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Developing a risk-based stress testing framework for microfinance banks in Uzbekistan: A SVAR approach

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Abstract

This paper develops a risk-based stress-testing framework for emerging microfinance banks using a structural vector autoregressive (SVAR) approach. The model captures the dynamic transmission of key macroeconomic shocks, including economic activity, monetary policy, and exchange-rate movements, to supervisory-relevant banking indicators, including non-performing loans, capital adequacy, and lending behaviour.

The empirical analysis focuses on identifying macro-financial transmission channels that are particularly relevant for supervisory stress testing in newly established banking segments. Impulse response functions are used to derive baseline and adverse macroeconomic scenarios and to evaluate how shocks propagate to banking-sector risk indicators over time.

The results highlight the important role of external and monetary shocks in shaping asset quality and capital resilience, underscoring the relevance of macro-financial linkages for the supervision of microfinance banks. The framework proposed in this study provides a transparent and operational tool for translating macroeconomic disturbances into supervisory risk indicators and supports the implementation of risk-based supervision as the microfinance banking sector develops in Uzbekistan.

Keywords: stress testing, SVAR, macro-financial linkages, microfinance banks, exchange rate shocks, capital adequacy, non-performing loans.

JEL: (C32; E44; E58; F31; G21; G28)

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1. Introduction

Over the past decade, Uzbekistan's financial system has undergone profound institutional and structural transformation. Reforms in monetary policy, exchange rate management, and financial-sector regulation have fundamentally altered the macro-financial environment in which financial institutions operate. In parallel, the supervisory framework has been evolving from a predominantly compliance-based approach toward a forward-looking, risk-based supervision (RBS) architecture, where supervisory judgement is increasingly anchored in the identification and assessment of emerging vulnerabilities rather than in backward-looking indicators alone.

A central element of this transition is the establishment of a new microfinance banking segment. Following the adoption of a dedicated legal framework for microfinance banks, the first licenses are expected to be issued in the near term. This development represents a qualitative shift in the financial system: microfinance institutions are moving toward bank-like structures, with broader balance sheets, increased reliance on market-based funding, and closer integration with the macroeconomic and financial cycle. For supervisors, this raises a practical and immediate challenge. While the institutional segment is new and historical data are limited, supervisory authorities are required to assess resilience, calibrate prudential requirements, and design stress scenarios consistent with a risk-based supervision framework.

In this context, the key supervisory question is not whether macroeconomic shocks affect microfinance banks, but **which shocks matter most, through which transmission channels, and with what timing**. This distinction is critical in an emerging supervisory environment. External shocks, monetary tightening, and fluctuations in domestic economic activity may differ substantially in their implications for asset quality, capital adequacy, and lending behaviour. Without a structured framework to quantify these dynamics, supervisory responses risk being either overly conservative or insufficiently forward-looking.

Stress testing provides a natural analytical bridge between macroeconomic developments and balance-sheet vulnerabilities. International supervisory guidance emphasises that stress tests should be scenario-based, forward-looking, and embedded in supervisory decision-making rather than treated as mechanical exercises. At the same time, implementing conventional bank-level stress testing models is particularly challenging in newly established banking segments. Granular default histories, long time series, and institution-specific stress parameters are often unavailable at early stages of sector development. In such environments, a parsimonious and transparent macro-financial framework can offer a more credible foundation for supervisory stress testing than highly parameterised micro-level models.

Against this background, this paper develops a **structural vector autoregressive (SVAR) based stress testing framework** tailored to an emerging microfinance banking system, with a specific application to Uzbekistan. The framework links key macroeconomic drivers, including economic activity, monetary policy, and exchange rate dynamics to supervisory-relevant banking indicators, including non-performing loans, capital adequacy, and the composition of lending portfolios. By tracing the dynamic propagation of macroeconomic shocks over time, the SVAR approach provides a coherent mechanism to translate adverse but plausible macroeconomic scenarios into stress paths for bank resilience indicators.

The choice of a SVAR framework reflects supervisory priorities. Rather than imposing a tightly specified structural model, the approach allows macro-financial transmission mechanisms to be identified empirically while remaining sufficiently transparent for supervisory interpretation. This balance is particularly important in the Uzbek context, where supervisors must combine limited historical evidence with forward-looking judgement. To address data constraints arising from the recent licensing of microfinance banks, commercial bank data are used as proxies to estimate underlying macro-financial relationships, following established practice in stress testing applications for newly formed or transforming financial systems.

Recent evidence suggests that the entry of traditional banks into microfinance markets can significantly alter competitive dynamics and risk profiles in the sector (Fu et al., 2025).

This study makes three contributions. **First**, it provides an operational stress testing template suitable for emerging microfinance banking segments operating under data limitations, complementing the developing risk-based supervision framework. **Second**, it identifies and ranks macroeconomic transmission channels according to their persistence and supervisory relevance, allowing regulators to distinguish between shocks that generate temporary volatility and those that pose sustained risks to capital and asset quality. **Third**, it translates impulse-response analysis into a practical stress-scenario calibration toolkit, supporting the design of baseline, adverse, and severe scenarios consistent with empirically observed macro-financial dynamics. To my knowledge, this is one of the first studies applying a SVAR-based stress testing framework to an emerging microfinance banking system.

The remainder of the paper is organised as follows. Section 2 outlines the conceptual background and positions the framework within the macro-financial stress testing literature. Section 3 describes the data, model specification, and identification strategy. Section 4 presents the empirical results, focusing on the supervisory interpretation of impulse responses and variance decompositions. Section 5 discusses stress-scenario calibration and policy implications for risk-based supervision of microfinance banks in Uzbekistan. Section 6 concludes.

2. Literature review and conceptual framework

A central theme in the stress testing literature is the evolution from mechanical, compliance-oriented exercises toward forward-looking analytical tools that actively support supervisory judgement. The International Monetary Fund (2012) argues that stress testing should be understood as an integral component of systemic risk analysis rather than as a standalone quantitative technique. In this view, its primary function is to translate adverse macroeconomic developments into balance-sheet vulnerabilities in a way that informs supervisory decision-making. The IMF (2014) further emphasises that stress testing outcomes gain policy relevance only when embedded within a broader macroprudential framework, where they contribute to the calibration of preventive instruments such as capital buffers and countercyclical measures.

The Basel Committee on Banking Supervision (2018) reinforces this perspective by stressing that effective stress testing is defined not merely by numerical precision, but by the plausibility of scenarios and the credibility of transmission mechanisms. Supervisors, according to BCBS (2018), should prioritise internal consistency of assumptions and ensure that stress-test outcomes meaningfully inform capital planning and supervisory intervention strategies. Importantly, stress testing frameworks must be proportionate to the structure and maturity of the financial system a consideration particularly relevant for emerging banking segments with limited historical data and evolving institutional design.

From a macroprudential standpoint, the BIS (2011; 2018) highlights the role of stress testing in identifying systemic vulnerabilities arising from common exposures and cyclical amplification. Ignoring feedback loops between the real economy and the financial sector may lead to systematic underestimation of risk. Montoro and Moreno (2011) demonstrate that policy instruments, including reserve requirements, can significantly influence credit dynamics, underscoring the necessity of incorporating monetary and macroprudential variables into macro-financial stress testing frameworks.

Empirical research consistently confirms the importance of macroeconomic conditions for banking-sector stability. Demirgüç-Kunt and Detragiache (1998) show that output contractions and external shocks significantly increase the probability of banking crises across both advanced and developing economies. Hardy and Schmieder (2009) argue that stress testing frameworks in emerging markets should prioritise economically meaningful shock magnitudes and solvency-focused outcomes rather than excessive model complexity. Similarly, Čihák (2007) emphasises that applied stress testing must balance methodological sophistication with operational feasibility in supervisory contexts.

Recent contributions further analyse the transmission of macroeconomic and monetary policy shocks to credit risk indicators. Ekananda (2017) and Nwanja, Ezie, and Oniore (2024) find that adverse macroeconomic shocks and monetary tightening exert statistically significant and persistent effects on non-performing loans in emerging banking systems. Engelmann (2024) extends this argument by demonstrating that structural vulnerabilities including portfolio concentration and limited time-series depth may amplify stress outcomes in emerging markets if not explicitly incorporated into modelling frameworks.

The interaction between macroeconomic shocks and credit supply behaviour has also received increasing attention. Lown and Morgan (2006) and Bassett et al. (2014) show that lending standards both respond to and amplify macroeconomic fluctuations. These findings are particularly relevant for stress testing models that incorporate portfolio composition variables, such as the share of business loans, which captures shifts in risk appetite and credit allocation during periods of stress.

Methodologically, vector autoregressive models have become central tools in macro-financial analysis. Sims (1980) introduced VAR models as flexible empirical systems capable of capturing dynamic interdependencies without imposing restrictive theoretical assumptions. Lütkepohl (2007) formalised the econometric foundations of VAR and SVAR analysis, demonstrating how impulse response functions and forecast error variance decompositions can trace the timing, magnitude, and persistence of shocks. Dees, Henry, and Martin (2007) argue that structural macroeconomic models are particularly suitable for stress testing applications because they allow economically interpretable shocks to be linked directly to financial variables.

In emerging market contexts, SVAR frameworks have been successfully applied to analyse monetary transmission and credit dynamics. Berkelmans (2005), Singh and Majumdar (2013), Lojanica (2018), and Kabashi and Suleva (2018) demonstrate that SVAR models capture the interaction between macroeconomic disturbances and banking indicators in small open economies. Serwa and Wdowiński (2016) and Jensen and Pedersen (2019) further show that SVAR-based stress testing enables supervisors to rank shocks by persistence and systemic relevance an important feature for risk-based supervision. While alternative identification approaches, such as sign restrictions (Uhlig, 2005), offer additional flexibility, they also introduce complexity that may reduce transparency a trade-off that is particularly salient in supervisory environments.

In the context of microfinance and financial inclusion, Cull, Demirgüç-Kunt, and Morduch (2009) argue that the increasing commercialisation of microfinance institutions has fundamentally altered their risk profile. As these institutions scale up and integrate into formal financial systems, they become exposed to macroeconomic cycles and funding conditions in ways increasingly comparable to commercial banks. Klapper and Demirgüç-Kunt (2012) highlight the systemic importance of financial inclusion, while Zulkhibri and Ismail (2022) note that stress testing practices in emerging markets must adapt to structurally transforming financial sectors.

Recent empirical research also highlights how the expansion of traditional banking institutions into microfinance markets can significantly reshape the risk environment of microfinance institutions. Using cross-country microfinance data, Fu, Ioannidou, and Mishra (2025) show that bank entry into microfinance markets generates important spillover effects on competition, lending behaviour, and risk-taking dynamics. Their findings suggest that increased competition may initially expand credit supply but can also alter portfolio risk and institutional resilience. These insights are particularly relevant for emerging financial systems where microfinance institutions gradually transition toward bank-like structures.

Conceptual framework

Drawing on this literature, this study adopts a macro-financial stress testing framework in which structural macroeconomic shocks propagate to microfinance bank stability indicators through identifiable transmission channels. Macroeconomic variables represent the external environment and policy stance, while banking-sector indicators capture institutional resilience in terms of asset quality, capital adequacy, and lending behaviour. The SVAR framework enables the identification of structural shocks and the quantification of their dynamic effects through impulse response and variance decomposition analysis.

Consistent with the literature's emphasis on transparency, plausibility, and supervisory relevance, the framework prioritises parsimony and stability over excessive complexity. This design reflects the practical constraints faced by supervisors in emerging banking segments, where forward-looking judgement must compensate for limited historical data. Rather than aiming for precise point-loss estimation, the model focuses on identifying and ranking macroeconomic transmission channels according to their magnitude and persistence.

While the existing literature provides extensive insights into macro-financial stress testing, its direct application to newly established microfinance banking segments remains limited. In Uzbekistan, microfinance banks represent a nascent institutional category operating at the intersection of financial inclusion and prudential regulation. Supervisors must therefore design forward-looking stress testing tools despite short data histories and evolving risk-management infrastructures.

In this setting, I argue that stress testing frameworks should prioritise structured scenario calibration grounded in empirically observed macro-financial relationships. For microfinance banks, distinguishing between transitory volatility and persistent systemic stress is more critical than precise short-run loss estimates. A parsimonious SVAR-based framework offers a pragmatic compromise between analytical rigour and operational feasibility, allowing supervisors to extract policy-relevant signals while maintaining transparency and interpretability.

In this sense, the contribution of this paper is not only methodological but also institutional: it operationalises a macro-financial mapping tool tailored to the early-stage development of a risk-based supervisory architecture.

3. Data and Methodology

3.1 Data and variables

From a supervisory perspective, variable selection in a macro-financial stress testing framework extends beyond a purely technical modelling choice. As emphasised in policy-oriented SVAR applications, the credibility of stress testing outcomes depends critically on whether the selected variables meaningfully capture the core transmission channels relevant for supervisory decision-making (Sims, 1980; Serwa and Wdowiński, 2016).

In newly established banking segments such as microfinance banks in Uzbekistan, this consideration is particularly important. Data availability is inherently constrained, while supervisory authorities require models that are transparent, interpretable, and robust. Consistent with this view, the present study adopts a parsimonious specification that prioritises economic relevance and supervisory interpretability over dimensional richness.

The empirical analysis is conducted using quarterly data covering the period from 2016Q1 to 2025Q4. This sample spans multiple macroeconomic regimes, including sustained economic growth, episodes of external and domestic shocks, and periods of monetary policy tightening. Such variation is essential for identifying macro-financial transmission mechanisms that are structurally meaningful rather than regime-specific.

The SVAR model comprises six endogenous variables, organised into a macroeconomic block and a banking-sector block:

$$Y_t = (GDP_t, i_t,\ EXR_t,\ NPL_t, CAR_t, BLS_t)$$

This block structure follows standard practice in macro-financial SVAR models employed by central banks and supervisory authorities (Serwa and Wdowiński, 2016; Jensen and Pedersen, 2019). It allows macroeconomic shocks to be clearly distinguished from banking-sector responses, while preserving dynamic interaction between the two blocks.

Real GDP growth captures fluctuations in aggregate economic activity and borrower income dynamics, which the literature identifies as a primary determinant of credit quality and default risk (Bernanke et al., 1999). The policy interest rate reflects the stance of monetary policy and domestic financial conditions. The exchange rate represents external and balance-sheet shocks, which are particularly relevant in small open economies where currency movements can rapidly affect borrowers' repayment capacity and banks' asset quality.

The banking-sector block includes the non-performing loan ratio, the capital adequacy ratio, and the share of business loans. NPL and CAR are standard prudential indicators widely used in supervisory stress testing frameworks (IMF, 2012; BCBS, 2018). The inclusion of the share of business loans reflects an institutional feature of the Uzbek microfinance banking framework, where lending to entrepreneurial and income-generating activities plays a central role. From a macro-financial perspective, this variable captures portfolio allocation and risk-taking behaviour, which the literature identifies as an important amplification channel during periods of stress (Gilchrist and Zakrajšek, 2012).

Given the recent introduction of microfinance bank licenses in Uzbekistan, sufficiently long historical time series for these institutions are not yet available. In line with established practice in studies of structurally transforming financial systems, commercial bank data are therefore used as proxies to estimate underlying macro-financial transmission mechanisms (IMF, 2012; Jensen and Pedersen, 2019). While this approach entails limitations, it allows the analysis to focus on dynamic relationships that are relevant for supervisory stress testing, while explicitly acknowledging data constraints.

3.2 SVAR specification

The Structural Vector Autoregression framework is adopted because it aligns well with the practical requirements of supervisory stress testing. As originally argued by Sims (1980), VAR-based models offer a flexible and empirically grounded approach to analysing complex macro-financial interactions without imposing overly restrictive theoretical assumptions.

Formally, the reduced-form VAR of order p is specified as:

$$Y_t = c + \sum_{i=1}^{p} A_i Y_{t-i} + u_i$$

where Y_t denotes a_n $n\times1$ vector of endogenous variables, c is a vector of intercepts, A_i are coefficient matrices, and u_t represents reduced-form innovations with covariance matrix Σ_u.

While the reduced-form VAR captures the joint dynamics among variables, its residuals are contemporaneously correlated and therefore lack direct economic interpretation. As emphasised by Sims (1980) and Lütkepohl (2007), this limitation makes the reduced-form VAR insufficient for policy-oriented analysis and stress testing applications.

To obtain economically interpretable shocks, the model is transformed into its structural representation:

$$A_0 Y_t = \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_i$$

where A_0 is a contemporaneous impact matrix and ε_t is a vector of orthogonal structural shocks satisfying:

$$E(\varepsilon_t \varepsilon_t') = I$$

implying that structural disturbances are mutually uncorrelated and normalized to unit variance.

The relationship between reduced-form and structural disturbances is given by:

$$u = A_0^{-1} \varepsilon_t$$

which implies that the covariance matrix of reduced-form innovations satisfies

$$\sum\nolimits_u = A_0^{-1} \, (A_0^{-1})'$$

This relationship provides the basis for identifying structural shocks through the decomposition of the covariance matrix of reduced-form innovations. In empirical implementation, this decomposition is obtained using a Cholesky factorisation implied by the recursive ordering of variables.

3.3 Identification strategy

The identification of structural shocks represents one of the most critical methodological choices in SVAR analysis. The literature offers several identification approaches, including sign restrictions, long-run restrictions, and Bayesian identification schemes. However, recursive identification based on short-run restrictions remains one of the most widely used methods in applied macro-financial research due to its transparency and empirical tractability (Serwa and Wdowiński, 2016).

In policy-oriented and supervisory applications, recursive identification is particularly attractive because it prioritises interpretability and robustness over potentially fragile gains from more complex identification schemes. Stress testing frameworks used by central banks often rely on transparent identification structures that allow policymakers to clearly trace the transmission of macroeconomic shocks to banking-sector outcomes.

$$A_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix}$$

In this study, the contemporaneous impact matrix A_0 is specified as a lower triangular matrix, implying a recursive causal ordering among the variables. In practice, this recursive identification corresponds to a **Cholesky decomposition** of the reduced-form covariance matrix, which transforms the correlated residuals of the reduced-form VAR into orthogonal structural shocks.

The ordering adopted in the model reflects economically motivated assumptions about the relative speed of adjustment of macroeconomic and banking-sector variables. Macroeconomic variables real GDP growth, the policy interest rate, and the exchange rate are assumed to adjust more slowly within a quarter than banking-sector balance-sheet indicators. Consequently, macroeconomic and monetary policy shocks may affect banking-sector variables contemporaneously, while feedback from banking-sector conditions to macroeconomic aggregates occurs only with a lag.

This ordering reflects the typical transmission structure in small open economies where macroeconomic variables adjust more slowly than financial-sector balance-sheet indicators.

Such ordering assumptions are widely used in macro-financial SVAR models and are consistent with empirical applications in supervisory stress-testing frameworks (Jensen and Pedersen, 2019). From a supervisory perspective, this identification strategy provides a transparent and economically interpretable structure that allows macroeconomic disturbances to be mapped directly into banking-sector risk indicators. In my view, this recursive structure represents a pragmatic compromise between empirical credibility and operational simplicity, which is particularly important in emerging financial systems where data limitations constrain the use of more complex identification approaches.

To assess the robustness of the identification assumptions, alternative variable orderings are examined in the robustness section.

3.4 Impulse Response Functions and Forecast Error Variance Decomposition

A key advantage of the SVAR framework lies in its ability to trace the dynamic transmission of macroeconomic shocks through the financial system. In policy-oriented macro-financial analysis, this dynamic perspective is essential, as the effects of macroeconomic disturbances on banking-sector risk indicators typically unfold over time rather than materialising instantaneously (Sims, 1980; Lütkepohl, 2007).

Provided that the VAR system is stable, the structural model admits an infinite moving-average (MA) representation:

$$Y_t = \mu + \sum_{h=0}^{\infty} \Theta_h \, \varepsilon_{t-h}$$

where the matrices Θ_h describe the dynamic propagation of orthogonal structural shocks. These matrices are obtained as:

$$\Theta_h = \Psi_h A_0^{-1}$$

with Ψ_h denoting the MA coefficients of the reduced-form VAR and A_0^{-1} capturing the contemporaneous impact of structural shocks.

where, the matrices Ψ_h capture of dynamic effect of a one-time structural shock across all variables, ε_t is orthogonal structural shocks.

The matrices Ψ_h describe how a one-time structural disturbance affects all endogenous variables over subsequent periods. As shown by Lütkepohl (2007), this MA representation forms the theoretical basis for impulse response analysis.

In matrix form, the MA representation can be written as:

$$\begin{pmatrix} \Delta GDP_t \\ i_t \\ EXR_t \\ NPL_t \\ CAR_t \\ BLS_t \end{pmatrix} = \mu + \sum_{h=0}^{\infty} \begin{pmatrix} \theta_{11}^{(h)} & \cdots & \theta_{16}^{(h)} \\ \vdots & \ddots & \vdots \\ \theta_{61}^{(h)} & \cdots & \theta_{66}^{(h)} \end{pmatrix} \begin{pmatrix} \varepsilon_{t-h}^{GDP} \\ \varepsilon_{t-h}^{MP} \\ \varepsilon_{t-h}^{EXR} \\ \varepsilon_{t-h}^{NPL} \\ \varepsilon_{t-h}^{CAR} \\ \varepsilon_{t-h}^{BLS} \end{pmatrix}$$

This formulation makes explicit how each structural shock affects all macroeconomic and banking-sector variables over time.

Impulse Response Functions

Impulse response functions (IRFs) measure the response of variable i to a one-standard-deviation structural shock in variable j at horizon h:

$$IRF_{i,j}(h) = e_j' \Theta_h e_j$$

where e_i and e_j are selection vectors. IRFs provide a transparent depiction of the timing, magnitude, and persistence of macro-financial transmission channels and are therefore widely used in supervisory stress testing applications (Serwa and Wdowiński, 2016; Jensen and Pedersen, 2019).

From a supervisory perspective, the primary value of IRFs lies in their ability to illustrate how risks accumulate and dissipate over time. Rather than focusing on instantaneous effects, IRFs allow supervisors to assess whether adverse macroeconomic shocks generate short-lived disturbances or persistent pressures on asset quality, capital buffers, and lending behaviour.

Forecast Error Variance Decomposition

While impulse response functions trace the dynamic effects of individual shocks, forecast error variance decomposition (FEVD) provides complementary information on the relative importance of different shocks in explaining fluctuations in each variable.

The *H*-step-ahead forecast error variance of variable *i* attributable to structural shock *j* is defined as:

This measure quantifies the proportion of the forecast error variance of variable *i* that is explained by shock *j* at horizon *H*.

$$FEVD_{i,j}(H) = \frac{\sum_{h=0}^{H}(e_i'\Theta_h e_j)^2}{\sum_{h=0}^{H} e_i'\Theta_h\Theta_h' e_j}$$

In macro-financial applications, FEVD plays a crucial role in identifying the dominant transmission channels affecting banking-sector risk indicators. As shown by Serwa and Wdowiński (2016), fluctuations in banking-sector variables in emerging market economies are often driven to a large extent by macroeconomic and external shocks rather than by purely idiosyncratic banking disturbances. Similarly, Jensen and Pedersen (2019) demonstrate that FEVD-based analysis helps distinguish between temporary and structurally important sources of financial instability.

From a supervisory standpoint, FEVD results are particularly useful for stress-test calibration, as they indicate which macroeconomic shocks warrant priority attention when designing adverse scenarios.

Relevance for stress testing applications

The joint use of impulse response functions and forecast error variance decomposition provides a coherent empirical foundation for forward-looking stress testing. IRFs translate macroeconomic disturbances into dynamic stress paths for banking-sector variables, while FEVD identifies the shocks that account for the largest share of risk variation.

Unlike static stress testing approaches based on ad hoc assumptions, the SVAR-based framework ensures internal consistency between macroeconomic shocks and banking-sector outcomes. By grounding stress scenarios in empirically observed macro-financial transmission mechanisms, the analysis enhances both the credibility and policy relevance of supervisory stress tests, consistent with international guidance on sound stress testing practices.

4. Empirical results

4.1 Model diagnostics

The empirical analysis relies on a VAR(2) specification estimated over the period 2016Q3–2025Q4 (see Lag-order selection Table 1 in Appendix). While information criteria such as AIC and FPE favour higher-order specifications, The model adopts a parsimonious VAR(2) structure. The results suggest that given the relatively short quarterly sample and the supervisory objective of interpretability, additional lags would introduce excessive parameterisation without materially improving structural inference. This trade-off between statistical fit and economic transparency is consistent with supervisory-oriented SVAR applications (Serwa and Wdowiński, 2016).

Similar parsimonious lag structures are frequently used in supervisory-oriented SVAR applications where interpretability is prioritised over statistical fit.

Stability diagnostics confirm the adequacy of the specification. As illustrated in Figure 1 (Appendix), all eigenvalues of the companion matrix lie strictly within the unit circle. This ensures the existence of a valid moving-average representation and guarantees that structural shocks dissipate over time. From a stress testing perspective, this property is critical: it implies that impulse responses are economically meaningful and converge rather than producing explosive dynamics.

Residual diagnostics further support model adequacy. The Lagrange-multiplier test for serial correlation (Appendix A, Table 2, "Autocorrelation of residuals") fails to reject the null hypothesis at conventional significance levels ($p = 0.146$). This indicates that the VAR(2) structure sufficiently captures dynamic interdependencies among macroeconomic and banking-sector variables.

Taken together, these diagnostics provide confidence that the structural identification and subsequent stress testing analysis are grounded in a stable and internally consistent empirical framework.

4.2 Impulse Response Analysis

This section presents the dynamic transmission of macroeconomic shocks to supervisory-relevant banking indicators over a 12-quarter horizon. The main impulse responses are reported in Appendix A (Selected IRFs), while the full set of responses is presented in Appendix C.

In interpreting the results, I deliberately prioritise economic magnitude, persistence, and supervisory relevance over short-run statistical significance. For stress testing purposes, the timing and durability of shocks matter more than isolated t-statistics.

Exchange rate shock

A depreciation shock equivalent to approximately 10 percent produces the strongest and most immediate deterioration across all banking indicators (Appendix A, Figures on EXR shocks).

Capital adequacy declines sharply within the first two quarters, with the trough occurring around quarter 2. The peak decline reaches approximately 1 percentage point relative to baseline. Recovery is gradual and incomplete within the 12-quarter horizon, indicating persistent capital pressure. In my assessment, this persistence reflects balance-sheet effects typical for small open economies with currency mismatches.

Non-performing loans increase rapidly, peaking around quarter 4 at roughly 1.1 percentage points above baseline. Unlike monetary shocks, the NPL response is both strong and persistent, remaining elevated throughout the projection horizon. This suggests that exchange-rate depreciation transmits not only through immediate valuation effects but also via sustained borrower distress.

The share of business loans contracts abruptly within the first two quarters, declining by approximately 0.8 percentage points. The immediate nature of this response indicates that banks adjust lending behaviour quickly under external uncertainty.

Across magnitude, timing, and persistence, exchange-rate shocks clearly dominate other macroeconomic disturbances. This hierarchy is visible both in Appendix A IRFs and in the comparative patterns summarised in Appendix C.

Monetary policy shock

A contractionary monetary policy shock generates more gradual but still economically meaningful stress dynamics (Appendix A, Policy Rate shocks).

Capital adequacy declines progressively, with the trough observed around quarter 4 (approximately 0.7 percentage points below baseline). Compared to exchange-rate shocks, the decline is less abrupt but more evenly distributed over time.

Non-performing loans respond with a lag, becoming economically visible after two quarters and peaking between quarters 5 and 6. The delayed transmission is consistent with the time required for higher funding costs to translate into borrower solvency deterioration.

Lending behaviour adjusts earlier than asset quality. The share of business loans contracts within the first three quarters, reflecting tighter credit standards during monetary tightening cycles.

From a supervisory standpoint, monetary shocks represent medium-term rather than immediate risk. Their persistence makes them relevant for forward-looking monitoring frameworks.

GDP growth shock

A positive GDP growth shock acts as a stabilising force (Appendix A, GDP shocks).

Non-performing loans decline gradually, reaching a maximum reduction of approximately 0.6 percentage points around quarter 5. Capital adequacy increases moderately, peaking near quarter 6. Lending to business segments expands in a smooth and sustained manner.

In contrast to exchange-rate and policy shocks, real-sector improvements unfold gradually and do not generate abrupt structural shifts. This asymmetry between stress and recovery dynamics is economically intuitive and important for stress calibration.

Comparative transmission hierarchy

Taken together, the impulse responses reveal a clear ranking:

1. Exchange-rate shocks generate the largest and most immediate systemic stress.
2. Monetary policy shocks produce delayed but persistent vulnerability.
3. GDP shocks primarily reinforce resilience.

This hierarchy forms the empirical foundation for the stress-scenario prioritisation discussed later in the paper.

4.3 Forecast Error Variance Decomposition

Forecast error variance decomposition quantifies the relative importance of structural shocks at different horizons.

For capital adequacy, GDP growth shocks explain the largest share of long-run variance (8–12 quarters), highlighting the importance of sustained economic performance for capital resilience. Exchange-rate shocks explain a meaningful short-run portion of variance, consistent with their strong immediate impact.

For lending behaviour, monetary policy shocks dominate variance decomposition at medium horizons, confirming that financial conditions are the primary drivers of portfolio allocation dynamics.

For non-performing loans, both GDP and monetary shocks account for substantial long-run variance, while exchange-rate shocks explain a larger fraction of short-run variability but a smaller share at longer horizons.

The findings indicate this distinction between short-run dominance (exchange-rate) and long-run drivers (growth and policy) is particularly relevant for designing baseline versus severe stress scenarios (detailed FEVD results are reported in Appendix B).

4.4 Stress scenario calibration and robustness

Stress scenario calibration

Impulse response analysis provides the dynamic transmission of one-standard-deviation structural shocks. However, for supervisory purposes, these responses must be translated into economically meaningful stress magnitudes. In this section, I map the estimated impulse responses into baseline, adverse, and severe stress scenarios consistent with supervisory practice (BCBS, 2018).

The magnitude of the stress scenarios is designed to remain economically plausible rather than purely hypothetical. The calibration broadly reflects the historical volatility of the Uzbek macroeconomic environment as well as the magnitude of shocks observed in the impulse response functions. In particular, episodes of exchange-rate depreciation in emerging markets frequently exceed 10 percent, making the adverse and severe scenarios used in this analysis consistent with realistic macro-financial stress events.

Baseline scenario

The baseline scenario corresponds to historical average volatility embedded in the SVAR innovations. Under this scenario, capital adequacy fluctuates within a relatively narrow band, and NPL dynamics remain contained. The baseline therefore serves as a consistency benchmark rather than a binding constraint scenario.

Adverse scenario (10 percent depreciation)

Building on the impulse response analysis, I calibrate an adverse external shock equivalent to a 10 percent exchange rate depreciation.

Under this scenario:

Capital adequacy declines by approximately 1 percentage point at its trough (quarter 2).

Non-performing loans increase by roughly 1.1 percentage points, peaking around quarter 4.

The share of business loans contracts by about 0.8 percentage points within the first two quarters.

Importantly, while CAR declines materially, it does not breach the minimum regulatory requirement under the baseline capital buffer assumption. However, the margin of safety narrows significantly, implying that institutions with thinner buffers could face supervisory intervention thresholds.

From a supervisory perspective, this scenario captures the most systemically relevant macro-financial transmission channel identified in Sections 4.2–4.3.

Severe scenario (scaled shock)

To evaluate tail risk, I scale the exchange rate shock proportionally to simulate a 20 percent depreciation episode. This linear scaling approach is standard in SVAR-based stress calibration when non-linearities are not explicitly modelled.

Under the severe scenario:

- CAR declines by approximately 2 percentage points at peak.
- NPL increases approach 2 percentage points above baseline.
- Lending contraction intensifies and persists beyond eight quarters.

In this configuration, capital adequacy may approach or temporarily breach prudential thresholds for institutions operating close to minimum requirements. This finding underscores the systemic relevance of exchange rate risk in the emerging microfinance banking segment.

In my assessment, the calibration exercise confirms that exchange-rate shocks represent the primary stress vector requiring supervisory prioritisation.

Robustness to identification assumptions

Structural identification inevitably relies on economically motivated assumptions regarding contemporaneous relationships among variables (Sims, 1980). To ensure that the stress calibration is not an artefact of recursive ordering, I conduct a series of robustness checks.

Alternative ordering: policy-first structure

First, I re-estimate the SVAR under a policy-first ordering, allowing the policy rate to respond contemporaneously before GDP and exchange rate variables.

The qualitative ranking of shocks remains unchanged. Exchange rate disturbances continue to generate the largest and most persistent impact on CAR and NPL. Monetary policy shocks retain delayed transmission patterns. This confirms that the main conclusions are not driven by baseline ordering assumptions.

Exchange-rate-dominant ordering

Second, I implement an exchange-rate-first specification, reflecting the characteristics of small open economies.

Results remain directionally consistent. While magnitudes vary slightly, the dominance of exchange rate shocks in short-run capital deterioration persists. This reinforces the structural importance of external shocks in the Uzbek macro-financial environment.

Higher-order lag structure

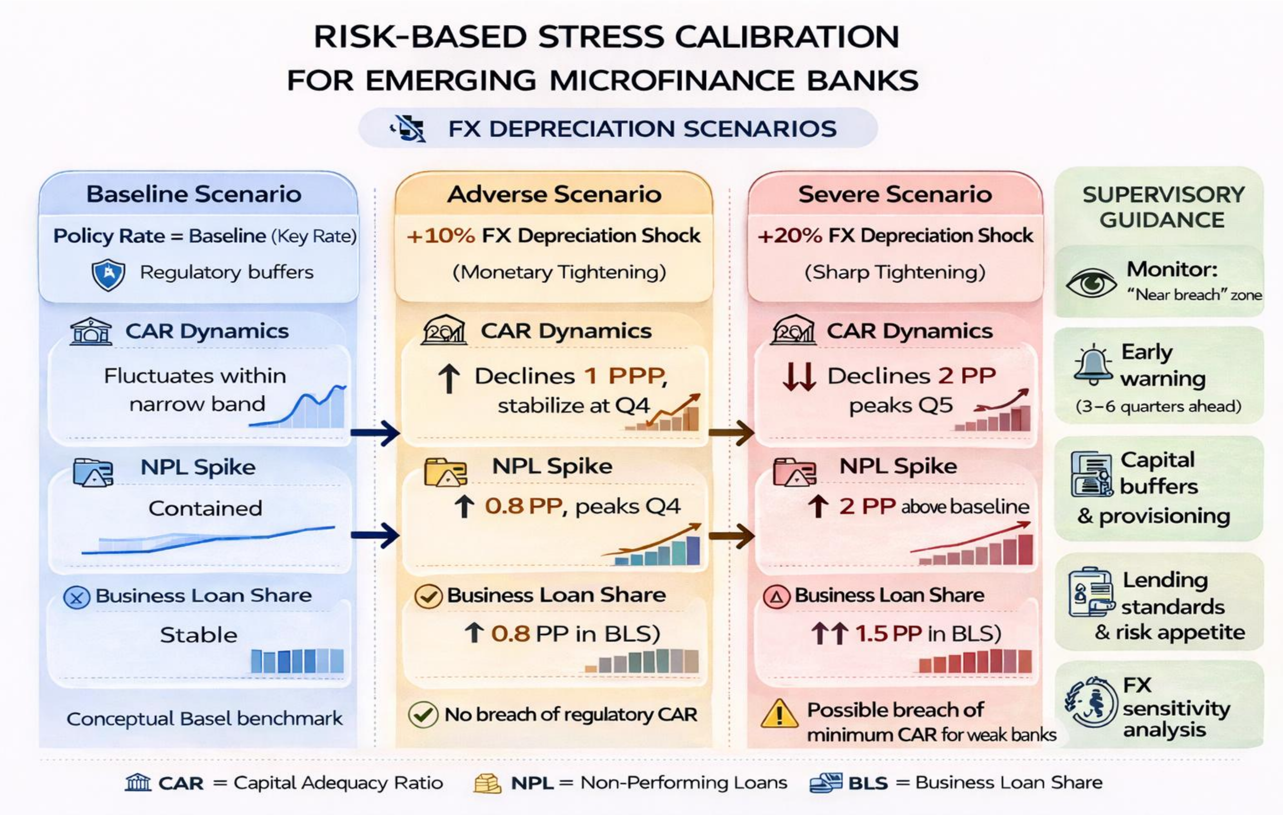
To further evaluate the robustness of the empirical results with respect to lag selection, I also estimate alternative specifications with higher lag structures, including VAR(4) and VAR(6). Although the inclusion of additional lags leads to slightly smoother impulse response profiles, the qualitative transmission patterns remain unchanged.

In particular, exchange-rate shocks continue to generate the strongest and most immediate deterioration in capital adequacy and non-performing loans, while monetary policy shocks retain their delayed but persistent effects on asset quality. These findings suggest that the main conclusions of the analysis are not sensitive to the baseline VAR(2) lag specification.

Supervisory interpretation

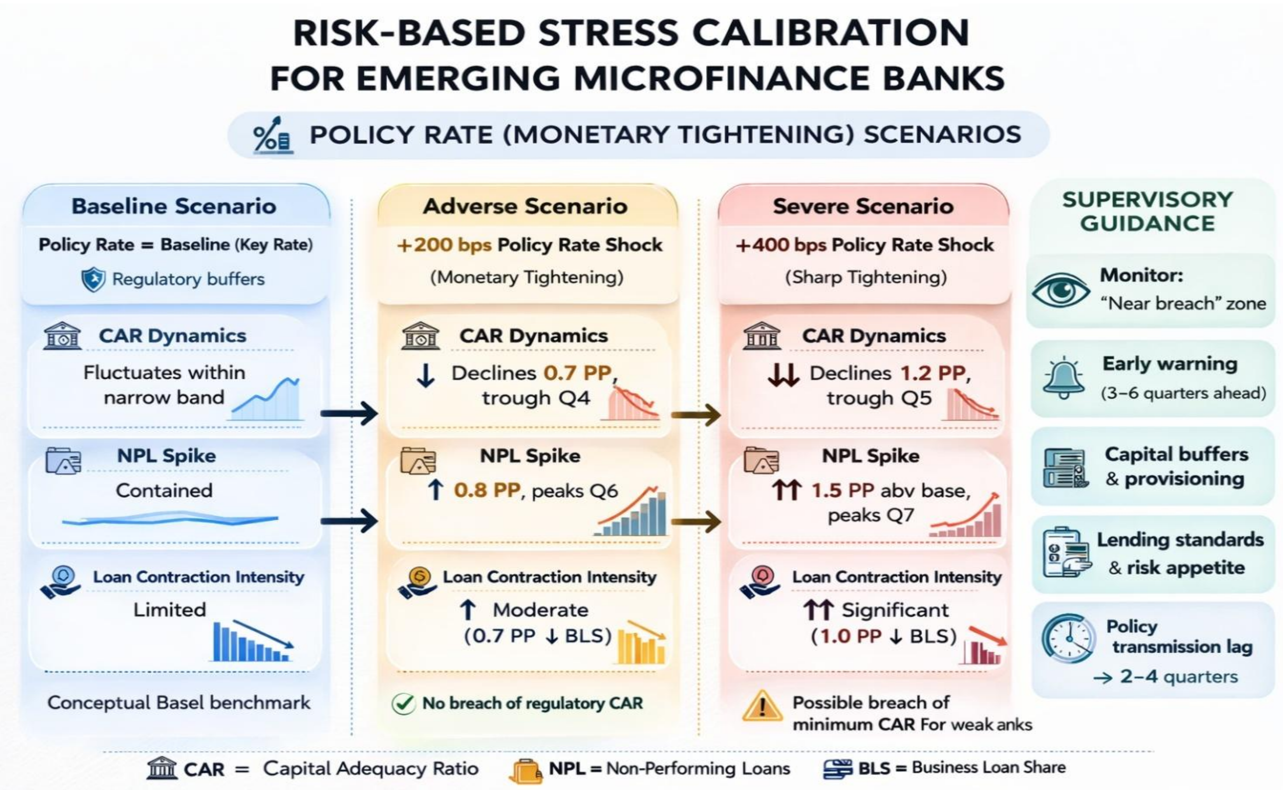
The joint evidence from impulse responses, FEVD results (Appendix B), and robustness checks supports three supervisory conclusions:

1. Exchange rate risk constitutes the primary macro-financial vulnerability for emerging microfinance banks.



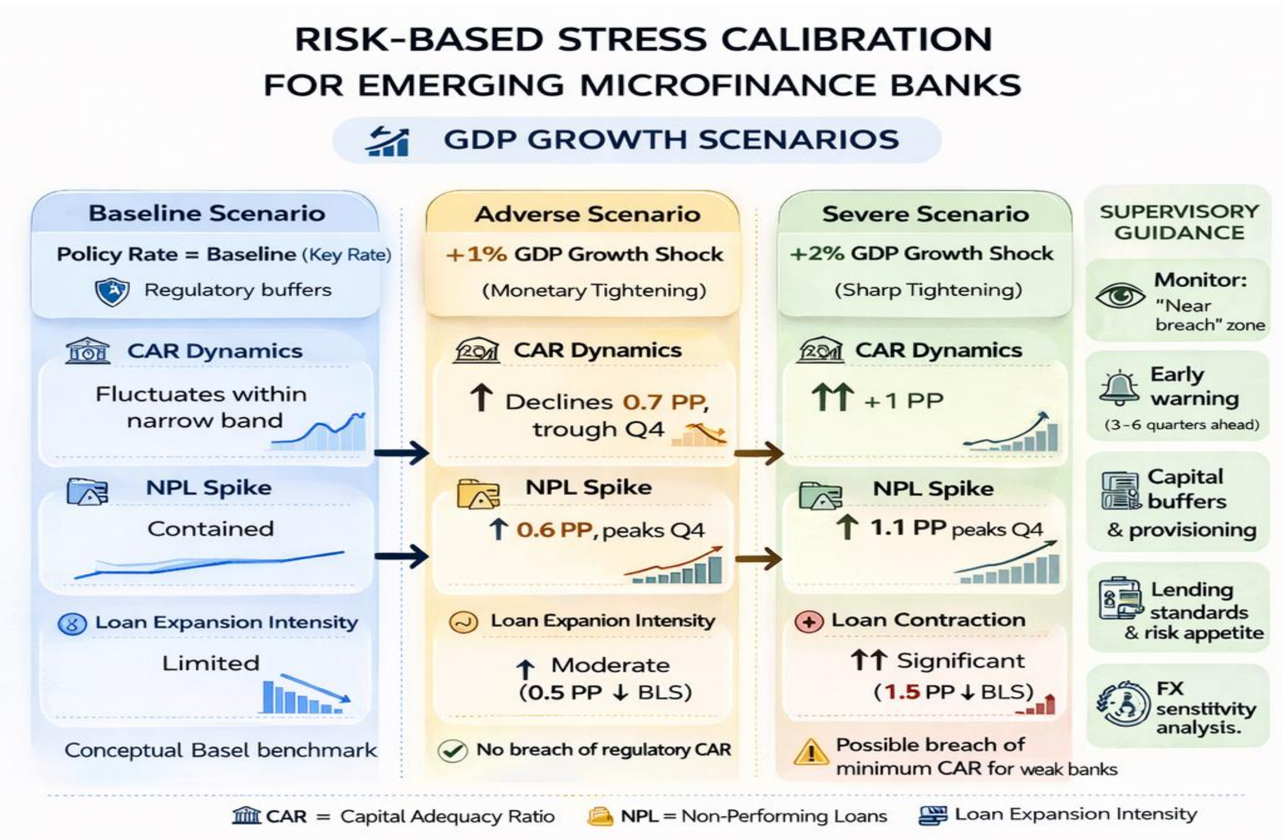
Source: author's calculations

2. Monetary policy tightening produces delayed but persistent asset-quality deterioration.



Source: author's calculations

3. Real economic growth provides stabilisation but cannot offset severe external shocks.



Source: author's calculations

The findings indicate the integration of SVAR-based stress calibration into the supervisory toolkit offers a transparent and empirically grounded mechanism to translate macroeconomic scenarios into prudential monitoring thresholds.

5. Policy implications

The empirical results presented in Section 4 carry important implications for the design of risk-based supervision in the emerging microfinance banking sector of Uzbekistan. Rather than treating stress testing as a purely technical exercise, the findings provide a quantitative foundation for prioritising supervisory attention across different macro-financial risk channels. In this section, the econometric evidence is translated into operational supervisory considerations.

Exchange rate risk as the primary systemic channel

The impulse response analysis and stress-scenario calibration consistently indicate that exchange-rate shocks represent the most powerful transmission channel affecting banking-sector stability. Currency depreciation generates the most immediate and pronounced deterioration in both capital adequacy and asset quality, with effects that persist over several quarters. This finding suggests that external vulnerability constitutes the dominant systemic risk channel for microfinance banks operating in a small open economy such as Uzbekistan.

From a supervisory perspective, this result implies that exchange-rate sensitivity should play a central role in stress-testing frameworks. Regular supervisory stress tests should incorporate explicit depreciation scenarios in the range of 10–20 percent in order to assess the resilience of bank capital buffers under plausible external shocks. In addition, supervisory monitoring should focus closely on foreign-currency mismatches not only on banks' balance sheets but also at the borrower level, where currency movements may rapidly weaken repayment capacity. The empirical results further suggest that prudential capital buffers should be calibrated to withstand externally driven increases in non-performing loans of approximately one to two percentage points. Given the structural openness of Uzbekistan's economy, exchange-rate volatility should not be treated as an exceptional tail risk but rather as a recurring macro-financial disturbance that must be explicitly incorporated into supervisory risk assessments.

Delayed transmission of monetary policy

The empirical analysis also highlights the lagged nature of monetary policy transmission to banking-sector risk indicators. Monetary tightening does not produce immediate capital stress but instead generates a delayed deterioration in asset quality, with the strongest effects materialising several quarters after the initial policy shock. This dynamic pattern reflects the gradual adjustment of borrower balance sheets and financing conditions to tighter monetary environments.

For supervisory practice, this lag structure carries important implications. First, reliance on contemporaneous non-performing loan indicators during monetary tightening cycles may lead to an underestimation of emerging risks. Supervisors should therefore incorporate forward-looking projections, particularly over horizons of three to six quarters, when evaluating banking-sector resilience. Second, supervisory dialogue during tightening episodes should place greater emphasis on forward-looking provisioning strategies and dynamic capital planning rather than reacting only after credit deterioration becomes visible in realised data. The results suggest, integrating SVAR-based projections into supervisory monitoring frameworks could significantly enhance early-warning capabilities and improve the timing of supervisory interventions.

Economic growth as a stabilising but limited buffer

Positive shocks to economic growth exert a stabilising influence on banking-sector indicators by improving borrower repayment capacity and supporting capital adequacy through stronger profitability dynamics. However, the magnitude of this stabilising effect is considerably smaller than the destabilising impact generated by exchange-rate shocks. The empirical evidence therefore suggests a clear asymmetry between macroeconomic expansion and external financial disturbances.

This asymmetry has important implications for risk-based supervision. While favourable macroeconomic conditions contribute to financial stability, they should not be interpreted as a substitute for adequate prudential buffers. Supervisory authorities should therefore avoid procyclical relaxation of capital standards during periods of strong economic growth. Maintaining structural capital buffers independent of temporary macroeconomic improvements remains essential for preserving banking-sector resilience in the face of potential external shocks.

Institutional contribution for emerging banking segments

Beyond the individual empirical findings, the broader contribution of this study lies in demonstrating how macro-financial modelling can support supervisory decision-making in newly established banking segments characterised by limited historical data. In the case of microfinance banks in Uzbekistan, traditional institution-level stress testing faces several practical constraints, including the absence of long historical default series and the limited availability of reliable bank-specific risk parameters.

Under such conditions, supervisory analysis must rely on empirically grounded macro-financial relationships that can serve as proxies for underlying risk dynamics. The SVAR-based framework developed in this study provides a parsimonious yet transparent mapping between macroeconomic shocks and key prudential indicators such as capital adequacy, credit quality, and lending behaviour. By complementing institution-level supervisory assessments with macro-financial scenario analysis, this approach strengthens the internal consistency and credibility of supervisory stress-testing practices.

6. Conclusion

In this paper, I develop a SVAR-based stress testing framework tailored to the emerging microfinance banking sector in Uzbekistan. Using quarterly data covering the period from 2016 to 2025, I analyse how key macroeconomic shocks GDP growth, monetary policy changes, and exchange-rate movements transmit to supervisory-relevant banking indicators, including capital adequacy, non-performing loans, and lending behaviour.

The empirical results reveal three central findings. First, I find that exchange-rate shocks constitute the most powerful transmission channel affecting banking-sector stability. Currency depreciation produces the largest and most immediate deterioration in capital adequacy and asset quality, with stress calibration suggesting that a ten percent depreciation may reduce the capital adequacy ratio by approximately one percentage point while simultaneously increasing credit risk indicators.

Second, the analysis shows that monetary policy shocks affect the banking sector through delayed transmission channels. Monetary tightening does not generate immediate capital stress but gradually weakens asset quality, with non-performing loans increasing several quarters after the initial policy shock. Third, I find that positive GDP growth shocks contribute to banking-sector stability by improving borrower repayment capacity and supporting capital resilience. However, the stabilising effect of economic growth appears weaker than the destabilising effects generated by external shocks.

The stress calibration exercises and robustness checks further indicate that these findings remain broadly stable across alternative model specifications and identification assumptions. In my view, this stability strengthens the credibility of the macro-financial transmission mechanisms identified in the model and supports their use in supervisory stress-testing applications.

More broadly, this study shows that relatively parsimonious macro-financial models can still provide meaningful supervisory insights in financial systems characterised by limited historical data and newly emerging institutional structures. In the case of Uzbekistan, where microfinance banks are only beginning to operate, traditional institution-level stress-testing frameworks remain difficult to implement due to the absence of long historical time series and well-established internal risk parameters.

I therefore argue that integrating SVAR-based stress testing into the supervisory toolkit could play an important role in strengthening forward-looking risk assessment. By linking macroeconomic scenarios with key prudential indicators, the framework developed in this paper can help supervisors prioritise risk scenarios, improve early-warning monitoring, and enhance the analytical credibility of supervisory stress-testing practices.

As the microfinance banking sector in Uzbekistan continues to develop, the need for transparent, proportionate, and analytically grounded supervisory tools will become increasingly important. In this context, the framework proposed in this study provides a practical starting point for supporting the prudent and resilient development of this new banking segment.

Appendix.

Table 1. Lag-order selection criteria

Sample: 2016Q1 – 2025Q4
Endogenous: GDPgrw, policyrate, EXR, NPL, CAR, BLS.
Exogenous: _cons

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	*310.126*			*1.9e-15*	*-16.8959*	*-16.8038*	*-16.632*
1	*482.131*	*344.01*	*0.000*	*1.0e-18*	*-24.4517*	*-23.8069*	*-22.6043*
2	*523.083*	*81.904*	*0.000*	*9.0e-19*	*-24.7268*	*-23.5293*	*-21.2959*
3	*578.819*	*111.47*	*0.000*	*5.0e-19*	*-25.8233*	*-24.0731*	*-20.8088*
4	*676.253*	*194.87**	*0.000*	*5.7e-20**	*-29.2363**	*-26.9334**	*-22.6383**

Source: author's calculations

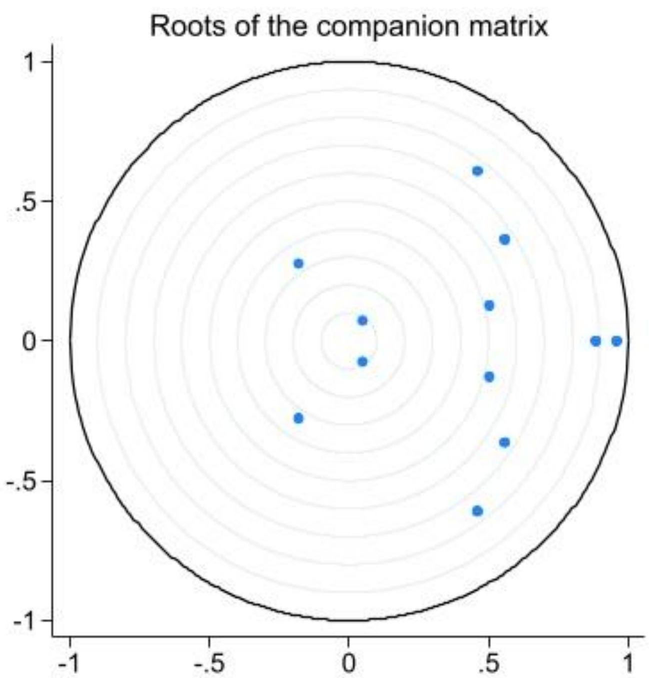
Table 2. Lagrange-multiplier test

Autocorrelation of residuals in the VAR(2) model
H_0: no autocorrelation at lag order

Lag	chi2	df	Prob>chi2
1	44.9185	36	0.14637

Source: author's calculations

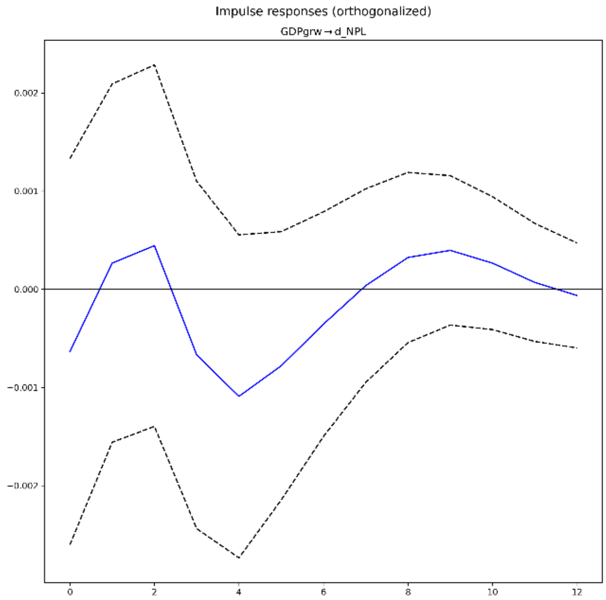
Figure 1. Stability of the VAR (2) model

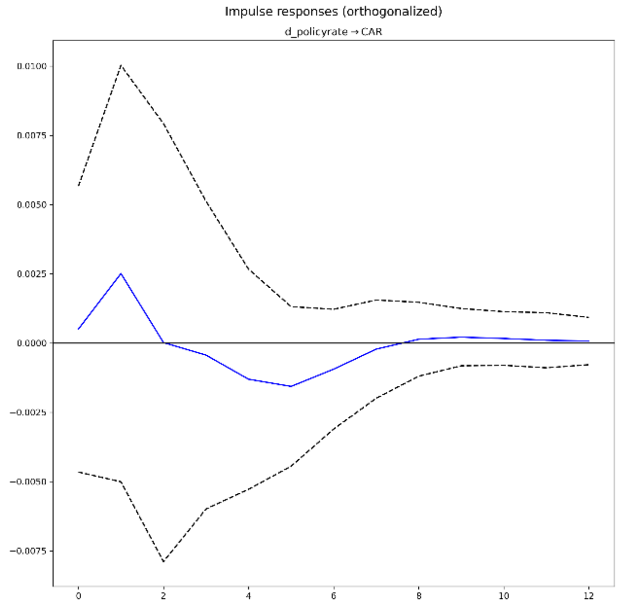


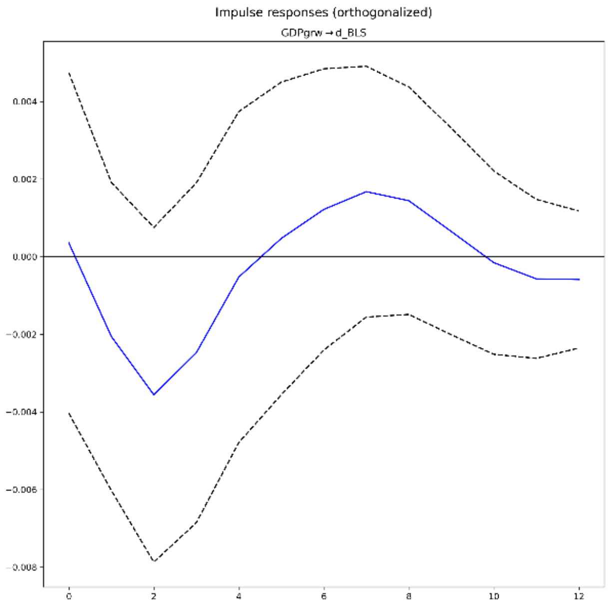
Source: author's calculations

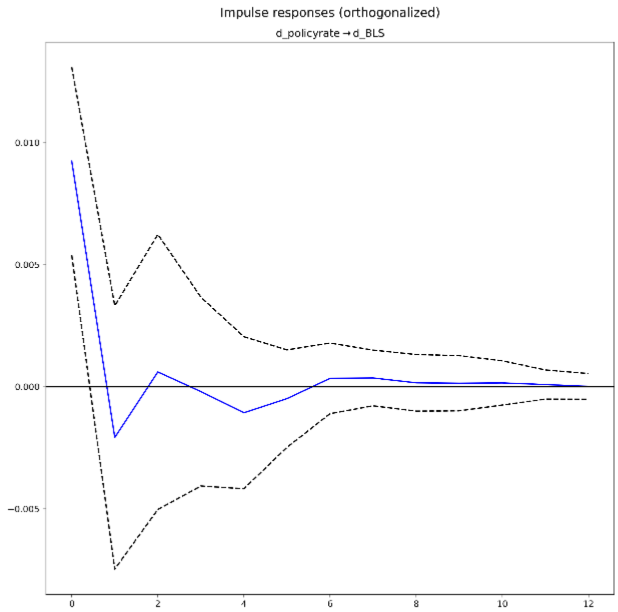
Appendix A. Selected Impulse Response Functions (main results)

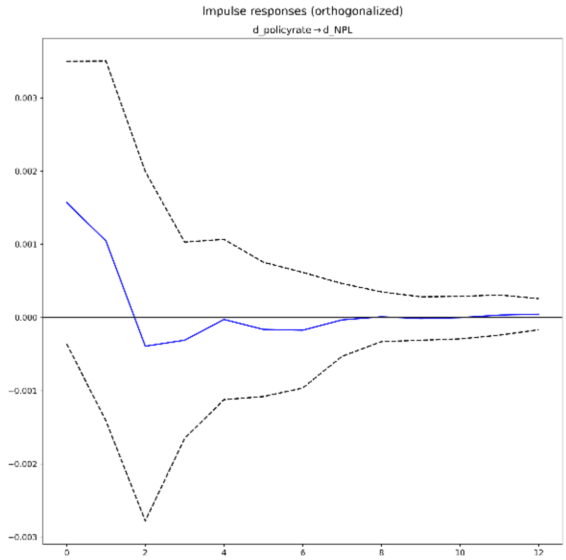
This appendix reports the impulse response functions referenced in Sections 4.2–4.4 of the main text. Figures are organised by shock type and banking-sector indicator.

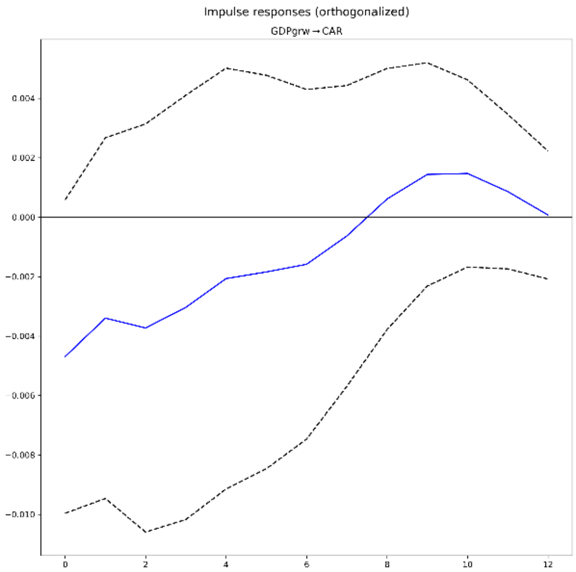


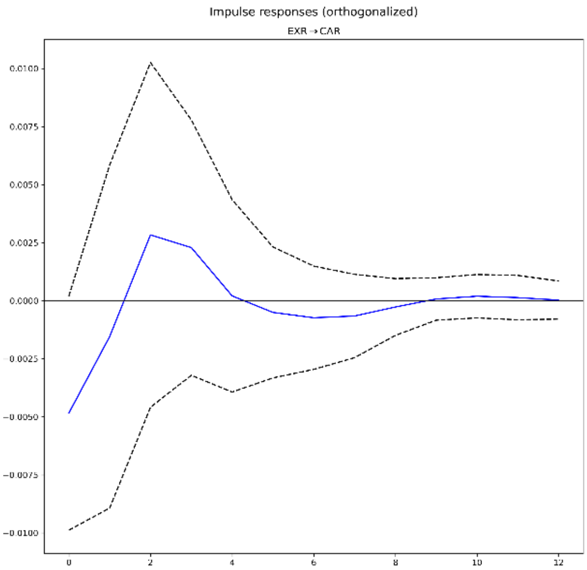


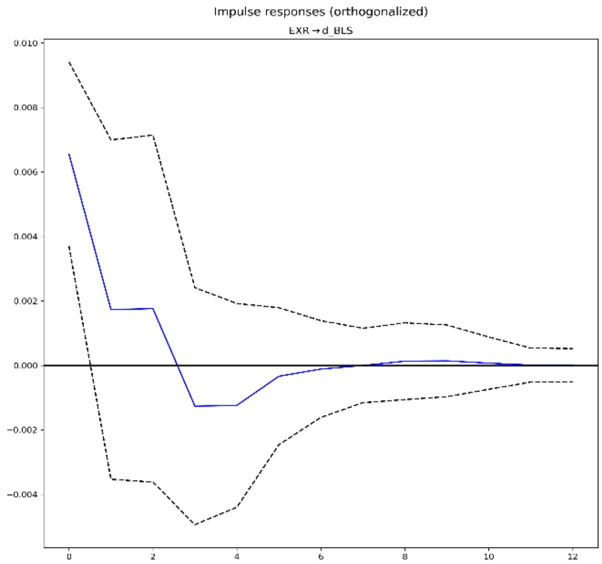


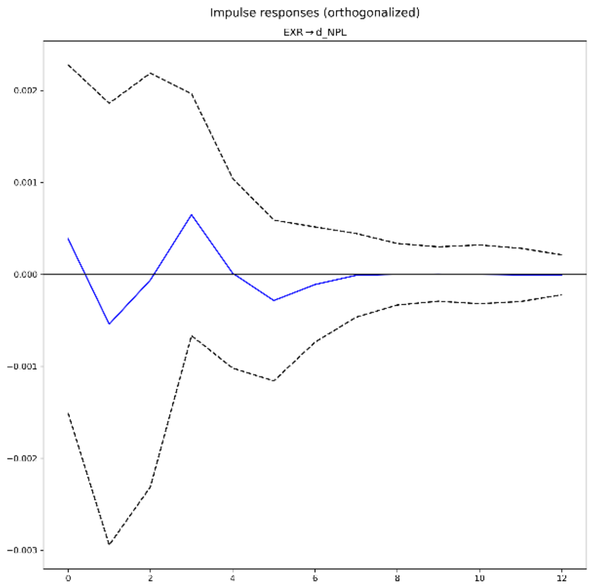



Impulse responses (orthogonalized)
d_policyrate → d_NPL

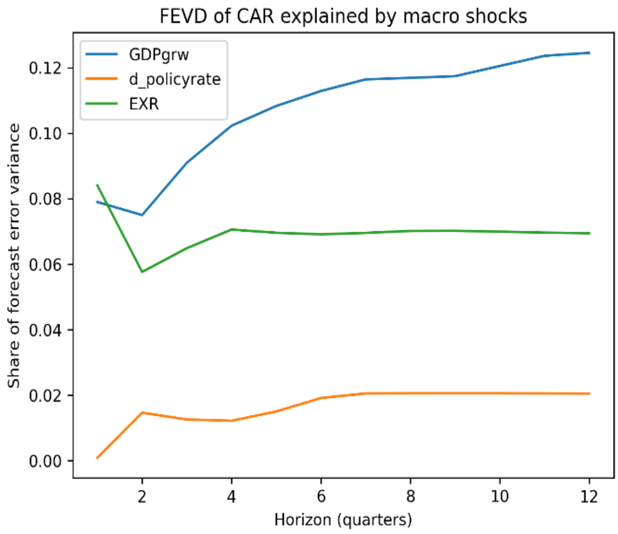

Impulse responses (orthogonalized)
GDPgrw → CAR

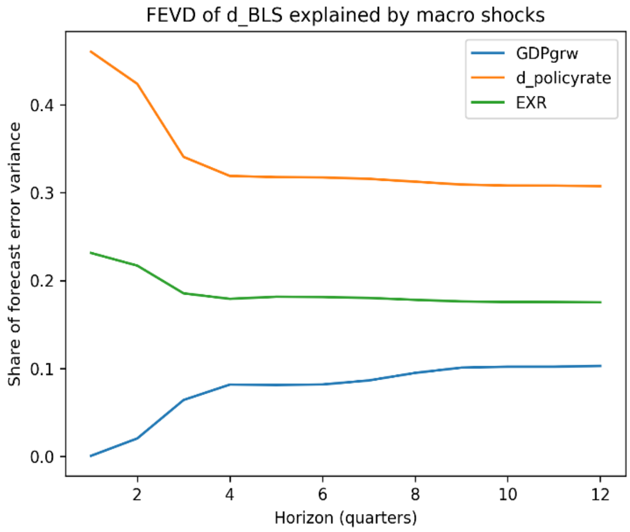

Impulse responses (orthogonalized)
EXR → CAR

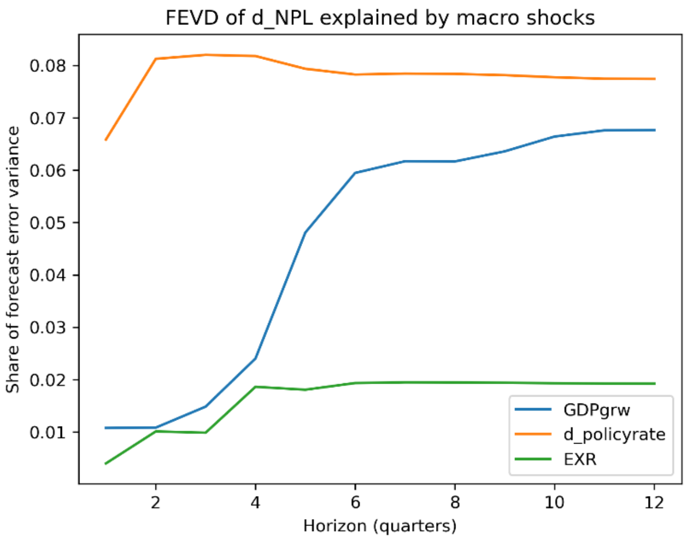

Impulse responses (orthogonalized)
EXR → d_BLS


Impulse responses (orthogonalized)
EXR → d_NPL

Appendix B. Forecast Error Variance Decomposition results

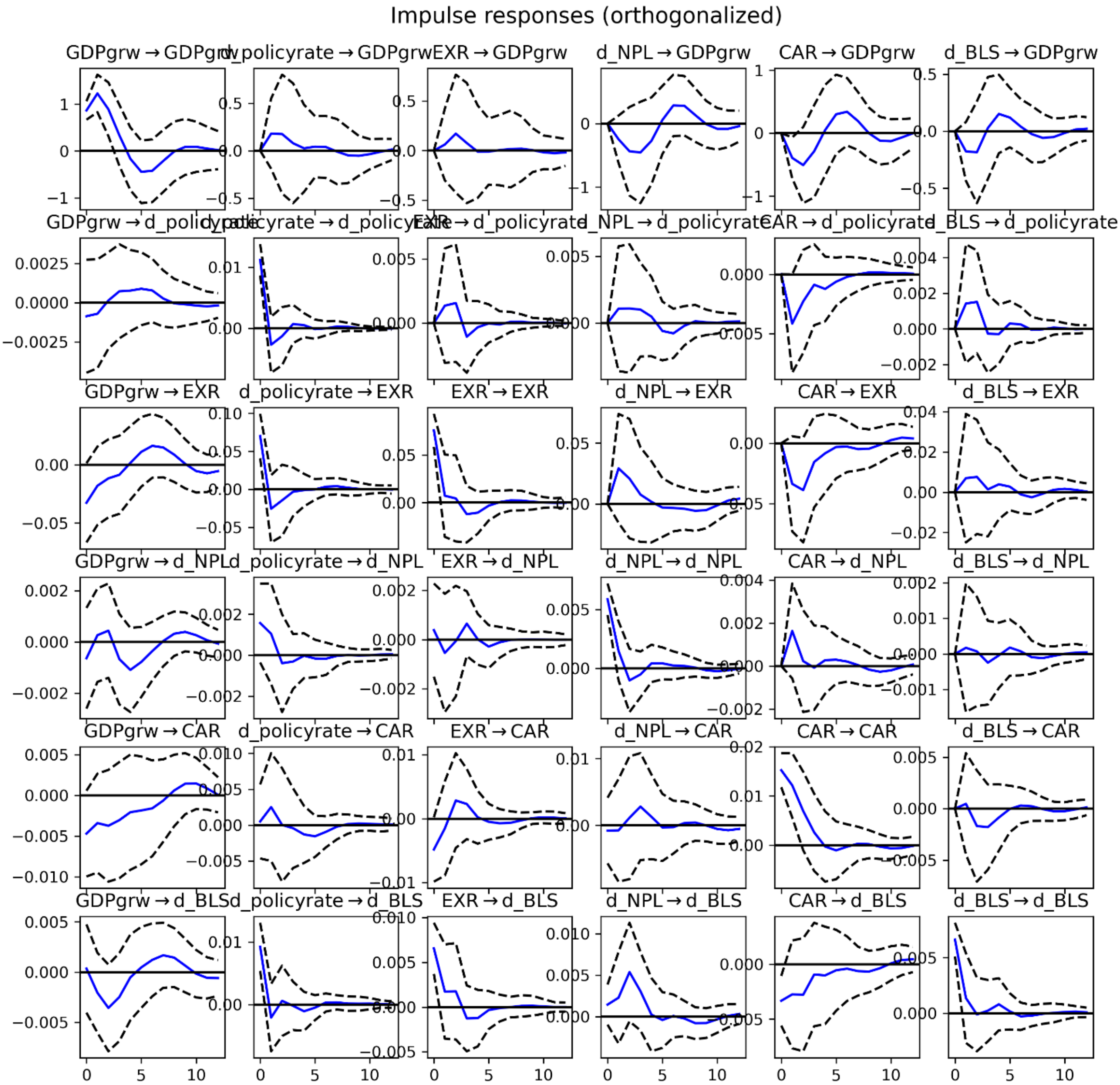






This appendix reports the forecast error variance decomposition results discussed in Section 4.3 of the paper.

Appendix C. Full set of Impulse Response Functions



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