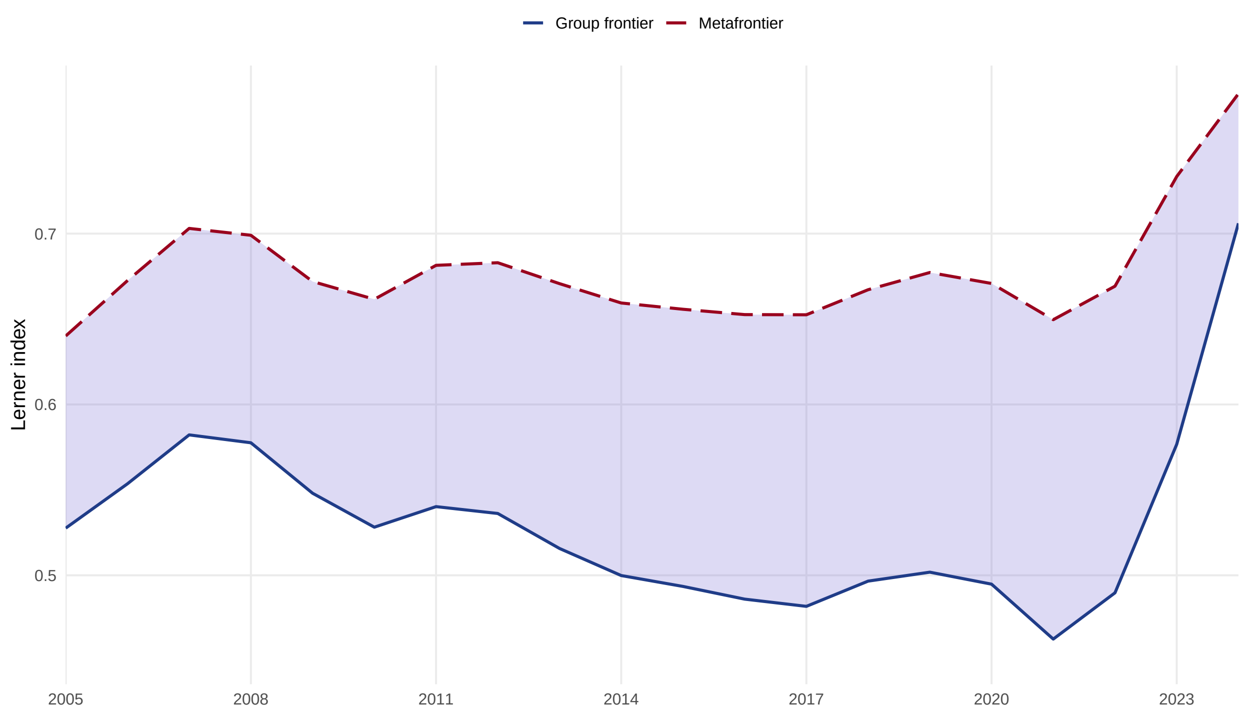
Figure 16: Trend of median metafrontier Lerner index by region



Note: The figure reports the trend of the Lerner index following Equation (26).

Figure 17 plots the average trend of both the metafrontier and country frontier Lerner index. The figure reinforces this technology interpretation. The global series $\widehat{L}_{it}^{M}$ tracks above the country series $\widehat{L}_{it}^{(g)}$ throughout, while both exhibit broadly co-moving dynamics over time. The sustained vertical gap indicates that the technology-adjustment component is persistent rather than episodic: changes in competitive conditions (or common shocks to pricing and costs) are reflected in both indices, but the level difference is driven by the counterfactual marginal cost implied by the global best-practice technology. Episodes in which the gap widens can be read as periods when technology dispersion (or the distance between domestic and best-practice frontiers) increases, magnifying the markup implied by the global benchmark; conversely, narrowing gaps observed after 2021 are consistent with convergence toward best practice, in which case $\widehat{L}_{it}^{(g)}$ and $\widehat{L}_{it}^{M}$ become more similar and inferred market power is more robust to the choice of technology benchmark.

Figure 17: Trend of average metafrontier and country Lerner index



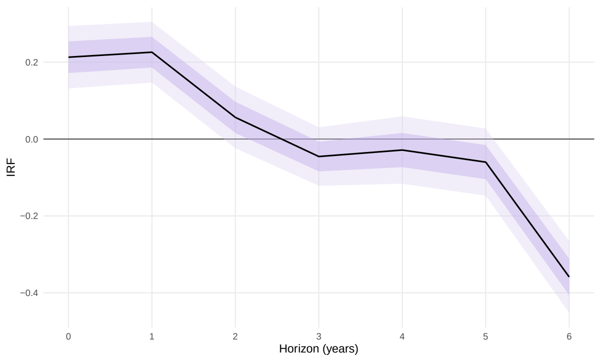
We proceed to discuss the results of the monetary policy-stability nexus, conditional on the competitive environment, which is proxied by the Lerner index derived earlier. In the local projection framework, as in Equation (15), we condition the impulse responses of bank stability to a tightening shock on the distribution of the Lerner index (25th, 50th, and 75th percentiles). The resulting IRFs in Figures 19 and 20 indicate that tightening raises stability on impact across all competition regimes. This finding is consistent with a risk-discipline interpretation of monetary tightening: a higher policy rate compresses the set of profitable, marginally risky lending opportunities, strengthens screening incentives, and reduces risk-taking at the extensive margin. Importantly, the on-impact stabilisation is larger for banks operating in less competitive markets (higher market power), as reflected by the higher immediate response at lower competition (25th percentile) relative to more competitive environments.

The cross-regime differences in the dynamic responses are particularly informative. While all regimes exhibit an initial improvement in stability, low-competition markets display a flatter and more persistent path, whereas the responses under high competition are more pronounced and less smooth over the horizon. A plausible interpretation is that market power enhances the intertemporal transmission of monetary shocks by providing a buffer in terms of profitability and balance-sheet management. Banks with greater pricing power can adjust loan and deposit rates more strategically, smooth margins through the cycle, and avoid sharp contractions in intermediation that may otherwise amplify borrower distress and subsequent credit losses. This seem to support the competition-fragility view (Keeley, 1990; Beck, De Jonghe, and Schepens, 2013; Berger, Klapper, and Turk-Ariss, 2017) where lower competition improves banking stability. In contrast, under intense competition, pricing is more constrained, and pass-through can be more mechanical. The resulting profit compression and more abrupt portfolio adjustments can generate greater volatility in bank performance and asset quality dynamics, producing a less smooth stability response. In this sense, competition acts as an amplifier of the propagation of policy shocks even when the impact effect is stabilising.

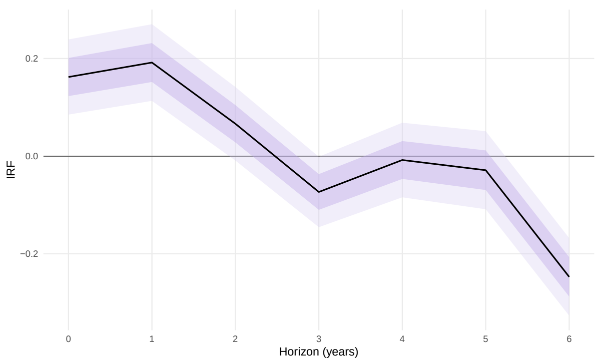
These results have two implications for the paper's central mechanism. First, they underscore that the stabilising effect of tightening is not confined to a particular market structure: the impact response is positive throughout the competition distribution. Second, they suggest that market power is associated with resilience in propagation: lower competition does not merely raise stability contemporaneously, but also dampens the subsequent sensitivity of stability to the tightening shock. This pattern aligns with the view that charter value and pricing power mitigate short-run profitability pressures and reduce incentives to "reach for yield" following policy changes, thereby smoothing the adjustment to stability. Taken together, the Lerner-conditioned IRFs complement the cost efficiency heterogeneity analysis by highlighting an additional structural margin, the competitive environment, that shapes the persistence and volatility of monetary policy transmission in relation to banking stability.

Figure 18: Local projections responses of banking stability (Z-score) to monetary policy shock, conditional on bank competition

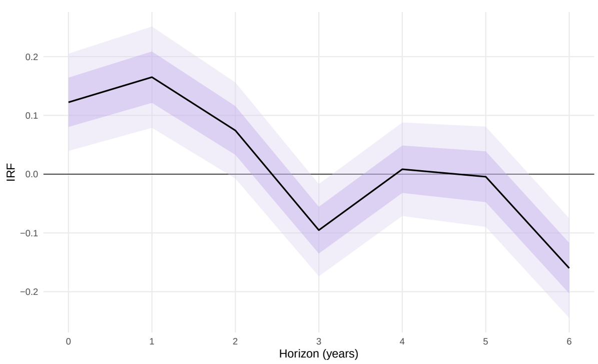
(i) One Lag of Predictors



25th percentile

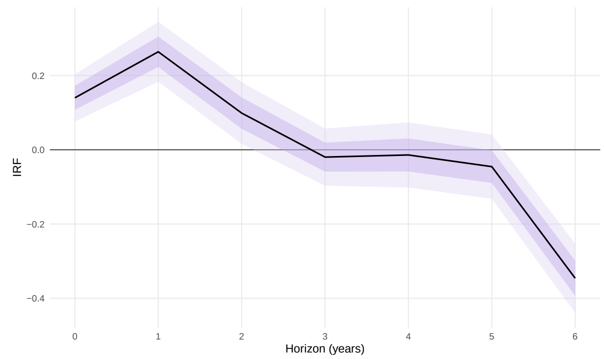


50th percentile

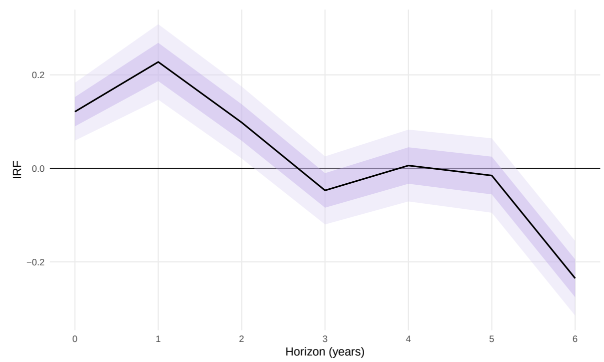


75th percentile

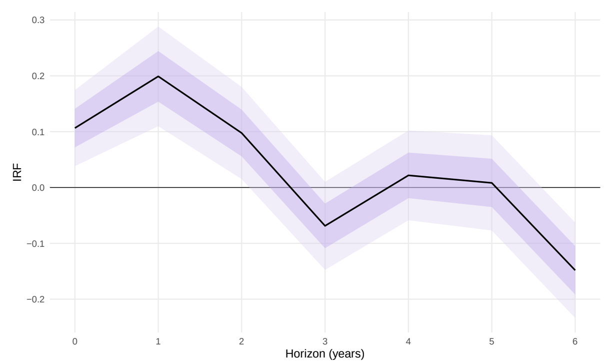
(ii) One Lag of Z-score & Predictors



25th percentile



50th percentile

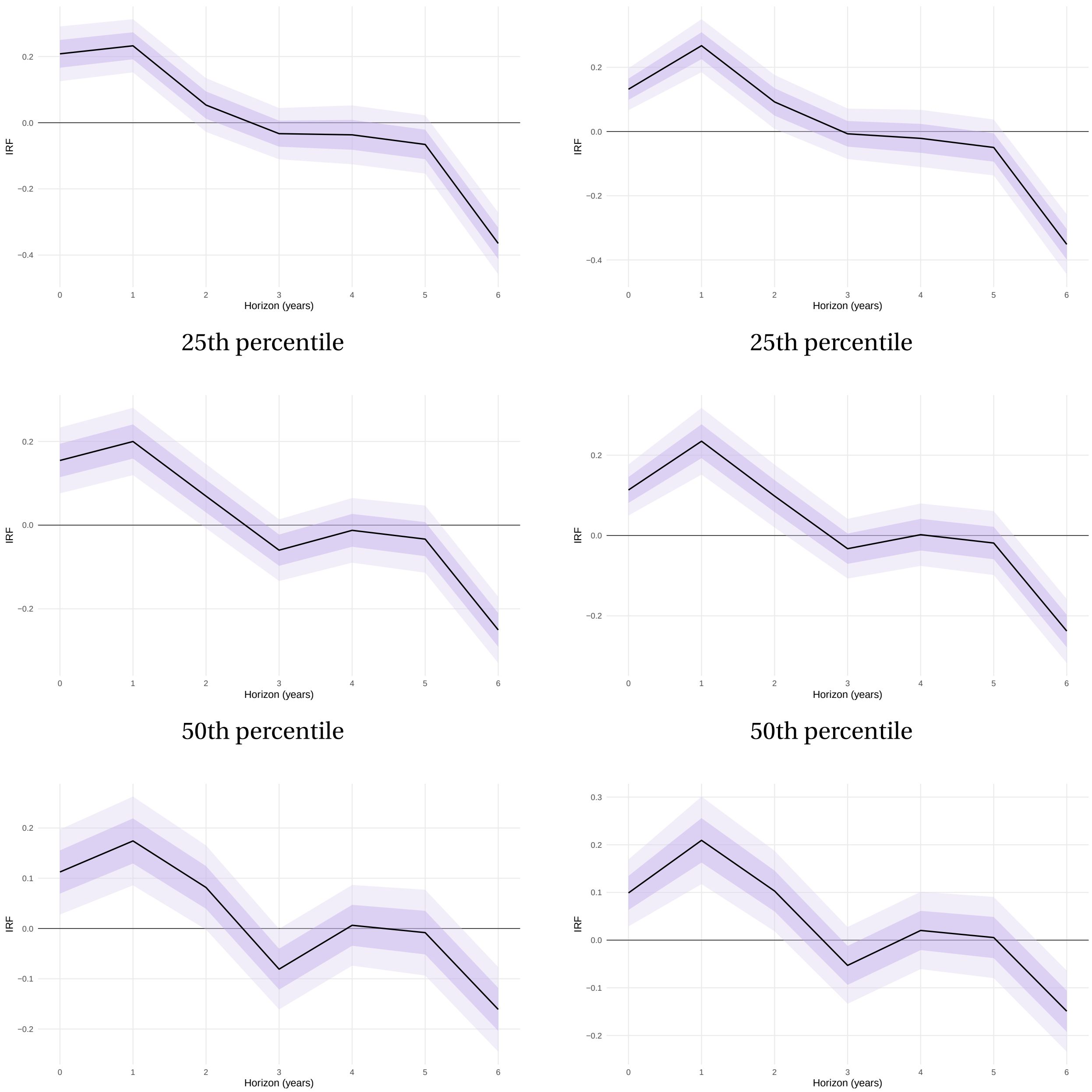


75th percentile

Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank competition (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of credit growth and predictors.

Figure 19: Local projections responses of banking stability (Z-score) to monetary policy shock, conditional on bank competition, controlling for macroprudential policies (Liquidity and LFX)

(i) One Lag of Predictors **(ii) One Lag of Z-score & Predictors**



25th percentile | 25th percentile

50th percentile | 50th percentile

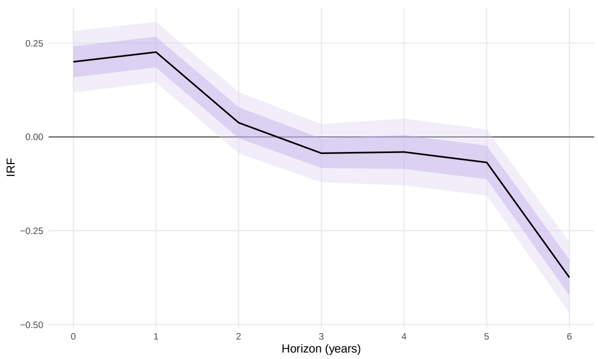
75th percentile | 75th percentile

Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank competition (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LFX). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of Z-score and predictors.

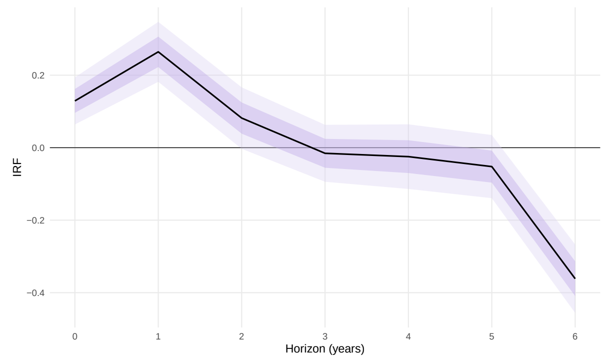
Figure 20: Local projections responses of banking stability (Z-score) to monetary policy shock, conditional on bank competition, controlling for macroprudential policies (Liquidity and LTV)

(i) One Lag of Predictors

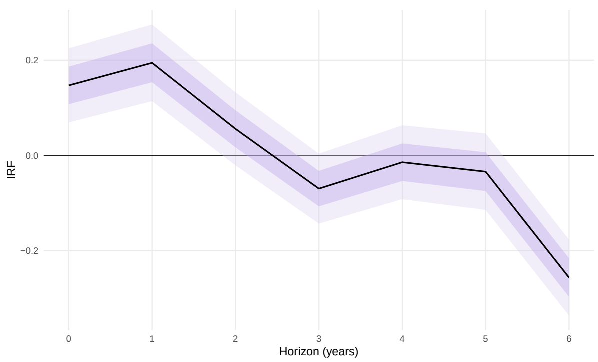
(ii) One Lag of Z-score & Predictors



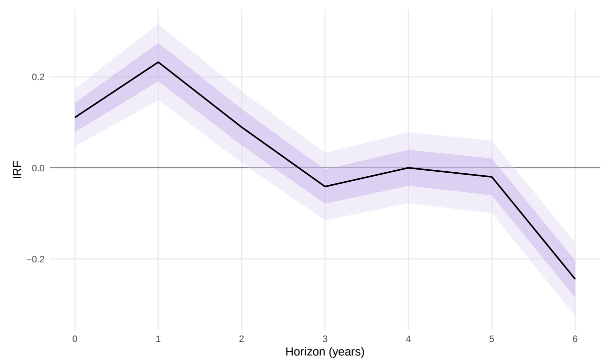
25th percentile



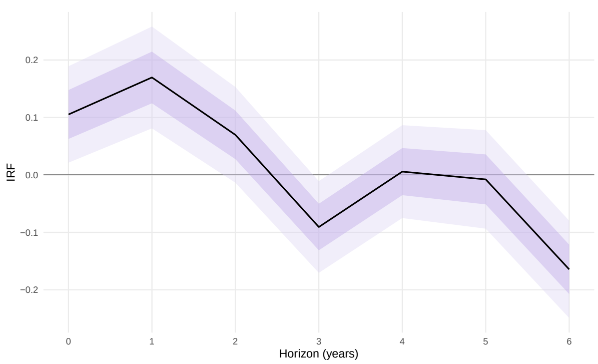
25th percentile



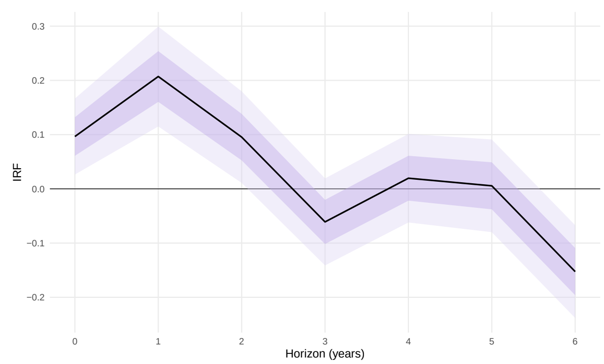
50th percentile



50th percentile



75th percentile



75th percentile

Note: The figure plots local projections responses of banking stability (Z-score) to a one-standard-deviation monetary policy shock, conditional on bank competition (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LTV). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of Z-score and predictors.

6.3 Robustness: instrumental variables–two-stage least squares (IV-2SLS)

The study employs the two-stage least squares (2SLS) instrumental variables (IV) approach to further strengthen the identification of monetary policy stance. Given the second stage model as in Equation (8) using the predicted monetary policy stance, $\hat{Policy}^{z}_{j,t-1}$, following from the first stage regression as specified below:

$$Policy^{z}_{j,t-1} = \alpha_i + \mu_j + \delta_t + \beta_2 \text{CBI}_{j,t} + \gamma' \text{Controls}_{ijt} + \xi_{j,t} \tag{28}$$

where all variables are as defined earlier. Here, we instrument monetary policy variable using a measure of central bank independence,$\text{CBI}_{j,t}$ sourced from Garriga (2016). It is an index that aggregates 16 legal indicators into four main categories: tenure of the bank's governor, an indicator related to policy formulation, an indicator related to the central bank's objectives, and an indicator related to the limitation on lending to the government. The index ranges from 0 to 1, with higher values suggesting more independence. We use the aggregate measure, which takes the average of the four indicators. The advantage of the CBI from Garriga (2016) is that the dataset is comprehensive, covering approximately 182 countries, unlike previous studies that focused on developed countries and provided limited samples from developing countries. It is by far the most extensive dataset that computes the Cukierman, Webb and Neyapty (CWN) index, which is updated yearly from 1970 to 2024.

Identification strategy We exploit cross-country and over-time variation in central bank independence (CBI) as an instrument for monetary policy. Conceptually, CBI captures the central bank's capacity to control monetary instruments (Bernhard, 2002) or, equivalently, the set of legal and institutional constraints on the government's ability to influence the conduct of monetary policy (Garriga, 2016). We use CBI as an instrument because it is theoretically well grounded and highly correlated with the monetary policy stance, while offering a credible exclusion restriction. The exclusion restriction is also plausible. Conditional on bank, country, and year fixed effects, the degree of central bank independence is unlikely to have a direct effect on banking-sector stability, except through its influence on monetary policy choices. CBI has no direct effect on banks' risk-taking or balance-sheet decisions once monetary policy is controlled for. Formally, we assume that CBI is predetermined with respect to bank-level shocks and affects banking stability only through monetary policy, implying that CBI is orthogonal to the structural error term, $\varepsilon_{i,j,t}$.

Table 10: Impact of monetary policy on banking stability – 2SLS

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	5.45*	7.25**	4.00*	5.33**
	(2.92)	(3.22)	(2.11)	(2.31)
Cost efficiency	5.00***	2.61***	4.65***	2.28***
	(0.937)	(0.876)	(0.862)	(0.860)
Bank liquidity	0.031***	0.017***	0.031***	0.016***
	(0.003)	(0.003)	(0.003)	(0.003)
Size	-2.60***	-1.61***	-2.62***	-1.63***
	(0.213)	(0.219)	(0.209)	(0.209)
Asset structure	0.121***	0.059*	0.120***	0.056
	(0.039)	(0.036)	(0.039)	(0.035)
Bank Concentration	0.047***	0.082***	0.045***	0.077***
	(0.017)	(0.023)	(0.016)	(0.021)
GDP growth	-0.301	-0.362*	-0.224	-0.270*
	(0.195)	(0.186)	(0.152)	(0.141)
Inflation (CPI)	-0.010	-0.023	-0.0009	-0.019
	(0.031)	(0.024)	(0.025)	(0.020)
Institutional Quality	-2.96	-5.22	-1.85	-3.74
	(3.50)	(4.07)	(2.88)	(3.33)
First Stage Regression				
CBI → $Policy^{z}_{j,t-1}$	-0.778***	-0.738***	-1.060***	-1.002***
	(0.123)	(0.120)	(0.139)	(0.138)
F-stats (1st stage)	38.530	29.620	67.634	51.619
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,883	3,755	3,883	3,755
N	42,287	38,948	42,287	38,948
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table 10 reports the baseline two-stage least squares (2SLS) estimates of the impact of monetary policy on banking stability, where the monetary policy stance is instrumented using central bank independence (CBI). Across all specifications, the coefficient on the lagged monetary policy stance is positive and statistically significant, regardless of whether the Hybrid or Official policy measure is used. This suggests that an exogenous monetary tightening, identified through higher CBI, is associated with an increase in bank stability. The magnitude of the effect is economically meaningful and larger in specifications that include lagged controls (Models (2) and (4)), suggesting that accounting for persistence in bank characteristics strengthens the stabilising role of monetary tightening. The first-stage results confirm the relevance of the instrument: CBI is strongly and negatively associated with the monetary policy stance, consistent with the notion that more independent central banks implement tighter policy frameworks. The first-stage F-statistics comfortably exceed conventional thresholds (10), alleviating concerns about weak instruments and supporting a causal interpretation of the second-stage estimates.

Tables 11 and 12 extend the baseline analysis by explicitly controlling for macroprudential policy instruments, focusing on liquidity-based measures and limits on foreign exchange (LFX) and loan-to-value (LTV) ratios. Importantly, the positive and significant effect of monetary tightening on bank stability remains robust to the inclusion of these policy tools, both in magnitude and significance. This suggests that the stabilising effect of monetary policy is not merely capturing the operation of macroprudential regulation but reflects an independent transmission channel. Among the macroprudential controls, LFX measures are consistently positive and significant, indicating that restrictions on foreign currency exposures complement monetary tightening in enhancing bank resilience. By contrast, liquidity- and LTV-based macroprudential tools display weaker and less precisely estimated effects, particularly in lagged specifications. Overall, the 2SLS evidence implies that monetary tightening, when plausibly exogenous and insulated from reverse causality via CBI, contributes to higher banking stability even in regulatory environments where macroprudential policies are actively deployed.

Table 11: Impact of monetary policy on banking stability, controlling for macroprudential policies (Liquidity and LFX) – 2SLS

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	5.78**	7.63**	4.18**	5.54**
	(2.93)	(3.21)	(2.08)	(2.26)
Cost efficiency	5.14***	2.63***	4.74***	2.27***
	(0.986)	(0.889)	(0.890)	(0.864)
Bank liquidity	0.031***	0.017***	0.031***	0.017***
	(0.003)	(0.003)	(0.003)	(0.003)
Size	-2.65***	-1.66***	-2.66***	-1.67***
	(0.212)	(0.212)	(0.209)	(0.204)
Asset structure	0.127***	0.062*	0.124***	0.058
	(0.040)	(0.037)	(0.040)	(0.036)
Bank Concentration	0.047***	0.084***	0.045***	0.078***
	(0.018)	(0.024)	(0.017)	(0.021)
GDP growth	-0.376*	-0.443**	-0.271	-0.318**
	(0.224)	(0.215)	(0.168)	(0.158)
Inflation (CPI)	-0.008	-0.011	0.001	-0.009
	(0.027)	(0.022)	(0.022)	(0.018)
Institutional Quality	-3.89	-6.12	-2.59	-4.39
	(3.67)	(4.17)	(2.97)	(3.37)
Macroprudential: Liquidity	0.093	0.239	0.033	0.145
	(0.161)	(0.204)	(0.129)	(0.161)
Macroprudential: LFX	0.485***	0.546***	0.298**	0.296**
	(0.175)	(0.203)	(0.127)	(0.144)
First Stage Regression				
CBI $\rightarrow \text{Policy}^{z}_{j,t-1}$	-0.782***	-0.747***	-1.081***	-1.029***
	(0.123)	(0.121)	(0.141)	(0.140)
F-stats (1st stage)	39.856	31.180	72.166	55.937
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,796	3,669	3,796	3,669
N	41,458	38,204	41,458	38,204
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).LFX: Limits on FX.

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table 12: Impact of monetary policy on banking stability, controlling for macroprudential policies (Liquidity and LTV) – 2SLS

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$	5.74*	7.62**	4.17**	5.55**
	(2.97)	(3.25)	(2.12)	(2.30)
Cost efficiency	5.07***	2.60***	4.69***	2.24**
	(0.961)	(0.892)	(0.878)	(0.873)
Bank liquidity	0.031***	0.017***	0.031***	0.017***
	(0.003)	(0.003)	(0.003)	(0.003)
Size	-2.64***	-1.65***	-2.65***	-1.66***
	(0.215)	(0.216)	(0.211)	(0.207)
Asset structure	0.127***	0.064*	0.125***	0.060*
	(0.041)	(0.037)	(0.041)	(0.036)
Bank Concentration	0.048***	0.085***	0.045***	0.079***
	(0.018)	(0.025)	(0.017)	(0.022)
GDP growth	-0.385	-0.463**	-0.279	-0.336**
	(0.239)	(0.230)	(0.181)	(0.171)
Inflation (CPI)	-0.022	-0.033	-0.009	-0.026
	(0.036)	(0.028)	(0.028)	(0.023)
Institutional Quality	-3.85	-6.14	-2.57	-4.43
	(3.70)	(4.23)	(3.01)	(3.42)
Macroprudential: Liquidity	0.101	0.255	0.041	0.160
	(0.174)	(0.218)	(0.141)	(0.173)
Macroprudential: LTV	0.569	0.845*	0.402	0.638*
	(0.436)	(0.474)	(0.345)	(0.373)
First Stage Regression				
CBI → $\text{Policy}^{z}_{j,t-1}$	-0.769***	-0.737***	-1.058***	-1.011***
	(0.120)	(0.118)	(0.136)	(0.136)
F-stats (1st stage)	38.813	30.526	69.731	54.405
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,796	3,669	3,796	3,669
N	41,458	38,204	41,458	38,204
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).LTV: Limits on Loan-to-Value Ratio
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

7 A DSGE Model with Bank Cost Efficiency, Risk Management, and Stability Dynamics

7.1 Overview and empirical targets

This section develops a tractable dynamic stochastic general equilibrium (DSGE) model to replicate three empirical regularities documented in the local-projection evidence. First, a contractionary monetary policy innovation raises bank stability on impact but is followed by a subsequent deterioration at medium horizons (sign reversal). Second, this medium-run deterioration is systematically smoother for more cost-efficient banks. Third, intermediation margins compress on impact after tightening, while credit growth declines with heterogeneity across efficiency groups. The model is deliberately parsimonious: it embeds a standard New Keynesian (NK) core to discipline aggregate dynamics and augments it with a banking block in which heterogeneity in cost efficiency governs banks' risk-management responses and loss absorption.

The framework builds on three strands of the literature. The NK core follows the canonical sticky-price monetary DSGE environment (Woodford and Walsh, 2005; Galí, 2015). The mechanism linking monetary policy to bank risk and balance-sheet conditions is motivated by the risk-taking channel of monetary policy (Borio and Zhu, 2012) and by balance-sheet/financial-frictions approaches that emphasise how macro shocks translate into borrower quality and intermediated credit conditions (Bernanke and Gertler, 1995; Gertler and Kiyotaki, 2010). Heterogeneity in banks' operational performance is introduced through a reduced-form representation of efficiency and managerial capability, consistent with interpreting cost efficiency as a shifter of operating technology and risk-control capacity (Berger and DeYoung, 1997).

The key modelling choice is to separate two forces through which tightening affects banks. A slow borrower-distress state rises persistently after monetary tightening and pushes default risk upward over time. In parallel, a fast risk-management response increases on impact and mitigates default risk; this response is stronger (and less costly) for high-efficiency banks. The interaction of these channels generates the horizon-dependent sign reversal in stability and delivers the efficiency-conditioned smoothing observed in the data.

7.2 Set up

Time is discrete. A representative household supplies labour, consumes, and holds bank deposits. The production sector features Calvo price rigidity. Monetary policy follows a Taylor rule with an innovation interpreted as an exogenous tightening shock. The banking sector intermediates deposits into loans and is heterogeneous by cost efficiency. In the baseline theoretical exposition, bank type is indexed by $k \in \{25, 50, 75\}$ to mirror the percentile-based local-projection responses, corresponding to the low-, median-, and high-efficiency groups (labelled $P25$, $P50$, and $P75$ in figures and text). Bank efficiency governs: i) the marginal and adjustment costs of risk management and ii) the effectiveness of risk management in reducing default risk. Heterogeneous pass-through in intermediation margins ensures that NIM compresses on impact and recovers more slowly for high-efficiency banks.

The model is calibrated to match the following LP-based impulse-response targets (tightening shock) at horizons $h = 0, \dots, 6$:

1. $I\hat{R}F_Z^k(h)$ for $k \in \{25, 50, 75\}$ (bank stability);
2. $I\hat{R}F_\mu^k(h)$ for $k \in \{25, 50, 75\}$ (net interest margin);
3. $I\hat{R}F_{\Delta\ell}^k(h)$ for $k \in \{25, 50, 75\}$ (credit growth, log changes);
4. $I\hat{R}F_{\Delta \log(\mathrm{NPL})}^k(h)$ for $k \in \{25, 50, 75\}$ (NPL growth, log changes);
5. $I\hat{R}F_{\Delta \log(\mathrm{NPL}) - \Delta \log(L)}^k(h)$ for $k \in \{25, 50, 75\}$ (NPL growth relative to loan growth; growth-rate analogue of the NPL ratio).

7.3 Households

A representative household maximises:

$$\max_{\{C_t, N_t, D_t\}_{t \geq 0}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right], \tag{29}$$

where C_t is consumption, N_t denotes labour supply, $\beta \in (0,1)$, $\sigma > 0$, and $\varphi > 0$.

Let P_t be the aggregate price level, D_t be the nominal deposits held at banks, W_t the nominal wage, and R_t^D the gross nominal deposit rate paid from t to $t+1$. Household profits/transfers are denoted Π_t and T_t. The nominal budget constraint is:

$$P_t C_t + D_t \leq W_t N_t + R_{t-1}^D D_{t-1} + \Pi_t + T_t. \tag{30}$$

The optimality conditions are:

$$\textbf{Euler (deposits):} \quad 1 = \beta \, \mathbb{E}_t \left[\left(\frac{C_t}{C_{t+1}} \right)^{\sigma} \frac{R_t^D}{\Pi_{t+1}} \right], \tag{31}$$

$$\textbf{Labour supply:} \quad \frac{W_t}{P_t} = C_t^{\sigma} N_t^{\varphi}, \tag{32}$$

where $\Pi_{t+1} \equiv P_{t+1}/P_t$ is gross inflation.

7.4 Firms and price setting

Final good. A competitive final-goods firm aggregates a continuum of intermediate goods $Y_t(i)$, $i \in [0,1]$, into Y_t:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \qquad \varepsilon > 1. \tag{33}$$

Demand for variety i is:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} Y_t. \tag{34}$$

Intermediate goods. Each intermediate firm produces with labour:

$$Y_t(i) = A_t N_t(i), \tag{35}$$

where A_t is aggregate productivity (normalised to one in steady state; omitted below for brevity). Real marginal cost is:

$$MC_t \equiv \frac{W_t}{P_t A_t}. \tag{36}$$

Calvo pricing. Prices are set à la Calvo rigidity: each period, a firm can reset its price with probability $1-\alpha$, $\alpha \in (0,1)$. Optimal reset pricing and the resulting New Keynesian Phillips curve are standard; for completeness, the full derivation is placed in Appendix G.1. In log-linear form around a zero-inflation steady state, inflation satisfies:

$$\pi_t = \beta \, \mathbb{E}_t[\pi_{t+1}] + \kappa \, x_t, \tag{37}$$

where π_t is (log) inflation, x_t is the output gap, and $\kappa \equiv \kappa(\alpha, \beta, \varepsilon)$.

7.5 Monetary policy

The monetary authority sets the gross nominal policy rate R_t using a Taylor rule with inertia:

$$\log\left(\frac{R_t}{\bar{R}}\right) = \rho_R \log\left(\frac{R_{t-1}}{\bar{R}}\right) + (1-\rho_R)\left[\phi_\pi \log\left(\frac{\Pi_t}{\bar{\Pi}}\right) + \phi_x x_t\right] + \varepsilon_t^R, \tag{38}$$

where $\rho_R \in (0,1)$, $\phi_\pi > 1$, $\phi_x \geq 0$, and ε_t^R is a monetary policy innovation (tightening when $\varepsilon_t^R > 0$). Consistent with the empirical standardisation of the policy stance proxy, the model

IRFs are reported for a one-standard-deviation innovation, so scaling affects magnitudes but not equilibrium signs or ordering.

Deposits are remunerated at the policy rate up to an institutional wedge:

$$R_t^D = R_t \exp(\psi), \qquad \psi \geq 0, \tag{39}$$

which can capture deposit competition/regulatory frictions.[10]

7.6 Borrower distress and default risk (slow channel)

A reduced-form borrower-distress state d_t summarises medium-run repayment pressure (cash-flow stress, rollover risk, and credit quality deterioration). Distress evolves as:

$$d_t = \rho_d d_{t-1} + \phi_d \varepsilon_t^R + \phi_{dx} x_t + \varepsilon_t^d, \qquad 0 < \rho_d < 1,\ \phi_d > 0, \tag{40}$$

where ε_t^d is an orthogonal distress shock which is set to 0 in the baseline IRFs. The key restriction for sign reversal is that d_t is persistent relative to the risk-management response (formalised in Appendix G.3).

For a bank of type $k \in \{25, 50, 75\}$, default probability on the representative loan portfolio is:

$$p_{k,t} = \bar{p} + \pi_d d_t - \chi_k m_{k,t}, \qquad \pi_d > 0,\ \chi_k > 0, \tag{41}$$

where $m_{k,t} \geq 0$ denotes risk-management intensity (screening/monitoring/provisioning). Higher $m_{k,t}$ reduces default risk; higher efficiency is permitted to imply larger effectiveness, $\chi_{75} \geq \chi_{50} \geq \chi_{25}$.

7.7 Banking sector with cost-efficiency heterogeneity (fast channel)

Balance sheet. Each bank type k intermediates deposits into loans with bank equity:

$$L_{k,t} = D_{k,t} + E_{k,t}. \tag{42}$$

Funding leg. Deposits serve as the passive funding leg at annual frequency: we do not model bank-specific deposit reallocation or a separate deposit-market-clearing block, and instead discipline deposit pricing through (39) while focusing on the interaction of borrower distress and efficiency-conditioned risk management.

[10] In the log-linear implementation used for IRFs, this wedge is absorbed into constants and does not affect dynamics.

Loan pricing, deposit pricing, and net interest margins. Loans are priced off the policy rate and a risk-based spread component. Let $\hat{R}_t \equiv \log(R_t/\bar{R})$ denote the log deviation of the policy rate from steady state. We assume incomplete pass-through of the policy rate into the effective loan rate faced by borrowers:

$$\hat{R}^L_{k,t} = \alpha_{L,k}\,\hat{R}_t + s_{k,t}, \qquad \alpha_{L,k} > 0, \tag{43}$$

where $s_{k,t}$ is the (log) spread component linked to default risk. Deposits are remunerated with a (potentially different) pass-through:

$$\hat{R}^D_{k,t} = \beta_{D,k}\,\hat{R}_t, \qquad \beta_{D,k} \geq 0, \tag{44}$$

where any steady-state wedge is absorbed into constants in the log-linear system.

Net interest margins (NIM) are defined as the spread between the effective loan rate and the deposit rate:

$$\mu_{k,t} \equiv \hat{R}^L_{k,t} - \hat{R}^D_{k,t} = (\alpha_{L,k} - \beta_{D,k})\,\hat{R}_t + s_{k,t}. \tag{45}$$

Thus, a monetary tightening compresses margins on impact whenever $\beta_{D,k} > \alpha_{L,k}$, i.e. when funding costs reprice faster than loan yields at the relevant horizon. Cross-sectional heterogeneity in margin dynamics is governed by $(\alpha_{L,k}, \beta_{D,k})$; in particular, more persistent compression for high-efficiency banks can be captured by a more negative $(\alpha_{L,75} - \beta_{D,75})$ relative to $(\alpha_{L,25} - \beta_{D,25})$.

Risk-management technology and efficiency. Bank cost efficiency is represented by a type-specific parameter $\theta_k > 0$ (higher θ denotes higher efficiency). Risk management incurs operating and adjustment costs:

$$\mathscr{C}^m(m_{k,t};\theta_k) = \frac{\kappa_m}{2\theta_k}\,m^2_{k,t}, \tag{46}$$

$$\mathscr{C}^a(m_{k,t}, m_{k,t-1};\theta_k) = \frac{\varphi_m}{2\theta_k}\,(m_{k,t} - m_{k,t-1})^2, \tag{47}$$

with $\kappa_m > 0$, $\varphi_m > 0$. Higher efficiency reduces both the level and adjustment costs, consistent with the interpretation that cost efficiency reflects operational capability and process scalability. In the log-linear implementation, these costs are approximated around steady state by a reduced-form linear term $c_{m,k}m_{k,t}$ and the adjustment-cost component is absorbed into the partial-adjustment law for $m_{k,t}$.

Per-period bank payoff and equity dynamics. Let λ denote LGD and the expected credit-loss component per unit lending as $\lambda p_{k,t}$. A tractable per-period payoff (per unit scale) that matches the empirical objects is:

$$\Pi^B_{k,t} = \mu_{k,t} - \lambda p_{k,t} - \mathscr{C}^m(m_{k,t};\theta_k) - \mathscr{C}^a(m_{k,t}, m_{k,t-1};\theta_k), \tag{48}$$

and bank equity evolves with retained earnings (reduced-form, consistent with slow-moving regulatory capital at annual frequency):

$$e_{k,t} = \rho_e e_{k,t-1} + \phi_e \Pi^B_{k,t}, \qquad 0 < \rho_e < 1,\ \phi_e > 0, \tag{49}$$

where $e_{k,t}$ is (log) equity deviation from steady state. This equity block provides an internal propagation mechanism into lending.

Risk-management choice (FOC). In each period, bank type k chooses $m_{k,t}$ to maximise Equation (48) taking $(d_t, m_{k,t-1})$ as given. The first-order condition is:

$$\underbrace{\lambda\chi_k}_{\text{marginal benefit via lower losses}} - \underbrace{\frac{\kappa_m}{\theta_k} m_{k,t}}_{\text{marginal operating cost}} \underbrace{- \frac{\varphi_m}{\theta_k}(m_{k,t} - m_{k,t-1})}_{\text{marginal adjustment cost}} = 0. \tag{50}$$

Solving yields a partial-adjustment policy rule,

$$m_{k,t} = \rho_m m_{k,t-1} + \xi\,\theta_k \chi_k, \qquad \rho_m \equiv \frac{\varphi_m}{\kappa_m + \varphi_m},\ \xi \equiv \frac{\lambda}{\kappa_m + \varphi_m}. \tag{51}$$

Linking monetary policy innovations to the fast channel. To operationalise the risk-taking channel in the minimal way required by the empirics (tightening induces stronger risk management), the marginal benefit of $m_{k,t}$ is allowed to rise with the monetary innovation:

$$\lambda\chi_k \longrightarrow \lambda\chi_k(1 + \eta\,\varepsilon^R_t), \qquad \eta > 0, \tag{52}$$

which implies

$$m_{k,t} = \rho_m m_{k,t-1} + \xi\,\theta_k \chi_k + \underbrace{\big(\xi\,\eta\,\theta_k \chi_k\big)}_{\nu_k} \varepsilon^R_t. \tag{53}$$

Thus, higher efficiency (higher θ_k) and/or higher effectiveness (χ_k) increases the short-run response of risk management to tightening, delivering the empirical interaction mechanism. In the log-linear system, $m_{k,t}$ is measured as a deviation from its steady-state level, so the constant term drops out.

7.8 Lending and credit growth

To match the empirical credit-growth IRFs while remaining tractable at annual frequency, bank lending is represented by a reduced-form partial-adjustment relationship:

$$\ell_{k,t} = \rho_\ell \ell_{k,t-1} + (1-\rho_\ell)\Big(a_e e_{k,t} - a_{r,k} \hat{R}^L_{k,t} + a_y y_t - a_{m,k} m_{k,t}\Big) + b R_k \varepsilon^R_t, \qquad k \in \{25, 50, 75\}, \tag{54}$$

where $\hat{R}^L_{k,t}$ is the effective loan rate in Equation (43), $\rho_\ell \in (0,1)$ captures lending inertia, $a_{r,k}$ allows heterogeneity in the semi-elasticity of lending to the loan rate, $a_{m,k}$ captures tightening of lending standards associated with risk-management intensity, and bR_k allows a direct contemporaneous lending response to a tightening innovation. Credit growth is the change in log lending:

$$\Delta\ell_{k,t} \equiv \ell_{k,t} - \ell_{k,t-1}. \tag{55}$$

7.9 Bank stability index and correspondence to the Z-score

Let the empirical bank-stability proxy be the Z-score. This follows our empirical calculation as follows:

$$Z_{k,t} \approx \frac{\text{ROA}_{k,t} + K_{k,t}}{\sigma_k}, \tag{56}$$

where ROA is return on assets, K is a capital ratio, and σ_k is return volatility (slow-moving). To align model objects with estimated IRFs, we define a log-linear stability index $z_{k,t}$:

$$z_{k,t} = z_\mu \mu_{k,t} - z_p \lambda p_{k,t} + z_m m_{k,t} - z_d d_t, \tag{57}$$

with weights (z_μ, z_p, z_m, z_d) chosen to avoid double-counting of distress when $p_{k,t}$ already embeds d_t through Equation (41). The calibrated weights used in the IRF-generating implementation set $z_d = 0$ and place sufficient mass on the fast channel $(m_{k,t})$ to replicate the impact stabilisation and efficiency-conditioned smoothing.

7.10 Asset quality and NPL dynamics: mapping the model to NPL growth and the NPL ratio

Bank stability is proxied by the Z-score, which is a forward-looking buffer concept combining profitability and capitalisation relative to return volatility. Non-performing loans (NPLs) provide a complementary, balance-sheet-based measure of realised credit impairment. Because NPLs reflect both new problem-loan inflows and resolution/write-offs, and because the NPL ratio mechanically co-moves with the loan stock, aligning the model and the empirics requires tracking: i) the NPL stock and ii) the loan stock jointly.

Let $NPL_{k,t}$ denote the (gross) NPL stock of bank type $k \in \mathscr{K} \equiv \{25, 50, 75\}$ and let $L_{k,t}$ denote the loan stock. NPL ratio is defined as:

$$\mathsf{nplr}_{k,t} \equiv \frac{NPL_{k,t}}{L_{k,t}}. \tag{58}$$

In log deviations (or log changes), changes in the NPL ratio admit the approximation:

$$\Delta \ln(\mathsf{nplr}_{k,t}) \approx \Delta \ln(NPL_{k,t}) - \Delta \ln(L_{k,t}), \tag{59}$$

which matches the empirical difference measure.

To mirror the empirical dynamics while remaining consistent with the log-linear Dynare implementation, we specify NPL dynamics directly in log deviations for each efficiency type. Let $npl_{k,t}$ denote the log deviation of the NPL stock (or an NPL index) from steady state. The law of motion is:

$$npl_{k,t} = \rho_{npl,k}\, npl_{k,t-1} + (1-\rho_{npl,k})\mathsf{Inflow}_{k,t} + bN_k\, \varepsilon_t^R, \qquad k \in \{25, 50, 75\}, \tag{60}$$

where $\rho_{npl,k} \in (0,1)$ governs persistence (resolution/workout inertia) and $bN_k\, \varepsilon_t^R$ allows for contemporaneous recognition/reclassification effects following tightening. Inflows are increasing in borrower distress and decreasing in bank risk management:

$$\mathsf{Inflow}_{k,t} = \iota_d\, d_t - \iota_{m,k}\, m_{k,t}, \qquad \iota_d > 0,\ \iota_{m,k} > 0, \tag{61}$$

with d_t the slow-moving distress state and $m_{k,t}$ the fast risk-management effort as defined earlier. This structure ensures that: i) tightening can affect measured impairment on impact through contemporaneous distress and/or recognition/reclassification effects (captured by $bN_k\, \varepsilon_t^R$), while ii) subsequent NPL dynamics depend on the interaction of persistence in distress and efficiency-conditioned mitigation and resolution.

The simulated counterparts to the empirical NPL objects are defined as log changes:

$$\Delta \ln(\text{NPL})_{k,t} \equiv npl_{k,t} - npl_{k,t-1}, \tag{62}$$

$$\Delta \ln(\text{NPL})_{k,t} - \Delta \ln(L)_{k,t} \equiv \big(npl_{k,t} - npl_{k,t-1}\big) - \big(\ell_{k,t} - \ell_{k,t-1}\big), \tag{63}$$

which is the model analogue of the empirical growth-rate approximation to changes in the NPL ratio, $\Delta \ln(\mathsf{nplr}_{k,t}) \approx \Delta \ln(\text{NPL}_{k,t}) - \Delta \ln(L_{k,t})$.

7.11 Equilibrium and log-linear implementation

Equilibrium. An equilibrium is a set of processes

$$\{C_t, N_t, Y_t, \Pi_t, R_t, R_t^D, W_t\}_{t\geq 0} \cup \{d_t, m_{k,t}, p_{k,t}, s_{k,t}, \mu_{k,t}, e_{k,t}, \ell_{k,t}\}_{t\geq 0,k}$$

such that: i) households satisfy Equation (31)–(32); ii) firms satisfy optimal labour demand and Calvo pricing (Appendix G.1) implying Equation (37) in log-linear form; iii) monetary policy satisfies Equation (38); iv) distress satisfies Equation (40); v) for each k, banks satisfy Equation (41)–(53), Equation (43)–(49), Equation (54); and vi) goods market clears:

$$Y_t = C_t + G_t + \sum_k \left[\mathscr{C}^m(m_{k,t};\theta_k) + \mathscr{C}^a(m_{k,t}, m_{k,t-1};\theta_k)\right], \tag{64}$$

where G_t is exogenous government spending.

Log-linear system used for IRFs. The Dynare implementation corresponds to the log-linear equilibrium conditions (IS curve, NKPC, Taylor rule, and the banking/distress block) obtained by linearising around a zero-inflation steady state.

7.12 Calibration

The implementation is a log-linear New Keynesian macro block augmented with a reduced-form banking block that is heterogeneous by cost efficiency (three types indexed by $k \in \{25, 50, 75\}$). The model is calibrated at the same frequency as the empirical estimation (annual in the baseline). A key modelling choice is that the monetary policy shock follows a persistent AR(1) process ($\rho_\varepsilon = 0.50$), so that $\varepsilon_t^R = \rho_\varepsilon \varepsilon_{t-1}^R + \sigma_R e_t^R$. This persistence is essential for the slow borrower-distress channel to accumulate sufficiently over intermediate horizons and eventually dominate the fast risk-management response, thereby generating the sign reversal in the stability index observed in the empirical local projections. Without shock persistence ($\rho_\varepsilon = 0$), the distress state receives only a single impulse and decays monotonically, so the stability index improves on impact but never reverses — inconsistent with the data.

Table 13 reports the calibration. The New Keynesian block parameters are conventional; the banking-block parameters are disciplined via a minimum-distance estimation targeting the LP-based impulse responses of stability (z_k), net interest margins (μ_k), and credit growth ($\Delta\ell_k$) across the three efficiency groups. The estimation minimises the weighted sum of squared deviations between model-implied and empirical IRFs at horizons $h = 0, \dots, 6$, with inverse-LP-variance weighting. The resulting calibration simultaneously matches the qualitative features of the LP evidence: impact stabilisation, horizon-dependent sign reversal, efficiency-conditioned smoothing, and NIM compression that is strongest for high-efficiency banks.

Table 13: Baseline calibration

Parameter	Value	Interpretation
A. New Keynesian macro block		
β	0.99	Discount factor (log-linearised NK block)
σ	1.5	Intertemporal elasticity parameter (IS slope)
κ	0.10	NK Phillips curve slope
ρ_R	0.80	Interest-rate smoothing
ϕ_π	1.50	Taylor-rule inflation response
ϕ_x	0.10	Taylor-rule output-gap response
ρ_ε	0.50	Monetary shock persistence (AR(1) in ε_t^R)
σ_R	0.15	Shock scaling: $\varepsilon_t^R = \rho_\varepsilon \varepsilon_{t-1}^R + \sigma_R e_t^R$
B. Slow borrower-distress state		
ρ_d	0.85	Distress persistence (slow channel)
ϕ_d	0.60	Tightening → distress loading
ϕ_{dx}	0.00	Optional output-gap → distress loading
C. Risk management, default risk, spreads, and NIM		
ρ_m	0.40	Risk-management persistence (fast channel)
$\nu_{25}, \nu_{50}, \nu_{75}$	$(0.35, 0.55, 0.80)$	Tightening → risk-management response by efficiency
π_d	0.50	Distress → default risk loading
$\chi_{25}, \chi_{50}, \chi_{75}$	$(0.38, 0.40, 0.55)$	Risk-management effectiveness (reduces default risk)
ω_p	0.50	Default risk → spread mapping
λ	0.45	Loss-given-default (LGD)
$\alpha_{L,25}, \alpha_{L,50}, \alpha_{L,75}$	$(0.70, 0.65, 0.60)$	Loan-rate pass-through
$\beta_{D,25}, \beta_{D,50}, \beta_{D,75}$	$(0.92, 0.94, 0.95)$	Deposit beta ($\beta_{D,k} > \alpha_{L,k}$ generates NIM compression)
$c_{m,25}, c_{m,50}, c_{m,75}$	$(0.05, 0.05, 0.05)$	Operating cost slope in risk management (linearised)
D. Equity and lending dynamics (with heterogeneity)		
ρ_e	0.90	Equity persistence
ϕ_e	0.15	Equity sensitivity to (risk-adjusted) profits
ρ_ℓ	0.60	Lending inertia (partial adjustment)
a_e	0.50	Equity → lending elasticity
a_y	0.05	Output → lending elasticity
$a_{r,25}, a_{r,50}, a_{r,75}$	$(0.15, 0.25, 0.35)$	Semi-elasticity of lending to $(\hat{R}_t + s_{k,t})$ by efficiency
$a_{m,25}, a_{m,50}, a_{m,75}$	$(0.05, 0.10, 0.15)$	Risk-management → lending tightness channel by efficiency
$bR_{25}, bR_{50}, bR_{75}$	$(0.087, 0.018, -0.014)$	Direct impact of tightening on lending growth (discipline vs. volume defence)
E. Model stability index (mapping to empirical Z-score dynamics)		
z_μ	0.15	Weight on NIM in $z_{k,t}$
z_p	1.80	Weight on expected-loss term $\lambda p_{k,t}$ in $z_{k,t}$
z_m	0.60	Weight on risk-management (fast channel) in $z_{k,t}$
z_d	0.00	Additional distress weight (set to zero to avoid double-counting via $p_{k,t}$)
F. NPL dynamics (stock, growth, and relative growth)		
$\rho_{n,25}, \rho_{n,50}, \rho_{n,75}$	$(0.80, 0.70, 0.65)$	NPL stock persistence (lower ⇒ faster adjustment/clean-up)
ι_d	0.10	Distress → NPL inflow loading
$\iota_{m,25}, \iota_{m,50}, \iota_{m,75}$	$(0.22, 0.15, 0.12)$	Risk-management mitigates NPL inflows (heterogeneous)
$bN_{25}, bN_{50}, bN_{75}$	$(-0.10, -0.20, -0.30)$	Impact recognition/clean-up term in NPL block (tightening → lower measured NPL growth on impact)

The parameters $\{\rho_d, \phi_d, \rho_m, \nu_k, \chi_k, \alpha_{L,k}, \beta_{D,k}, \rho_e, \phi_e, a_e, a_{r,k}, a_y, \rho_\ell, a_{m,k}, bR_k\}$ primarily govern the sign reversal and heterogeneity patterns in stability, NIM, and credit growth. When matching the asset-quality responses, the NPL block is additionally governed by $\{\rho_{npl,k}, \iota_d, \iota_{m,k}, bN_k\}$. In applications that require tighter discipline, these parameters can be selected using minimum-distance estimation based on the LP-based IRF targets. These targets can be stacked into a moment vector $\widehat{g}$ and matched by the model-implied IRFs $g(\Theta)$. If a formal minimum-distance routine is implemented, parameters are selected by:

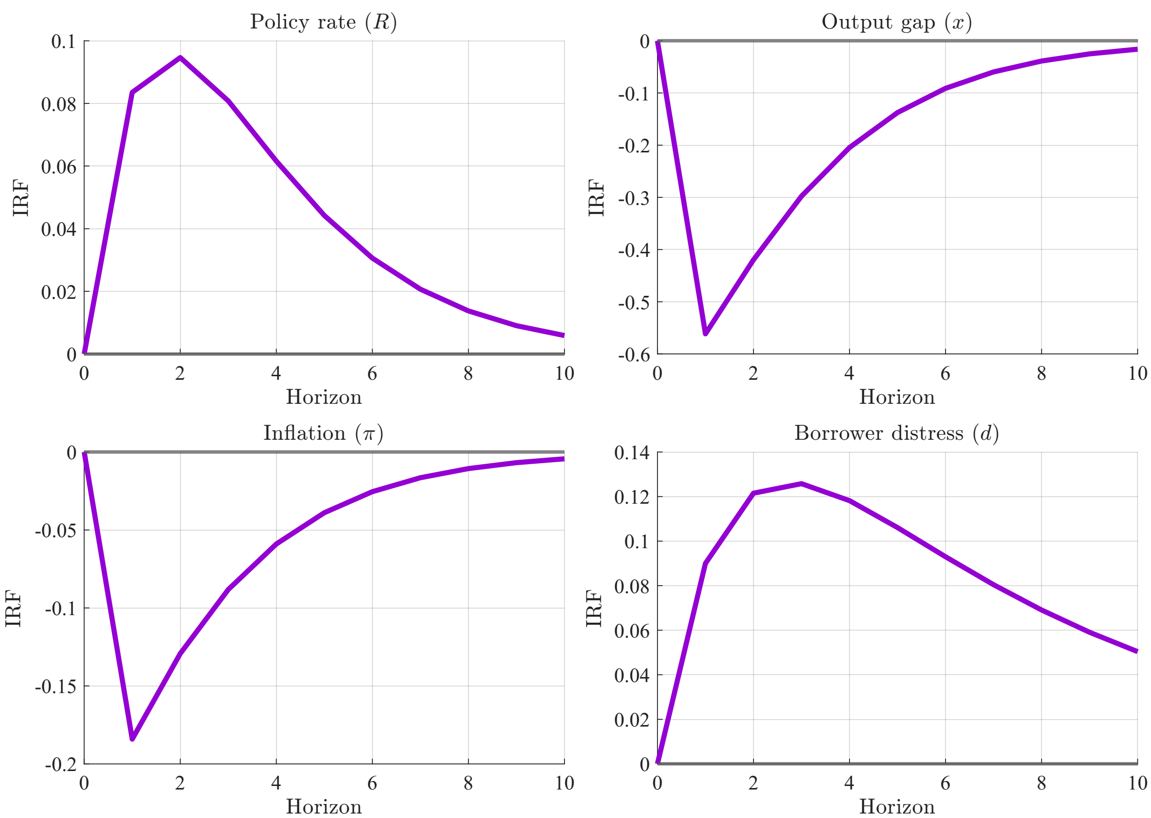
$$\min_{\Theta} \, (\widehat{g} - g(\Theta))' W (\widehat{g} - g(\Theta)), \tag{65}$$

where W is typically diagonal with entries proportional to the inverse LP variances (constructed from the reported LP standard errors), or alternatively set to robust user-chosen weights to emphasise specific horizons (e.g., impact and the reversal horizon).

7.13 DSGE results: impulse responses to a monetary tightening

This section interprets the model-implied impulse responses to a one-standard-deviation monetary tightening shock and relates them to the empirical local-projection (LP) evidence on: i) bank stability, ii) net interest margins (NIM), and iii) credit growth by cost-efficiency groups. Throughout, the cost-efficiency groups correspond to the empirical quantiles $P25$ (low efficiency), $P50$ (median), and $P75$ (high efficiency).

Figure 21: Macro impulse responses to a one-standard deviation monetary tightening shock



Note: The figure reports the responses of the policy rate R_t, the output gap x_t, inflation π_t, and borrower distress d_t.

Macro transmission and the slow borrower-distress state. Figure 21 reports the macro block. A contractionary monetary shock increases the policy rate R_t on impact and then gradually mean-reverts due to policy-rate smoothing. Consistent with standard New Keynesian transmission, the output gap x_t and inflation π_t decline sharply at short horizons and return smoothly to steady state. The borrower-distress state d_t increases on impact and decays more slowly, capturing the idea that repayment pressure and cash-flow stress remain elevated after the initial demand contraction. This persistent distress state provides the model's slow channel through which tightening can worsen credit conditions beyond the contemporaneous policy-rate impulse.

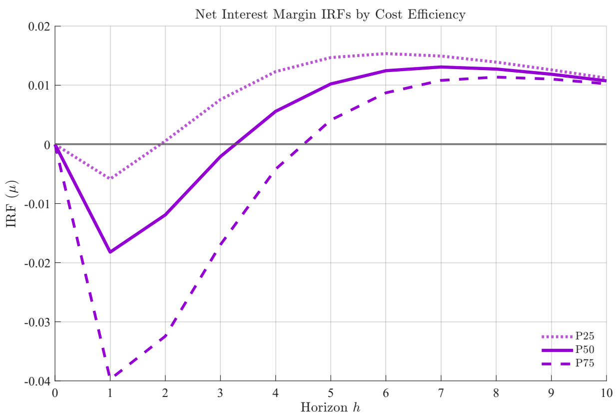
Net interest margins: impact compression and heterogeneous recovery. Figure 22 shows net interest margins μ_k by efficiency group. NIM compresses on impact for all groups, reflecting repricing asymmetries in which funding costs adjust more quickly than asset yields. The cross-sectional ordering aligns with the empirical pattern: the initial compression is strongest and most persistent for high-efficiency banks ($P75$), while low-efficiency banks ($P25$) exhibit a smaller drop and a faster recovery. In the model, this ordering is consistent with either: i) stronger funding-cost pass-through for high-efficiency banks (higher deposit betas) and/or ii) weaker spread-widening following tightening (pricing discipline), both of which imply less near-term margin relief for $P75$ even when those banks display superior stability dynamics.

Bank stability: impact stabilisation with efficiency-conditioned smoothing. Figure 22 plots the stability index z_k, the model analogue of the bank Z-score dynamics. Stability rises on impact for all groups, and the impact response is increasing in cost efficiency, delivering the ranking $P75 > P50 > P25$ at short horizons. This is the model's fast channel: high-efficiency banks respond more strongly through risk management m_k, which reduces default risk $p_k = \pi_d d - \chi_k m_k$ and therefore dampens expected loss pressure at short horizons. Importantly, the stability ordering arises despite the fact that NIM compression is more severe for $P75$ (Figure 22); that is, short-run resilience is governed primarily by loss containment rather than contemporaneous margin dynamics.

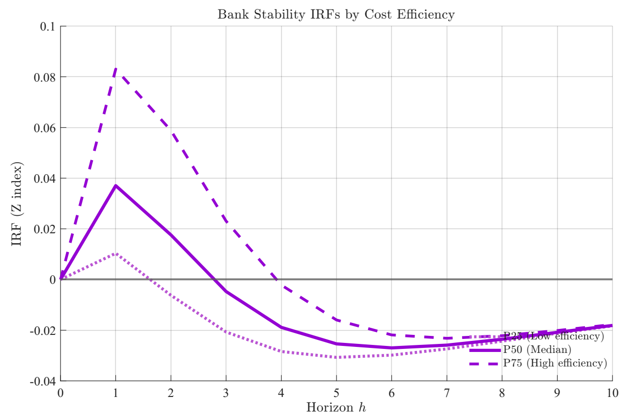
At intermediate horizons, the stability index reverses sign for all groups as the slow borrower-distress channel progressively dominates: the persistent monetary shock feeds distress d_t, which accumulates via its AR(1) structure and raises default risk faster than the now-decaying risk-management response can offset. The reversal occurs earliest for low-efficiency banks ($P25$) and latest for high-efficiency banks ($P75$), consistent with the empirical LP evidence. This horizon-dependent sign reversal is the central qualitative prediction of the two-channel structure and would not arise in a model without shock persistence (see the calibration discussion).

Efficiency gap in stability. Figure 22 reports the efficiency smoothing gap $z_{75} - z_{25}$. The gap is sharply positive on impact and then decays monotonically toward zero as the shock dissipates. This statistic summarises the key cross-sectional prediction: high-efficiency banks exhibit a larger short-run stabilisation and a smoother adjustment path, with the advantage concentrated early and diminishing as both macro conditions and bank-specific states revert.

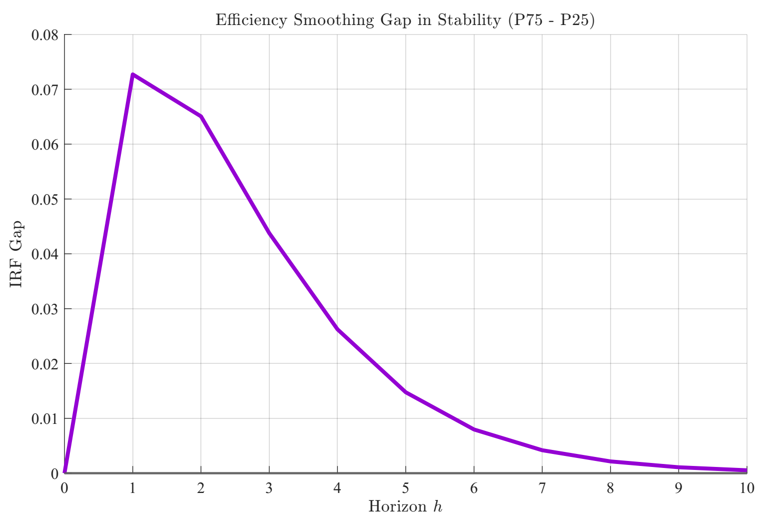
Figure 22: Bank-block impulse response to a one-standard deviation monetary policy tightening by cost efficiency: margins, stability, and the efficiency smoothing gap



(a) Net interest margin μ_k



(b) Stability index z_k

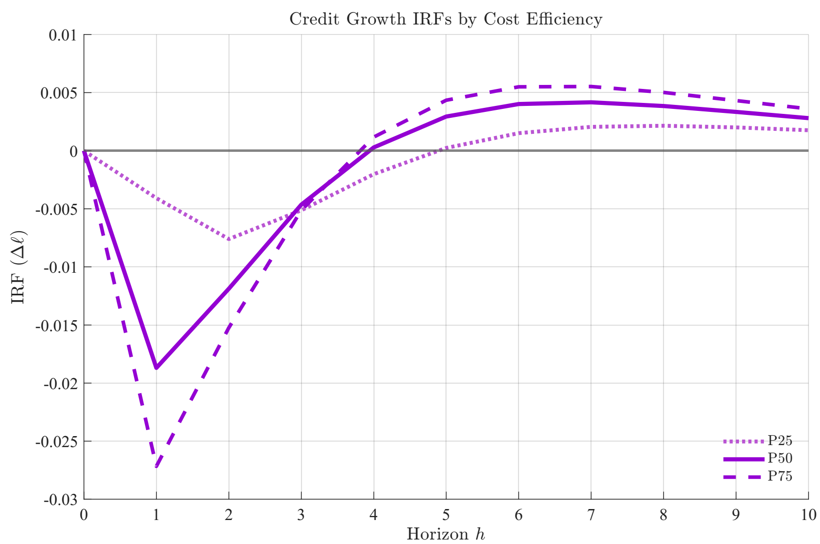


(c) Gap $z_{75} - z_{25}$

Note: The panels jointly show that: i) tightening compresses margins more for high-efficiency banks, while ii) stability improves more on impact for high-efficiency banks, and iii) the resulting efficiency gap is front-loaded and mean-reverting.

Credit growth: contraction, rebound, and cross-sectional separation. Figure 23 reports credit growth $\Delta\ell_k$. Following a monetary tightening, loan growth weakens at short horizons, consistent with tighter effective lending rates and softer demand, and then partially rebounds as the shock mean-reverts. The cross-sectional ordering is most evident early in the response and around the rebound phase, indicating that lending dynamics are shaped by bank-level balance-sheet channels (profits/equity and the effective lending rate $R+s_k$) rather than purely by the aggregate impulse. This timing is useful for interpreting the asset-quality evidence below: the period in which lending adjusts most sharply is also the window in which changes in problem-loan dynamics relative to credit expansion are most informative.

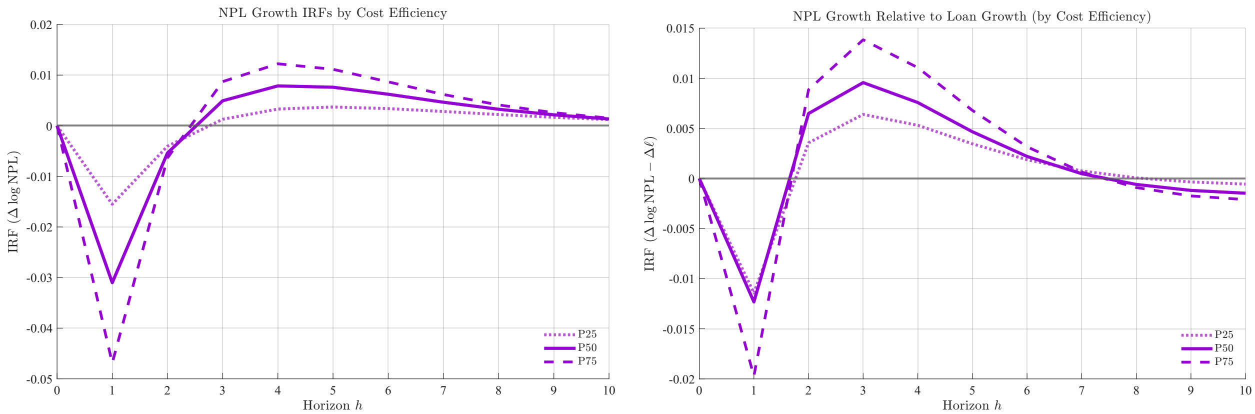
Figure 23: Credit growth impulse response to a one-standard deviation monetary policy tightening by cost efficiency group



Note: The figure reports $\Delta\ell_k$ for $k \in \{25, 50, 75\}$.

Non-performing loans (NPLs): asset-quality dynamics in the DSGE model. In line with the empirical evidence, we use NPL dynamics as an additional lens on credit risk within the DSGE bank block. This is useful because composite stability indicators can improve in the near term through profitability and balance-sheet channels even when impairment recognition or reclassification is occurring. The model delivers the same horizon dependence as the local projections: NPL growth tends to decline at the shortest horizons, can increase at intermediate horizons as the slow distress component feeds into realised impairment with a lag, and then fades as the shock dissipates. The growth-rate analogue of the NPL ratio, $\Delta \ln(\text{NPL}) - \Delta \ln(L)$, is initially negative — reflecting that early NPL growth does not outpace the contemporaneous adjustment in lending — but turns positive when loan growth contracts more sharply than NPLs adjust, before declining again as balance sheets normalise. Read together with the credit-growth responses, the implication is that tightening induces a front-loaded contraction in loan supply, while problem-loan dynamics respond more slowly; consequently, asset-quality pressure can temporarily intensify relative to a shrinking loan base even as near-term composite stability measures improve.

Figure 24: Impulse responses of asset-quality dynamics to a one-standard deviation monetary tightening shock by cost-efficiency group



(a) NPL growth $\Delta \ln(\text{NPL})$ (b) NPL growth minus loan growth $\Delta \ln(\text{NPL}) - \Delta\ell$

Note: The left panel reports NPL growth, while the right panel reports NPL growth relative to loan growth, highlighting whether problem loans expand faster or slower than the loan book over the adjustment path.

Mapping to the empirical LP evidence Taken together, Figures 22–23 replicate the two central empirical facts: monetary tightening compresses net interest margins — most persistently for high-efficiency banks — yet the stability response is more favourable and smoother for these banks. In the model, this wedge arises because cost efficiency primarily determines the strength and effectiveness of the risk-management response, which reduces default risk and mitigates expected losses. Thus, cross-sectional resilience is driven primarily by a loss-mitigation (operational-buffer) channel rather than by the faster recovery of post-tightening margins.

7.14 Testing non-linearity in policy stance

To further assess the economically plausible state dependence of stability response to monetary policy stance, we complement our earlier estimations with a parsimonious quadratic term in the policy stance measure. This exercise is intended as a diagnostic of functional form—testing for diminishing returns or threshold effects consistent with nonlinear balance-sheet channels—rather than as a replacement for the main empirical design. Our baseline specifications remain the workhorse because they deliver a transparent average marginal effect that is directly comparable across local projections and the linearised DSGE mapping.

Table 14: Impact of monetary policy on banking stability—testing non-linear effect

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	0.0990**	0.0728**	0.1227***	0.1002***
	(0.0392)	(0.0366)	(0.0397)	(0.0376)
$Policy^{z}_{j,t-1}$ sq.	-0.0764***	-0.0776***	-0.0812***	-0.0823***
	(0.0226)	(0.0209)	(0.0225)	(0.0215)
Cost efficiency	4.253***	2.582***	4.281***	2.593***
	(0.8216)	(0.7872)	(0.8219)	(0.7871)
Bank liquidity	0.0297***	0.0160***	0.0297***	0.0161***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.771***	-1.871***	-2.768***	-1.867***
	(0.1978)	(0.1780)	(0.1980)	(0.1781)
Asset structure (%)	0.1090***	0.0575	0.1091***	0.0574
	(0.0402)	(0.0378)	(0.0402)	(0.0378)
Bank Concentration	0.0265**	0.0430***	0.0273**	0.0441***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0459***	0.0388***	0.0442***	0.0371***
	(0.0153)	(0.0142)	(0.0153)	(0.0143)
Inflation (CPI)	0.0363***	0.0093	0.0358***	0.0089
	(0.0116)	(0.0109)	(0.0116)	(0.0109)
Institutional Quality	2.673***	2.987***	2.568***	2.871***
	(0.7169)	(0.7326)	(0.7161)	(0.7320)
Threshold ($Policy^{z}_{j,t-1}$)	0.6478	0.4693	0.7561	0.6085
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table 15: Impact of monetary policy on banking stability controlling for macroprudential policies (Liquidity and LFX) —testing non-linear effect

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	0.0991**	0.0650*	0.1243***	0.0916**
	(0.0402)	(0.0374)	(0.0407)	(0.0385)
$Policy^{z}_{j,t-1}$ sq.	-0.0744***	-0.0761***	-0.0792***	-0.0813***
	(0.0230)	(0.0213)	(0.0229)	(0.0219)
Cost efficiency	4.196***	2.516***	4.225***	2.527***
	(0.8302)	(0.7944)	(0.8305)	(0.7943)
Bank liquidity	0.0299***	0.0163***	0.0299***	0.0164***
	(0.0030)	(0.0023)	(0.0030)	(0.0023)
Size	-2.784***	-1.878***	-2.781***	-1.875***
	(0.2014)	(0.1805)	(0.2015)	(0.1806)
Asset structure (%)	0.1123***	0.0591	0.1124***	0.0589
	(0.0414)	(0.0388)	(0.0414)	(0.0387)
Bank Concentration	0.0244**	0.0407***	0.0252**	0.0418***
	(0.0110)	(0.0122)	(0.0110)	(0.0122)
GDP growth	0.0460***	0.0480***	0.0439**	0.0460***
	(0.0170)	(0.0154)	(0.0171)	(0.0155)
Inflation (CPI)	0.0315**	0.0050	0.0312**	0.0048
	(0.0126)	(0.0119)	(0.0126)	(0.0119)
Institutional Quality	2.427***	2.868***	2.319***	2.752***
	(0.7379)	(0.7550)	(0.7368)	(0.7542)
Macroprudential: Liquidity	-0.1731***	-0.1928***	-0.1697***	-0.1891***
	(0.0453)	(0.0446)	(0.0453)	(0.0446)
Macroprudential: LFX	0.2913***	0.2970***	0.2888***	0.2953***
	(0.1086)	(0.1085)	(0.1086)	(0.1084)
Threshold ($Policy^{z}_{j,t-1}$)	0.6658	0.4271	0.7851	0.5635
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,690	38,426	41,690	38,426
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4). LFX: Limits on FX positions.
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table 16: Impact of monetary policy on banking stability controlling for macroprudential policies (Liquidity and LTV) —testing non-linear effect

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^z_{j,t-1}$	0.0877**	0.0540	0.1142***	0.0819**
	(0.0403)	(0.0372)	(0.0407)	(0.0383)
$Policy^z_{j,t-1}$ sq.	-0.0733***	-0.0757***	-0.0780***	-0.0807***
	(0.0230)	(0.0212)	(0.0228)	(0.0219)
Cost efficiency	4.257***	2.566***	4.285***	2.577***
	(0.8305)	(0.7943)	(0.8308)	(0.7943)
Bank liquidity	0.0299***	0.0163***	0.0300***	0.0163***
	(0.0030)	(0.0023)	(0.0030)	(0.0023)
Size	-2.789***	-1.885***	-2.786***	-1.882***
	(0.2012)	(0.1804)	(0.2014)	(0.1806)
Asset structure (%)	0.1124***	0.0584	0.1125***	0.0583
	(0.0414)	(0.0386)	(0.0414)	(0.0385)
Bank Concentration	0.0239**	0.0402***	0.0248**	0.0413***
	(0.0110)	(0.0122)	(0.0110)	(0.0122)
GDP growth	0.0571***	0.0585***	0.0548***	0.0562***
	(0.0167)	(0.0151)	(0.0167)	(0.0152)
Inflation (CPI)	0.0370***	0.0105	0.0364***	0.0102
	(0.0125)	(0.0118)	(0.0125)	(0.0118)
Institutional Quality	2.410***	2.851***	2.303***	2.736***
	(0.7361)	(0.7535)	(0.7352)	(0.7530)
Macroprudential: Liquidity	-0.1872***	-0.2063***	-0.1836***	-0.2023***
	(0.0448)	(0.0443)	(0.0448)	(0.0443)
Macroprudential: LTV	-0.2494***	-0.2469***	-0.2428***	-0.2396***
	(0.0920)	(0.0851)	(0.0920)	(0.0850)
Threshold ($Policy^z_{j,t-1}$)	0.5986	0.3562	0.7321	0.5070
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,816	3,687	3,816	3,687
N	41,690	38,426	41,690	38,426
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4). LTV: Limits on Loan-to-Value Ratio
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Across Tables 14–16, the policy stance enters with a positive linear term and a negative quadratic term, implying a concave (inverted-U) relationship between tightening and banking stability: the marginal effect of a higher policy stance is positive at relatively accommodative-to-moderate settings but declines monotonically as policy becomes more restrictive, turning negative beyond the estimated inflection point (see Figures 25–27). Economically, this pattern is consistent with a "discipline" phase in which moderate tightening improves stability (e.g., via stronger screening/risk management and reduced risk-taking) followed by a "strain" phase in which further tightening compresses margins and worsens borrower stress, thereby eroding stability. The implied turning points are stable across specifications and controls: for the hybrid measure they lie between 0.356 and 0.666 (Models (2)–(1) across the baseline and macroprudential controls), and for the official measure between 0.507 and 0.785 (Models (4)–(3)), indicating that the peak stabilising effect occurs at moderately restrictive stances and that, beyond this region, additional tightening reduces stability; the downward-sloping marginal-effect profiles reinforce that interpretation.

Because $Policy^{z}_{j,t-1}$ is standardised, the inflection points are naturally interpreted in standard-deviation units of the stance distribution. Using the sample standard deviations for the standardised series (hybrid $\approx$ 0.95, official $\approx$ 0.96), the turning points correspond to roughly 0.38–0.70 s.d. for the hybrid measure (0.356/0.95 to 0.666/0.95) and 0.53–0.82 s.d. for the official measure (0.507/0.96 to 0.785/0.96). To translate these thresholds into basis points, note that a one-standard-deviation move in the raw (non-standardised) stance series equals $\sigma^{\text{raw}}_{\text{Policy}}$ in percentage points, i.e. $100\sigma^{\text{raw}}_{\text{Policy}}$ basis points. With $\sigma^{\text{raw}}_{\text{Policy}} = 0.7872$ percentage points (i.e. 78.72 bp), the turning point in basis points is:

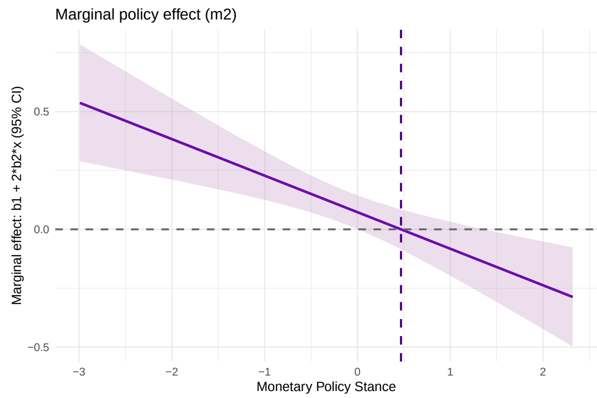
$$\text{Turning point (bp)} = (100\sigma^{\text{raw}}_{\text{Policy}}) \times \frac{x^*}{\text{sd}(Policy^z)} = 78.72 \times \frac{x^*}{\text{sd}(Policy^z)}.$$

Hence the implied peaks occur at approximately 29.5–55.2 bp for the hybrid measure (from $78.72 \times 0.356/0.95$ to $78.72 \times 0.666/0.95$) and 41.6–64.4 bp for the official measure (from $78.72 \times 0.507/0.96$ to $78.72 \times 0.785/0.96$). Interpreted as policy-rate-equivalent magnitudes, these values indicate that the stabilising region is reached at moderate tightening (tens of basis points relative to the sample's typical policy-rate variation), after which marginal tightening becomes progressively less stabilising and eventually destabilising; consistent with that, Models (2) and (4) deliver lower x^*, implying an earlier onset of the adverse marginal effects when all covariates are lagged.

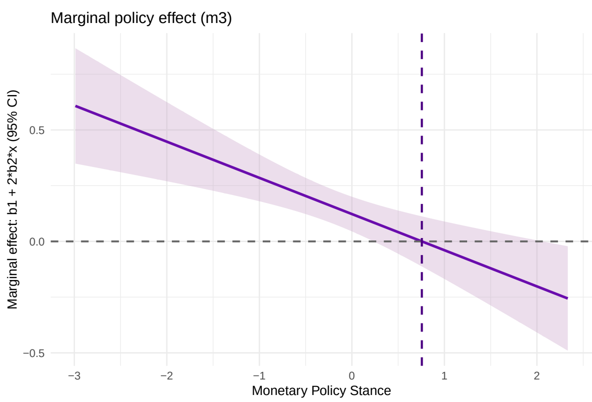
Figure 25: Marginal effect of monetary policy stance ($Policy^{z}_{j,t-1}$) with quadratic term on banking stability based on Table 14

(i) No Lag of predictors **(ii) One Lag of all Predictors**

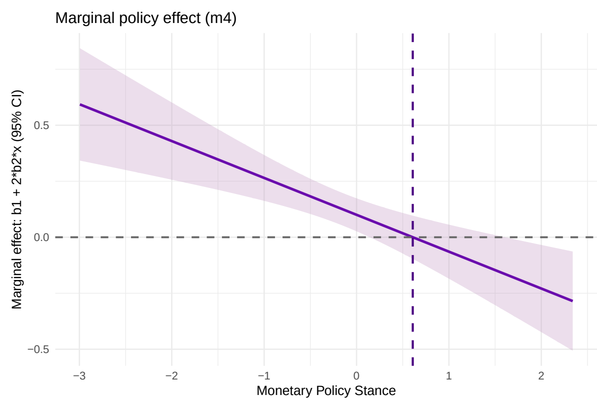
Policy, Hybrid



Policy, Hybrid



Policy, Official



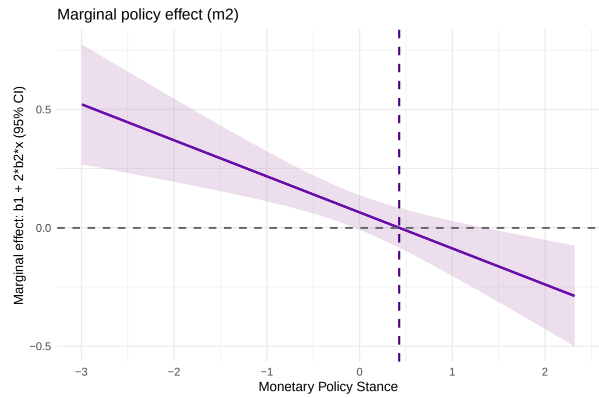
Policy, Official

Note: Column (i) No lag of other predictors; column (ii) includes of all predictors.

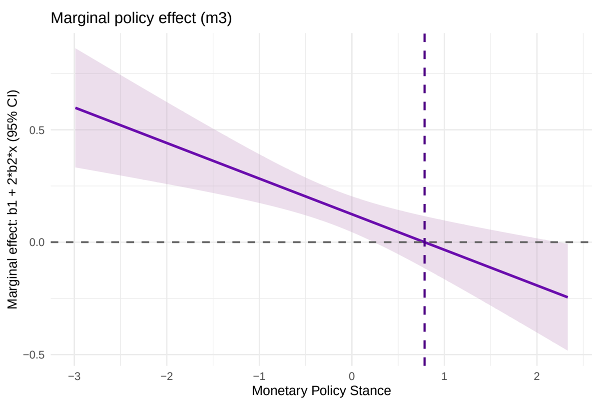
Figure 26: Marginal effect of monetary policy stance ($Policy^{z}_{j,t-1}$) with quadratic term on banking stability, controlling for macroprudential policies (Liquidity and LFX) based on Table 15

(i) No Lag of predictors | **(ii) One Lag of all Predictors**

Policy, Hybrid



Policy, Hybrid

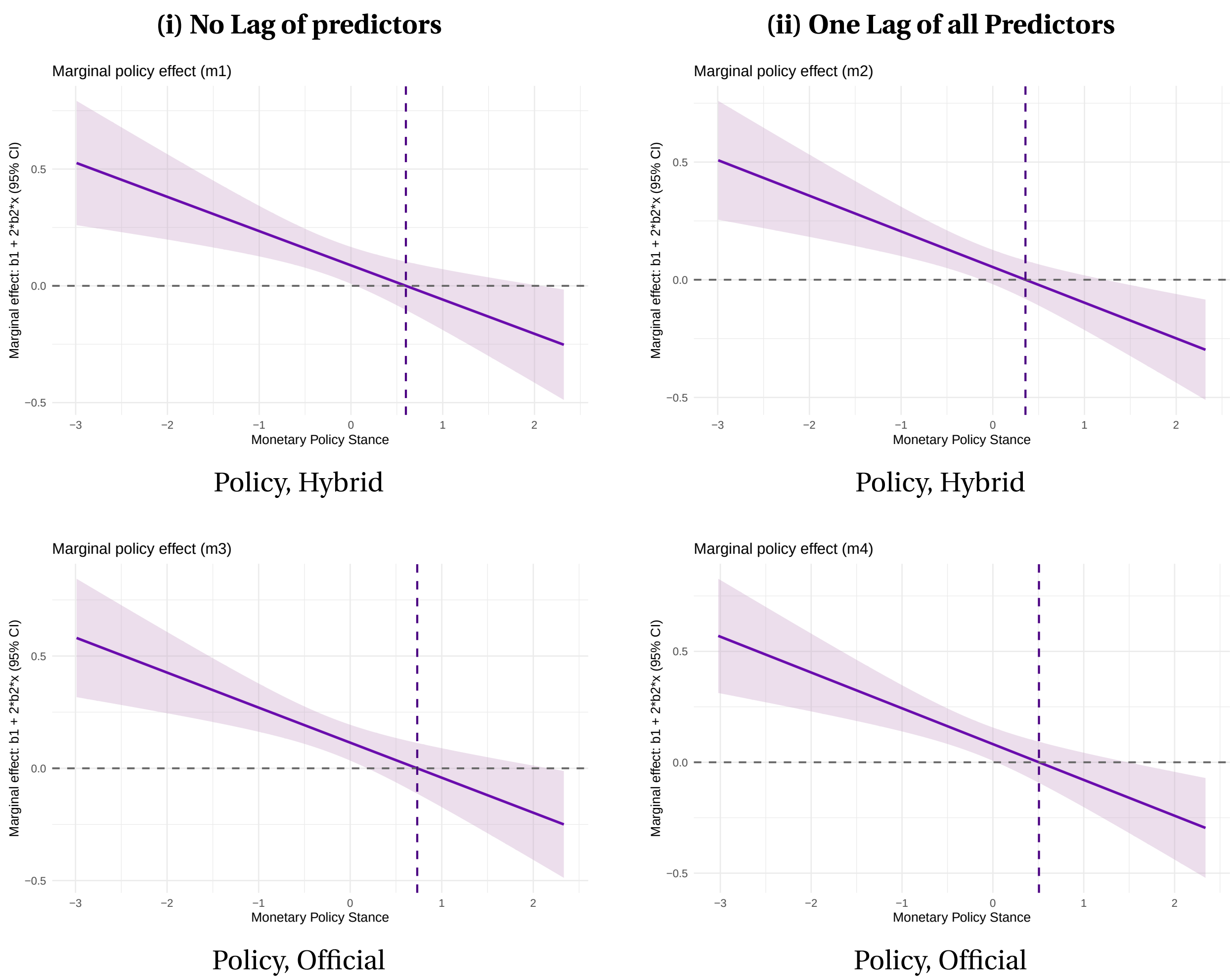


Policy, Official

Policy, Official

Note: Column (i) No lag of other predictors; column (ii) includes of all predictors.

Figure 27: Marginal effect of monetary policy stance ($Policy^{z}_{j,t-1}$) with quadratic term on banking stability, controlling for macroprudential policies (Liquidity and LTV) based on Table 16



Note: Column (i) No lag of other predictors; column (ii) includes of all predictors.

8 Conclusion and Policy Discussions

This paper re-examines the relationship between monetary policy and banking stability through a lens that has received limited direct attention in the empirical transmission literature: bank cost efficiency as a fundamental governing risk-control capacity, loss absorption, and the smoothness of medium-run stability dynamics. The motivating gap is that existing work on the risk-taking channel and bank heterogeneity has largely focused on balance-sheet buffers (capitalisation, liquidity, or funding structure), while treating operational efficiency either as secondary or as an outcome rather than a state variable that conditions the stability response to monetary policy shocks. We address this gap by integrating a cross-country efficiency framework into the identification and interpretation of monetary policy effects on bank stability, and by explicitly linking reduced-form evidence to a structural mechanism.

Empirically, we implement a two-stage design. In the first stage, we recover bank-level cost efficiency using a stochastic translog cost frontier, and then construct metafrontier efficiency measures that map country-specific technologies to broader technology sets (global and group-based benchmarks). This provides a comparable cross-country measure of the managerial/operational components of bank resilience, which is applicable across heterogeneous banking systems. In the second stage, we estimate the effect of monetary policy on banking stability, controlling for bank, time, and country fixed effects. We find that, overall, monetary tightening increases banking stability, with the results being robust to different sub-samples, estimation techniques, and controlling for macroprudential policies. Moreover, we also estimate the dynamic effects of monetary policy on bank stability and its underlying channels using local projections (LP), allowing for flexible impulse responses and horizon-by-horizon inference. These results demonstrate that monetary policy shocks have economically significant effects on stability and key intermediating margins, and that these effects are heterogeneous in a manner consistent with cost efficiency shaping banks' capacity to manage risk and smooth stability dynamics in the medium term.

Finally, we develop a parsimonious DSGE model with bank heterogeneity to provide a structural interpretation of the reduced-form facts. The model combines a standard New Keynesian core with a slow-moving borrower distress state and a fast risk-management channel, whose responsiveness and effectiveness increase with cost efficiency. In the model, a monetary tightening compresses net interest margins on impact through repricing frictions, while simultaneously inducing risk-management adjustments that reduce default probabilities and improve the credit composition. The interaction of these forces generates stability dynamics that match the qualitative pattern observed in the data and clarifies the conditions under which stability improvements are front-loaded versus delayed. The structural exercise, therefore, serves two roles: it rationalises why sign reversals can occur at particular horizons in the reduced-form estimates, and it formalises the interpretation of cost efficiency as a foundational determinant governing the smoothness of the medium-run stability response.

The policy implications are immediate. First, monetary policy and financial stability cannot be evaluated through a single monotone "tightening is stabilising" or "tightening is destabilising" narrative; the net effect depends on the regime and the composition of bank balance sheets, as well as on banks' operational capacity to manage risk. Second, supervisory assessments should treat cost efficiency as more than an operational performance metric: it contains information about risk-control capability and shock absorption that is relevant for macro-financial resilience. This implies that macroprudential policy and supervision can improve the stability consequences of monetary tightening by strengthening the operational foundations of risk management—through governance, monitoring technologies, and the organisational capacity to reprice, rebalance, and provision promptly. Third, because efficiency and market power are distinct and benchmark-dependent concepts in a cross-country setting, policy frameworks should avoid conflating competitive conditions with operational resilience. The evidence supports designing macroprudential buffers and supervisory intensity to account for efficiency heterogeneity, even among banks with similar capital and liquidity positions.

Overall, the paper presents a unified empirical-structural account of how monetary policy is transmitted to banking stability when banks differ in cost efficiency. By combining a cross-country stochastic metafrontier measurement of efficiency with dynamic LP inference, IV identification, and a mechanism-consistent DSGE interpretation, we provide evidence that efficiency conditions the stability response to policy in a meaningful way over the medium term. The broader implication is that improving the operational and managerial foundations of intermediation can strengthen the stabilising component of the risk-taking channel and reduce the likelihood that tightening episodes propagate into fragility through valuation losses and credit deterioration.

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Online Appendix

This Appendix provides some additional tables, robustness tests and model derivations from the DSGE model. Tables include the additional robustness results from the sub-sample analysis and the main regression estimations of monetary policy on banking stability, as well as tables showing the results of our robustness analysis relating to the use of a different measure of Z-score (using a 3-year rolling standard deviation of ROAA in calculating Z-score).

A List of Countries, Number of Banks and Observations

Table A1: List of countries, number of banks and observations

Country (banks, obs)	Country (banks, obs)	Country (banks, obs)
Argentina (14, 62)	Guyana (4, 44)	Paraguay (9, 88)
Australia (36, 435)	Honduras (17, 182)	Peru (44, 406)
Austria (28, 338)	Hong Kong SAR, China (21, 234)	Philippines (34, 372)
Azerbaijan (12, 102)	Hungary (5, 60)	Poland (31, 390)
Bahamas (3, 35)	India (147, 1,865)	Portugal (12, 134)
Bahrain (16, 75)	Indonesia (83, 965)	Qatar (10, 114)
Bangladesh (102, 1,043)	Ireland (8, 104)	Republic of Korea (62, 654)
Belgium (7, 81)	Israel (11, 161)	Republic of Moldova (8, 87)
Bolivia (6, 77)	Italy (76, 856)	Romania (9, 99)
Botswana (10, 110)	Jamaica (17, 159)	Russian Federation (84, 640)
Brazil (53, 510)	Japan (85, 980)	Saudi Arabia (16, 206)
Bulgaria (12, 120)	Jordan (22, 292)	Serbia (23, 262)
Canada (11, 138)	Kazakhstan (36, 284)	Singapore (10, 127)
Chile (10, 148)	Kenya (19, 190)	Slovakia (7, 104)
China (108, 1,105)	Kuwait (25, 230)	Slovenia (10, 116)
Colombia (22, 251)	Kyrgyzstan (5, 33)	South Africa (19, 251)
Costa Rica (4, 64)	Lebanon (7, 66)	Spain (23, 296)
Croatia (27, 298)	Lithuania (6, 73)	Sri Lanka (62, 428)
Cyprus (7, 76)	Luxembourg (10, 146)	Sweden (21, 220)
Czech Republic (7, 105)	Malaysia (35, 447)	Switzerland (48, 642)
Côte d'Ivoire (7, 51)	Malta (10, 141)	Thailand (60, 545)
Denmark (39, 487)	Mauritius (10, 113)	Trinidad and Tobago (8, 86)
Ecuador (10, 86)	Mexico (9, 59)	Turkiye (52, 646)
Egypt (47, 454)	Mongolia (5, 45)	Uganda (4, 20)
El Salvador (14, 127)	Morocco (17, 187)	Ukraine (82, 125)
Estonia (5, 79)	Nepal (178, 1,177)	United Kingdom (45, 521)
Finland (11, 125)	Netherlands (18, 225)	Tanzania (8, 69)
France (71, 1,021)	Nigeria (45, 465)	U.S. (1257, 15,984)
Georgia (6, 70)	North Macedonia (17, 204)	Uzbekistan (22, 147)
Germany (64, 735)	Norway (74, 840)	Vietnam (57, 655)
Ghana (14, 163)	Oman (20, 141)	Zambia (8, 56)
Greece (13, 170)	Pakistan (50, 453)	

B Other Sub-sample Stochastic Metafrontier Results

Table B1: Stochastic metafrontier results – regional groups

	R1	R2	R3	R4	R5	R6	R7
Frontier							
ln(Loans)	0.605***	0.340***	0.925***	0.095***	0.669***	0.827***	0.902***
	(0.021)	(0.012)	(0.022)	(0.029)	(0.001)	(0.007)	(0.039)
ln(w2/w1)	-0.005	0.101***	0.126***	0.223***	0.193***	0.440***	0.259***
	(0.025)	(0.013)	(0.030)	(0.042)	(0.002)	(0.017)	(0.060)
ln(w3/w1)	0.150***	0.187***	0.158***	0.319***	0.114***	-0.053**	1.040***
	(0.040)	(0.015)	(0.051)	(0.037)	(0.002)	(0.022)	(0.082)
ln(Loans) × ln(w2/w1)	0.004***	-0.003***	-0.007***	-0.013***	-0.010***	-0.026***	-0.021***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.001)	(0.003)
ln(Loans) × ln(w3/w1)	-0.008***	-0.010***	-0.008***	-0.022***	-0.003***	0.005***	-0.044***
	(0.002)	(0.001)	(0.003)	(0.002)	(0.000)	(0.001)	(0.004)
ln(w2/w1) × ln(w3/w1)	0.010***	-0.009***	0.004	0.012***	-0.006***	-0.006***	-0.093***
	(0.002)	(0.001)	(0.004)	(0.004)	(0.000)	(0.002)	(0.009)
0.5[ln(Loans)]^2	0.019***	0.039***	0.005***	0.061***	0.026***	0.016***	0.010***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.002)
0.5[ln(w2/w1)]^2	0.002	0.006***	0.016***	0.007	-0.011***	0.026***	0.042***
	(0.003)	(0.001)	(0.003)	(0.005)	(0.000)	(0.003)	(0.012)
0.5[ln(w3/w1)]^2	0.038***	0.006***	0.083***	0.005	0.057***	0.009***	0.149***
	(0.003)	(0.001)	(0.007)	(0.003)	(0.000)	(0.002)	(0.011)
Constant	4.090***	5.650***	0.880***	6.808***	2.553***	0.665***	1.028***
	(0.212)	(0.104)	(0.214)	(0.257)	(0.010)	(0.083)	(0.373)
Mu							
GDP p.c. growth	-0.024***	-0.008***	-0.008*	-0.057***	0.017***	-0.091***	-0.109***
	(0.008)	(0.003)	(0.005)	(0.006)	(0.001)	(0.015)	(0.012)
Inflation	-0.096***	-0.008***	0.004**	0.000	-0.159***	-0.025**	-0.000
	(0.021)	(0.002)	(0.002)	(0.002)	(0.003)	(0.011)	(0.001)
Usigma							
Constant	-0.373***	-0.604***	-0.704***	0.017	-5.445***	-1.004***	-0.110**
	(0.080)	(0.020)	(0.041)	(0.038)	(0.026)	(0.101)	(0.047)
Vsigma							
Constant	-3.050***	-3.286***	-3.310***	-2.530***	-7.186***	-4.108***	-3.636***
	(0.110)	(0.041)	(0.077)	(0.078)	(0.013)	(0.071)	(0.148)
Observations	6,872	12,392	2,826	4,026	16,756	5,414	1,806
Log Likelihood	-4468.153	-7557.901	-1678.136	-3826.647	33800.153	-807.326	-1348.248
Wald χ^2	577243.81	597737.63	292378.85	105668.48	68871893.50	1623993.71	73588.09

Note: Standard errors in parentheses. R1: East Asia & Pacific, R2: Europe & Central Asia, R3: Latin America & Caribbean. R4: Middle East & North Africa, R5: North America, R6:South Asia, R7: Sub-Saharan Africa.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B2: Stochastic metafrontier results – development status

	Developed	Developing
Frontier		
ln(Loans)	0.747***	0.844***
	(0.004)	(0.006)
ln(w2/w1)	-0.017**	0.190***
	(0.007)	(0.014)
ln(w3/w1)	0.023***	-0.104***
	(0.007)	(0.015)
ln(Loans) × ln(w2/w1)	0.005***	-0.007***
	(0.000)	(0.001)
ln(Loans) × ln(w3/w1)	-0.001	0.001
	(0.000)	(0.001)
ln(w2/w1) × ln(w3/w1)	-0.004***	0.013***
	(0.001)	(0.001)
$0.5[\ln(\text{Loans})]^2$	0.014***	0.010***
	(0.000)	(0.000)
$0.5[\ln(w2/w1)]^2$	-0.001	0.002
	(0.001)	(0.002)
$0.5[\ln(w3/w1)]^2$	0.006***	-0.001
	(0.001)	(0.002)
Constant	2.476***	1.284***
	(0.038)	(0.065)
Mu		
GDP p.c. growth	-0.057***	-0.115***
	(0.003)	(0.003)
Inflation	-0.042***	-0.001
	(0.003)	(0.001)
Usigma		
Constant	-0.867***	0.090***
	(0.012)	(0.014)
Vsigma		
Constant	-4.864***	-3.570***
	(0.028)	(0.044)
Observations	30,243	19,616
Log Likelihood	-9009.575	-15661.108
Wald χ^2	4942193.91	1562177.59

Note: Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3: Stochastic metafrontier results – ECB membership

	Non-ECB	ECB
Frontier		
ln(Loans)	0.809***	0.225***
	(0.003)	(0.014)
ln(w2/w1)	0.032***	0.349***
	(0.007)	(0.018)
ln(w3/w1)	-0.009	0.226***
	(0.006)	(0.020)
ln(Loans) × ln(w2/w1)	0.002***	-0.017***
	(0.000)	(0.001)
ln(Loans) × ln(w3/w1)	-0.003***	-0.011***
	(0.000)	(0.001)
ln(w2/w1) × ln(w3/w1)	0.010***	-0.006***
	(0.001)	(0.002)
$0.5[\ln(\text{Loans})]^2$	0.011***	0.052***
	(0.000)	(0.001)
$0.5[\ln(w2/w1)]^2$	-0.001	0.002
	(0.001)	(0.002)
$0.5[\ln(w3/w1)]^2$	0.001	0.005***
	(0.001)	(0.001)
Constant	1.825***	5.750***
	(0.035)	(0.133)
Mu		
GDP p.c. growth	-0.073***	0.010*
	(0.002)	(0.006)
Inflation	0.003***	-0.124***
	(0.000)	(0.015)
Usigma		
Constant	-0.484***	-0.333***
	(0.008)	(0.031)
Vsigma		
Constant	-4.351***	-4.464***
	(0.020)	(0.108)
Observations	44,921	4,938
Log Likelihood	-23966.248	-2782.731
Wald χ^2	7696152.33	312575.47

Note: Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C Robustness: Sub-sample Analysis using Global Metfrontier Cost Efficiency

This section presents the results of the sub-group analysis using the global metfrontier cost efficiency scores. These results are already discussed under subsection 5.3 in the main paper.

Table C1: Impact of monetary policy on banking stability, regional analysis – FE Results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × East Asia&Pacific	0.1311	0.0176	0.1606*	0.0640
	(0.0856)	(0.0831)	(0.0843)	(0.0829)
$Policy^{z}_{j,t-1}$ × Europe & Central Asia	-0.0954**	-0.0893*	-0.0738	-0.0633
	(0.0477)	(0.0469)	(0.0469)	(0.0459)
$Policy^{z}_{j,t-1}$ × Latin America & Caribbean	0.1455	0.1609	0.1855*	0.2038**
	(0.1016)	(0.0995)	(0.0996)	(0.0979)
$Policy^{z}_{j,t-1}$ × Middle East & North Africa	0.0981	-0.0181	0.2481***	0.1488*
	(0.0768)	(0.0775)	(0.0935)	(0.0867)
$Policy^{z}_{j,t-1}$ × North America	0.3791***	0.4226***	0.4400***	0.4865***
	(0.0631)	(0.0637)	(0.0675)	(0.0681)
$Policy^{z}_{j,t-1}$ × South Asia	0.1547	0.0426	0.1165	0.0167
	(0.1256)	(0.0987)	(0.1047)	(0.0896)
$Policy^{z}_{j,t-1}$ × Sub-Saharan Africa	0.2960***	0.3015***	0.2852***	0.2774***
	(0.1042)	(0.0976)	(0.1017)	(0.0947)
Cost efficiency	4.299***	2.628***	4.294***	2.611***
	(0.8221)	(0.7867)	(0.8225)	(0.7869)
Bank liquidity	0.0297***	0.0162***	0.0297***	0.0162***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.740***	-1.842***	-2.736***	-1.836***
	(0.1981)	(0.1782)	(0.1981)	(0.1782)
Asset structure	0.1078***	0.0565	0.1080***	0.0566
	(0.0404)	(0.0384)	(0.0404)	(0.0383)
Bank Concentration	0.0277**	0.0450***	0.0280**	0.0453***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0508***	0.0400***	0.0483***	0.0377***
	(0.0160)	(0.0146)	(0.0161)	(0.0146)
Inflation (CPI)	0.0299**	0.0005	0.0286**	-0.0008
	(0.0117)	(0.0111)	(0.0117)	(0.0111)
Institutional Quality	2.710***	2.955***	2.598***	2.817***
	(0.7148)	(0.7278)	(0.7134)	(0.7268)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table C2: Impact of monetary policy on banking stability, regional analysis – FE Results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × High Income	0.1009**	0.1172***	0.1322***	0.1534***
	(0.0452)	(0.0453)	(0.0470)	(0.0469)
$Policy^{z}_{j,t-1}$ × Low Income	1.176***	1.385***	1.053***	1.116***
	(0.3270)	(0.2023)	(0.2766)	(0.1943)
$Policy^{z}_{j,t-1}$ × Lower Middle	0.1185*	-0.0156	0.1872***	0.0799
	(0.0688)	(0.0704)	(0.0697)	(0.0692)
$Policy^{z}_{j,t-1}$ × Upper Middle	0.0604	-0.0193	0.0902	0.0186
	(0.0799)	(0.0714)	(0.0754)	(0.0689)
Cost efficiency	4.313***	2.636***	4.289***	2.611***
	(0.8211)	(0.7864)	(0.8218)	(0.7867)
Bank liquidity	0.0297***	0.0161***	0.0297***	0.0160***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.754***	-1.853***	-2.755***	-1.854***
	(0.1980)	(0.1780)	(0.1981)	(0.1781)
Asset structure	0.1086***	0.0568	0.1086***	0.0569
	(0.0404)	(0.0382)	(0.0404)	(0.0382)
Bank Concentration	0.0276**	0.0441***	0.0283***	0.0447***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0425***	0.0350**	0.0392**	0.0323**
	(0.0153)	(0.0142)	(0.0154)	(0.0142)
Inflation (CPI)	0.0357***	0.0071	0.0355***	0.0072
	(0.0116)	(0.0109)	(0.0116)	(0.0109)
Institutional Quality	2.959***	3.288***	2.904***	3.199***
	(0.7147)	(0.7277)	(0.7138)	(0.7267)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table C3: Impact of monetary policy on banking stability, development status – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$ × Developed	0.1202***	0.1408***	0.1502***	0.1734***
	(0.0456)	(0.0456)	(0.0472)	(0.0470)
$\text{Policy}^{z}_{j,t-1}$ × Developing	0.1717***	0.0694	0.2109***	0.1220***
	(0.0517)	(0.0463)	(0.0508)	(0.0467)
Cost efficiency	4.297***	2.625***	4.291***	2.613***
	(0.8219)	(0.7866)	(0.8220)	(0.7869)
Bank liquidity	0.0298***	0.0161***	0.0298***	0.0161***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.753***	-1.856***	-2.751***	-1.853***
	(0.1980)	(0.1781)	(0.1980)	(0.1781)
Asset structure	0.1087***	0.0578	0.1089***	0.0577
	(0.0405)	(0.0384)	(0.0404)	(0.0383)
Bank Concentration	0.0273**	0.0440***	0.0276**	0.0443***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0416***	0.0347**	0.0384**	0.0322**
	(0.0153)	(0.0142)	(0.0154)	(0.0142)
Inflation (CPI)	0.0366***	0.0082	0.0363***	0.0080
	(0.0116)	(0.0109)	(0.0116)	(0.0109)
Institutional Quality	2.931***	3.216***	2.876***	3.150***
	(0.7135)	(0.7262)	(0.7126)	(0.7252)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table C4: Impact of monetary policy on banking stability, ECB *vs* Non-ECB – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × Non-ECB	0.1525***	0.1283***	0.1896***	0.1700***
	(0.0417)	(0.0406)	(0.0423)	(0.0413)
$Policy^{z}_{j,t-1}$ × ECB	0.0709	0.0573	0.0881*	0.0764
	(0.0537)	(0.0525)	(0.0534)	(0.0522)
Cost efficiency	4.295***	2.616***	4.288***	2.603***
	(0.8223)	(0.7871)	(0.8225)	(0.7875)
Bank liquidity	0.0298***	0.0161***	0.0298***	0.0161***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.751***	-1.852***	-2.748***	-1.849***
	(0.1981)	(0.1782)	(0.1982)	(0.1782)
Asset structure	0.1087***	0.0577	0.1089***	0.0576
	(0.0405)	(0.0384)	(0.0405)	(0.0383)
Bank Concentration	0.0272**	0.0441***	0.0275**	0.0444***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0427***	0.0361**	0.0399***	0.0337**
	(0.0154)	(0.0142)	(0.0155)	(0.0143)
Inflation (CPI)	0.0360***	0.0087	0.0354***	0.0083
	(0.0116)	(0.0110)	(0.0116)	(0.0109)
Institutional Quality	2.900***	3.233***	2.832***	3.157***
	(0.7142)	(0.7258)	(0.7129)	(0.7245)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

D Robustness using Group-specific Metafrontier Cost Efficiency

This section presents the results of the sub-group analysis using the various group-specific metafrontier cost efficiency. These results are discussed under subsection 5.3 in the main paper.

Table D1: Impact of monetary policy on banking stability, regional analysis – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$ × East Asia &Pacific	0.1378	0.0262	0.1672**	0.0720
	(0.0856)	(0.0829)	(0.0843)	(0.0827)
$\text{Policy}^{z}_{j,t-1}$ × Europe & Central Asia	-0.0963**	-0.0897*	-0.0750	-0.0639
	(0.0478)	(0.0469)	(0.0470)	(0.0459)
$\text{Policy}^{z}_{j,t-1}$ × Latin America & Caribbean	0.1625	0.1607	0.2022**	0.2032**
	(0.1016)	(0.0994)	(0.0997)	(0.0978)
$\text{Policy}^{z}_{j,t-1}$ × Middle East & North Africa	0.1029	-0.0143	0.2535***	0.1524*
	(0.0774)	(0.0775)	(0.0943)	(0.0867)
$\text{Policy}^{z}_{j,t-1}$ × North America	0.3905***	0.4334***	0.4511***	0.4968***
	(0.0629)	(0.0633)	(0.0673)	(0.0677)
$\text{Policy}^{z}_{j,t-1}$ × South Asia	0.1552	0.0438	0.1175	0.0186
	(0.1254)	(0.0986)	(0.1045)	(0.0896)
$\text{Policy}^{z}_{j,t-1}$ × Sub-Saharan Africa	0.2833***	0.3033***	0.2745***	0.2798***
	(0.1041)	(0.0975)	(0.1017)	(0.0947)
Cost efficiency	3.779***	2.242***	3.782***	2.237***
	(0.6910)	(0.6522)	(0.6911)	(0.6522)
Bank liquidity	0.0295***	0.0160***	0.0295***	0.0160***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.747***	-1.845***	-2.743***	-1.839***
	(0.1976)	(0.1778)	(0.1977)	(0.1779)
Asset structure	0.1099***	0.0574	0.1102***	0.0575
	(0.0410)	(0.0387)	(0.0410)	(0.0386)
Bank Concentration	0.0266**	0.0447***	0.0270**	0.0451***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0514***	0.0404***	0.0488***	0.0381***
	(0.0160)	(0.0146)	(0.0160)	(0.0146)
Inflation (CPI)	0.0284**	-0.0001	0.0271**	-0.0014
	(0.0117)	(0.0111)	(0.0117)	(0.0111)
Institutional Quality	2.912***	3.079***	2.798***	2.939***
	(0.7147)	(0.7281)	(0.7134)	(0.7271)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table D2: Impact of monetary policy on banking stability, regional analysis – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × East Asia & Pacific	0.1367	0.0331	0.1664**	0.0782
	(0.0857)	(0.0826)	(0.0844)	(0.0824)
$Policy^{z}_{j,t-1}$ × Europe & Central Asia	-0.0914*	-0.0897*	-0.0696	-0.0640
	(0.0476)	(0.0469)	(0.0468)	(0.0460)
$Policy^{z}_{j,t-1}$ × Latin America & Caribbean	0.1462	0.1380	0.1873*	0.1810*
	(0.1015)	(0.1006)	(0.0995)	(0.0990)
$Policy^{z}_{j,t-1}$ × Middle East & North Africa	0.1008	-0.0102	0.2549***	0.1524*
	(0.0790)	(0.0776)	(0.0962)	(0.0865)
$Policy^{z}_{j,t-1}$ × North America	0.3907***	0.4324***	0.4526***	0.4953***
	(0.0628)	(0.0635)	(0.0672)	(0.0678)
$Policy^{z}_{j,t-1}$ × South Asia	0.1584	0.0470	0.1235	0.0208
	(0.1282)	(0.0988)	(0.1090)	(0.0897)
$Policy^{z}_{j,t-1}$ × Sub-Saharan Africa	0.2591**	0.2950***	0.2586**	0.2777***
	(0.1073)	(0.0987)	(0.1041)	(0.0960)
Cost efficiency × East Asia & Pacific	4.658**	3.282	4.677**	3.324
	(2.180)	(2.086)	(2.180)	(2.085)
Cost efficiency × Europe & Central Asia	4.672***	0.7531	4.689***	0.7608
	(1.227)	(1.140)	(1.227)	(1.140)
Cost efficiency × Latin America & Caribbean	-1.162	-3.361	-1.139	-3.347
	(2.040)	(2.059)	(2.043)	(2.064)
Cost efficiency × MiddleEast & North Africa	9.105	8.853	9.143	8.834
	(6.110)	(5.440)	(6.104)	(5.442)
Cost efficiency × North America	3.068***	2.306***	3.055***	2.282***
	(0.9375)	(0.8630)	(0.9373)	(0.8621)
Cost efficiency × South Asia	2.864	3.039	2.851	3.012
	(2.904)	(2.843)	(2.912)	(2.843)
Cost efficiency × Sub-Saharan Africa	10.03***	7.670***	10.10***	7.716***
	(2.350)	(2.208)	(2.348)	(2.213)
Bank liquidity	0.0297***	0.0160***	0.0297***	0.0160***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.730***	-1.845***	-2.726***	-1.839***
	(0.1975)	(0.1785)	(0.1976)	(0.1786)
Asset structure	0.1116***	0.0596	0.1118***	0.0597
	(0.0417)	(0.0393)	(0.0417)	(0.0393)
Bank Concentration	0.0277**	0.0457***	0.0281***	0.0461***
	(0.0109)	(0.0122)	(0.0109)	(0.0122)
GDP growth	0.0490***	0.0383***	0.0464***	0.0361**
	(0.0159)	(0.0145)	(0.0160)	(0.0146)
Inflation (CPI)	0.0297**	-0.0006	0.0284**	-0.0019
	(0.0116)	(0.0110)	(0.0116)	(0.0110)
Institutional Quality	2.903***	3.100***	2.787***	2.959***
	(0.7101)	(0.7255)	(0.7088)	(0.7244)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table D3: Impact of monetary policy on banking stability, income groups using global metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$ × High Income	0.1096**	0.1212***	0.1411***	0.1573***
	(0.0451)	(0.0452)	(0.0470)	(0.0467)
$\text{Policy}^{z}_{j,t-1}$ × Low Income	1.148***	1.350***	1.033***	1.088***
	(0.3278)	(0.2008)	(0.2771)	(0.1931)
$\text{Policy}^{z}_{j,t-1}$ × Lower Middle	0.1135*	-0.0119	0.1834***	0.0843
	(0.0689)	(0.0702)	(0.0698)	(0.0690)
$\text{Policy}^{z}_{j,t-1}$ × Upper Middle	0.0698	-0.0138	0.0993	0.0238
	(0.0801)	(0.0714)	(0.0756)	(0.0689)
Cost efficiency	3.991***	2.211***	3.980***	2.207***
	(0.7565)	(0.7140)	(0.7569)	(0.7141)
Bank liquidity	0.0297***	0.0158***	0.0297***	0.0158***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.743***	-1.845***	-2.743***	-1.846***
	(0.1976)	(0.1777)	(0.1978)	(0.1779)
Asset structure	0.1093***	0.0564	0.1094***	0.0566
	(0.0408)	(0.0382)	(0.0407)	(0.0382)
Bank Concentration	0.0252**	0.0428***	0.0259**	0.0434***
	(0.0109)	(0.0120)	(0.0109)	(0.0120)
GDP growth	0.0421***	0.0353**	0.0388**	0.0326**
	(0.0153)	(0.0142)	(0.0154)	(0.0143)
Inflation (CPI)	0.0338***	0.0060	0.0336***	0.0061
	(0.0116)	(0.0110)	(0.0116)	(0.0109)
Institutional Quality	3.084***	3.372***	3.026***	3.283***
	(0.7141)	(0.7279)	(0.7133)	(0.7270)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table D4: Impact of monetary policy on banking stability, income groups using income group metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × High Income	0.1059**	0.1159**	0.1349***	0.1499***
	(0.0449)	(0.0451)	(0.0467)	(0.0466)
$Policy^{z}_{j,t-1}$ × Low Income	1.131***	1.313***	1.023***	1.028***
	(0.3294)	(0.2260)	(0.2814)	(0.2132)
$Policy^{z}_{j,t-1}$ × Lower Middle	0.1130	-0.0180	0.1809***	0.0771
	(0.0689)	(0.0699)	(0.0698)	(0.0686)
$Policy^{z}_{j,t-1}$ × Upper Middle	0.0985	0.0206	0.1189	0.0495
	(0.0808)	(0.0722)	(0.0761)	(0.0696)
Cost efficiency × High Income	3.691***	1.737**	3.688***	1.735**
	(0.7544)	(0.7139)	(0.7543)	(0.7138)
Cost efficiency × Low Income	3.315**	2.215	3.295**	2.484
	(1.438)	(1.529)	(1.437)	(1.525)
Cost efficiency × Lower Middle	3.005**	1.990	2.975**	1.957
	(1.402)	(1.323)	(1.405)	(1.324)
Cost efficiency × Upper Middle	6.220***	4.817***	6.194***	4.784***
	(1.089)	(1.056)	(1.089)	(1.056)
Bank liquidity	0.0294***	0.0156***	0.0294***	0.0156***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.739***	-1.836***	-2.740***	-1.833***
	(0.2001)	(0.1791)	(0.2002)	(0.1791)
Asset structure	0.1097***	0.0567	0.1098***	0.0569
	(0.0408)	(0.0384)	(0.0408)	(0.0384)
Bank Concentration	0.0268**	0.0443***	0.0274**	0.0446***
	(0.0109)	(0.0120)	(0.0109)	(0.0120)
GDP growth	0.0440***	0.0374***	0.0410***	0.0349**
	(0.0151)	(0.0140)	(0.0152)	(0.0140)
Inflation (CPI)	0.0361***	0.0087	0.0359***	0.0086
	(0.0116)	(0.0109)	(0.0115)	(0.0109)
Institutional Quality	2.932***	3.244***	2.879***	3.184***
	(0.7130)	(0.7292)	(0.7125)	(0.7291)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table D5: Impact of monetary policy on banking stability, development status using global metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$ × Developed	0.1249***	0.1405***	0.1548***	0.1732***
	(0.0456)	(0.0456)	(0.0471)	(0.0471)
$\text{Policy}^{z}_{j,t-1}$ × Developing	0.1702***	0.0706	0.2097***	0.1237***
	(0.0517)	(0.0463)	(0.0508)	(0.0467)
Cost efficiency	3.882***	2.114***	3.877***	2.102***
	(0.7859)	(0.7504)	(0.7859)	(0.7507)
Bank liquidity	0.0295***	0.0156***	0.0295***	0.0156***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.745***	-1.850***	-2.743***	-1.847***
	(0.1979)	(0.1781)	(0.1980)	(0.1781)
Asset structure	0.1078***	0.0562	0.1080***	0.0562
	(0.0403)	(0.0381)	(0.0403)	(0.0380)
Bank Concentration	0.0270**	0.0438***	0.0273**	0.0441***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0415***	0.0349**	0.0384**	0.0323**
	(0.0153)	(0.0142)	(0.0154)	(0.0142)
Inflation (CPI)	0.0359***	0.0075	0.0355***	0.0073
	(0.0116)	(0.0109)	(0.0116)	(0.0109)
Institutional Quality	2.964***	3.246***	2.908***	3.181***
	(0.7141)	(0.7267)	(0.7132)	(0.7257)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table D6: Impact of monetary policy on banking stability, development status using development status metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^z_{j,t-1}$ × Developed	0.1269***	0.1399***	0.1568***	0.1726***
	(0.0455)	(0.0456)	(0.0471)	(0.0471)
$\text{Policy}^z_{j,t-1}$ × Developing	0.1675***	0.0714	0.2066***	0.1237***
	(0.0523)	(0.0464)	(0.0513)	(0.0467)
Cost efficiency × Developed	3.260***	1.335*	3.259***	1.324*
	(0.8458)	(0.7943)	(0.8458)	(0.7943)
Cost efficiency × Developing	5.138***	3.785**	5.126***	3.772**
	(1.604)	(1.539)	(1.604)	(1.540)
Bank liquidity	0.0293***	0.0153***	0.0293***	0.0153***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.746***	-1.854***	-2.744***	-1.851***
	(0.1980)	(0.1781)	(0.1981)	(0.1781)
Asset structure	0.1085***	0.0570	0.1087***	0.0570
	(0.0405)	(0.0383)	(0.0405)	(0.0382)
Bank Concentration	0.0284**	0.0453***	0.0287***	0.0456***
	(0.0110)	(0.0122)	(0.0110)	(0.0122)
GDP growth	0.0403***	0.0346**	0.0372**	0.0321**
	(0.0154)	(0.0142)	(0.0155)	(0.0142)
Inflation (CPI)	0.0378***	0.0098	0.0374***	0.0096
	(0.0117)	(0.0110)	(0.0117)	(0.0110)
Institutional Quality	2.914***	3.164***	2.858***	3.098***
	(0.7089)	(0.7220)	(0.7080)	(0.7209)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table D7: Impact of monetary policy on banking stability, ECB membership using global metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$\text{Policy}^{z}_{j,t-1}$ × Non-ECB Member	0.1518***	0.1280***	0.1890***	0.1698***
	(0.0417)	(0.0406)	(0.0423)	(0.0413)
$\text{Policy}^{z}_{j,t-1}$ × ECB Member	0.0860	0.0583	0.1030*	0.0773
	(0.0538)	(0.0526)	(0.0535)	(0.0523)
Cost efficiency	4.375***	2.697***	4.368***	2.684***
	(0.8024)	(0.7645)	(0.8026)	(0.7650)
Bank liquidity	0.0299***	0.0162***	0.0299***	0.0162***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.753***	-1.854***	-2.750***	-1.851***
	(0.1983)	(0.1782)	(0.1983)	(0.1782)
Asset structure	0.1090***	0.0578	0.1092***	0.0578
	(0.0405)	(0.0384)	(0.0405)	(0.0383)
Bank Concentration	0.0269**	0.0439***	0.0272**	0.0443***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0427***	0.0363**	0.0398**	0.0339**
	(0.0154)	(0.0142)	(0.0155)	(0.0143)
Inflation (CPI)	0.0365***	0.0090	0.0360***	0.0086
	(0.0116)	(0.0110)	(0.0116)	(0.0109)
Institutional Quality	2.922***	3.247***	2.854***	3.171***
	(0.7138)	(0.7253)	(0.7125)	(0.7240)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

Table D8: Impact of monetary policy on banking stability, ECB membership using ECB & Non-ECB membership metafrontier cost efficiency – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$ × Non-ECB Member	0.1518***	0.1277***	0.1889***	0.1694***
	(0.0417)	(0.0406)	(0.0423)	(0.0413)
$Policy^{z}_{j,t-1}$ × ECB Member	0.0835	0.0481	0.1006*	0.0672
	(0.0548)	(0.0536)	(0.0544)	(0.0533)
Cost efficiency × Non-ECB Member	4.430***	2.927***	4.423***	2.913***
	(0.8410)	(0.7933)	(0.8412)	(0.7937)
Cost efficiency × ECB Member	3.977***	1.026	3.972***	1.020
	(1.302)	(1.334)	(1.302)	(1.334)
Bank liquidity	0.0299***	0.0162***	0.0299***	0.0161***
	(0.0030)	(0.0022)	(0.0030)	(0.0022)
Size	-2.752***	-1.851***	-2.749***	-1.848***
	(0.1983)	(0.1782)	(0.1983)	(0.1782)
Asset structure	0.1090***	0.0579	0.1092***	0.0579
	(0.0405)	(0.0384)	(0.0405)	(0.0383)
Bank Concentration	0.0270**	0.0441***	0.0273**	0.0445***
	(0.0109)	(0.0121)	(0.0109)	(0.0121)
GDP growth	0.0426***	0.0360**	0.0398**	0.0336**
	(0.0154)	(0.0142)	(0.0155)	(0.0143)
Inflation (CPI)	0.0367***	0.0096	0.0361***	0.0092
	(0.0116)	(0.0110)	(0.0116)	(0.0109)
Institutional Quality	2.927***	3.280***	2.860***	3.204***
	(0.7146)	(0.7261)	(0.7133)	(0.7248)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,903	3,773	3,903	3,773
N	42,519	39,170	42,519	39,170
R^2	0.95	0.96	0.95	0.96

Note: Lag 1 of all predictors in Models (2) and (4).

Clustered (bank level) standard errors in parentheses.

****p<0.01, **p<0.05, *p<0.1.*

E Robustness: 3-year Rolling Window Standard Deviation of Returns

We provide robustness by using the 3-year rolling standard deviation of returns on average assets to calculate our banking stability measure (Z-score), as shown in Equation (9).

Table E1: Impact of monetary policy on banking stability, using robust Z-score (3-year rolling standard deviation of ROAA) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	2.553***	2.465***	3.284***	3.223***
	(0.7569)	(0.7807)	(0.7682)	(0.7859)
Cost efficiency	79.92***	71.04***	79.84***	70.81***
	(9.594)	(9.727)	(9.593)	(9.722)
Bank liquidity	0.0694***	0.0545***	0.0693***	0.0542***
	(0.0259)	(0.0192)	(0.0259)	(0.0192)
Size	2.676	4.605***	2.718	4.660***
	(1.766)	(1.716)	(1.766)	(1.717)
Asset structure	-0.1310	-0.3590	-0.1279	-0.3598
	(0.2118)	(0.2327)	(0.2114)	(0.2319)
Bank Concentration	-0.2108*	-0.1189	-0.2051*	-0.1120
	(0.1246)	(0.1397)	(0.1246)	(0.1397)
GDP growth	-0.0206	0.1228	-0.0853	0.0692
	(0.2684)	(0.2422)	(0.2692)	(0.2423)
Inflation (CPI)	-0.1976	-0.2714*	-0.2077	-0.2779*
	(0.1640)	(0.1534)	(0.1642)	(0.1535)
Institutional Quality	65.32***	69.49***	64.03***	68.08***
	(8.893)	(9.079)	(8.895)	(9.081)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,830	3,771	3,830	3,771
N	42,308	39,112	42,308	39,112
R^2	0.34	0.34	0.34	0.34

Note: Lag 1 of all predictors in Models (2) and (4).
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table 17: Impact of monetary policy on banking stability, controlling for macroprudential policies (Liquidity and LFX), using robust Z-score (3-year rolling standard deviation of ROAA) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	2.694***	2.669***	3.435***	3.440***
	(0.7810)	(0.8044)	(0.7921)	(0.8085)
Cost efficiency	82.21***	71.10***	82.17***	70.86***
	(9.707)	(9.811)	(9.706)	(9.806)
Bank liquidity	0.0718***	0.0548***	0.0716***	0.0545***
	(0.0268)	(0.0198)	(0.0268)	(0.0198)
Size	3.086*	4.767***	3.121*	4.819***
	(1.796)	(1.740)	(1.797)	(1.741)
Asset structure	-0.0727	-0.3155	-0.0694	-0.3163
	(0.2083)	(0.2325)	(0.2078)	(0.2317)
Bank Concentration	-0.1989	-0.1095	-0.1926	-0.1020
	(0.1253)	(0.1404)	(0.1253)	(0.1404)
GDP growth	-0.1945	-0.1200	-0.2652	-0.1800
	(0.3088)	(0.2766)	(0.3092)	(0.2762)
Inflation (CPI)	0.0220	-0.0581	0.0143	-0.0617
	(0.1790)	(0.1659)	(0.1790)	(0.1658)
Institutional Quality	65.36***	69.44***	63.96***	67.93***
	(9.155)	(9.311)	(9.161)	(9.313)
Macroprudential: Liquidity	6.899***	6.784***	6.952***	6.848***
	(1.022)	(1.028)	(1.022)	(1.027)
Macroprudential: LFX	4.305**	5.532**	4.221**	5.443**
	(2.121)	(2.217)	(2.120)	(2.216)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,743	3,685	3,743	3,685
N	41,484	38,372	41,484	38,372
R^2	0.34	0.34	0.34	0.34

Note: Lag 1 of all predictors in Models (2) and (4). LFX: Limits on FX positions.
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

Table 18: Impact of monetary policy on banking stability, controlling for macroprudential policies (Liquidity and LTV), using robust Z-score (3-year rolling standard deviation of ROAA) – FE results

Policy variable:	Hybrid		Official	
Model:	(1)	(2)	(3)	(4)
$Policy^{z}_{j,t-1}$	2.769***	2.787***	3.539***	3.595***
	(0.7796)	(0.8053)	(0.7908)	(0.8098)
Cost efficiency	82.08***	71.25***	82.01***	70.99***
	(9.705)	(9.804)	(9.704)	(9.799)
Bank liquidity	0.0716***	0.0553***	0.0714***	0.0551***
	(0.0269)	(0.0198)	(0.0269)	(0.0198)
Size	3.116*	4.817***	3.155*	4.874***
	(1.796)	(1.740)	(1.796)	(1.741)
Asset structure	-0.0665	-0.3075	-0.0631	-0.3079
	(0.2079)	(0.2326)	(0.2074)	(0.2317)
Bank Concentration	-0.1970	-0.1087	-0.1903	-0.1006
	(0.1254)	(0.1407)	(0.1253)	(0.1406)
GDP growth	-0.2312	-0.1932	-0.3099	-0.2616
	(0.3076)	(0.2783)	(0.3080)	(0.2781)
Inflation (CPI)	-0.0426	-0.1570	-0.0540	-0.1644
	(0.1848)	(0.1747)	(0.1849)	(0.1747)
Institutional Quality	65.02***	68.73***	63.59***	67.16***
	(9.142)	(9.295)	(9.147)	(9.296)
Macroprudential: Liquidity	6.902***	6.809***	6.964***	6.883***
	(1.017)	(1.021)	(1.017)	(1.021)
Macroprudential: LTV	2.245	3.540**	2.394	3.698**
	(1.462)	(1.558)	(1.463)	(1.559)
Fixed-effects				
Bank	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
No. of Banks	3,743	3,685	3,743	3,685
N	41,484	38,372	41,484	38,372
R^2	0.34	0.34	0.34	0.34

Note: Lag 1 of all predictors in Models (2) and (4). LTV: Limits on Loan-to-Value Ratio
Clustered (bank level) standard errors in parentheses.
****p<0.01, **p<0.05, *p<0.1.*

F Channel Analysis: Portfolio Rebalancing

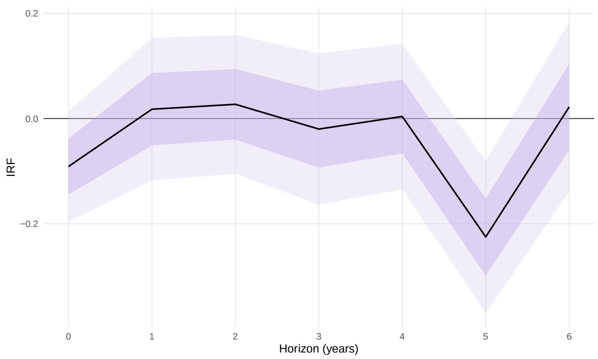
We next examine a portfolio rebalancing margin through which banks respond to tighter monetary conditions by adjusting the composition of their balance sheets. In this exercise, portfolio rebalancing is proxied by the loans-to-assets ratio, Loans/Assets, which captures shifts in the relative weight of lending within total assets. Unlike credit growth, Loans/Assets is a composition object and can move due to changes in the numerator (loans), the denominator (total assets), or both. We estimate LPs analogous to the credit-growth specifications, using Loans/Assets as the dependent variable and interacting the monetary policy shock with lagged cost efficiency. Figures F1-F3 report the corresponding impulse responses across efficiency percentiles.

The results indicate that monetary tightening reduces Loans/Assets on impact, consistent with banks reallocating away from loan exposures and/or expanding non-loan/liquid positions as funding costs rise and risk constraints tighten. The impact response is heterogeneous by cost efficiency: the decline in Loans/Assets is larger for high-efficiency banks (p75), while the response for low-efficiency banks (p25) is flatter and, in some specifications, close to zero at short horizons. This pattern suggests that cost-efficient banks rebalance more actively and rapidly when policy tightens, consistent with greater operational flexibility, lower adjustment costs, and more effective balance-sheet management.

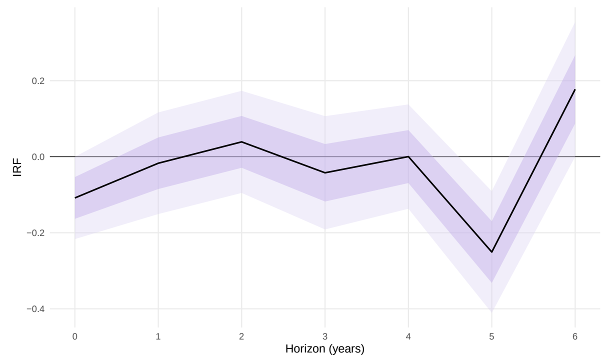
The dynamic profiles reinforce this interpretation. High-efficiency banks exhibit a more pronounced rebalancing trajectory over subsequent horizons, indicating an earlier and more decisive shift in portfolio composition when monetary conditions tighten. Low-efficiency banks, by contrast, display a smoother and muted adjustment path—consistent with limited capacity to reallocate assets quickly, higher internal frictions, and slower updating of portfolio targets. Taken together, these findings support the broader theme of the paper: cost efficiency is associated not only with higher stability outcomes, but also with the shape of balance-sheet adjustment to monetary tightening—more front-loaded and active among efficient banks, and more inertial among less efficient banks.

Figure F1: Local projections responses of loan share (Loans/Assets) to monetary policy shock, conditional on bank cost efficiency

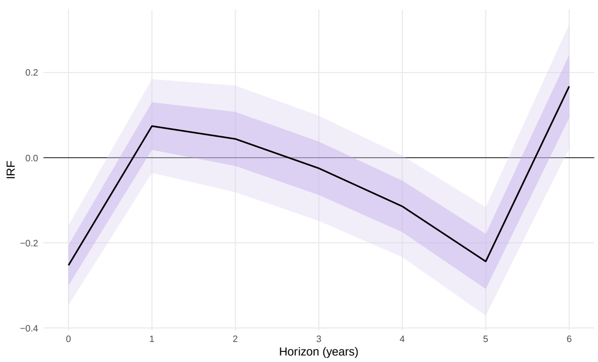
(i) One Lag of Predictors | **(ii) One Lag of Loan share & Predictors**



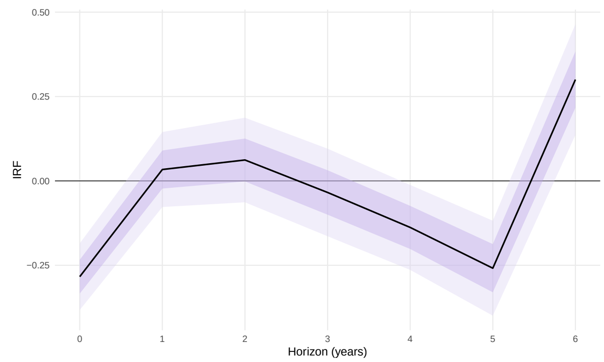
25th percentile



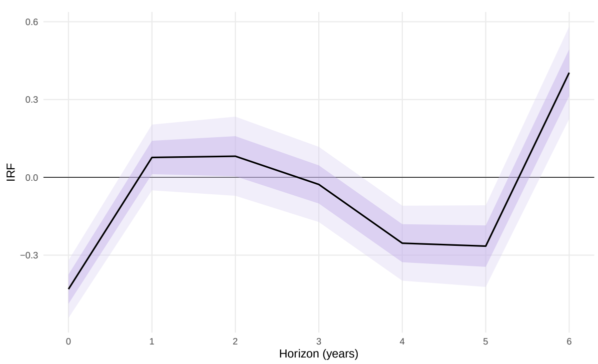
25th percentile



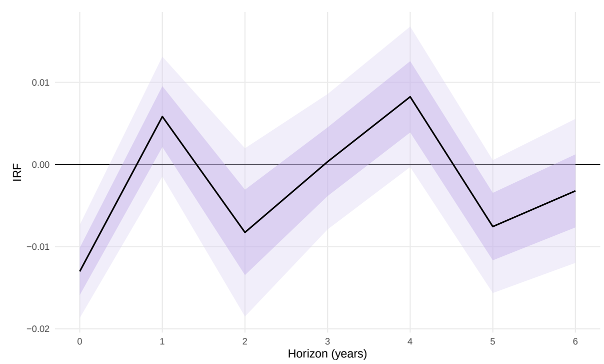
50th percentile



50th percentile



75th percentile

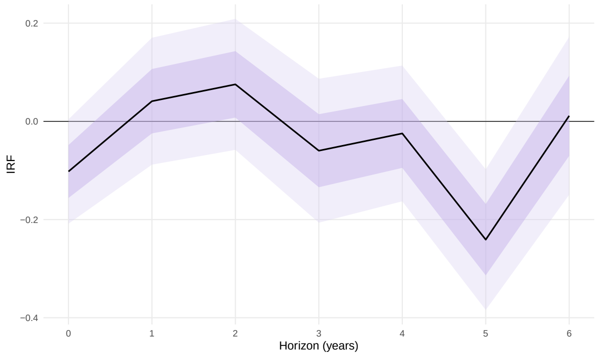


75th percentile

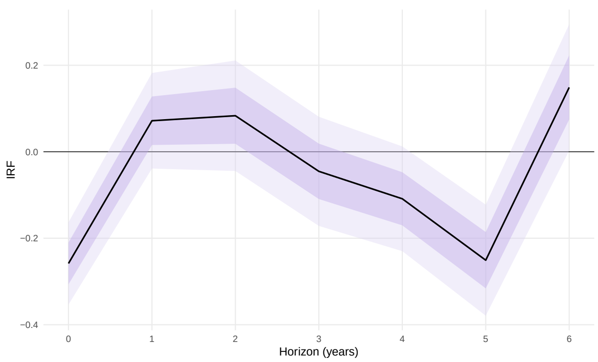
Note: The figure plots local projections responses of loan share (Loans/Assets) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of loan share and predictors.

Figure F2: Local projections responses of ploan share (Loans/Assets) to monetary policy shock, conditional on bank cost efficiency, controlling for macroprudential policies (Liquidity and LFX)

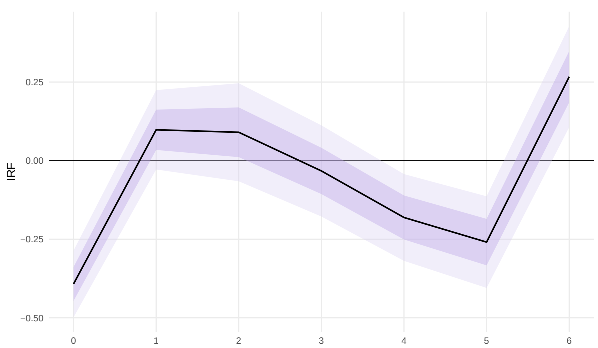
(i) One Lag of Predictors



25th percentile

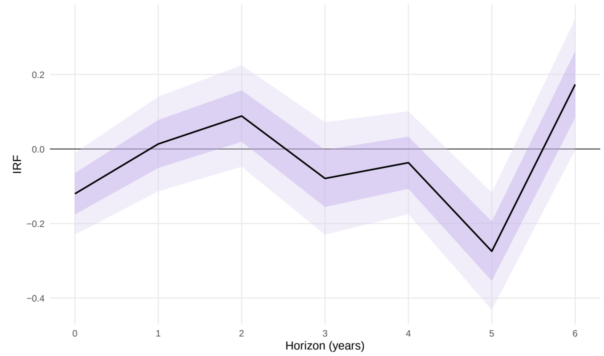


50th percentile

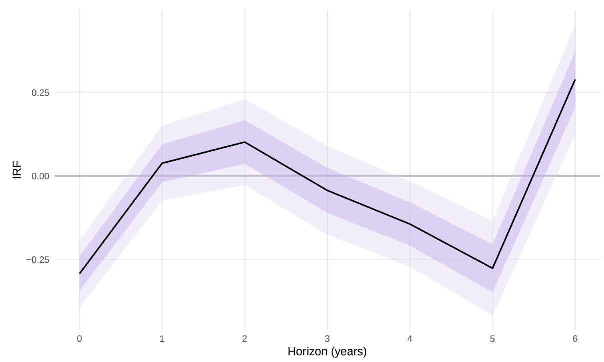


75th percentile

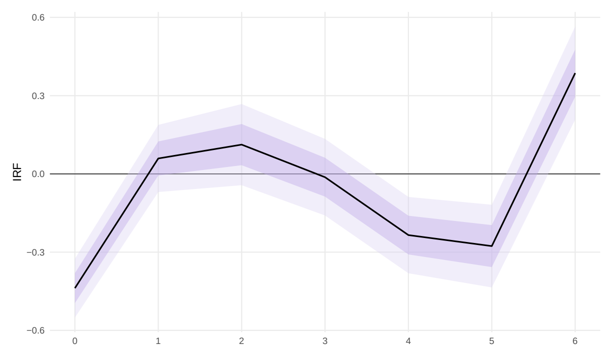
(ii) One Lag of loan share & Predictors



25th percentile



50th percentile



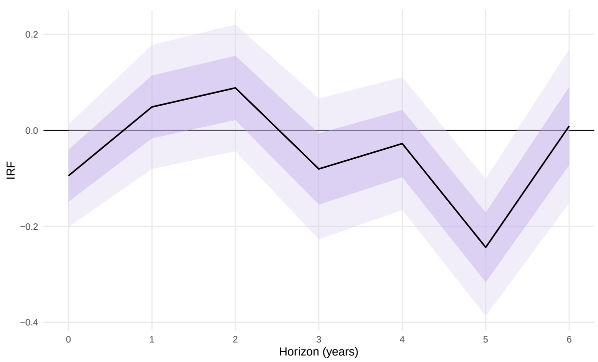
75th percentile

Note: The figure plots local projections responses of loan share (Loans/Assets) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LFX). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of loan share and predictors.

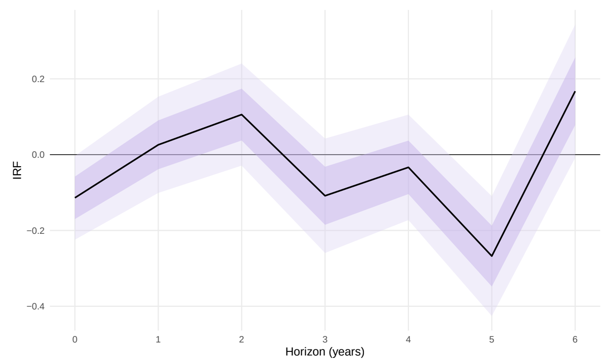
Figure F3: Local projections responses of loan share (Loans/Assets) to monetary policy shock, conditional on bank cost efficiency, controlling for macroprudential policies (Liquidity and LTV)

(i) One Lag of Predictors

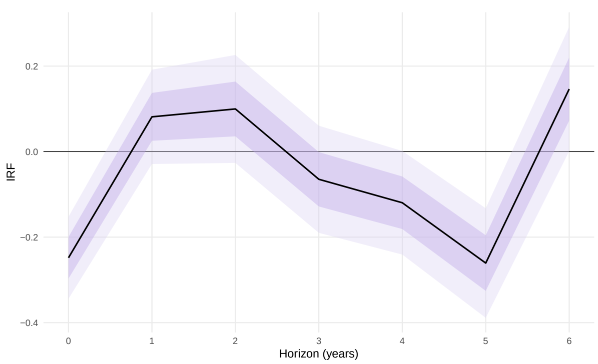
(ii) One Lag of loan spread & Predictors



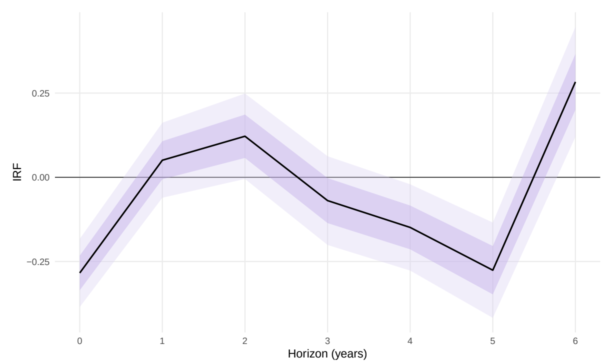
25th percentile



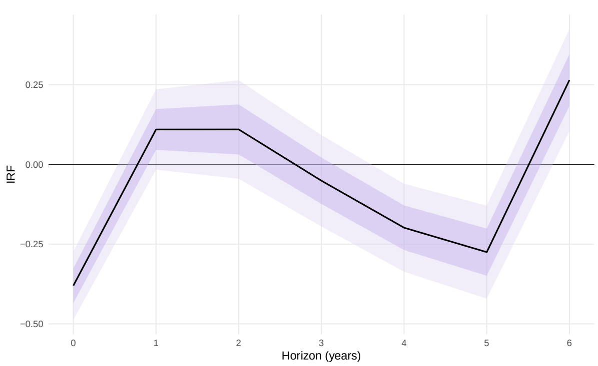
25th percentile



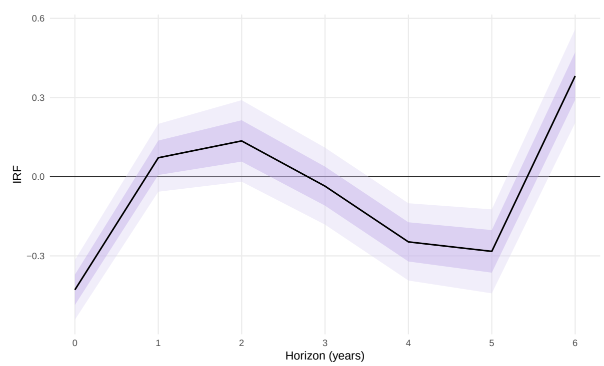
50th percentile



50th percentile



75th percentile



75th percentile

Note: The figure plots local projections responses of loan share (Loans/Assets) to a one-standard-deviation monetary policy shock, conditional on bank cost efficiency (evaluated at the 25th, 50th, and 75th percentiles), controlling for macroprudential policies (Liquidity and LTV). The lighter and darker bands represent 68% and 95% error bands, respectively. Column (i) includes 1 lag of all predictors; column (ii) includes one lag of loan share and predictors.

G Additional DSGE Derivation

G.1 Price setting and the New Keynesian Phillips curve

This appendix collects the standard Calvo price-setting problem. A firm resetting price at t chooses $P_t^\star$ to maximise expected discounted profits while the price remains in effect:

$$\max_{P_t^\star} \mathbb{E}_t \sum_{n=0}^{\infty} (\alpha\beta)^n \Lambda_{t,t+n} \left[\left(\frac{P_t^\star}{P_{t+n}} - MC_{t+n} \right) Y_{t+n|t} \right], \tag{G.1}$$

where $\Lambda_{t,t+n}$ is the household stochastic discount factor and $Y_{t+n|t}$ is demand conditional on $P_t^\star$:

$$Y_{t+n|t} = \left(\frac{P_t^\star}{P_{t+n}} \right)^{-\varepsilon} Y_{t+n}.$$

The first-order condition for $P_t^\star$ is:

$$\mathbb{E}_t \sum_{n=0}^{\infty} (\alpha\beta)^n \Lambda_{t,t+n} Y_{t+n|t} \left[\varepsilon \left(\frac{P_t^\star}{P_{t+n}} - MC_{t+n} \right) + \frac{P_t^\star}{P_{t+n}} \right] = 0. \tag{G.2}$$

Log-linearisation around a symmetric steady state yields the NKPC in Equation (37), with slope

$$\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} \cdot \frac{1}{1+\varphi} \quad \text{(under standard normalisations).}$$

G.2 Banking block—full static FOCs and partial adjustment

For bank type k, substitute Equation (41) into Equation (48) and differentiate with respect to $m_{k,t}$:

$$\frac{\partial \Pi_{k,t}^B}{\partial m_{k,t}} = -\lambda \frac{\partial p_{k,t}}{\partial m_{k,t}} - \frac{\partial \mathscr{C}^m}{\partial m_{k,t}} - \frac{\partial \mathscr{C}^a}{\partial m_{k,t}} = \lambda \chi_k - \frac{\kappa_m}{\theta_k} m_{k,t} - \frac{\varphi_m}{\theta_k} (m_{k,t} - m_{k,t-1}).$$

Setting this to zero gives Equation (50). Solving yields Equation (51). Under the policy scaling (52), the same steps deliver Equation (53).

G.3 Sign reversal and efficiency-conditioned smoothing

The stability index (57) depends on $(\mu_{k,t}, p_{k,t}, m_{k,t})$. Using Equations (41) and (53), tightening increases d_t persistently and increases $m_{k,t}$ front-loaded. A sufficient condition for sign reversal is that the distress process is more persistent than the risk-management adjustment:

$$\rho_d > \rho_m. \tag{G.3}$$

Moreover, the marginal effect of a tightening innovation on $m_{k,t}$ is increasing in (θ_k, χ_k) via $\nu_k = \xi\eta\theta_k\chi_k$, implying efficiency-conditioned smoothing at horizons where the slow channel dominates.

G.4 Log-linear equilibrium conditions

This section reports the log-linear equilibrium conditions. All variables are expressed as log deviations (or linear deviations, where appropriate) from the deterministic steady state. Expectations are rational and are taken with respect to information at time t. The system is organised into a New Keynesian (NK) core and a banking block with three efficiency types $k \in \{25, 50, 75\}$.

G.4.1 A. Exogenous monetary innovation process

$$\varepsilon_t^R = \rho_\varepsilon \varepsilon_{t-1}^R + \sigma_R e_t^R. \tag{G.4}$$

G.4.2 B. New Keynesian core

IS curve.

$$x_t = \mathbb{E}_t[x_{t+1}] - \frac{1}{\sigma}\Big(R_t - \mathbb{E}_t[\pi_{t+1}]\Big). \tag{G.5}$$

New Keynesian Phillips curve.

$$\pi_t = \beta\,\mathbb{E}_t[\pi_{t+1}] + \kappa\, x_t. \tag{G.6}$$

Taylor rule.

$$R_t = \rho_R R_{t-1} + (1-\rho_R)\Big(\phi_\pi \pi_t + \phi_x x_t\Big) + \varepsilon_t^R. \tag{G.7}$$

Output gap identity.

$$y_t = x_t. \tag{G.8}$$

G.4.3 Borrower distress (slow channel)

$$d_t = \rho_d d_{t-1} + \phi_d\, \varepsilon_t^R + \phi_{dx}\, x_t. \tag{G.9}$$

G.4.4 Banking block with efficiency heterogeneity

Risk management (fast channel). For $k \in \{25, 50, 75\}$:

$$m_{25,t} = \rho_m m_{25,t-1} + \nu_{25}\,\varepsilon_t^R, \tag{G.10}$$

$$m_{50,t} = \rho_m m_{50,t-1} + \nu_{50}\,\varepsilon_t^R, \tag{G.11}$$

$$m_{75,t} = \rho_m m_{75,t-1} + \nu_{75}\,\varepsilon_t^R. \tag{G.12}$$

Default risk.

$$p_{25,t} = \pi_d d_t - \chi_{25} m_{25,t}, \tag{G.13}$$

$$p_{50,t} = \pi_d d_t - \chi_{50} m_{50,t}, \tag{G.14}$$

$$p_{75,t} = \pi_d d_t - \chi_{75} m_{75,t}. \tag{G.15}$$

Spreads.

$$s_{25,t} = \omega_p\, p_{25,t}, \tag{G.16}$$

$$s_{50,t} = \omega_p\, p_{50,t}, \tag{G.17}$$

$$s_{75,t} = \omega_p\, p_{75,t}. \tag{G.18}$$

Effective loan and deposit rates (pass-through).

$$r^L_{25,t} = \alpha_{L,25} R_t + s_{25,t}, \tag{G.19}$$

$$r^L_{50,t} = \alpha_{L,50} R_t + s_{50,t}, \tag{G.20}$$

$$r^L_{75,t} = \alpha_{L,75} R_t + s_{75,t}, \tag{G.21}$$

$$r^D_{25,t} = \beta_{D,25} R_t, \tag{G.22}$$

$$r^D_{50,t} = \beta_{D,50} R_t, \tag{G.23}$$

$$r^D_{75,t} = \beta_{D,75} R_t. \tag{G.24}$$

Net interest margins.

$$\mu_{25,t} = r^L_{25,t} - r^D_{25,t}, \tag{G.25}$$

$$\mu_{50,t} = r^L_{50,t} - r^D_{50,t}, \tag{G.26}$$

$$\mu_{75,t} = r^L_{75,t} - r^D_{75,t}. \tag{G.27}$$

Equity dynamics (retained earnings).

$$e_{25,t} = \rho_e e_{25,t-1} + \phi_e \Big(\mu_{25,t} - \lambda_{\text{lgd}} p_{25,t} - c_{m,25} m_{25,t} \Big), \tag{G.28}$$
$$e_{50,t} = \rho_e e_{50,t-1} + \phi_e \Big(\mu_{50,t} - \lambda_{\text{lgd}} p_{50,t} - c_{m,50} m_{50,t} \Big), \tag{G.29}$$
$$e_{75,t} = \rho_e e_{75,t-1} + \phi_e \Big(\mu_{75,t} - \lambda_{\text{lgd}} p_{75,t} - c_{m,75} m_{75,t} \Big). \tag{G.30}$$

G.4.5 Lending and credit growth

Loan stock (log) dynamics.

$$\ell_{25,t} = \rho_\ell \ell_{25,t-1} + (1-\rho_\ell)\Big(a_e e_{25,t} - a_{r,25} r^L_{25,t} + a_y y_t - a_{m,25} m_{25,t} \Big) + b_{R,25} \varepsilon^R_t, \tag{G.31}$$
$$\ell_{50,t} = \rho_\ell \ell_{50,t-1} + (1-\rho_\ell)\Big(a_e e_{50,t} - a_{r,50} r^L_{50,t} + a_y y_t - a_{m,50} m_{50,t} \Big) + b_{R,50} \varepsilon^R_t, \tag{G.32}$$
$$\ell_{75,t} = \rho_\ell \ell_{75,t-1} + (1-\rho_\ell)\Big(a_e e_{75,t} - a_{r,75} r^L_{75,t} + a_y y_t - a_{m,75} m_{75,t} \Big) + b_{R,75} \varepsilon^R_t. \tag{G.33}$$

Credit growth (log change).

$$\Delta \ell_{25,t} = \ell_{25,t} - \ell_{25,t-1}, \tag{G.34}$$
$$\Delta \ell_{50,t} = \ell_{50,t} - \ell_{50,t-1}, \tag{G.35}$$
$$\Delta \ell_{75,t} = \ell_{75,t} - \ell_{75,t-1}. \tag{G.36}$$

G.4.6 NPL dynamics and relative growth

NPL stock (log) dynamics.

$$npl_{25,t} = \rho_{npl,25}\, npl_{25,t-1} + (1-\rho_{npl,25})\Big(\iota_d d_t - \iota_{m,25} m_{25,t} \Big) + b_{N,25} \varepsilon^R_t, \tag{G.37}$$
$$npl_{50,t} = \rho_{npl,50}\, npl_{50,t-1} + (1-\rho_{npl,50})\Big(\iota_d d_t - \iota_{m,50} m_{50,t} \Big) + b_{N,50} \varepsilon^R_t, \tag{G.38}$$
$$npl_{75,t} = \rho_{npl,75}\, npl_{75,t-1} + (1-\rho_{npl,75})\Big(\iota_d d_t - \iota_{m,75} m_{75,t} \Big) + b_{N,75} \varepsilon^R_t. \tag{G.39}$$

NPL growth (log change).

$$\Delta npl_{25,t} = npl_{25,t} - npl_{25,t-1}, \tag{G.40}$$
$$\Delta npl_{50,t} = npl_{50,t} - npl_{50,t-1}, \tag{G.41}$$
$$\Delta npl_{75,t} = npl_{75,t} - npl_{75,t-1}. \tag{G.42}$$

NPL growth relative to credit growth (log-change analogue of $\Delta\ln(\text{NPL})-\Delta\ln(L)$).

$$\Delta npl_{25,t}-\Delta\ell_{25,t}=\Delta npl_{25,t}-\Delta\ell_{25,t}, \tag{G.43}$$

$$\Delta npl_{50,t}-\Delta\ell_{50,t}=\Delta npl_{50,t}-\Delta\ell_{50,t}, \tag{G.44}$$

$$\Delta npl_{75,t}-\Delta\ell_{75,t}=\Delta npl_{75,t}-\Delta\ell_{75,t}. \tag{G.45}$$

G.4.7 Model stability index (mapping to empirical Z-score dynamics)

$$z_{25,t}=z_\mu\mu_{25,t}-z_p\,\lambda_{\text{lgd}}\,p_{25,t}+z_m m_{25,t}-z_d d_t, \tag{G.46}$$

$$z_{50,t}=z_\mu\mu_{50,t}-z_p\,\lambda_{\text{lgd}}\,p_{50,t}+z_m m_{50,t}-z_d d_t, \tag{G.47}$$

$$z_{75,t}=z_\mu\mu_{75,t}-z_p\,\lambda_{\text{lgd}}\,p_{75,t}+z_m m_{75,t}-z_d d_t. \tag{G.48}$$

G.5 LP-based IRF targets for moment-guided calibration or minimum-distance estimation

Let $I\widehat{RF}_y^{\,k}(h)$ denote the empirical LP impulse response at horizon h for outcome $y\in\{Z,\mu,\Delta\ell,\Delta\log(\text{NPL}),\Delta\text{l}$ $\Delta\log(L)\}$ and efficiency group $k\in\{25,50,75\}$, where the monetary policy stance shock is standardised. The corresponding model moments are the Dynare IRFs to a $+1\sigma$ policy innovation.

Bank stability (Z-score).

$$I\widehat{RF}_Z^{\,p25}(h):\ (0.0836, 0.1001, 0.0037, -0.1463, -0.0654, -0.0479, -0.1528),$$

$$I\widehat{RF}_Z^{\,p50}(h):\ (0.1320, 0.1346, 0.0270, -0.0901, -0.0639, -0.0907, -0.2604),$$

$$I\widehat{RF}_Z^{\,p75}(h):\ (0.1730, 0.1638, 0.0468, -0.0425, -0.0626, -0.1270, -0.3515),$$

for $h=0,\ldots,6$.

Net interest margin (NIM).

$$I\widehat{RF}_\mu^{\,p25}(h):\ (-0.0343, 0.0144, -0.0041, -0.0066, -0.0180, -0.0443, -0.0232),$$

$$I\widehat{RF}_\mu^{\,p50}(h):\ (-0.0378, -0.0057, -0.0330, -0.0024, -0.0041, -0.0253, -0.0234),$$

$$I\widehat{RF}_\mu^{\,p75}(h):\ (-0.0408, -0.0228, -0.0574, 0.0012, 0.0077, -0.0092, -0.0236).$$

Credit growth (log changes).

$$\widehat{IRF}^{p25}_{\Delta\ell}(h): (0.0073, -0.0029, -0.0175, 0.0014, 0.00001, -0.02166, -0.03041),$$
$$\widehat{IRF}^{p50}_{\Delta\ell}(h): (-0.0047, -0.0002, -0.0141, -0.0022, 0.0013, -0.0166, -0.0210),$$
$$\widehat{IRF}^{p75}_{\Delta\ell}(h): (-0.0149, 0.0021, -0.0112, -0.0051, 0.0024, -0.0123, -0.0130).$$

NPL growth (log changes).

$$\widehat{IRF}^{p25}_{\Delta\log(\text{NPL})}(h): (-0.0123, -0.0219, 0.0299, 0.0389, -0.0083, -0.0119, 0.0038),$$
$$\widehat{IRF}^{p50}_{\Delta\log(\text{NPL})}(h): (-0.0266, -0.0255, 0.0425, 0.0330, -0.0026, -0.0305, 0.0213),$$
$$\widehat{IRF}^{p75}_{\Delta\log(\text{NPL})}(h): (-0.0387, -0.0286, 0.0531, 0.0280, 0.0023, -0.0462, 0.0360),$$

for $h = 0, \ldots, 6$.

NPL growth relative to loan growth.

$$\widehat{IRF}^{p25}_{\Delta\log(\text{NPL})-\Delta\log(L)}(h): (-0.0199, -0.0184, 0.0475, 0.0367, -0.0091, 0.0106, 0.0339),$$
$$\widehat{IRF}^{p50}_{\Delta\log(\text{NPL})-\Delta\log(L)}(h): (-0.0216, -0.0251, 0.0565, 0.0348, -0.0034, -0.0140, 0.0420),$$
$$\widehat{IRF}^{p75}_{\Delta\log(\text{NPL})-\Delta\log(L)}(h): (-0.0231, -0.0308, 0.0641, 0.0331, 0.0015, -0.0347, 0.0489).$$