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How do interest rate levels affect credit loss rates? A rule of thumb approach[1]

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Abstract

This paper investigates how changes in monetary policy interest rates affect credit loss rates in advanced and emerging market economies using annual data for 113 countries over the past three decades. Applying local projections, we find that a 1 percentage point increase in policy rates raises loan loss rates, on average, by 0.1 percentage points - an economically significant effect that is larger in relative terms in advanced economies than in emerging market economies. These rule-of-thumb estimates are robust across methodologies, including instrumental-variable estimation, exogenous monetary policy shocks, and bank-level data. Crucially, the effect of rate hikes is strongly state dependent: it intensifies when pre-tightening monetary policy is loose, private debt is high, fiscal policy is contractionary, the economy is in a downturn, and central bank balance sheets are shrinking at the same time. Banks with riskier pre-tightening loan portfolios record larger increases in credit losses. Our findings suggest that central banks and prudential authorities should account for the side effects of monetary policy and incorporate credit-risk dynamics into macroprudential and stress-testing frameworks to safeguard financial stability.

Keywords: Credit loss rates, Interest rates, Monetary policy, Financial stability, Macro-financial conditions

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1 Introduction

The relationship between interest rate levels and credit losses lies at the intersection of monetary policy and financial stability. During monetary tightening, higher interest rates can weaken borrowers' debt-servicing capacity and increase banks' exposure to credit risk. Conversely, a low-for-long interest rate environment can encourage leverage and risk-taking, thereby amplifying vulnerabilities once rates rise. Understanding the interest-rate elasticity of credit loss rates is therefore important for both monetary authorities and financial regulators, particularly when private debt is high and inflation dynamics are uncertain.

Recent monetary policy cycles - most notably the sharp tightening of 2022-23 following a prolonged period of ultra-low rates in major currencies after the Great Financial Crisis (GFC) and during the Covid-19 pandemic - have revived the debate about the trade-off between restoring price stability and preserving financial stability. Despite concerns that rapid rate hikes would trigger broad-based credit deterioration, realised credit losses have remained contained so far, not least due to buffers accumulated by borrowers with policy support during the Covid-19 pandemic (IMF 2024). Even so, the issue remains highly relevant given elevated debt levels and the less predictable macro-financial environment in which central banks now operate.

To this end, we explore several policy-relevant empirical questions:

- How large is the typical response of credit loss rates to monetary tightening?
- Under what conditions does it intensify, and
- What does this imply for the design and timing of policy interventions to safeguard financial stability?

While a substantial literature examines the credit channel of monetary policy, few studies directly link policy-rate levels to realised credit losses. One recent contribution, Lo Duca et al. (2024), finds that interest-rate hikes slightly increase corporate probabilities of default using granular data for four major European economies and a local-projections approach, but the sample is limited to the low-rate period of 2014-19 rather than historical tightening episodes. Bouis et al. (2025) analyse how higher interest rates affect different components of bank profitability, including loan loss provisions, for banks from 31 countries. We extend this emerging literature by constructing a broad cross-country panel covering more than 100 economies from 1990 to 2022 and combining macro-financial indicators with bank-level data on loan loss rates from FitchConnect. Using local projections, we estimate impulse responses of credit losses to policy-rate changes and quantify how these responses vary across macro-financial states to draw conclusions for financial stability.

The link between interest rates and credit losses is central to finance and macroeconomics. Bernanke and Gertler (1989) argue that rising interest rates increase credit risk by raising borrowers' debt-servicing costs, especially for variable-rate borrowers, thereby increasing default probabilities and credit losses. Likewise, Merton's (1974) structural model implies that higher interest rates can raise default risk by weakening firms' cash flows and profitability. More broadly, interest rates influence not only the cost of borrowing but also credit allocation and financial stability. Understanding the channels through which interest-rate changes affect credit losses is therefore essential for policymakers, financial institutions and investors.

Our analysis contributes to the broader empirical literature on the relationship between interest rates and risk in the financial system. This literature can be grouped into four main strands, each relevant to our study in a different way.

A first strand (for example, Gertler and Karadi 2015; Palazzo and Yamarthy 2022) examines the effect of monetary tightening shocks on corporate credit risk, typically measured by corporate bond spreads or CDS spreads. Using high-frequency data and often focusing on the United States, these studies find that unexpected monetary tightening around policy meetings widens credit spreads for listed corporates. Palazzo and Yamarthy (2022) and Anderson and Cesa-Bianchi (2022) show that the effect is stronger for ex ante riskier or more leveraged firms. Our approach differs in three respects: it focuses on realised credit losses rather than market-based risk (bond or CDS spreads) proxies; it captures the credit risk of the full borrower base of banks, especially unlisted firms and households; and it covers a much broader set of countries.

A second strand studies the relationship between interest-rate levels and bank profitability, of which credit impairments are one component. Using bank-level data from 14 advanced economies over 1995-2012, Borio et al. (2017) find that higher short-term rates and a steeper yield curve are associated with stronger bank profitability, measured by return on assets. Their results imply that increases in interest-rate levels affect net interest income more strongly than credit losses and non-interest income. Much of this literature, however, was shaped by the post-GFC low-for-long environment and therefore focused on the effects of lower or persistently low rates on bank profitability rather than on rate increases. On aggregate, it finds that the decline in net interest income in a low-rate environment weighs more heavily on profitability than the offset from lower credit losses (for example, Claessens et al. 2018). Bouis et al. (2025) also find that higher rates are associated with higher bank profitability, but with substantial heterogeneity: banks with higher non-performing loans and more flexible-rate lending may see profitability fall when rates rise.

A third strand examines the relationship between interest-rate levels or changes and financial stability. Several papers conclude that higher policy rates can increase the likelihood of financial stress, especially when hikes follow a period of excessive credit growth (Schularick et al. 2021; Boissay et al. 2025) and/or a low-for-long environment (Jimenez et al. 2025). Using data for advanced and emerging economies, including tightening episodes and financial crises (Laeven and Valencia 2020), Boissay et al. (2025) find that tighter prudential policy before and during tightening helps prevent financial stress, thereby reducing the risk of financial dominance and giving central banks more room to tackle inflation. They also show that high private debt amplifies the risk of stress after tightening shocks.

A fourth strand studies the drivers of credit-loss or NPL increases, which is also relevant for the credit-risk satellite models used in bank stress testing. Much of this literature emerged during and after the GFC, when NPLs reached record levels in many countries. Many studies in this area, such as Beck et al. (2013), identify interest-rate levels as significant determinants of NPL increases alongside other macroeconomic variables.

Empirical work also shows that periods of rising interest rates often coincide with deteriorating credit quality, particularly among highly leveraged corporates and subprime borrowers (Altman 2000). Ong et al. (2023), drawing on a global database of credit loss rates, note that the wave of interest-rate hikes in the early 2020s raised debt-servicing costs but had only a limited effect on realised credit losses, partly because of public support measures.

At the same time, the relationship between interest rates and credit losses - and the broader implications for financial stability - is not mechanical (Section 2.1). Although higher rates can strain borrowers' repayment capacity, they may also induce lenders to tighten credit standards, which could mitigate losses over time. The effect further depends on the broader macroeconomic environment, including growth, employment and inflation, all of which interact with credit markets.

Against this backdrop, this study combines cross-country and bank-level analysis to assess under which conditions interest-rate increases affect credit losses and by how much. The recent shift from a prolonged low-rate environment to a tighter monetary policy stance, together with elevated debt levels and central banks' renewed focus on inflation control, makes this question especially relevant.

We find that contractionary monetary policy increases credit losses. In the baseline specification, a 1 percentage point (p.p.) increase in the policy rate raises the loan loss rate by around 0.1 p.p. over a three-to-five-year horizon. Although this effect may appear modest, it becomes economically meaningful when tightening is large. Moreover, a combination of adverse macro-financial conditions can magnify it to 0.2-0.3 p.p. for a 1 p.p. increase in the policy rate. This potential trade-off between monetary tightening and financial stability is consistent with studies that link monetary policy to financial stress (Schularick et al. 2021; Boissay et al. 2025; Jimenez et al. 2025; Uppal 2025).

The effect of monetary policy depends on macro-financial conditions before tightening. A loose pre-tightening monetary stance, high private-sector debt, high inflation and cyclical downturns all amplify the effect of higher interest rates on credit losses. We also find that simultaneous central bank balance-sheet reduction intensifies the increase in credit losses associated with higher policy rates. By contrast, an expansionary fiscal stance - especially in stress episodes - and a higher prevalence of fixed-rate lending dampen the rise in credit losses following rate hikes.

A key contribution of our study is to derive simple, policy-relevant rules of thumb for the effect of monetary tightening on bank loan losses under different macro-financial conditions.

The rest of the paper is organised as follows. Section 2 describes the data, presents stylised facts and outlines the empirical approach. Section 3 reports the results. Section 4 summarises the main findings as rules of thumb and discusses selected policy-relevant scenarios. Section 5 concludes.

2 Conceptual background, data and empirical strategy

2.1 Theoretical perspective on interest rates and credit losses

Increases in central bank policy rates affect borrowers and bank credit losses through several channels. At the microeconomic level, higher interest rates raise the cost of borrowing and debt servicing for households and non-financial corporates. As Bernanke and Gertler (1989) emphasise, borrowers with variable-rate debt, or those seeking new financing or rollover financing, face higher interest expenses, which can strain cash flows and increase the probability of default (PD). Higher interest rates can also depress collateral values, for example by lowering the present value of income-generating assets through a higher discount rate. Lower collateral values not only increase lenders' loss given default (LGD) but can also reduce borrowers' net worth and access to additional credit (Zabai 2017). More broadly, higher borrowing costs tend to weigh on credit markets and on the prices of assets commonly financed with bank loans, such as real estate.

At the macroeconomic level, higher interest rates reduce business investment and consumer spending in standard models. The resulting slowdown in economic activity worsens conditions for households and depresses the profitability of non-financial firms, especially those that are cyclical. In open economies with flexible exchange rates, tighter monetary policy may also appreciate the currency, reducing the competitiveness of exporters and weakening their debt-servicing capacity.

An additional consideration is the macroeconomic context and policy motivation for monetary tightening:

i. The standard case is an increase in policy rates by a central bank in pursuit of its price stability objective, responding to a cyclical upswing with inflation above target. An example is the monetary tightening by major central banks in the early 2000s before the onset of the GFC.

ii. A different case is an increase in policy rates by a central bank again with the price stability objective in mind, yet this time in response to a supply shock that sets inflationary dynamics in motion. Wage-price spirals are in the focus of policymakers in such scenario, possibly resulting in a period of sustained high inflation rates, nominal wage growth, and economic stagnation after the initial inflation shock. While all the above-mentioned factors are at play in this case as well and expected to increase credit losses over time, a counterbalancing short-term effect is the reduction in the real value of existing debt, which benefits borrowers and limits credit losses in the short run. Examples for this case are the monetary tightening episodes following the post-Covid pandemic inflation surge (2022/23) or during the cost-push inflation of advanced economies in the 1970s.

iii. The above cases can be distinguished from another stylized case, in which the central bank increases policy rates primarily in an effort to stabilize the FX rate, rather than to fight inflation, in an environment of capital outflows and depreciation pressures. Examples include the monetary tightening episodes of East Asian economies during the Asian financial crisis 1997, Western European countries during the Exchange Rate Mechanism crisis of the early 1990s, or some Central and Eastern European countries at the onset of the GFC (e.g. Romania in 2008).

Credit losses are only one channel through which higher interest rates affect bank risk and system-wide stability. Other important solvency channels are: (i) market risk, such as valuation losses on long-dated securities, as seen in the 2023 U.S. regional bank failures; (ii) higher funding costs due to greater reliance on market funding (Grimm 2025); and (iii) an offsetting profitability channel through higher net interest income when lending rates reprice faster than deposit rates (Borio et al. 2017). Whether higher rates ultimately weaken or strengthen solvency depends on the balance of these channels. The implications for financial stability depend on how these effects are distributed across banks, how they interact with liquidity conditions, and whether sustained higher policy rates spill over to public-sector balance sheets and sovereign risk premia. We focus on credit losses here and return to broader solvency and stability implications in Section 4.

2.2 Data and stylized facts

Our country-level analysis uses annual data for 113 countries over 1990-2022. The panel is unbalanced and covers 34 advanced and 79 emerging market economies, with sample selection driven by data availability. On average, we observe almost 18 years of data per country. Graph C.1 in the Appendix lists the countries included and the number of observations available for each.

The dependent variable is the loan loss rate, sourced from FitchConnect and defined as annual net loan loss provisions reported in the profit-and-loss account as a percentage of net loans outstanding. The main explanatory variable is the policy interest rate, sourced from the BIS database and, where unavailable, from the Global Macro Database (GMD) of Mueller et al. (2025). In robustness checks, we also use alternative monetary-policy measures: the short-term interest rate from the GMD and the monetary-policy shocks of Choi et al. (2024). Control variables include standard macro-financial drivers of credit risk: real GDP growth, inflation, gross fixed capital formation (% of GDP), private credit (% of GDP), and the year-on-year change in the nominal exchange rate. These variables are drawn mainly from IMF and World Bank databases and from the GMD. Table C.1 in the Appendix provides full variable definitions and data sources, while Table C.2 reports descriptive statistics.

Before turning to the econometric analysis, we document several stylised facts on credit loss rates and interest-rate movements. For the United States, long historical series confirm the well-known pattern that credit loss rates tend to rise during macro-financial crises (Graph 1.A), while short-term policy rates have become more volatile over the post-war period (Graph 1.B).

Over the past 150 years, several U.S. episodes suggest that increases in interest rates - especially from low starting points - were followed by higher corporate default rates, with the strength of the relationship depending on macro-financial conditions. Among the most prominent examples over the past 35 years covered by our study (Graph 1.A) are:

- Late 1980s/early 1990s (Savings and Loan crisis): Credit-loss rates rose from 0.4% to 1.6% alongside increases in short-term interest rates (from 6% to 9%). This period also marked the start of the Great Moderation, the consolidation of central bank independence and the adoption of Taylor-rule-type policy frameworks from the mid-1980s.

- Great Financial Crisis (GFC): Credit loss rates increased sharply (from 0.3% to 2.5%), preceded by a gradual but substantial rise in policy rates (from 1% to 5%).

Interest and credit loss rates: Long-term trends in the U.S. Graph 1

A. Credit loss rates fluctuated strongly over time, especially before the 1930s…

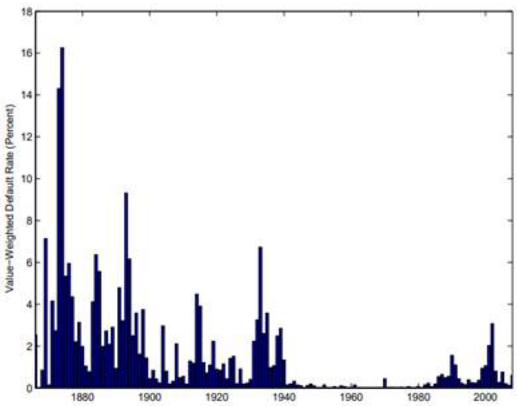
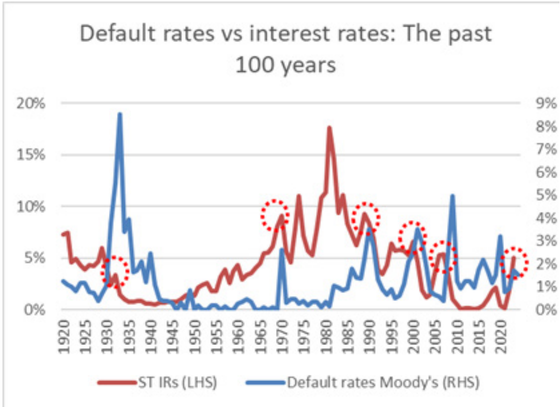


Figure 1. Historical Default Rates. This graph plots the annual value-weighted percentage default rates for bonds issued by domestic nonfinancial firms for the 1866–2008 period.

B. … while short-term interest rates started to fluctuate strongly after the second world war and particularly since the great moderation in the 1980s



Source: Giesecke et al. (2010) (left), Online Data - Robert Shiller (yale.edu) & Moody's (right graph)

Beyond these two episodes, which also featured other developments that could have affected the relationship between interest rates and loan loss rates, other periods show more mixed patterns, consistent with the presence of multiple drivers (Graph 1, right panel):

Late 1920s/early 1930s (Great Depression): A moderate increase in interest rates was followed by exceptionally high credit losses during the Depression.

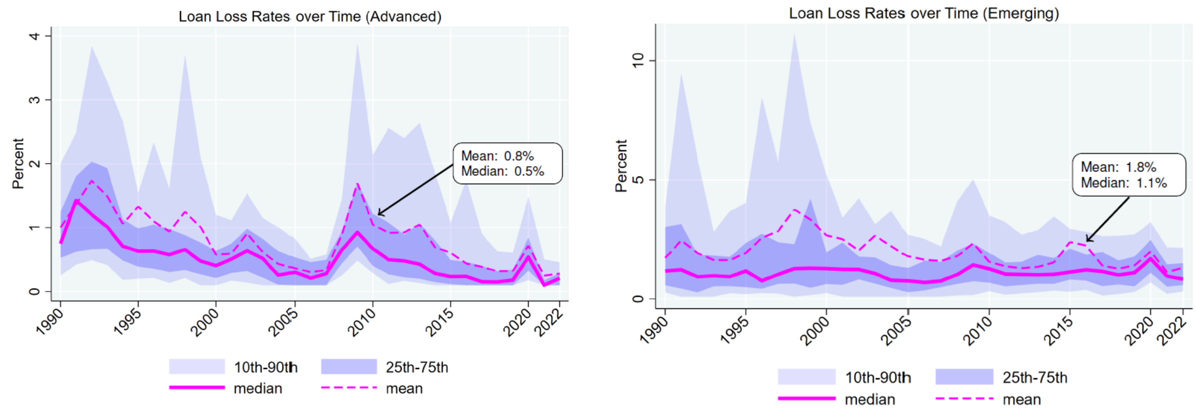
Late 1960s/early 1970s: Despite a sharp rise in interest rates, the corresponding increase in default rates was relatively limited.

Dot-com bust (early 2000s): Corporate credit-loss rates spiked from 0.2% to 1.6% after six consecutive years of stable but comparatively elevated interest rates.

Covid-19 pandemic: Bond loss rates increased, but less than expected—especially for bank loan loss rates—owing in part to extensive public support measures for borrowers.

We next present stylised facts on credit-loss trends across our country sample, distinguishing between advanced and emerging market economies (Graph 2). Both the median and mean loss rates are about twice as high in advanced economies (Graph 2, left panel) as in emerging market economies (Graph 2, right panel). At the same time, loss rates in advanced economies appear to have risen more sharply during both the GFC and the Covid-19 pandemic, whereas loss rates in emerging economies display greater cross-country heterogeneity. Globally, loss rates tend to increase around global recessions and financial crises, including the Asian financial crisis, the GFC and the Covid-19 pandemic. While some of these episodes coincided with higher interest rates, they also reflected other shocks that may have raised credit losses directly or in combination with tighter monetary policy.

Credit loss rates: Advanced vs. emerging economies Graph 2



Source: Based on data from FitchConnect

2.3 Empirical strategy

We estimate the response of credit loss rates to policy-rate changes using the local projection (LP) approach introduced by Jordà (2005). This flexible method allows us to estimate impulse responses directly without imposing the dynamic restrictions of a vector autoregression (VAR). The baseline specification includes macro-financial controls as well as country and year fixed effects.

To limit the influence of outliers, we exclude countries with average policy rates above 30%. We compute impulse responses for horizons of up to five years after a policy-rate change.

Our baseline specification follows the local-projections framework of Jordà (2005):

$$y_{i,t+h} - y_{i,t} = a_i^h + \beta_1^h \Delta R_{i,t} + \beta_{2j}^h \sum_{j=1}^{2} \Delta R_{i,t-j} + \beta_{3h}^h \sum_{h=1}^{h} \Delta R_{i,t+h} + \delta_l^h \sum_{l=0}^{1} (y_{i,t-l} - y_{i,t-1-l}) + \gamma^{h'} X_{i,t} + \tau_t + \epsilon_{i,t+h} \quad (1)$$

where y is the loan loss rate in country i and year t, R stands for policy rate, a_i^h and τ_t are country and time fixed effects, respectively. X represents the vector of control variables.[2] Finally, h is the forecast horizon (h = 1, ..., 5). The equation (1) is estimated separately for each forecast horizon.

In the baseline regressions, we rely on recursive identification of monetary-policy shocks, following Alpanda and Zubairy (2019) and Ahmed et al. (2024). The vector of controls X contains variables that enter the central bank reaction function, and equation (1) implicitly assumes that the policy rate may respond contemporaneously to all control variables, while the controls do not respond contemporaneously to the policy rate. This setup is analogous to ordering the policy rate last in the Cholesky decomposition of VAR residuals (Plagborg-Moller and Wolf 2021). The coefficients $\{\beta_1^h\}_{h=1}^5$ can therefore be interpreted as the dynamic effects of an exogenous increase in the policy rate. We use this approach in the baseline because it preserves sample size. In robustness checks, however, we also employ alternative identification strategies that provide sharper identification at the cost of fewer observations.

[2] The vector of control variables includes economic growth rate, inflation rate, gross fixed capital formation (% of GDP), private credit (% of GDP), and y-o-y nominal exchange rate change (%).

Following Jordà and Taylor (2025), we express the dependent variable in long differences. We also include leads of the policy-rate variable to address the bias from overlapping forecast horizons (Teulings and Zubanov 2014; Wiese et al. 2024), although the results are not sensitive to their inclusion. To address cross-sectional dependence, we rely on Driscoll and Kraay (1998) standard errors for statistical inference.

3 Empirical findings

This section presents the empirical findings: (i) baseline regressions quantifying the impact of monetary policy on country-level loan-loss rates; (ii) state-dependent local projections exploring how responses vary with macroeconomic conditions and the different policy paths; and (iii) bank-level empirical tests of the country-level conclusions and the role of bank-specific characteristics.

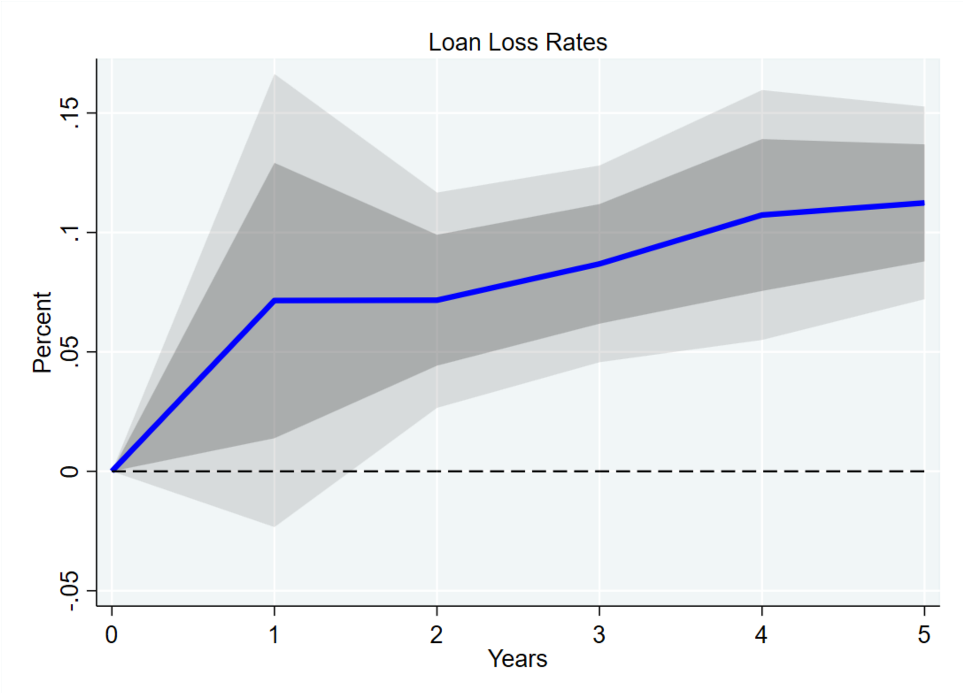
3.1 Baseline results

This subsection presents the results from the baseline specification in equation (1). The baseline uses the full country sample, includes leads and lags of the policy rate, one lag of the dependent variable, country and time fixed effects, and controls for economic growth, inflation, gross fixed capital formation, private credit, and changes in the nominal exchange rate.

Graph 3 plots the baseline response of bank loan loss rates - measured by the flow of loan loss provisions - to a 1 percentage point (p.p.) increase in the policy rate. The sample covers 113 countries with available data, excluding those with average policy rates above 30%.

Effect of 1 percentage point interest rate hike on Loan Loss Rates — Graph 3

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of loans loss rates to a 1 % increase in central bank interest rate. Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

A 1 p.p. increase in the policy rate raises loan loss rates by about 0.1 p.p. This implies that a one-standard-deviation increase in the policy rate (roughly 3 p.p.) raises the loan loss rate by around 0.35 p.p., relative to an average loan loss rate of 1.4% in our sample. For advanced economies, the median and mean hikes are 0.75 and 0.95 p.p.; for emerging market economies they are 1.25 and 2.66 p.p. In economic terms, the estimate is consistent with related work. Uppal (2025) reports for U.S. banks that a 1 p.p. increase in the federal funds rate raises cumulative loan loss provisions by about 0.1 p.p. over four years. Bouis et al. (2025) find for a global bank sample that a 1 p.p. increase in short-term rates is associated with a rise in loan loss provisions of around 0.2 p.p. in the following year.

Sensitivity analyses. Next, to verify the robustness of the baseline results, we conduct the following sensitivity checks:

- Alternative monetary policy indicators:
    - Replacing the policy rate with shadow rates where available (to address the period of the zero lower bound during the post-GFC period).
    - Replacing the policy rates with the short-term (3-month) interest rate.
- Additional controls (at the expense of a slightly smaller sample):
    - Adding an extra lag of all control variables.
    - Adding one-year-ahead IMF World Economic Outlook forecasts of inflation and growth.
    - Adding real property prices.
- Specification checks:
    - Dropping the leads of the policy-rate variable.
    - Dropping the lag of the dependent variable to address the Nickell (1981) bias.

Across these checks (Graph A.1 in the Appendix), higher interest rates remain associated with higher credit losses, confirming the baseline effect size. Policy rates may respond to the evolution of loss rates, especially during deep recessions triggered by severe banking-sector stress. To address this potential endogeneity, we re-estimate the baseline using exogenous monetary-policy shocks from Choi et al. (2024) instead of policy rates. Their dataset combines high-frequency financial-market surprises around policy announcements, Taylor-rule residuals where high-frequency data are unavailable, and anchor-currency shocks for countries without independent monetary policy. The results (Graph A.2 in the Appendix) again show a positive effect of monetary tightening on loan loss rates, with a somewhat larger magnitude.

Because this approach isolates only the exogenous component of policy, which is small in magnitude, we next estimate an instrumental-variables local projection (LP-IV), instrumenting policy rates with the exogenous monetary-policy shocks of Choi et al. (2024). The estimates (Graph A.3 in the Appendix) again indicate a positive and cumulative effect of tighter policy on loan loss rates, with a larger magnitude - about three times the baseline (roughly 0.3 p.p. versus 0.1 p.p.).

As an additional robustness check, focused mainly on advanced economies, we use Expected Default Frequency (EDF) as an alternative outcome variable. EDF is a default-risk metric that does not incorporate recovery rates. EDF also rises after monetary tightening, with cumulative increases persisting for up to five years after the shock (Graph A.4 in the Appendix).

Sample Splits. We also test whether the baseline results are driven by specific periods or country groups by splitting the sample by time (pre-2005 versus post-2005) and by country classification (advanced versus emerging). The effect of higher policy rates is smaller in the post-2005 period, plausibly reflecting the prolonged low-rate environment after the GFC (Graph A.5 in the Appendix). By contrast, heterogeneity across country groups is limited: higher interest rates are associated with higher loan loss rates in both advanced and emerging economies (Graph A.6 in the Appendix). Although the estimated effects in percentage points are similar across groups, the relative economic significance is smaller in emerging economies because their average credit loss rates are more than twice as high as in advanced economies (1.81% versus 0.76%).

3.2 State-dependent responses: What are the underlying drivers?

Having established that higher interest rates raise credit losses, we next explore factors that may amplify or attenuate this effect. We estimate state-dependent impulse responses, following Alpanda et al. (2021) and Ramey and Zubairy (2018), to test whether the impact of monetary tightening on loan-loss rates varies with the state of the economy.

$$y_{i,t+h} - y_{i,t} = I_{i,t-1}[a_i^{A,h} + \beta_1^{A,h}\Delta R_{i,t} + \gamma^{A,h'}X_{i,t}] + (1 - I_{i,t-1})[a_i^{B,h} + \beta_1^{B,h}\Delta R_{i,t} + \gamma^{B,h'}X_{i,t}] + \tau_t + \epsilon_{i,t+h} \quad (2)$$

where I is an indicator variable that takes the value of 1 for a particular state of the world.[3] Then, by comparing $\beta_1^{A,h}$ and $\beta_1^{B,h}$ coefficients, we can contrast the effect of monetary tightening in the different states of the world. Following earlier literature (Tenreyro and Thwaites 2016; Alpanda et al. 2021; Ahmed et al. 2024; Eichenbaum et al. 2025), we first study the conditionality of the effect of monetary policy on the stage of the business cycle, private sector credit, and the initial level of interest rate.[4]

Cyclical downturn. Contrary to Tenreyro and Thwaites (2016) and Alpanda et al. (2021), who find weaker real economy effects of monetary policy in downturns, we find that monetary tightening raises loan loss rates more when hikes occur during downturns (negative output gaps) than during expansions (upper-left panel of Graph 4).[5] This suggests that borrowers are more vulnerable to higher rates in weak cyclical conditions. Tightening after expansions is not associated with higher credit losses, indicating that higher rates alone are insufficient; they translate into higher losses when combined with adverse macroeconomic conditions.

High private sector credit. Interestingly, higher debt—proxied by a credit-to-GDP ratio above the sample median (which is approximately 50 %)—does not appear to raise credit losses (top-right panel of Graph 4). By contrast, Alpanda et al. (2021) and Ahmed et al. (2024) find that private-sector indebtedness shapes the transmission of monetary policy. A plausible explanation is the heterogeneity of our sample—spanning advanced and emerging economies with differing structural characteristics, including indebtedness. We therefore revisit the role of debt in the next subsection, allowing different sources of nonlinearity to compete.

Monetary policy stance. Following Ahmed et al. (2024) and Jimenez et al. (2025), the bottom-left panel of Graph 4 tests whether the pre-hike level of interest rates affects the subsequent response of bank loan loss rates. Tightening has only a small and temporary effect when the policy rate was already high before the hike, defined as the prior-year policy rate exceeding its five-year moving average. By contrast, when policy had been relatively loose before the hike, subsequent tightening has a more pronounced and persistent adverse effect on loan loss rates. Consistent with Jimenez et al. (2025), a period of loose policy may encourage overborrowing and leverage build-up; when rates rise, these vulnerabilities materialise in higher losses.

Much of the related literature proxies monetary policy stance with the level of interest rates (Alpanda et al. 2021; Ahmed et al. 2024; Eichenbaum et al. 2025). Yet an initial interest rate above the five-year moving average need not imply a tighter stance because it does not directly account for contemporaneous macroeconomic conditions. We therefore also construct an alternative stance measure using residuals from a panel Taylor-rule-type regression. Following Maddaloni and Peydro (2011), we interpret positive (negative) residuals as relatively tight (loose) monetary conditions given country fundamentals. Graph B.1 (panel A) shows that a looser stance in the year before a hike amplifies

[3] As an example, to identify whether the effect of monetary tightening on banks depends on the level of private sector indebtedness, we define I as taking the value of 1 for above-average credit-to-GDP and 0 otherwise.

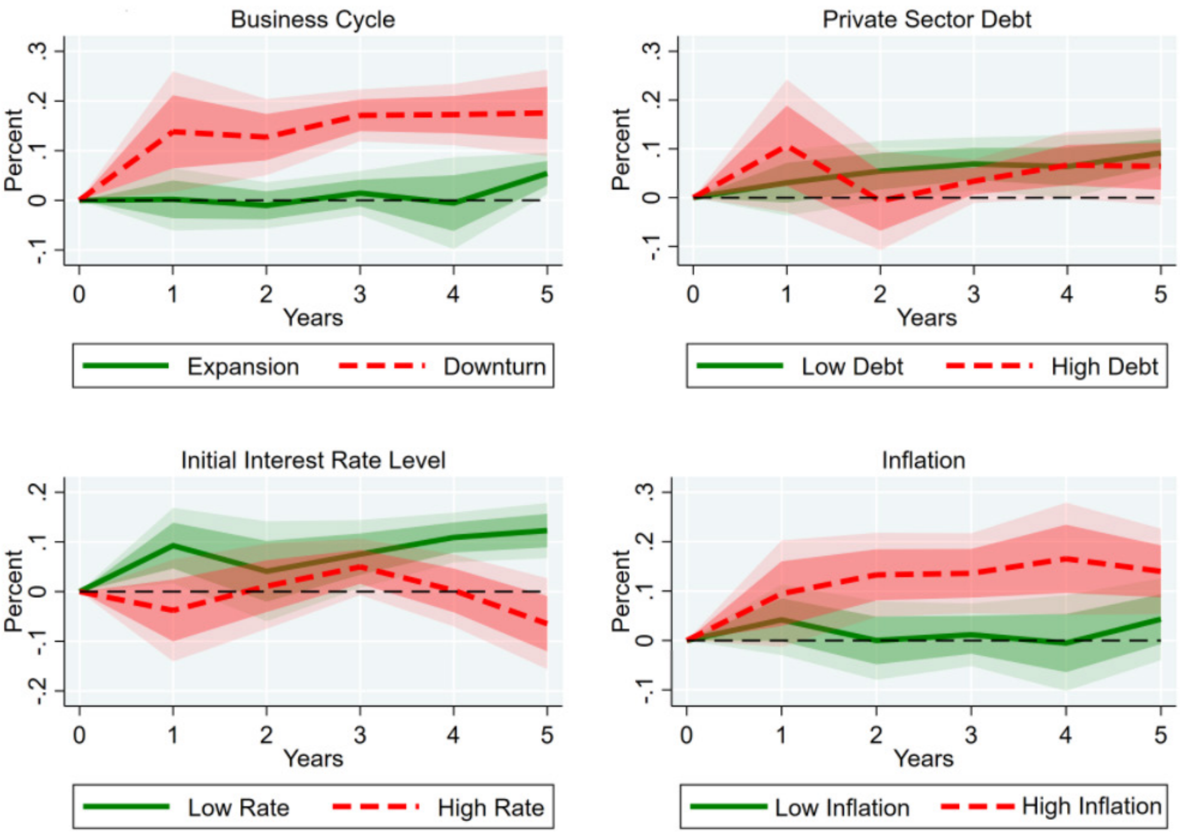
[4] These earlier studies have, however, focuses primarily on studying the effect of monetary policy on variables such as economic growth and/or inflation, but not on credit loss rates.

[5] We calculate the output gap using the Hodrick-Prescott filter.

the effect on loan loss rates: hikes preceded by a tight stance are not associated with higher losses, whereas those preceded by easy conditions raise loan loss rates by about 0.2 p.p. This is consistent with the view that prolonged monetary looseness encourages overborrowing, risk-taking and vulnerability (Jiménez et al. 2014; Geršl et al. 2015). Given the heterogeneity of our sample and the relatively small share of inflation targeters, we interpret these results with caution. Even so, Taylor-rule deviations offer a useful approximation of whether policy was high or low relative to contemporaneous inflation and growth. Accordingly, negative residuals can indicate a relatively loose stance even without independent monetary policy, or equivalently that the central bank was "behind the curve" (the rule would have implied higher rates in the prior year).

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates — Graph 4

Percent



Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^{5}$ and $\{\beta_1^{B,h}\}_{h=1}^{5}$ from equation (2). Top left panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the stage of the *business cycle*: Solid and dashed lines stand for expansion ($I_{i,t-1}$) and downturn ($1-I_{i,t-1}$), respectively. Expansion (downturn) states are defined as positive (negative) output gap. Top right panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the *private sector credit*: Solid and dashed lines stand for low ($I_{i,t-1}$) and high ($1-I_{i,t-1}$) private sector debt, respectively. Low (high) debt states are defined as credit-to-GDP ratio below (above) sample median. Bottom left panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the *interest rate level*: Solid and dashed lines stand for low ($I_{i,t-1}$) and high ($1-I_{i,t-1}$) central bank policy rate, respectively. Low (High) rate state is defined as policy rate during the year prior to monetary tightening being below (above) its 5-year moving average. Bottom right panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the *inflation level*: Solid and dashed lines stand for expansion ($I_{i,t-1}$) and downturn ($1-I_{i,t-1}$), respectively. Low (High) inflation state is defined as inflation rate during the year prior to monetary tightening being below (above) its 5-year moving average. The impulse responses are normalized to depict the response of loans loss rates to a 1 % increase in central bank interest rate in the given state. Solid/dashed lines represent the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Rate hikes following loose monetary conditions increase credit losses, consistent with our earlier findings—that low pre-hike interest rates and higher inflation exacerbate losses—and with prior studies. For example, Jimenez et al. (2025) find that prolonged low rates followed by hikes amplify the adverse financial-stability effects of tightening.

Overall, our baseline estimates indicate that higher interest rates raise credit losses, while state-dependent results show much larger increases under looser conditions. Although higher losses heighten bank vulnerability (Uppal, 2025), this must not necessarily translate into sizeable system-wide stress. We therefore replace loan loss rates with the Financial Stress Index (FSI) of Ahir et al. (2013), a broad measure available for most countries in our sample.[6] Graph B.1 (panel B) in the Appendix yields two insights. First, financial stress rises after tightening, but the effect is small: a 1 p.p. rate hike increases the FSI by about 0.01.[7] Second, stance matters: stress increases more when hikes follow loose conditions, although the difference between tight and loose states is smaller and less statistically significant than for credit losses. Overall, higher rates raise credit losses and modestly increase financial stress on average.

Inflation. We also assess the role of inflation, which – if high – might put pressure on borrowers' living costs and thus their repayment capacity. A combination of already relatively high inflation and monetary tightening might thus result in a more significant increase in credit losses. Given substantial cross-country differences in average inflation, we adopt the same relative-state approach: a high-inflation state is defined as inflation in the year before the hike exceeding its five-year moving average; a low-inflation state is the converse. The positive effect of higher policy rates on loan-loss rates is concentrated in high-inflation states (bottom-right panel of Graph 4), supporting the hypothesis that higher inflation prior to the tightening amplifies the adverse financial-stability effects of tightening.

Taken together, these results point to several amplifiers of the impact of monetary tightening on loan-loss rates—cyclical downturns, extended periods of initial low interest rates (capturing loose monetary policy stance), and higher inflation —many of which were present before the post-pandemic tightening (not in our sample). Yet that episode did not produce higher loan losses. We therefore also examine a factor that could help explain this divergence: expansionary fiscal policy.

Fiscal policy. We estimate state-dependent impulse responses conditional on fiscal stance. Expansionary (restrictive) fiscal policy is defined as a three-year deterioration (improvement) in the primary balance (% of GDP) in the year before tightening.[8] Left panel of Graph 5 shows that rate hikes raise loan-loss rates more when preceded by fiscal restriction; when preceded by fiscal expansion, the increase is not statistically significant, suggesting expansion provides a cushion for borrowers. We use the primary balance, rather than the cyclically adjusted measure, to maximise sample size. To address concerns that the primary balance is cyclical, the next subsection lets business-cycle and fiscal non-linearities compete.

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6 One drawback of using this measure is that the data is only available until 2018.

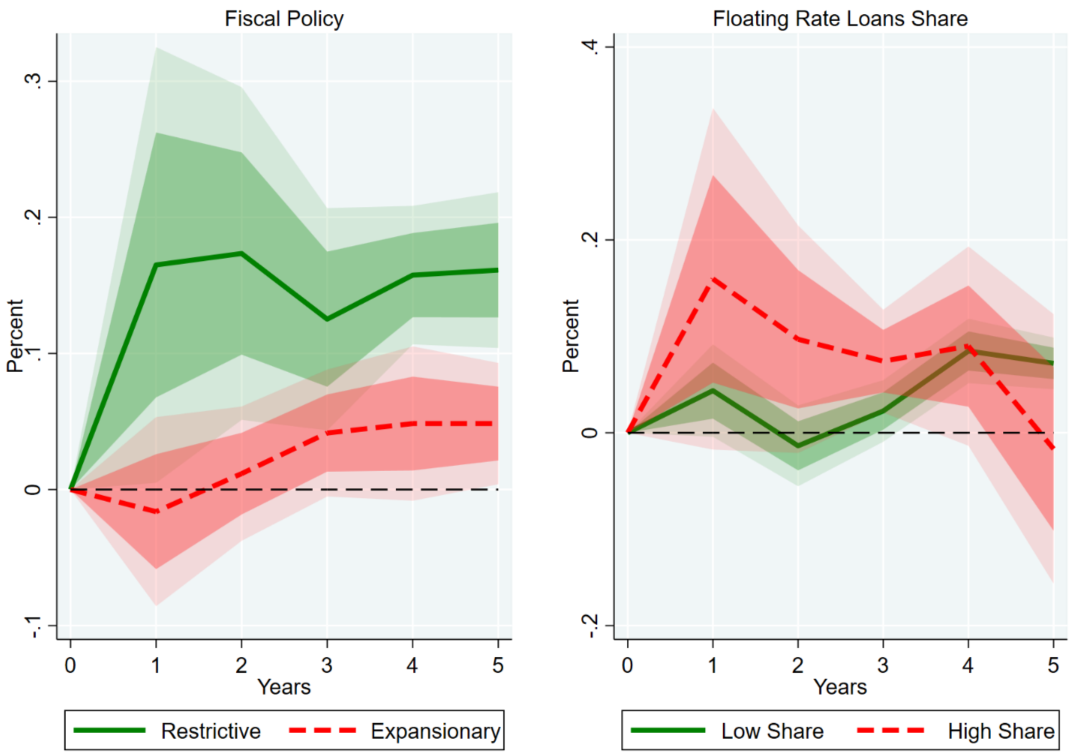
7 Average value of FSI for the countries in our sample is approximately 0.04, while standard deviation equals 0.11.

8 Our conclusions are robust to using alternative definitions of expansionary (restrictive) fiscal policy states, such as *annual* decrease/deterioration (increase/improvement) in primary balance to GDP ratio, or government deficit being above (below) sample average.

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of Fiscal Policy & Floating Rate Loans

Graph 5

Percent



Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^{5}$ and $\{\beta_1^{B,h}\}_{h=1}^{5}$ from equation (2). Left panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the *fiscal policy stance*: Solid and dashed lines stand for restrictive ($I_{i,t-1}$) and expansionary ($1 - I_{i,t-1}$) fiscal policy, respectively. Restrictive (expansionary) fiscal policy states are defined as positive (negative) 3-year change in the primary balance (% of GDP). Right panel shows the state-dependent responses of loan loss rates to monetary tightening conditional on the *share of floating loan rates*: Solid and dashed lines stand for low (I_i) and high ($1 - I_i$) floating rate loans share, respectively. High (low) floating share states are defined as countries with generally higher (lower) share of floating loans rates. The impulse responses are normalized to depict the response of loans loss rates to a 1 % increase in central bank interest rate in the given state. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Floating rate loans. Another explanation for the limited effects of the early-2020s monetary tightening on credit losses - and thus financial stability - may be the greater prevalence of fixed-rate loans, which dampens the immediate pass-through of higher rates. We incorporate information on relative shares of floating-rate loans (defined as loans with variable rates or rates that are refixed within a one year) in household loan portfolios of banks per country, drawing on data by Zhu (2006), van Hoenselaar et al. (2021), Andaloussi et al. (2024), De Stefani and Man (2025), ECB, and national authorities' websites, and allocate countries into those with predominantly fixed-term loans (e.g. Germany, France, United Kingdom, United States) or floating-rate loans (e.g. Finland, Ireland, Spain, Sweden).9 We classify as mostly floating-rate loans countries, which according to at least one of the sources listed above had a more than 50 % share of floating-rate loans. Comparing countries with higher versus lower shares of floating-rate loans, right panel of Graph 5 shows that credit losses rise much more, and faster, where floating-rate borrowing is more prevalent.

[9] The data on floating vs. variable rate loans is only available for 46 countries in our sample.

3.3 Multivariate state-dependent effects

The evidence above indicates substantial state-dependent effects of monetary policy on bank loan-loss rates, shaped by several factors. However, the empirical strategy in equation (2) identifies state dependence with respect to a single variable at a time and cannot compare the competing sources of the effects on loan loss rates. Following Ahmed et al. (2024), we therefore allow a combination of two factors behind state-dependent effects to compete:

$$y_{i,t+h} - y_{i,t} = a_i^h + \beta_1^h \Delta R_{i,t} + \gamma^{h'} X_{i,t} + I_{i,t-1}^A \left[a_i^{A,h} + \beta_1^{A,h} \Delta R_{i,t} + \gamma^{A,h'} X_{i,t}\right] + I_{i,t-1}^B \left[a_i^{B,h} + \beta_1^{B,h} \Delta R_{i,t} + \gamma^{B,h'} X_{i,t}\right] + \tau_t + \epsilon_{i,t+h} \quad (3)$$

where $I_{i,t-1}^A$ is an indicator variable for a state of conditioning variable *A*, while $I_{i,t-1}^B$ is an indicator variable for a state of another conditioning variable *B*. Then, by comparing the coefficients $\beta_1^{A,h}$ and $\beta_1^{B,h}$, we can compare the relative importance of the two factors. In Graph 6, we combined the private sector debt proxied by credit-to-GDP ratio and initial interest rate levels prior to the tightening as a proxy for monetary policy stance. The baseline effect of an interest rate hike on loan loss rates (represented by β_1^h coefficient from equation (3)) is approximately zero. That is, in countries with relatively higher interest rates[10] and below-average level of private sector debt, monetary tightening does not lead to a large or persistent increase in loan loss rates. Conversely, based on $\beta_1^{A,h}$ coefficients, if rate hike occurs in high private debt situation, it does lead to a temporary increase in loan loss rates – indicating that the higher private sector prior to monetary tightening makes banking sector more vulnerable.[11] Similarly, as per $\beta_1^{B,h}$ coefficients in Graph 6, tighter monetary policy leads to a more pronounced effect on loan loss rates in times of lower initial interest rates. That is, relatively lower interest rates prior to the rate hike also appear to make the banking sector more vulnerable to subsequent rate hikes. Based on Graph 6, no clear winner emerges from the "horse race" between the two potential sources of state-dependencies– as both high debt and lower interest rates exacerbate the effect of monetary tightening on loan loss rates. Although lower interest rate state seems to be associated with somewhat larger and also more persistent increase in loan loss rates. Importantly, based on equation (3), it is the sum of $\beta_1^h, \beta_1^{A,h}$ and $\beta_1^{B,h}$, which represents the effect of rate hikes in high debt countries with relatively lower interest rates. Therefore, the effect of an increase in policy rate by 1 p.p. leads to an increase in loan loss rates by some 0.2 p.p. in high-debt, lower interest rate countries – an effect that is almost twice as large as the average effect for the entire sample reported in Graph 3.

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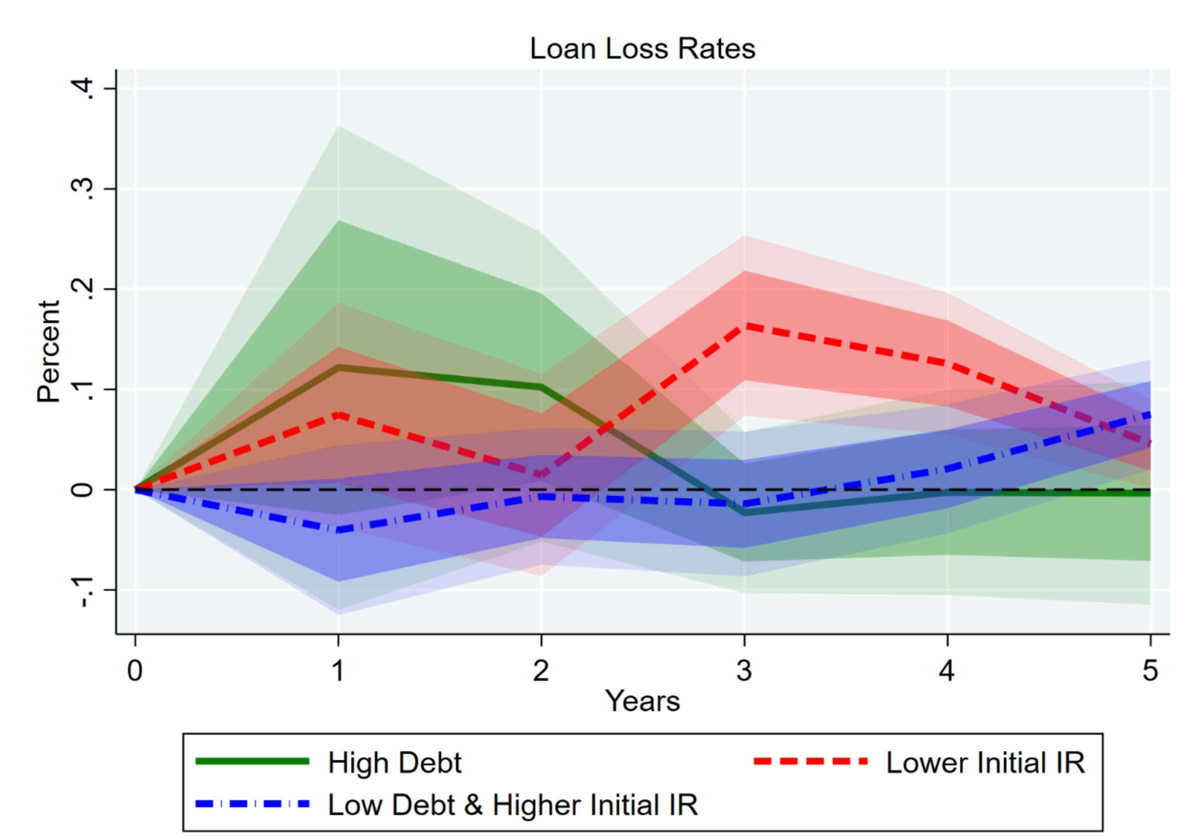
10 Higher initial interest rate state is defined as interest rate during the year prior to the tightening being above its 5-year moving average. Therefore, higher interest rate state could indicate tighter monetary conditions prior to the tightening.

11 The effect of rate hike in high debt countries is given by the sum of β_1^h and $\beta_1^{A,h}$ coefficients.

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of High Private Debt and Lower Initial Interest Rates

Graph 6

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$ and $\{\beta_1^{B,h}\}_{h=1}^5$ from equation (3). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries with below-average credit-to-GDP ratio and higher initial interest rates prior to the tightening. $\{\beta_1^{A,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *A* (high debt), while $\{\beta_1^{B,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *B* (lower initial interest rate). High debt state is identified as credit-to-GDP ratio being above the sample mean. Lower initial interest rate (IR) state is identified as policy rate during the year prior to monetary tightening being below its 5-year moving average. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Moreover, results reported in Graph 4 have shown that both economies with a cyclical downturn and economies with lower initial interest rate prior to a rate hike experience a larger increase in credit losses. However, since central banks often respond to adverse economic conditions with monetary easing, the simple state dependent impulse responses shown in Graph 4 may just reflect this correlation. As a result, we also run a "horse race" between cyclical downturn and lower initial interest rate (Graph 7). The results indicate that while both the cyclical downturn and lower initial interest rate are associated with higher credit losses

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of High Private Debt and Lower Initial Interest Rates

Graph 7

Percent

Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$ and $\{\beta_1^{B,h}\}_{h=1}^5$ from equation (3). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries with positive output gap (expansion) and higher initial interest rates prior to the tightening. $\{\beta_1^{A,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *A* (downturn), while $\{\beta_1^{B,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *B* (lower initial interest rate). Downturn state is defined as negative output gap. Lower initial interest rate (IR) state is identified as policy rate during the year prior to monetary tightening being below its 5-year moving average. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Next, we combine initial level of interest rates and inflation. This exercise enables us to examine, whether the effect of inflation on interest rate elasticity of credit losses shown in Graph 5 is rather driven by loose monetary policy stance (which is associated with higher inflation), or whether inflation has an effect of its own. Graph 8 shows that in a baseline situation of low inflation and high initial interest rate environment, monetary tightening does not significantly affect loan loss rates. By contrast, both high-inflation and low-initial-rate states raise the baseline effect by about 0.1 p.p. per 1 p.p. increase in the policy rate, with the low-initial-rate state exerting the larger impact. This indicates that higher inflation prior to the tightening has an effect of its own on the effect of rate hikes on credit losses: Higher inflation may increase borrowers' living costs, which makes it more difficult for borrowers to weather the subsequent increase in policy rates.

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of Higher Inflation and Lower Initial Interest Rates

Graph 8

Percent

Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$ and $\{\beta_1^{B,h}\}_{h=1}^5$ from equation (3). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries with relatively lower inflation and higher interest rates prior to the tightening. $\{\beta_1^{A,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *A* (higher inflation), while $\{\beta_1^{B,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *B* (lower initial interest rate). Higher inflation state is identified as inflation rate during the year prior to monetary tightening being above its 5-year moving average. Lower initial interest rate (IR) state is identified as policy rate during the year prior to monetary tightening being below its 5-year moving average. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Evidence in Graph 5 indicates that fiscal expansion mitigates loan losses from higher interest rates. Because fiscal stance is highly cyclical, we address the concern that this result may reflect the business cycle by including nonlinear effects of both the cycle and fiscal policy. Graph 9 shows that, even when both are considered, expansionary fiscal policy still reduces loan losses under tighter monetary policy, whereas being in a downturn prior to the hike amplifies losses.

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of Fiscal Policy and Business Cycle

Graph 9

Percent

Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$ and $\{\beta_1^{B,h}\}_{h=1}^5$ from equation (3). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries with positive output gap and fiscal restriction prior to the tightening. $\{\beta_1^{A,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *A* (downturn/negative output gap), while $\{\beta_1^{B,h}\}_{h=1}^5$ capture the additional effect (on top of baseline effect) of monetary tightening in state *B* (fiscal expansion). Economic downturn state is defined as negative output gap during the year prior to monetary tightening. Fiscal expansion state is defined as a negative 3-year change in primary balance (% of GDP) during the year prior to the rate hike. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

3.4 The role of the central bank balance sheet

The empirical exercises in subsections 3.2–3.3 examined state-dependent effects in the relationship between interest rates and loan loss rates. The state-dependent local projections in equations (2) and (3), standard in the literature (Alpanda et al. 2021; Ahmed et al. 2024), address endogeneity by lagging the conditioning (state) variables by one period. This identifies how transmission varies with pre-shock macro-financial conditions, but not which factors propagate higher rates into credit losses during the time of tightening. The theoretical model of Haas (2024) shows that while rate hikes depress bank net worth and harm financial stability, a limited expansion of the central bank balance sheet can mitigate these effects without compromising monetary stability. While in practice we would normally not see a central bank simultaneously increasing policy rate and expanding its balance sheet as a way of quantitative easing, we are interest how balance-sheet reduction – i.e. a reversal of quantitative easing - influence the rise in credit losses following monetary tightening.

To do so, we employ the Kitagawa–Blinder–Oaxaca (KBO) decomposition of local projections introduced by Cloyne et al. (2023) and recently applied to monetary policy by Alessandri et al. (2025). This approach decomposes impulse responses into baseline and state-dependent components by interacting our monetary-policy proxy with a demeaned contemporaneous variable that may shape transmission—here, central bank balance-sheet changes. We follow the regression specification in Cloyne et al. (2023), who use KBO to identify the effect of fiscal policy on output conditional on the monetary response:

$$y_{i,t+h} - y_{i,t} = a_i^h + \beta_1^h \Delta R_{i,t} + \gamma^{h'}\left(X_{i,t} - \overline{X_\iota}\right) + \theta_x^h \Delta R_{i,t}\left(X_{i,t} - \overline{X_\iota}\right) + \theta_{\Delta R}^h \Delta R_{i,t} \Theta_i^h + \tau_t + \epsilon_{i,t+h} \qquad (4)$$

where Θ_i^h is the indicator for central bank balance sheet changes. By interacting our proxy for central bank balance sheet changes (Θ_i^h) with interest rate hikes, equation (4) allows for the impact of rate hike to vary depending on the central bank balance sheet changes. Thus, in equation (4), coefficients $\{\theta_{\Delta R}^h\}_{h=1}^5$ are the coefficients of interest. Since in equation (4), unlike in equations (2) and (3), the condition variable is not lagged, it is vital to identify exogenous variation in the conditioning variable for the state-dependent IRFs to have causal interpretation (Cloyne et al. 2020). As there are not widely available instrumental variables for central bank balance sheet changes for our large sample of countries, we follow the approach of Cloyne et al. (2023) and we exploit the large cross-sectional variation in our panel of countries as our identification strategy. More specifically, we regress central bank balance sheet changes, calculated as annual change of central bank balance sheet as percentage of GDP, on changes in monetary policy rate[12] – allowing the coefficients of monetary policy rate to vary by country. These coefficients, Θ_i, represent the average cross-country sensitivity of central bank balance sheet to interest rate changes. In equation (4), we then use the estimated coefficients Θ_i, which are expressed relative to their sample mean, as a proxy for the central bank balance sheet response to monetary tightening.[13]

A crucial aspect of the KBO decomposition involves also interacting all the (demeaned) control variables with the monetary policy shock, captured by θ_x^h coefficients in equation (4). In the absence of these interactions, heterogeneity in the transmission of the monetary policy tightening associated with the control variables correlated with central bank balance sheet developments would be spuriously attributed to the central bank balance sheet interaction, invalidating the KBO decomposition.

We find that central bank balance sheet changes materially shape the transmission of monetary tightening to credit losses (Graph 10). A 0.5-standard-deviation decrease in central bank balance sheet (relative to the sample mean) roughly doubles the increase in losses compared to the baseline. Consistent with Graph 10, loan loss rates increase much more where tightening coincides with balance sheet shrinkage. Our results suggest that in terms of policy, given large balance sheets in many advanced economies, simultaneous rate hikes and balance-sheet contraction may exacerbate financial-stability risks; central banks commencing tightening could consider postponing balance-sheet reduction, provided this does not conflict with price-stability objectives. Conversely, a concurrent balance sheet expansion appears to limit the increase in credit losses associated with tighter monetary policy – presumably owing to the increased supply of liquidity in the financial system.

A key caveat to our finding that balance sheet expansion mitigates credit loss increases is that, for many central banks in our sample - especially in emerging economies - FX reserves constitute most of the asset side of the balance sheet. Thus, the trends observed on Graph 10 could be driven by FX interventions or associated exchange-rate movements rather than balance-sheet expansion per se. To assess this, we re-estimate conditioning on FX interventions and on the nominal exchange rate.[14] Results

[12] As well as all the control variables X.

[13] This identification strategy based on cross-country sensitivity is comparable to the approach of Guren et al. (2020).

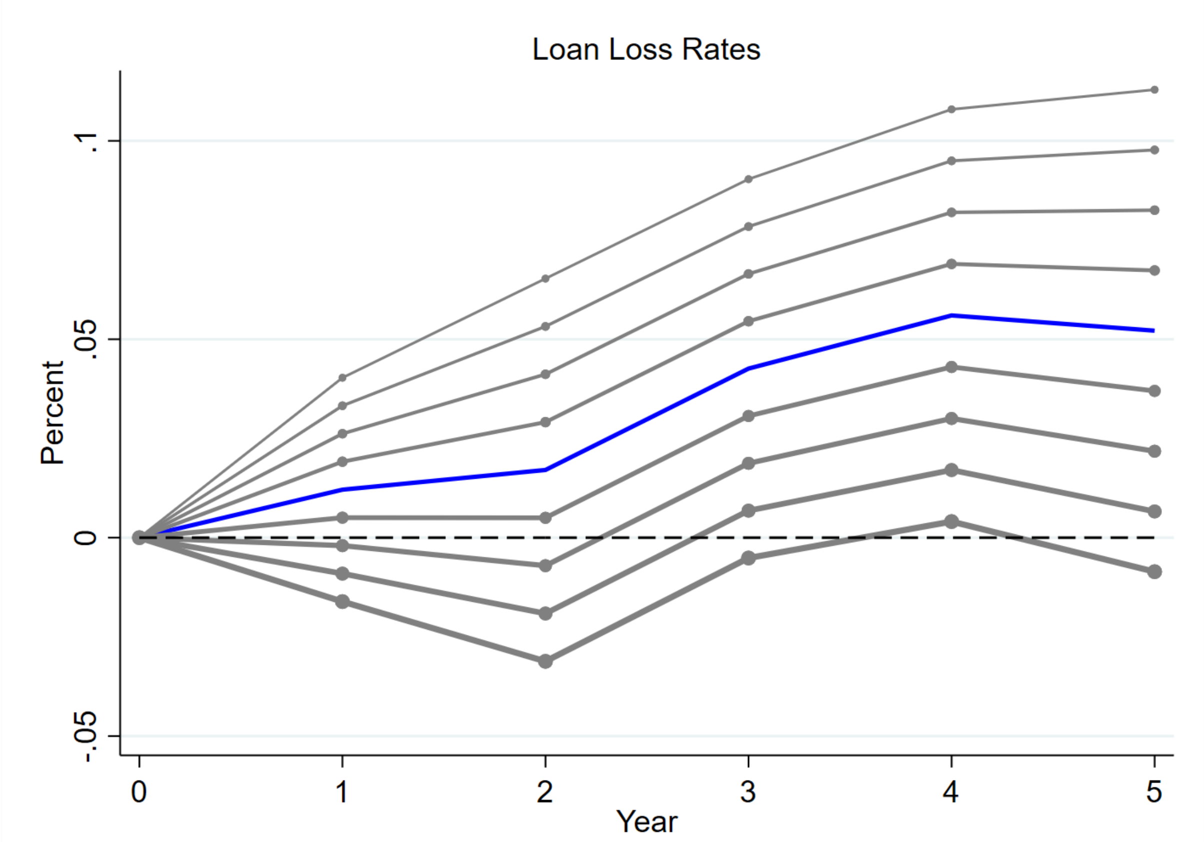
[14] Data on FX interventions are taken from the IMF and represent annual changes in foreign exchange reserves adjusted for valuation effects and interest income – based on average currency composition of FX reserves. Data on nominal exchange rates are also taken from the IMF and represent the nominal effective exchange rate (NEER) if the data is available, and

(Graphs B.2 and B.3, Appendix) show that while both variables affect the transmission of monetary policy to credit losses, their influence is less pronounced than that of balance-sheet expansion.

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Conditional on the Response of Central Bank Balance Sheet

Graph 10

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ and $\{\theta_{\Delta R}^h\}_{h=1}^5$ from equation (4). The impulse responses show how the response of loan loss rate to monetary tightening varies with the central bank balance sheet response. The blue line represents the direct (baseline) effect of monetary policy tightening on loan loss rate captured by $\{\beta_1^h\}_{h=1}^5$ coefficients from equation (4). The grey lines show how the effect of contractionary monetary policy depends on the response of central bank balance sheet to the monetary tightening, with varying magnitudes of central bank balance sheet change ($\{\beta_1^h +/- \theta_{\Delta R}^h\}_{h=1}^5$). A larger marker (thicker line) indicates a (larger) increase in central bank balance sheet. A smaller marker (thinner line) indicates a (larger) decrease in central bank balance sheet. The grey lines consider experiments in which we vary the degree of central bank balance sheet response to monetary tightening by 0.125 standard deviations. That is, the thickest (thinnest) grey line represents the increase (decrease) of central bank balance sheet by 0.5 standard deviations above (below) sample mean. The impulse responses are normalized to represent the response of loans loss rates to a 1 % increase in central bank interest rate. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Rate hikes accompanied by larger FX interventions against the domestic currency[15] are associated with smaller increases in loan loss rates, but the effect is modest and confined to the first two years after the hike; from year three onward, FX interventions no longer matter for transmission. Unless sterilised, interventions can raise money supply and ease domestic financing conditions, thereby dampening the impact on losses.

exchange rate vis-à-vis the U.S. dollar if NEER data is not available. The nominal exchange rate is expressed in indirect quotation – i.e., an increase in the value of the exchange rate represents nominal appreciation.

[15] Central bank purchases the foreign exchange and sells domestic currency, accumulating FX reserves.

The exchange-rate channel plays a minor role. When the domestic currency appreciates following a rate hike, the increase in loss rates is smaller than the baseline. Quantitatively, a 0.5-standard-deviation appreciation is associated with a 0.02 p.p. increase in loss rates, whereas a 0.5-standard-deviation depreciation leads to a 0.1 p.p. increase five years after the shock. A well-functioning exchange-rate channel—where hikes appreciate the currency—can reduce loan losses by lowering the cost of foreign borrowing (financial channel of the exchange rate; see Georgiadis et al. 2024).

In sum, FX interventions and exchange-rate movements do affect transmission, but their roles are limited and do not appear to drive the Graph 10 findings that highlight the importance of the central bank's balance-sheet response to tightening.

3.5 Bank-level results

All the evidence supplied so far is based on country-level data, which provides us with several interesting insights. Nevertheless, country-level data might mask important heterogeneity across banks operating within the country. Therefore, in the next step of our analysis, we use an unbalanced global panel of banks. Using data from Fitch Connect, we compile a dataset of 3,350 banks from 92 countries over the years 1990-2024.[16] First, we simply re-estimate the baseline regressions for this bank-level sample.

$$y_{b,i,t+h} - y_{b,i,t} = a_b^h + \beta_1^h \Delta R_{i,t} + \beta_{2j}^h \sum_{j=1}^{2} \Delta R_{i,t-j} + \delta_l^h \sum_{l=0}^{1} \left(y_{b,i,t-l} - y_{b,i,t-1-l}\right) + \gamma^{h'} X_{i,t} + \sigma^{h'} Z_{b,i,t} + \tau_t + \epsilon_{b,i,t+h} \quad (5)$$

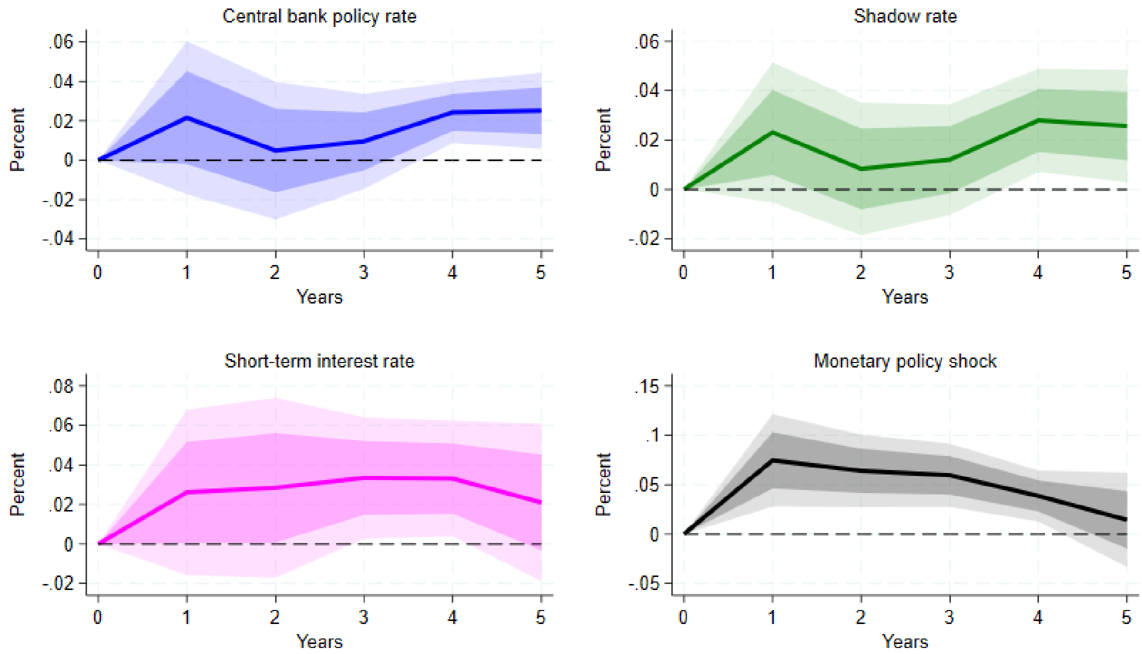
where $y_{b,i,t}$ is the loan loss rate of bank b from country i in year t. Our principal explanatory variable remains the annual change in policy rate $\Delta R_{i,t}$, which is country specific. Similar to the baseline regression, we include the vector of country-level control variables $X_{i,t}$. We also include a vector of bank-level controls $Z_{b,i,t}$, which includes the following variables: liquid assets (% of total assets), loans-deposits ratio, total assets (expressed in natural logarithms), total equity (% of total assets). The selection of the bank-level control variables follows related empirical studies (Bouis et al. 2025; Fungacova et al. 2023). In contrast to the equation (1), we do not include leads of the policy rate. Namely, the exclusion of leads did not influence our country-level estimates and since the leads are only country-specific, in the bank-level equations, we try to limit the number of country-specific controls to avoid multicollinearity issues. For the bank-level sample, following Doerr et al. (2025), we use standard errors clustered at a country level.

We present the results of estimating the equation (5) in Graph 11 where we use four different proxies for monetary policy (central bank policy rate, shadow rate, short-term interest rate, monetary policy shock of Choi et al. (2024)). Qualitatively, the results on bank-level data are similar to the country-level estimates shown in Graph 3. Higher interest rates do lead to an increase in loan loss rate. However, quantitatively, the effect of higher interest rate in credit losses is much smaller: For our main interest rate measure, central bank policy rate, a 1 p.p. increase in policy rate only increases credit loss rate by approximately 0.02 p.p. - a magnitude that is only one fifth of the magnitude observed for country-level data. Furthermore, the observed effect is only barely statistically significant – and it turns significant only several years after the shock. This observation also holds for the other monetary policy measures, except for monetary policy shock of Choi et al. (2024), which retains both its statistical and economic significance even with bank-level data.

[16] We only include in our sample those banks for which we have at least 10 years of data. However, relaxing this condition to at least 5 observations per bank does not affect our conclusions. Moreover, we drop from the sample banks that are classified as bank holding companies and private banks. For those banks for which we have both consolidated and unconsolidated data, we use the time series that maximizes the number of observations. But our results remain robust even if we use unconsolidated data in such cases.

Effect of Interest Rate Hike on Loan Loss Rates – Bank-Level Data | Graph 11

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (5) estimated on bank-level data. The top left panel shows the impulse response of loans loss rates to a 1 % increase in central bank interest rate. The top right panel shows the impulse response of loans loss rates to a 1 % increase in the shadow rate for those countries for which it is available. The bottom left panel shows the impulse response of loans loss rates to a 1 % increase in short-term interest rate. The bottom right panel shows the impulse response of loans loss rates to a 1 % monetary policy shock of Choi et al. (2024). Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on standard errors clustered at a country level. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

We hypothesize that the smaller magnitude of the estimated could be driven by the fact that the bank-level dataset is dominated by U.S. (and other advanced economies) banks – U.S. banks make up approximately a quarter of all observations. As a result, the period of zero lower bound makes up a significantly larger proportion of the sample than for the country-level data, which could reduce the size of the effect of higher interest rates. The fact that the effect of monetary policy shock largely retains its economic and statistical significance could lend some support to this hypothesis. To formally explore this possibility, we re-estimate the equation (5) for the sample excluding the U.S. banks. And indeed, both the magnitude and statistical significance of the effect of higher interest rates (for all interest rate measures) on loan loss rates is much larger for the sample of non-U.S. banks. To conclude, the bank-level estimates are broadly aligned with the country-level results. However, it appears that most banks' loan loss rates are not significantly affected by higher interest rates. As a result, in the next step of our empirical analysis, we proceed to exploit the large heterogeneity of the bank-level sample to identify those banks whose loan loss rates are the most affected by higher interest rates. To do so, we estimate the state-dependent local projections for the bank-level sample akin to equation (2):

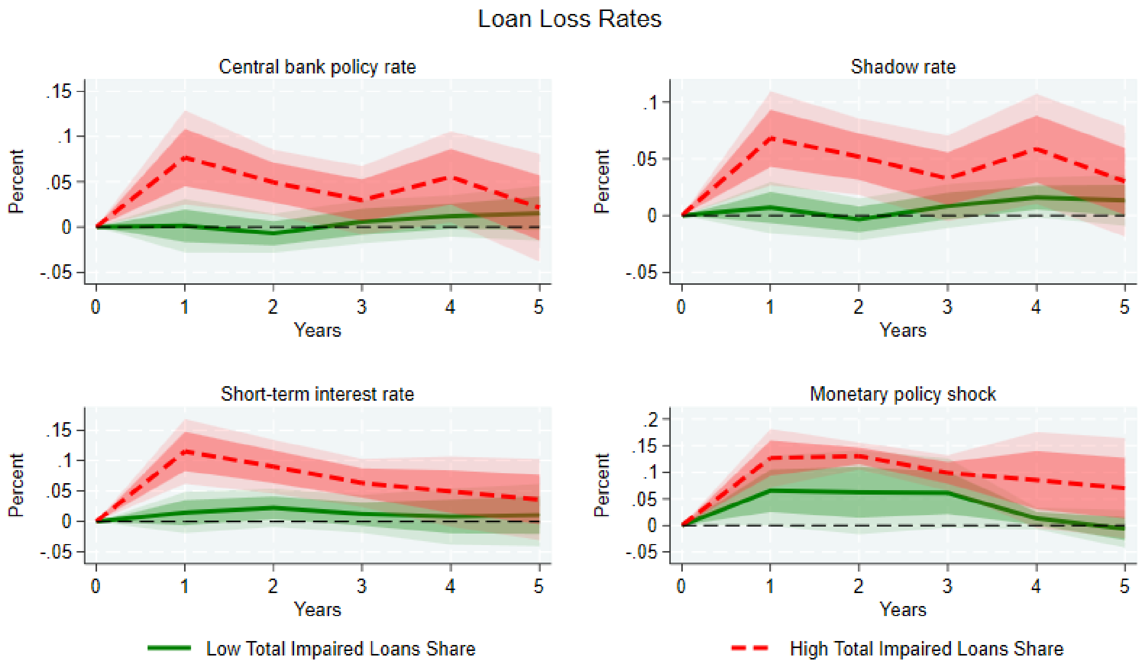
$$\begin{aligned} y_{b,i,t+h} - y_{b,i,t} = I_{b,i,t-1}\big[a_b^{A,h} + \beta_1^{A,h}\Delta R_{i,t} + \gamma^{A,h'}X_{i,t} + \sigma^{A,h'}Z_{b,i,t}\big] + (1 - I_{b,i,t-1})[a_b^{B,h} \\ + \beta_1^{B,h}\Delta R_{i,t} + \gamma^{B,h'}X_{i,t} + \sigma^{B,h'}Z_{b,i,t}] + \tau_t + \epsilon_{b,i,t+h} \end{aligned} \quad (6)$$

where $I_{b,i,t-1}$ is an indicator variable for a bank-specific characteristic. By comparing $\beta_1^{A,h}$ and $\beta_1^{B,h}$ coefficients from equation (6), we can estimate separate impulse response for banks with different characteristics.

First, we hypothesize that banks that already had worse loan portfolios *prior* to the tightening might be more vulnerable to rate hikes. Therefore, in the first empirical exercise, we specify $I_{b,i,t-1}$ as an indicator variable for below-average total impaired loans share. Considering the fact that banks operating in different countries might have different average shares of total impaired loans, we use *country-specific mean* of total impaired loans share in total loans to construct the indicator variable $I_{b,i,t-1}$. We find that banks with below-average impaired loans share prior to the rate hike, which can be viewed as banks with higher quality loan portfolios, do not experience any significant increase in their credit loss rates following the monetary contractions (Graph 12). Conversely, for banks with above-average impaired loans share, we observe an increase in loan loss rate that is substantially larger than the baseline effect recorded for the bank-level sample, with a 1 p.p. increase in policy rate increasing credit losses by almost 0.1 p.p. Moreover, the increase in loan loss rate also occurs much more swiftly for the banks with inferior loan portfolios – as the loss rate increases significantly already during the first year following the rate hike. This finding shows that it is the banks with relatively worse loans portfolios observable already prior to the monetary tightening that are most vulnerable to higher interest rates, underlining the importance of maintaining healthy loan portfolios for mitigating the negative side effects of contractionary monetary policy for financial stability.

Effect of Interest Rate Hike on Loan Loss Rates – Bank-Level Data | Graph 12

Percent



Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^{5}$ and $\{\beta_1^{B,h}\}_{h=1}^{5}$ from equation (6). The impulse responses depict the state-dependent responses of loan loss rates to monetary tightening conditional on the *share of total impaired loans* prior to the tightening: Solid and dashed lines stand for low ($I_{b,i,t-1}$) and high ($1 - I_{b,i,t-1}$) shares of total impaired loans, respectively. Low (high) total impaired loans share states are defined as below (above) country-specific average share of total impaired loans. The top left panel shows the impulse responses of loans loss rates to a 1 % increase in central bank interest rate. The top right panel shows the impulse responses of loans loss rates to a 1 % increase in the shadow rate for those countries for which it is available. The bottom left panel shows the impulse responses of loans loss rates to a 1 % increase in short-term interest rate. The bottom right panel shows the impulse responses of loans loss rates to a 1 % monetary policy shock of Choi et al. (2024). Solid/dashed lines represent the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on standard errors clustered at a country level. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

We use the total impaired loans share as a proxy for the quality of banks' loan portfolios as we have data available for this variable for most banks in our sample. Nonetheless, we also use an alternative measure of loan portfolio quality: 3-year rolling mean of loan loss rates prior to the tightening. We estimate the state-dependent impulse responses for below- and above-country-specific average of this alternative proxy for banks' loan quality and we report the results in Graph B.5 in the Appendix. The results are highly similar to the findings for impaired loans and indicate that only banks with relatively lower quality loan portfolios experience an increase in credit losses following monetary policy tightening.

The evidence from the country-level panel indicated that floating rate loans exacerbate the effect of higher interest rates for credit losses. In the final empirical exercise, we re-visit this hypothesis with bank-level data. While we do not have data on bank-specific share of floating rate loans, we use an alternative approach: Corporate loans are more likely to have floating interest rate. Therefore, we identify those banks that have a share of corporate loans in their total loans above 50% as banks with high corporate loans share. We assume that these banks are more vulnerable to higher interest rate, as their loans are more likely to have floating rate. Next, we compare the impulse responses of loan loss rates to higher interest rates for low and high corporate loans share banks. Graph B.6 in the Appendix corroborates our assumption that it is the high corporate loans share banks that are more affected by interest rate hikes.

4 Rules of thumb and financial stability impact

We now summarise the policy rate elasticity of credit loss rates across macro-financial conditions and lending structures, including the prevalence of variable rate loans and differences in the asset portfolio mix. Table 1 summarises of the state-dependent results from subsection 3.2 and identifies economic conditions under which credit loss rates rise more strongly after a rate hike. Graph 13 then shows the additional increase in country-level credit loss rates associated with each condition of these adverse states of the economy. Separately, Graph 14 summarizes the additional increase in credit loss rates for the bank-level characteristics identified in subsection 3.5. Using these state-dependent estimates, we can formulate simple **policy-oriented rules of thumb**:[17]

An increase in short-term interest rates by 1 p.p. results in an average increase in credit loss rates by 0.12 p.p. five years after the hike.

Macro-financial conditions amplify the effect as follows: in countries with high private sector debt prior to the tightening, credit loss rates increase by 0.09 p.p.[18] when compared to countries with low private sector debt, while low interest rates and higher levels of inflation prior to the hike are associated with a 0.17 p.p. and 0.11 p.p. higher increase in credit loss rates.

Unfavourable macroeconomic conditions amplify the relationship, as is widely known: a moderate cyclical downturn (1-in-10/15 year scenario) augments the effect of monetary tightening on loss rates by 0.16 p.p., while a 1 p.p. GDP contraction unrelated to monetary policy tightening increases credit loss rates by 6 p.p.[19]; in an adverse (1-in-20 year) downturn, this effect increases to 0.28 p.p., while it becomes 0.47 p.p. during severely adverse (1-in-50/100 year) downturn.

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17 For the rules of thumb, we focus on country-level conditioning factors.

18 For all the conditioning factors, the additional effect is defined as the difference between the high and low scenarios presented in Table 1.

19 Based on the coefficient of the variable economic growth, which is included among the control variables in all our regressions.

Lending characteristics (variable rates) and monetary policy stance prior to tightening also influence the elasticity of loan losses to interest rates: Economies with a high share of variable-rate loans experience larger and faster increases in credit losses after a monetary tightening—about 0.11 p.p. in the first year. A looser pre-tightening monetary policy stance also amplifies the impact of tightening on credit losses by roughly 0.22 p.p., with the effect fully materializing five years after the tightening. In addition, restrictive fiscal policy raises credit-loss rates, by around 0.19 p.p. when compared to rate hikes that followed fiscal expansions.

Table 1: Summary of State-Dependent Effects of Rate Hike on Loan Loss Rates

		State	
State variable	At horizon h	Low	High
Output gap	1	0.13	0.00
	3	0.17	0.01
	5	0.15	0.04
Private credit	1	0.02	0.11
	3	0.05	0.03
	5	0.06	0.05
Initial interest rate	1	0.09	-0.05
	3	0.06	0.05
	5	0.10	-0.07
Inflation	1	0.04	0.08
	3	0.01	0.12
	5	0.02	0.13
Government balance	1	0.17	-0.02
	3	0.13	0.04
	5	0.16	0.05
Floating loans share	1	0.04	0.15
	3	0.01	0.05
	5	0.07	-0.05
Monetary policy stance	1	0.07	0.03
	3	0.15	0.00
	5	0.21	-0.01

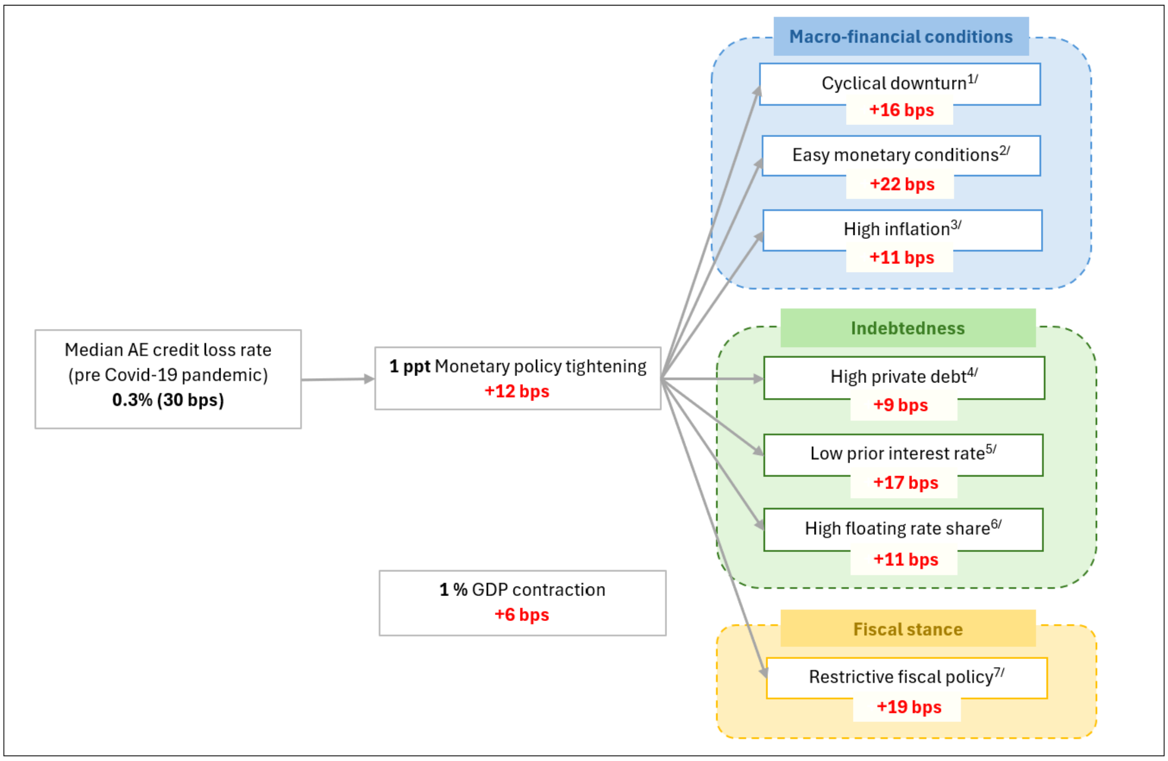
Notes: The table summarizes state-dependent estimates outlined in graphs 4-5, and B.1 in the Appendix. Coefficients from equation (2) are reported for low and high states for h=1, 3, 5.

The univariate results above indicate which pre-tightening macro-financial characteristics amplify the increase in credit losses after monetary tightening. These adverse states may, however, occur simultaneously (for example cyclical downturn and lower initial interest rates often coincide), so the additional effects shown in Graph 13 cannot simply be added up mechanically to infer the total effect.

Rules of Thumb I – Simulated Increase of Credit Loss Rates for a 1 p.p. Increase in Central Bank Policy Rates for Advanced Economies

Graph 13

Percent



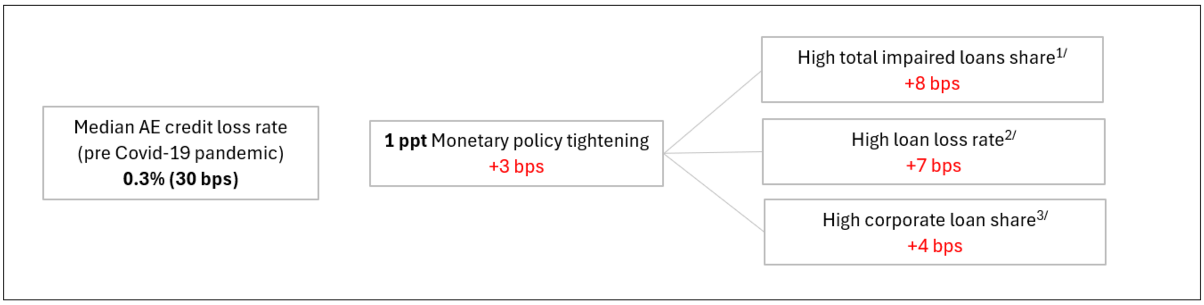
Notes: The graph outlines the baseline effect of monetary tightening (Graph 3), as well as additional effects of country-level conditioning factors (Graphs 4-5, Graph B.1 in the Appendix) on loan loss rate. The additional effect is calculated as the difference between low and high states. 1/ Defined as negative output gap, 2/ as negative residuals from the simple backward-looking Taylor rule, 3/ as inflation rate above its 5-year moving average, 4/ as credit-to-GDP ratio below sample median, 5/ as policy rate below its 5-year moving average, 6/ as country-level average share of variable rate mortgages above 50 %, and 7/ as positive 3-year change in the primary balance (% of GDP).

Source: Authors

Rules of Thumb II – Simulated Increase of Credit Loss Rates for a 1 p.p. Increase in Central Bank Policy Rates for Advanced Economies' Banks

Graph 14

Percent



Notes: The graph outlines the baseline effect of monetary tightening (top left panel of Graph 11), as well as additional effects of *bank-level* conditioning factors (Graph 12, Graphs B.5-B.6 in the Appendix) on loan loss rate. The additional effect for each state is calculated as the difference between low and high states. 1/ Defined as above country-specific average share of total impaired loans, 2/ as above country-specific average of 3-year rolling mean of loan loss rates, and 3/ as above 50 % share of corporate loans among total loans.

Source: Authors

The multivariate state-dependent estimates in subsection 3.3 allow us not only to compare the role of two states that may occur simultaneously (that is, a "horse race"), but also to assess the overall effect of monetary tightening when both states are present at the same time. The main drawback is that these horse races consider only two states of the economy, whereas the economy may simultaneously be in several adverse states. Nonetheless, it would not be feasible to extend the equation (3) to cover all the identified adverse states given too few observations. Hence, following Ahmed et al. (2024), we include at most three "competing states" in a single estimation:[20]

$$\begin{aligned} y_{i,t+h} - y_{i,t} = {} & a_i^h + \beta_1^h \Delta R_{i,t} + \gamma^{h'} X_{i,t} + I_{i,t-1}^A \left[a_i^{A,h} + \beta_1^{A,h} \Delta R_{i,t} + \gamma^{A,h'} X_{i,t} \right] + I_{i,t-1}^B [a_i^{B,h} \\ & + \beta_1^{B,h} \Delta R_{i,t} + \gamma^{B,h'} X_{i,t}] + I_{i,t-1}^C [a_i^{C,h} + \beta_1^{C,h} \Delta R_{i,t} + \gamma^{C,h'} X_{i,t}] + \tau_t + \epsilon_{i,t+h} \end{aligned} \tag{7}$$

Then, we estimate the equation (7) for the different combinations of adverse states from Table 1/Graph 13. That is, we only use those country-level characteristics as states (*A*, *B*, *C*), which were found to amplify the effect of rate hikes on credit losses. Then, we add the coefficients $\beta_1^h, \beta_1^{A,h}, \beta_1^{B,h}, \beta_1^{C,h}$ to construct scenarios regarding the expected effect of monetary tightening on loan losses when the economy is in three different adverse states simultaneously. We show the cumulative responses for different combinations of three adverse states in Graph 15.

The states of the economy that were found to amplify the effect of monetary tightening include macroeconomic characteristics (i.e., cyclical downturn, high private sector debt, high inflation, high floating rate loans share) as well as policy-related variables (i.e., low initial interest rate, loose monetary policy stance, restrictive fiscal policy). Therefore, to zero in on the potential role of policymakers in directly influencing the effect of rate hike on credit loss rates, in Graph 15, we show the different combinations of two adverse macroeconomic states (which are only indirectly influenced by the policymakers) and loose pre-tightening monetary policy stance[21], while in the Graph B.7 in the Appendix, we outline the combinations of two adverse macroeconomic states with restrictive fiscal policy. For this empirical exercise, we only include high floating loan share in only one scenario analysis – owing to substantially smaller sample size available for floating rate loans share.

Our results indicate that in most combinations of adverse states, an increase in policy rates by 1 p.p. is associated with an increase in loan loss rates of approximately 0.2 p.p. (approximately double the magnitude of the baseline estimate reported in Graph 3). For some combinations of adverse states, especially those that include high inflation and/or restrictive fiscal policy, the combined increase in credit loss rates reaches 0.25-0.30 p.p. Conversely, if the economy is not in any of the adverse states, monetary policy tightening does not lead to a statistically significant increase in credit losses. The latter is a very important finding, indicating that on their own, higher interest rates do not appear to put borrowers under significant pressure and thus they do not lead to higher loss rates. However, in combination with other factors tighter monetary policy can lead to higher credit loss rates, which could undermine financial stability. For instance, the substantial increase in credit losses during the GFC could be attributed to the combination of a global recession, high energy prices that preceded the GFC, and tighter monetary policy.

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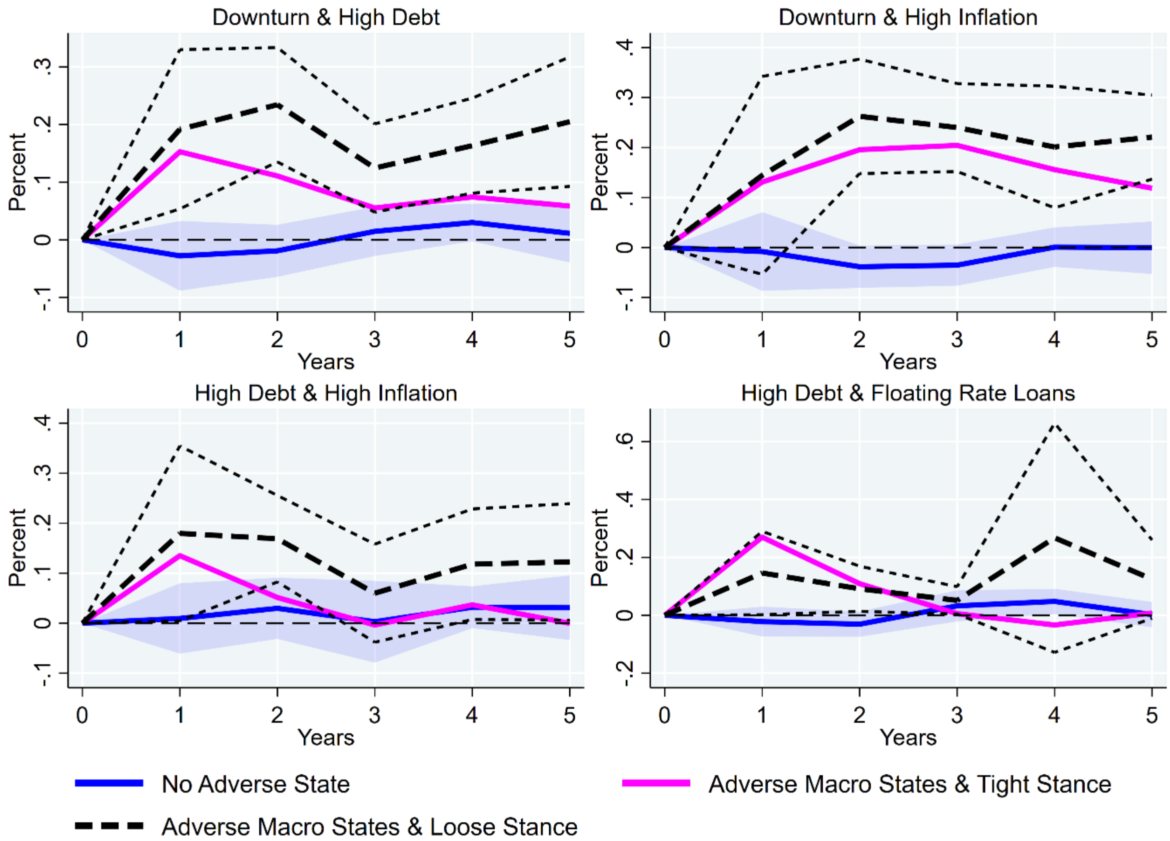
[20] That is, we extend the equation (3) to include one additional state (*C*).

[21] In this scenario analysis, we focus on loose monetary policy stance state defined as negative residuals from a simple Taylor rule regression instead of low initial interest rate state as it is a more direct proxy for monetary policy. However, our main conclusions remain unaffected even when we use the low initial interest rate state – though the overall increase in credit losses for the combination of all adverse states is somewhat smaller in magnitude.

Effect of Interest Rate Hike on Loan Loss Rates for a Combination of Adverse States – Role of Monetary Policy

Graph 15

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, and the sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, $\{\beta_1^{B,h}\}_{h=1}^5$ and $\{\beta_1^{C,h}\}_{h=1}^5$ from equation (7). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries, which were in none of the adverse macroeconomic states indicated in the title of each chart and which had a tight monetary policy stance prior to tightening (*No Adverse State*). The sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, $\{\beta_1^{B,h}\}_{h=1}^5$ and $\{\beta_1^{C,h}\}_{h=1}^5$ captures the *combined* effect of monetary tightening for countries, which were simultaneously in all of the adverse macroeconomic states indicated in the title of each chart and which had a loose monetary policy stance prior to tightening (*All Adverse Macro States & Loose Stance*). The sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, and $\{\beta_1^{B,h}\}_{h=1}^5$ captures the *combined* effect of monetary tightening for countries, which were simultaneously in all of the adverse macroeconomic states indicated in the title of each chart and which had a tight monetary policy stance prior to tightening (*All Adverse Macro States & Tight Stance*). *Downturn* state is defined as negative output gap during the year prior to monetary tightening. *High debt* state is defined as credit-to-GDP ratio above sample median. *High Inflation* state is defined as inflation rate during the year prior to monetary tightening being above its 5-year moving average. *Floating rate loan* state is defined as a country with a share of floating rate loans above 50 %. *Loose Stance* state is defined as negative residuals from the simple backward-looking Taylor rule. *Tight Stance* state is defined as positive residuals from the simple backward-looking Taylor rule. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Error bands are 90 % confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Importantly, the choice of monetary and fiscal policy stance prior to the tightening can aid in limiting the subsequent increase in credit losses, even in situations when the economy is in two adverse macroeconomic states simultaneously. A tighter monetary policy stance prior to the rate hike, which implies the central bank responding faster to macroeconomic conditions, reduces the overall increase in loss rates due to the hike by some 0.1 p.p. (depending on the combination of adverse macroeconomic states), while expansionary fiscal policy prior to the tightening cuts the effect by 0.1-0.15 p.p. on average.

Our results indicate that a 2-4 p.p. increase in policy rates falling together with a strong recession (drop of GDP by 3 p.p. more) and some of the other adverse states discussed above could lead to an increase in credit loss rates by 1-2 p.p. The policy rate hike would – directly or indirectly –

contribute a substantial portion to the increase in credit loss rates and such a shock could endanger financial stability. To this end, assessing credit loss rate scenarios within the broader context of bank solvency (i.e., studying the ultimate impact on capital ratios, akin to Hardy and Schmieder, 2013) would allow central banks and regulatory authorities to identify tipping points for financial stability under different circumstances.

5 Conclusions

We study the effect of monetary policy tightening on credit losses using a large panel dataset of 113 economies. Moreover, our results are also corroborated using a panel dataset of 3,350 banks from 92 countries. Our findings highlight a central policy dilemma: While monetary tightening is necessary to control inflation, it can increase credit losses and strain bank balance sheets, with potential negative consequences for financial stability, especially in economies with high debt levels and a recent history of loose monetary policy. Our evidence suggests that credit losses are further aggravated when monetary tightening follows periods of economic downturn, elevated inflation, and contractionary fiscal policy. In economies that experience several of these adverse conditions simultaneously, the effect of monetary tightening on credit losses is significantly larger: While on average, a 1 p.p. policy rate increase is associated with a higher loan loss rate by approx. 0.1 p.p., our scenario analyses indicate that for some combinations of adverse macro-financial conditions, the effect on loss rate increases to 0.2-0.3 p.p. for a 1 p.p. monetary tightening.

Our empirical results suggest that monetary policy design should consider macro-financial conditions, favouring timely, gradual monetary normalization over delayed or reactive monetary tightening. In other words, our findings imply that central banks that apply sustained dovish monetary policy should be particularly mindful of the pronounced side effect their policy stance may exert on borrower defaults and credit losses once rates eventually increase.

Macroprudential and supervisory frameworks can mitigate the effects on credit losses through expected loss provisioning, the countercyclical use of macroprudential capital buffers - such as the countercyclical capital buffer as the key time-varying instrument under Basel III – and bank solvency stress testing that accounts for state dependence. Integrating such elasticities into scenario design and scenario-conditional changes in risk parameters can better capture the trade-offs between monetary and financial stability. Our findings also suggest that financial sector policies that support the prevalence of fixed-rate loans in bank-customer business significantly reduce the interest rate sensitivity of credit losses. To which extent improvements in macroprudential and supervisory frameworks following the GFC already lowered the effect of rate hikes on credit losses, compared to the earlier part of our dataset (covering the 1990s and early 2000s), deserves further research.

This paper contributes the first global empirical assessment of the channel through which monetary policy might influence financial stability, i.e., by increasing loan losses. Using data for a longer period of time and a flexible econometric approach, we show that the transmission from monetary policy to credit losses is globally pervasive and non-linear. The magnitude and persistence of these effects underscore the importance of coordinated monetary and macroprudential policies to safeguard financial stability in the post-low-rate era.

Given the complexity and evolution of macro-financial states over time, there are substantial challenges to predict potential future conditions and their implications on credit losses in the years to come. One crucial scenario to consider is the ability of borrowers to manage sustained higher interest rates in an environment of historically elevated global private and public debt levels (IMF 2025), as is currently the case.

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Appendix A: Sensitivity Analyses

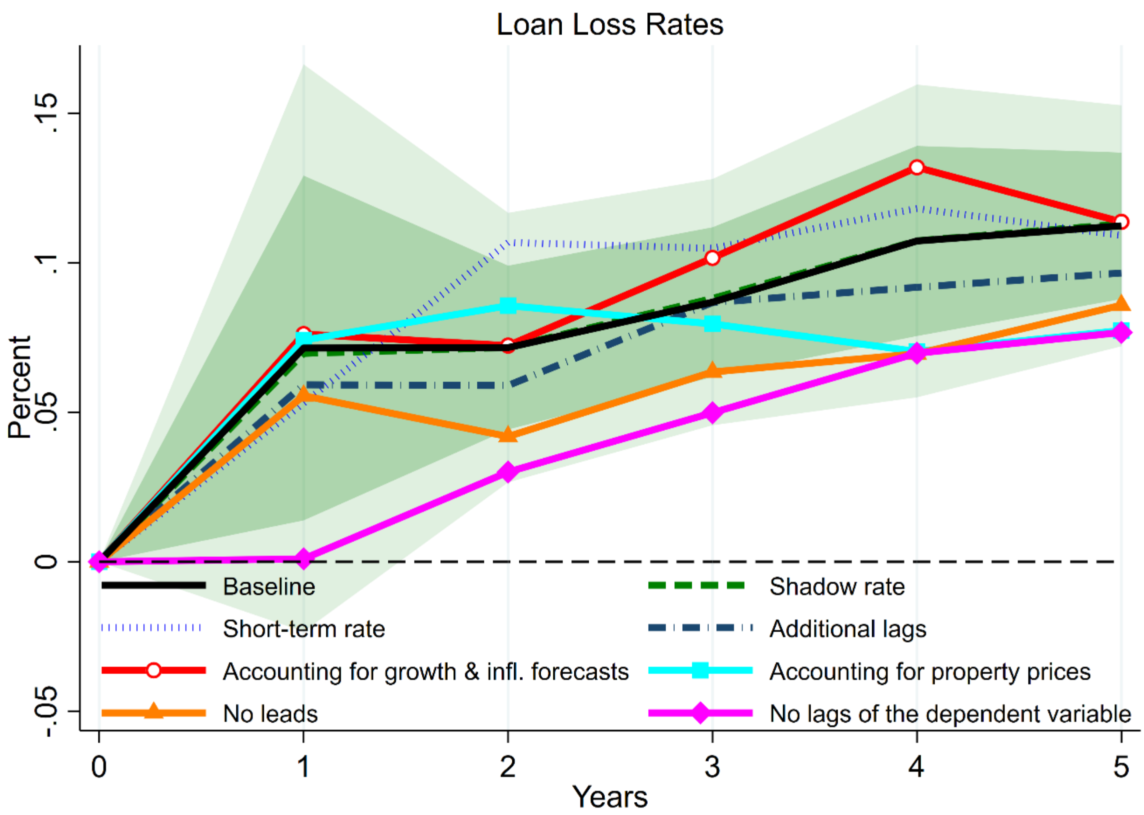
Table A.1: Effect of Interest Rate Hike on Loan Loss Rates

	(1)	(2)	(3)	(4)	(5)
			Δ Loan loss rate (%)		
	Year 1	Year 2	Year 3	Year 4	Year 5
Policy rate	0.079	0.082***	0.082***	0.113***	0.118***
	(0.062)	(0.027)	(0.025)	(0.031)	(0.024)
L1.Policy rate	0.014	0.031	0.031	0.047*	0.006
	(0.029)	(0.049)	(0.027)	(0.027)	(0.034)
F1.Policy rate	0.094	0.107	0.050	0.119***	0.124***
	(0.073)	(0.080)	(0.032)	(0.038)	(0.035)
F2.Policy rate		0.112	0.117	0.057	0.106**
		(0.069)	(0.085)	(0.048)	(0.041)
F3.Policy rate			0.059	0.085	0.049
			(0.063)	(0.082)	(0.055)
F4.Policy rate				0.081	0.132
				(0.053)	(0.078)
F5.Policy rate					0.057
					(0.063)
L1.Δ Loan loss rate	-0.298***	-0.506***	-0.438***	-0.428***	-0.389***
	(0.070)	(0.103)	(0.093)	(0.087)	(0.093)
L2.Δ Loan loss rate	-0.209***	-0.263***	-0.214***	-0.191**	-0.169***
	(0.066)	(0.076)	(0.058)	(0.073)	(0.060)
Economic growth	-0.064*	-0.008	0.061	0.010	0.044**
	(0.032)	(0.020)	(0.045)	(0.025)	(0.021)
Inflation	0.018	0.026	-0.007	0.008	-0.003
	(0.030)	(0.036)	(0.024)	(0.021)	(0.037)
Investments (% of GDP)	0.047**	0.065*	0.084***	0.094***	0.097***
	(0.021)	(0.033)	(0.030)	(0.029)	(0.027)
Private credit (% of GDP)	0.008**	0.016***	0.015***	0.011*	0.010
	(0.003)	(0.005)	(0.005)	(0.006)	(0.007)
Δ Nominal exchange rate	0.021**	0.031***	-0.001	0.017	0.033***
	(0.008)	(0.008)	(0.014)	(0.010)	(0.008)
Constant	-1.616***	-2.368**	-2.795***	-3.033***	-3.295***
	(0.445)	(1.024)	(0.891)	(0.979)	(1.037)
Country FEs	✓	✓	✓	✓	✓
Time FEs	✓	✓	✓	✓	✓
Within R^2	0.171	0.268	0.220	0.215	0.258
Observations	1,987	1,956	1,923	1,820	1,716
Countries	113	113	112	111	107

Notes: LP estimates of all parameters from equation (1). The coefficients of variable *Policy rate* are the $\{\beta_1^h\}_{h=1}^5$ coefficients from equation (1), which were used to construct the cumulative IRF in Graph 3. *L* stands for lags, while *F* stands for leads. Driscoll and Kraay (1998) standard errors are in parentheses. * indicates significance at 10 % level, ** at 5 % level and *** at 1 % level.

Sensitivity Analyses Graph A.1

Percent



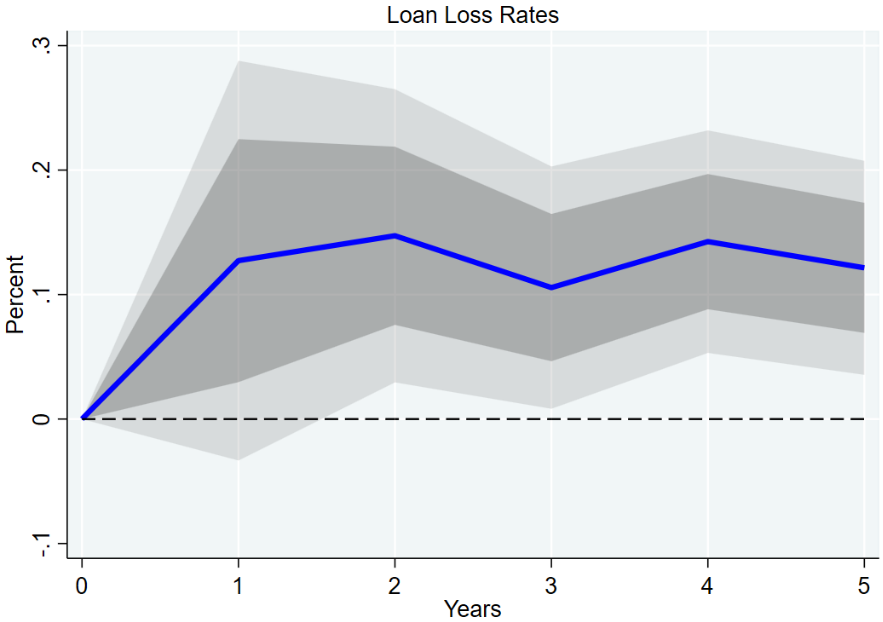
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse responses depict the response of loans loss rates to a 1 % increase in interest rates. Black solid line represents the point estimate based on the baseline LP specification (Graph 3). The other lines represent different sensitivity analyses: i) using shadow rates instead of policy rates for those countries for which they are available (green dashed line), ii) using short-term (3-month) interest rate instead of policy rate (blue dotted line), iii) including an additional lag of all the control variables (dark blue dashed line), iv) including one-year ahead forecasts of economic growth and inflation among the control variables (red line), v) including the annual change in real property prices index among the control variables (cyan line), vi) excluding leads of the policy rate from the control variables, and vii) excluding the lags of the dependent variable from the control variables (magenta line). Solid/dashed/dotted lines represent the point estimates based on the LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors for the baseline regression estimation (Graph 1). Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Monetary Policy Shock on Loan Loss Rate

Graph A.2

Percent

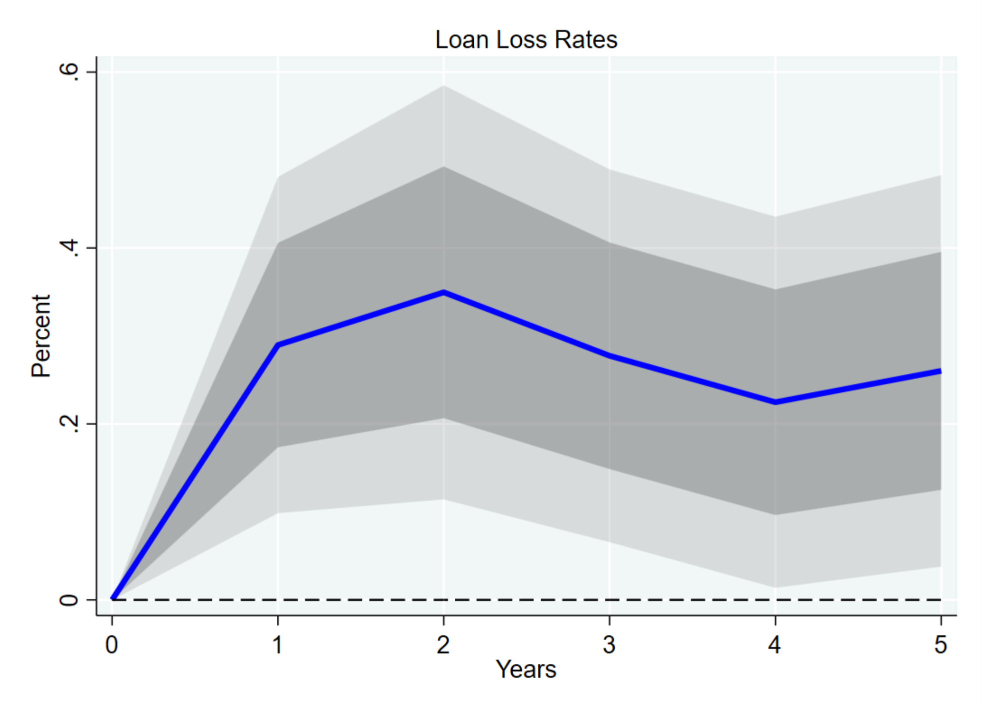


Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of loans loss rates to a 1 % monetary policy shock of Choi et al. (2024). Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Interest Rate Hike on Loan Loss Rates – Instrumental Variables Graph A.3

Percent



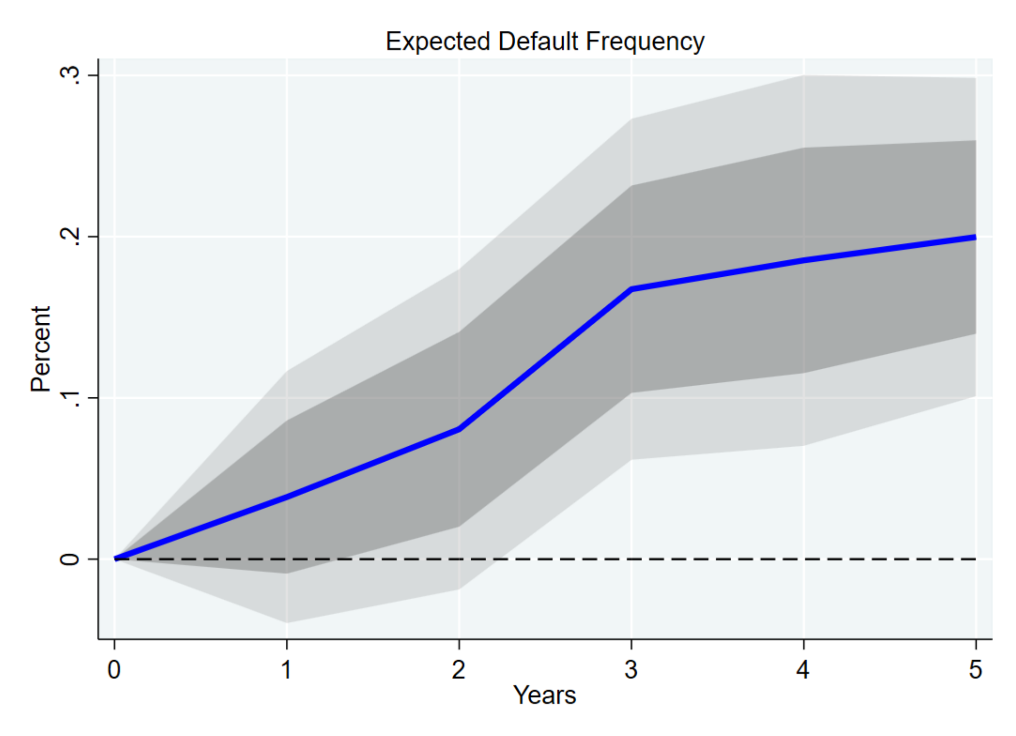
Notes: LP-IV estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of loans loss rates to a 1 % increase in central bank interest rate. Policy rate is instrumented with monetary policy shocks of Choi et al. (2024). Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Interest Rate Hike on Expected Default Frequency

Graph A.4

Percent

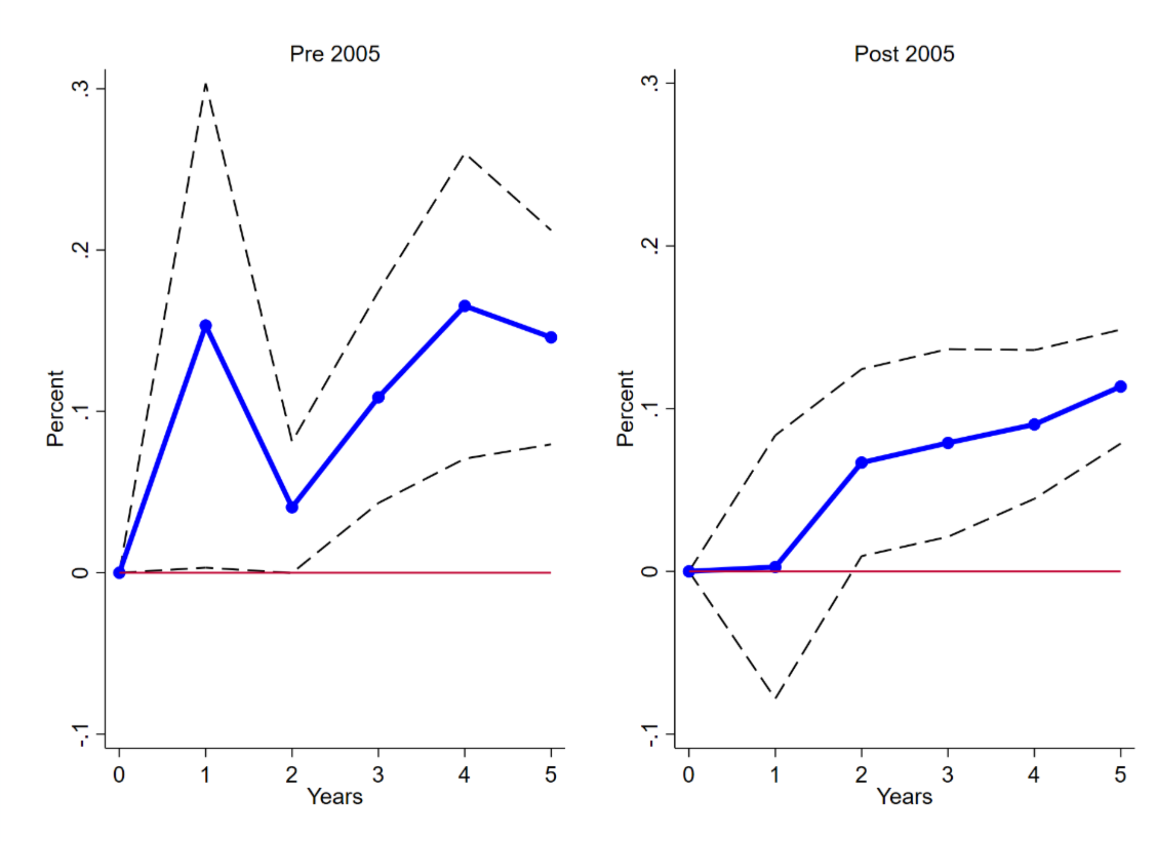


Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of expected default frequency to a 1 % increase in central bank interest rate. Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Interest Rate Hike on Loan Loss Rates – Pre- vs. Post-2005 Graph A.5

Percent



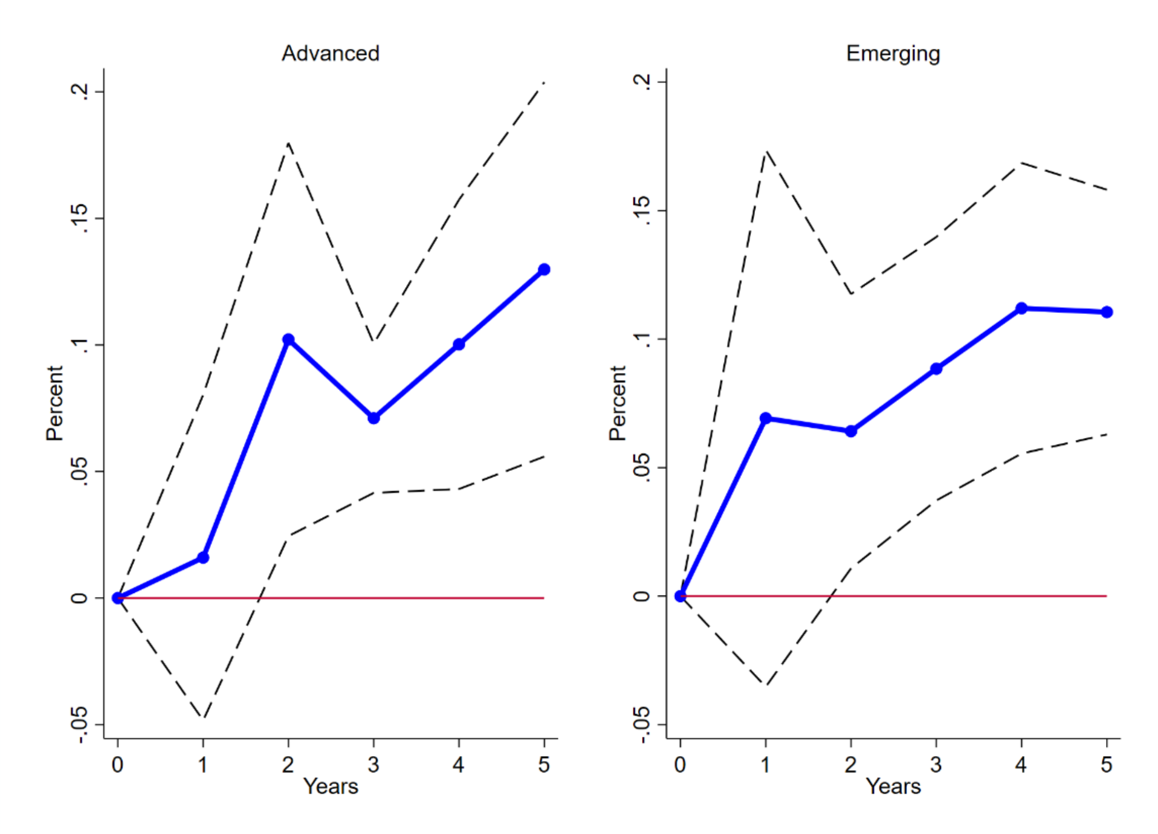
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of loans loss rates to a 1 % increase in central bank interest rate. Left panel reports the IRF estimated on a sub-sample covering the period 1990-2004. Right panel reports the IRF estimated on a sub-sample covering the period 2005-2020. Dashed lines indicate 90 % confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Interest Rate Hike on Loan Loss Rates – Advanced vs. Emerging

Graph A.6

Percent



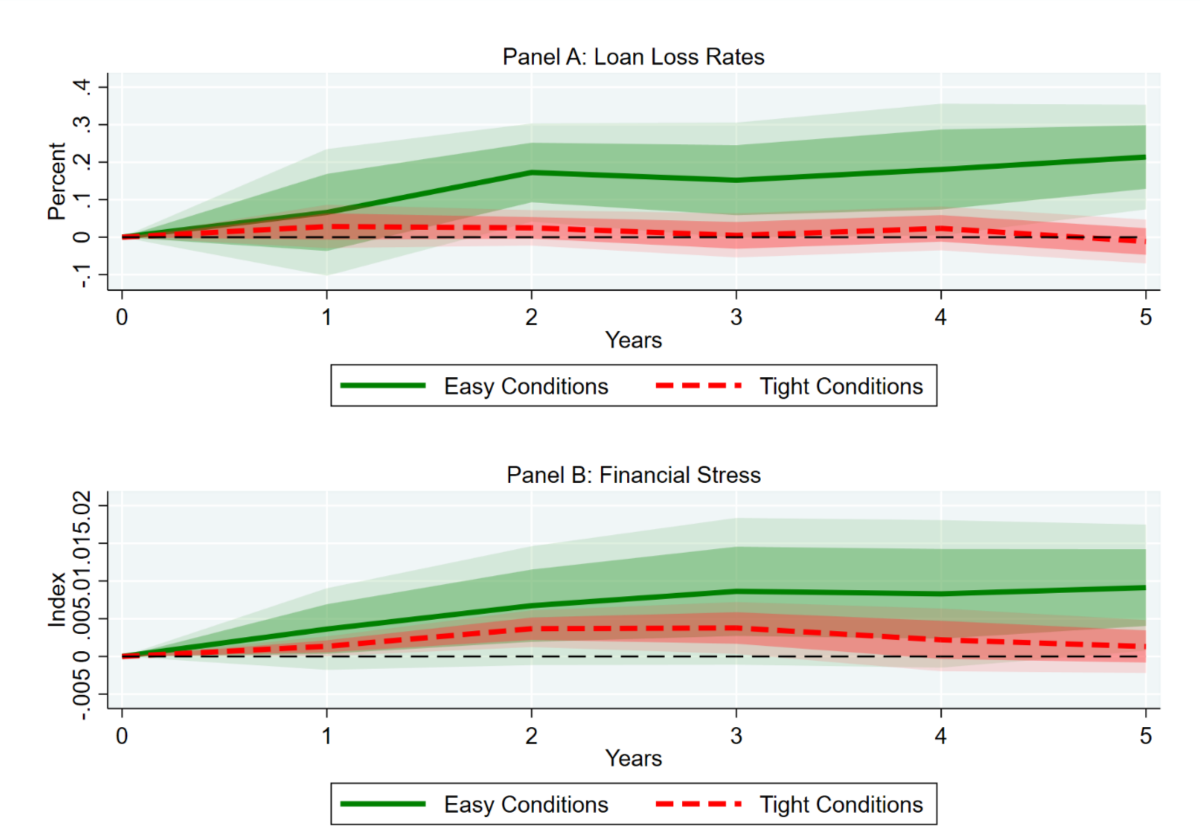
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (1). The impulse response depicts the response of loans loss rates to a 1 % increase in central bank interest rate. Left panel reports the IRF estimated on a sub-sample covering advanced economies. Right panel reports the IRF estimated on a sub-sample covering the emerging economies. Dashed lines indicate 90 % confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Appendix B: Additional Results

State-Dependent Effect of Interest Rate Hike Role of Monetary Policy Stance | Graph B.1

Percent



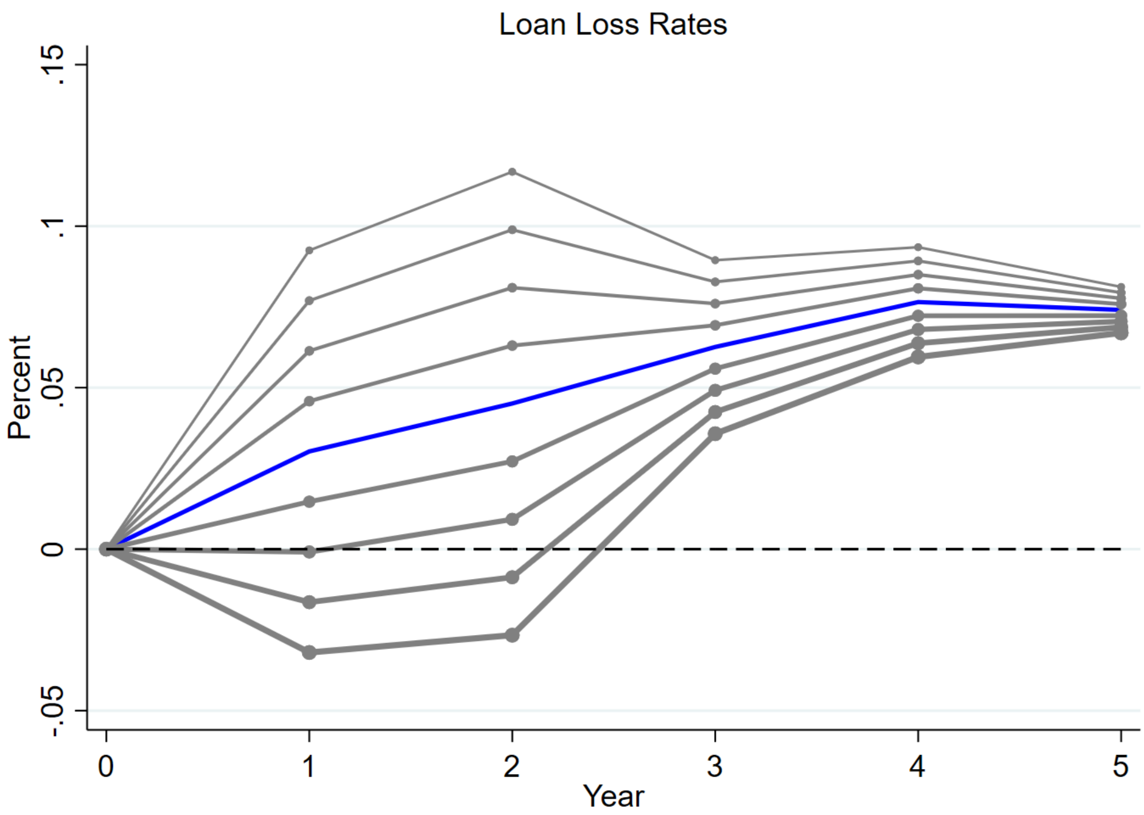
Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^{5}$ and $\{\beta_1^{B,h}\}_{h=1}^{5}$ from equation (2). The impulse responses show the state-dependent responses of loan loss rate (panel A) and of Financial Stress Index (FSI) of Ahir et al. (2023) (panel B) to monetary tightening conditional on the *monetary policy stance*: Solid and dashed lines stand for expansionary ($I_{i,t-1}$) and restrictive ($1 - I_{i,t-1}$) monetary policy, respectively. Easy (tight) monetary policy states are defined as negative (positive) residuals from the simple backward-looking Taylor rule. The impulse responses are normalized to depict the response of loans loss rates (panel A) and FSI (panel B) to a 1 % increase in central bank interest rate in the given state. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Conditional on the Response of Foreign Exchange (FX) Interventions

Graph B.2

Percent



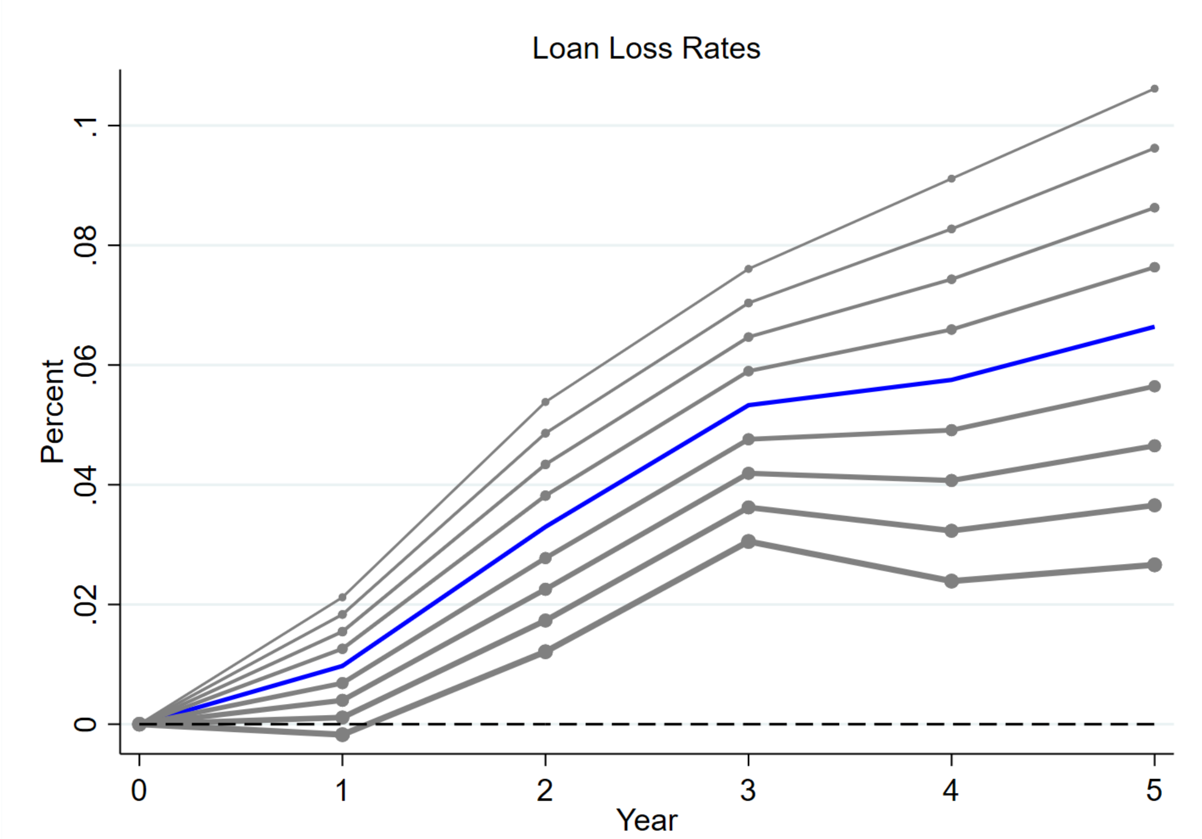
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ and $\{\theta_{\Delta R}^h\}_{h=1}^5$ from equation (4). The impulse responses show how the response of loan loss rate to monetary tightening varies with the foreign exchange (FX) interventions response. The blue line represents the direct (baseline) effect of monetary policy tightening on loan loss rate captured by $\{\beta_1^h\}_{h=1}^5$ coefficients from equation (4). The grey lines show how the effect of contractionary monetary policy depends on the response of FX interventions to the monetary tightening, with varying magnitudes of FX interventions ($\{\beta_1^h +/- \theta_{\Delta R}^h\}_{h=1}^5$). A larger marker (thicker line) indicates a (larger) increase in FX interventions. A smaller marker (thinner line) indicates a (larger) decrease in FX interventions. The grey lines consider experiments in which we vary the degree of FX interventions response to monetary tightening by 0.125 standard deviations. That is, the thickest (thinnest) grey line represents the increase (decrease) of FX interventions by 0.5 standard deviations above (below) sample mean. The impulse responses are normalized to represent the response of loans loss rates to a 1 % increase in central bank interest rate. Larger FX interventions represent the interventions against the domestic currency (i.e., the central bank purchases foreign exchange and sells the domestic currency, accumulating FX reserves and depreciating the domestic currency).

Source: Authors

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Conditional on the Response of Nominal Exchange Rate

Graph B.3

Percent



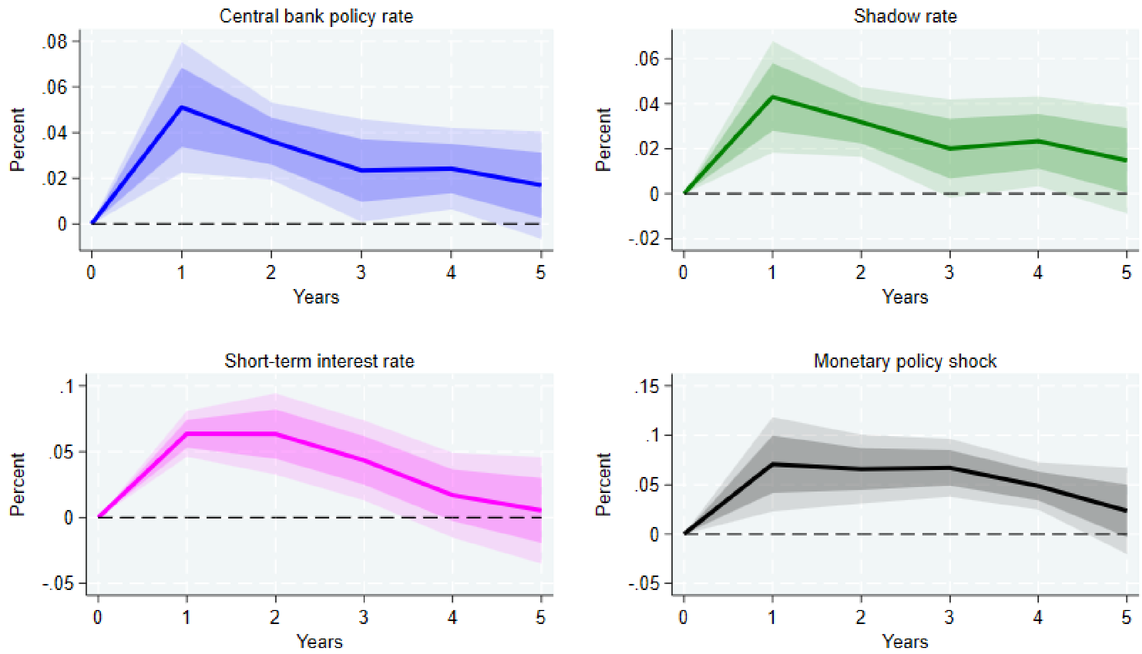
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ and $\{\theta_{\Delta R}^h\}_{h=1}^5$ from equation (4). The impulse responses show how the response of loan loss rate to monetary tightening varies with the nominal exchange rate response. The blue line represents the direct (baseline) effect of monetary policy tightening on loan loss rate captured by $\{\beta_1^h\}_{h=1}^5$ coefficients from equation (4). The grey lines show how the effect of contractionary monetary policy depends on the response of nominal exchange rate to the monetary tightening, with varying magnitudes of nominal exchange rate change ($\{\beta_1^h +/- \theta_{\Delta R}^h\}_{h=1}^5$). A larger marker (thicker line) indicates a (larger) appreciation (increase) of nominal exchange rate. A smaller marker (thinner line) indicates a (larger) depreciation (decrease) of nominal exchange rate. The grey lines consider experiments in which we vary the degree of nominal exchange rate response to monetary tightening by 0.125 standard deviations. That is, the thickest (thinnest) grey line represents the appreciation (depreciation) of nominal exchange rate by 0.5 standard deviations above (below) sample mean. The impulse responses are normalized to represent the response of loans loss rates to a 1 % increase in central bank interest rate. Nominal exchange rate is expressed in indirect quotation – that is, an increase in the value of exchange rate represents nominal appreciation.

Source: Authors

Effect of Interest Rate Hike on Loan Loss Rates – Bank-Level Data (Excluding U.S. Banks)

Graph B.4

Percent



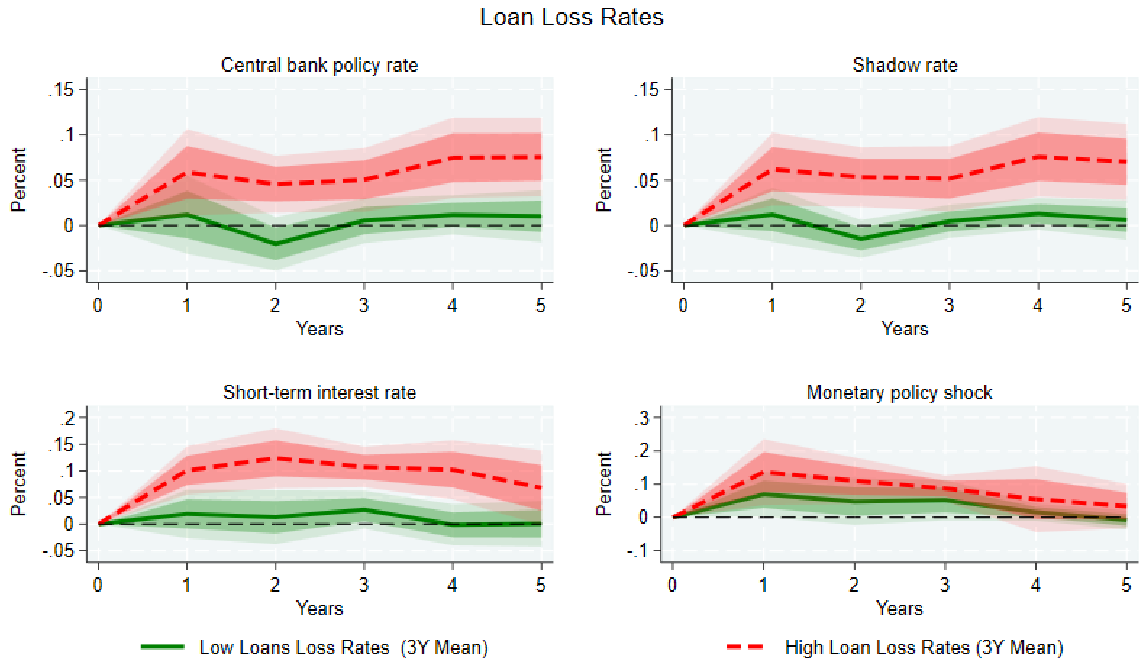
Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$ from equation (5) estimated on bank-level data excluding the U.S. banks. The top left panel shows the impulse response of loans loss rates to a 1 % increase in central bank interest rate. The top right panel shows the impulse response of loans loss rates to a 1 % increase in the shadow rate for those countries for which it is available. The bottom left panel shows the impulse response of loans loss rates to a 1 % increase in short-term interest rate. The bottom right panel shows the impulse response of loans loss rates to a 1 % monetary policy shock of Choi et al. (2024). Solid line represents the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on standard errors clustered at a country level. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of Loan Loss Rate Levels

Graph B.5

Percent



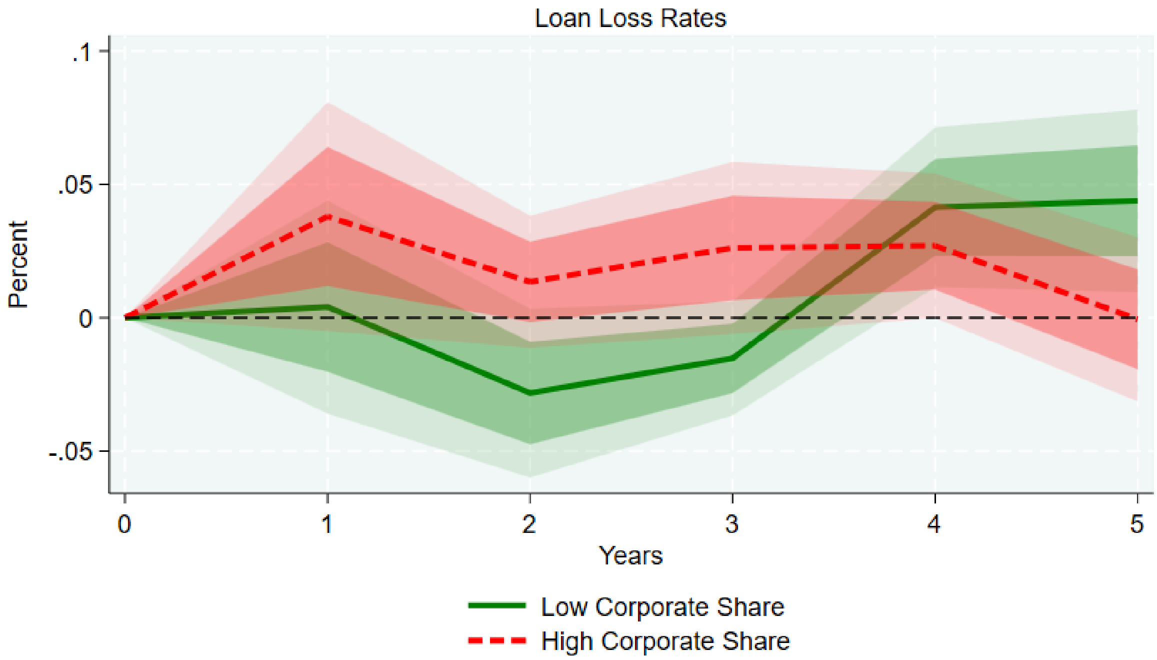
Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^5$ and $\{\beta_1^{B,h}\}_{h=1}^5$ from equation (6). The impulse responses depict the state-dependent responses of loan loss rates to monetary tightening conditional on the *3-year rolling mean level of loan loss rates* prior to the tightening: Solid and dashed lines stand for low ($I_{b,i,t-1}$) and high ($1 - I_{b,i,t-1}$) loan loss rate levels, respectively. Low (high) loan loss rate states are defined as below (above) country-specific average of 3-year rolling mean of loan loss rates. The top left panel shows the impulse responses of loans loss rates to a 1 % increase in central bank interest rate. The top right panel shows the impulse responses of loans loss rates to a 1 % increase in the shadow rate for those countries for which it is available. The bottom left panel shows the impulse responses of loans loss rates to a 1 % increase in short-term interest rate. The bottom right panel shows the impulse responses of loans loss rates to a 1 % monetary policy shock of Choi et al. (2024). Solid/dashed lines represent the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on standard errors clustered at a country level. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

State-Dependent Effect of Interest Rate Hike on Loan Loss Rates – Role of Corporate Loans Share

Graph B.6

Percent



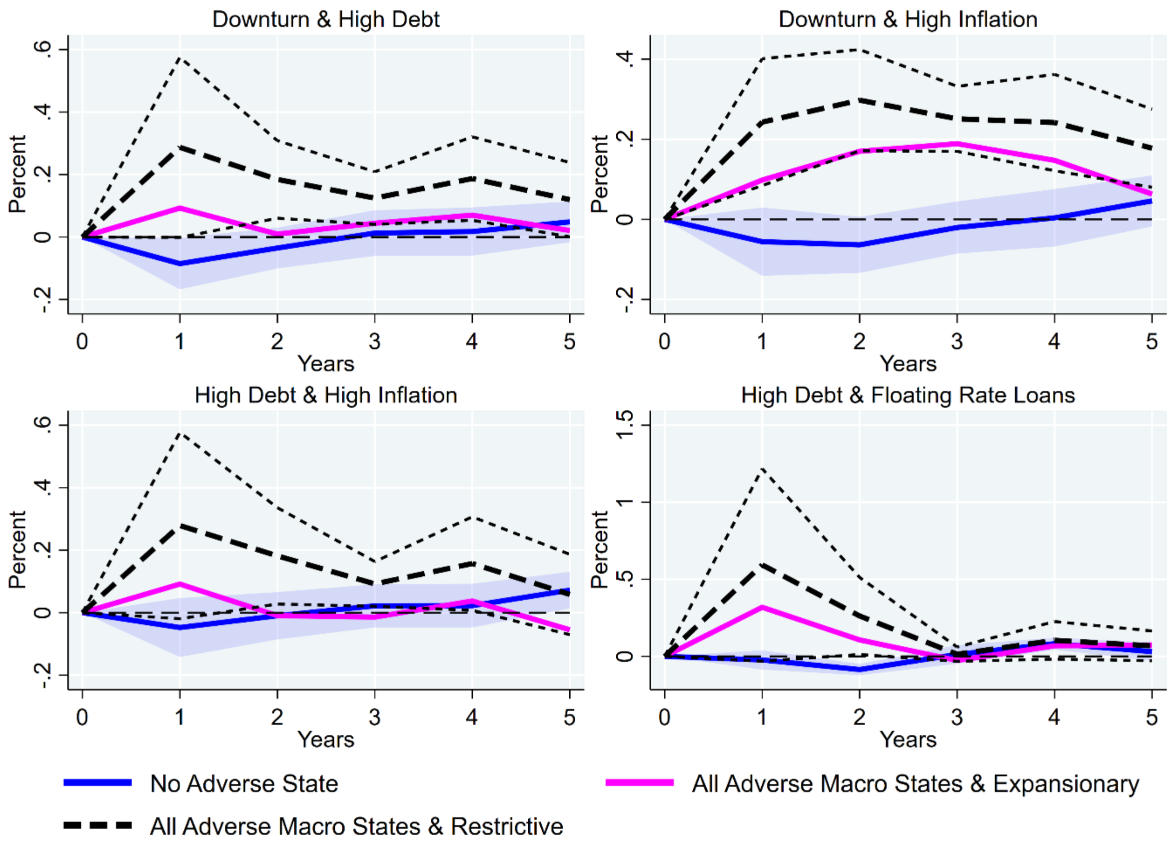
Notes: LP estimates of $\{\beta_1^{A,h}\}_{h=1}^{5}$ and $\{\beta_1^{B,h}\}_{h=1}^{5}$ from equation (6). The impulse responses depict the state-dependent responses of loan loss rates to monetary tightening conditional on the *share of corporate loans* prior to the tightening: Solid and dashed lines stand for low ($I_{b,i,t-1}$) and high ($1 - I_{b,i,t-1}$) corporate loans shares, respectively. Low (high) corporate loans share states are defined as below (above) 50 % share of corporate loans among bank's total loans. The figure shows impulse responses of loans loss rates to a 1 % increase in central bank interest rate. Solid/dashed lines represent the point estimate based on the LP. Shaded areas indicate 90 % (light) and 68 % (dark) confidence intervals based on standard errors clustered at a country level. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Effect of Interest Rate Hike on Loan Loss Rates for a Combination of Adverse States – Role of Fiscal Policy

Graph B.7

Percent



Notes: LP estimates of $\{\beta_1^h\}_{h=1}^5$, and the sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, $\{\beta_1^{B,h}\}_{h=1}^5$ and $\{\beta_1^{C,h}\}_{h=1}^5$ from equation (7). $\{\beta_1^h\}_{h=1}^5$ capture the effect of monetary tightening for countries, which were in none of the adverse macroeconomic states indicated in the title of each chart and which had an expansionary fiscal policy prior to tightening (*No Adverse State*). The sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, $\{\beta_1^{B,h}\}_{h=1}^5$ and $\{\beta_1^{C,h}\}_{h=1}^5$ captures the *combined* effect of monetary tightening for countries, which were simultaneously in all of the adverse macroeconomic states indicated in the title of each chart and which had a restrictive fiscal policy prior to tightening (*All Adverse Macro States & Restrictive*). The sum of $\{\beta_1^h\}_{h=1}^5$, $\{\beta_1^{A,h}\}_{h=1}^5$, and $\{\beta_1^{B,h}\}_{h=1}^5$ captures the *combined* effect of monetary tightening for countries, which were simultaneously in all of the adverse macroeconomic states indicated in the title of each chart and which had an expansionary fiscal policy prior to tightening (*All Adverse Macro States & Expansionary*). *Downturn* state is defined as negative output gap during the year prior to monetary tightening. *High debt* state is defined as credit-to-GDP ratio above sample median. *High Inflation* state is defined as inflation rate during the year prior to monetary tightening being above its 5-year moving average. *Floating rate loan* state is defined as a country with a share of floating rate loans above 50 %. *Restrictive* fiscal policy state is defined as a positive 3-year change in primary balance (% of GDP) during the year prior to the rate hike. *Expansionary* fiscal policy state is defined as a negative 3-year change in primary balance (% of GDP) during the year prior to the rate hike. The impulse responses depict the response of loans loss rates to a 1 % increase in central bank interest rate. Error bands are 90 % confidence intervals based on Driscoll and Kraay (1998) standard errors. Y-axis: deviation in percentage points. X-axis: time in years.

Source: Authors

Appendix C: Data

Table C.1: Variable Description and Sources

Variable	Description	Source
Loan loss rate	Annual (net) loan loss provisioning reported in the P&L account as a percentage of (net) loans outstanding.	FitchConnect
Policy rate	Key interest rate used to implement or signal monetary policy stance.	BIS & GMD
Short-term rate	Market rate on short-term government securities or interbank rates, generally three-months maturity.	GMD
Monetary policy shock	High-frequency financial market surprises around policy announcements; where unavailable, proxied by Taylor-rule residuals or anchor-currency shocks for countries without independent monetary policy.	Choi et al. (2024)
Shadow rate	Shadow short-term interest rate capturing the overall stance of monetary policy, including unconventional measures at the effective lower bound for the U.S., Euro Area countries and the United Kingdom, for the remaining countries, policy rate is used instead.	Wu and Xia (2016) & Wu and Xia (2017) & Wu and Xia (2020)
Economic growth	Annual percent change in real GDP.	World Bank
Inflation	Annual percent change in the consumer price index.	GMD
Investments (% of GDP)	Gross capital formation (% of GDP).	World Bank
Private credit (% of GDP)	Private credit by deposit money banks (% of GDP)	World Bank
Nominal exchange rate	Annual percent change of nominal effective exchange rate, and if not available, bilateral exchange rate of the domestic currency vis-à-vis the U.S. dollar; indirect quotation: an increase in the value of the exchange rate represents appreciation of the domestic currency.	IMF
Economic growth forecast	One-year ahead forecast for annual percent change in real GDP from Fall WEO.	IMF WEO
Inflation forecast	One-year ahead forecast for annual percent change in consumer prices from Fall WEO.	IMF WEO
Real property prices	Annual percent change in real selected residential property prices index, CPI-deflated, 2010=100.	BIS
Expected default frequency	Expected default frequency (EDF) for NFCs, sovereigns and banks.	Moody's Analytics
Primary balance (% of GDP)	Primary net lending/borrowing (% of GDP)	IMF
Share of floating rate loans	An indicator variable taking the value of 1 for countries with a share of mortgage loans with floating interest rates above 50 %.	*
Central bank balance sheet	Central bank assets (% of GDP)	World Bank
FX interventions	Annual changes in foreign exchange (FX) reserves adjusted for valuation effects and interest income – based on average currency composition of FX reserves.	IMF, own calculations

Notes: BIS stands for Bank for International Settlements, GMD for Global Macro Database of Mueller et al. (2025), IMF for International Monetary Fund, WEO for the World Economic Outlook database of the IMF. *Data on the share of floating rate loans is taken from several different sources: Zhu (2006), van Hoenselaar et al. (2021), Andaloussi et al. (2024), De Stefani and Man (2025), ECB, and national authorities' websites.

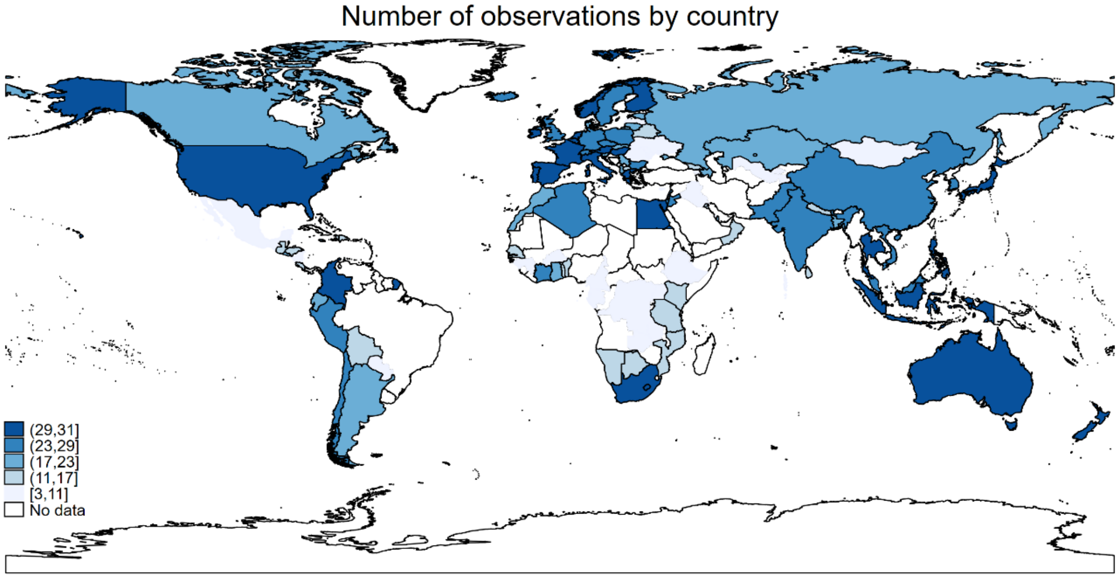
Table C.2: Descriptive Statistics

Variable	Units	Obs.	Mean	St. Dev.	Min	Max
			Baseline regressions			
Loan loss rate	%	1,987	1.29	2.29	0.10	40.00
Policy rate	%	1,987	6.13	5.98	-0.50	33.74
Economic growth	%	1,987	3.54	3.30	-8.92	17.33
Inflation	%	1,987	4.69	5.52	-1.08	35.79
Investments (% of GDP)	%	1,987	24.45	6.39	12.11	46.02
Private credit (% of GDP)	%	1,987	62.04	40.30	5.95	173.98
Nominal exchange rate	%	1,987	-1.67	7.82	-44.31	13.79
			Model extensions			
Short-term rate	%	1,717	5.81	5.57	-0.43	31.14
Monetary policy shock	%	1,935	-0.05	0.74	-3.61	2.76
Shadow rate	%	1,987	5.89	6.32	-6.96	33.74
Economic growth forecast	%	1,976	3.63	2.01	-1.50	9.95
Inflation forecast	%	1,975	4.32	3.64	0.13	21.35
Real property prices	%	1,067	1.80	6.86	-19.47	21.94
Expected default frequency	%	1,075	3.69	2.77	0.15	13.74
Primary balance (% of GDP)	%	1,885	-0.14	3.77	-11.29	27.72
Share of floating rate loans	dummy	1,012	0.74	0.44	0	1
Central bank balance sheet	%	1,968	4.98	8.57	0.01	89.67
FX interventions	%	1,978	0.86	3.28	-8.75	13.65

Country Coverage

Graph C.1

Percent



Notes: The figure indicates the countries included in our baseline sample (Graph 3), including the number of observations for each country.

Source: Authors