Semestre Económico (Puno-Perú)
Vol. 15, No. 2, Months: July-December, 2026
ISSN: 2072-0572 (Print version) | 2523-0840 (Digital version)
DOI. 10.26867/se.2026.v15i2.320, pp. 27-44
http://semestreeconomico.unap.edu.pe/index.php/revista/index

ORIGINAL ARTICLE

Effects of Macroprudential Policy Shocks on Macroeconomic and Financial Stability in Peru: An SVAR Analysis

Efectos de los choques de política macroprudencial sobre la estabilidad macroeconómica y financiera del Perú: un análisis SVAR

Cristian Rodrigo Vilca Mamani[*†] y Marcel Edgard Huaclla Gómez[*‡]

†Universidad Nacional del Altiplano, Puno, Perú; ORCID: 0009-0009-2512-6068
‡Universidad Nacional del Altiplano, Puno, Perú; ORCID: 0000-0003-4184-8852
*Correspondence to email: lockerodrigo@gmail.com; mehuaclla@hotmail.com

(Received November 16, 2025; accepted May 31, 2026)

Abstract

While empirical literature on macroprudential policy exists for both advanced and emerging economies, studies that simultaneously analyze its effects on macroeconomic and financial variables within the Peruvian context are scarce, limiting the availability of evidence for the design of public policies aimed at preserving national financial system stability. This study seeked to fill that gap by analyzing the effects of macroprudential policy on the preservation of macroeconomic and financial stability in Peru over the period 2003–2022, using monthly data. The policy tools evaluated are the global capital ratio and the reserve requirement; the stability variables considered include credit, asset prices, capital flows, liquidity, gross domestic product, inflation, and the exchange rate. Following a quantitative approach, a Structural Vector Autoregression econometric model was employed. The results suggest that the global capital ratio reduces credit, while the reserve requirement helps maintain liquidity in the banking system. From a financial stability perspective, these contractionary effects on credit and capital flows are desirable, as they reflect the capacity of these instruments to moderate the accumulation of systemic vulnerabilities. Additionally, favorable effects on asset prices were found, along with more moderate effects on GDP containment, CPI stability, and exchange rate control. Overall, the results indicate that macroprudential policies contribute positively to safeguarding the financial system and maintaining macroeconomic stability in Peru.

Keywords: Financial and Macroeconomic stability, Macroprudential policy, SVAR.
JEL Classification: E44

Resumen

Si bien existe literatura empírica sobre política macroprudencial en economías avanzadas y emergentes, los estudios que analizan simultáneamente sus efectos sobre variables macroeconómicas y financieras en el contexto peruano son escasos, lo que limita la disponibilidad de evidencia para el diseño de políticas públicas orientadas a la estabilidad del sistema financiero nacional. Esta investigación tuvo como propósito cubrir ese vacío, analizando los efectos de la política macroprudencial en la preservación de la estabilidad macroeconómica y financiera del Perú para el periodo 2003-2022, con periodicidad mensual. Las herramientas de política evaluadas son el ratio de capital global y el requerimiento de reserva; y las variables de estabilidad consideradas

incluyen el crédito, el precio de los activos, los flujos de capital, la liquidez, el producto bruto interno, la inflación y el tipo de cambio. Siguiendo un enfoque cuantitativo, se empleó el modelo econométrico de vectores autorregresivos estructurales. Los resultados muestran que el ratio de capital global reduce el crédito, mientras que el requerimiento de reserva contribuye a mantener la liquidez en los bancos. Desde una perspectiva de estabilidad financiera, estos efectos contractivos sobre el crédito y los flujos de capital son deseables, pues muestran la capacidad de dichas herramientas para moderar la acumulación de vulnerabilidades sistémicas. Asimismo, se encontraron efectos favorables sobre el precio de los activos y efectos más moderados en la contención del PBI, la estabilidad del IPC y el control del tipo de cambio. En general, los resultados indican que las políticas macroprudenciales contribuyen positivamente a salvaguardar el sistema financiero y a mantener la estabilidad macroeconómica en el Perú.

Palabras clave: Estabilidad macroeconómica y financiera, Política macroprudencial, SVAR.
Clasificación JEL: E44

1. Introduction

In crisis events and economic crisis risk scenarios, emerging economies are particularly vulnerable to adverse effects, which highlights the importance of macroprudential policies in preventing crises and containing risks developing within the financial sector, thereby mitigating their impact on the real economy. The turning point in the formalization of these policies was the international financial crisis of 2008. The Basel Committee suggested that financial regulation needed to adopt a systemic macroeconomic perspective, and it was the 2008 crisis that exposed the limitations of microprudential regulation in containing systemic risk. The repercussions of the crisis made evident that financial instability has significant negative effects on macroeconomic variables, which prompted central banks to reconsider their objectives and establish financial stability committees through the adoption of the Basel III regulatory framework (Smets, 2014; Ntwaepelo, 2021).

The objective of macroprudential policies is to contribute to the stability of the financial system and prevent the buildup of systemic risk, considering all entities within the financial system and their interactions Beyer et al. (2017), thereby limiting risk episodes that generate significant losses in terms of real output (Borio, 2003). To fulfill this objective, macroprudential policy employs capital-, asset-, and liquidity-based instruments (IMF et al., 2016). Its justification lies in the financial system's tendency to amplify adverse aggregate shocks: the financial system behaves procyclically, expanding credit during boom phases and contracting it during recessions, which amplifies fluctuations in the economic cycle. This occurs through the financial accelerator, whereby changes in agents' balance sheets expand credit conditions and increase the system's vulnerability to idiosyncratic shocks (Nier et al., 2013). In this sense, macroprudential policy seeks to contain systemic vulnerabilities that can spread to financial and macroeconomic variables by controlling structural risks (IMF et al., 2009). In the Peruvian case, its relevance stems from specific risks such as credit risk, liquidity risk, exchange rate fluctuations, asset price variations, capital flow volatility, and exposure to externalities.

Systemic risk has a cross-sectional dimension, associated with the spread of risk among interconnected institutions, and a temporal dimension, linked to the procyclical accumulation of vulnerabilities throughout the financial cycle. Financial stability refers to the system's capacity to allocate resources, manage risks, and absorb shocks without disruptions to the provision of financial services (Schinasi, 2006). Macroprudential policy reduces systemic risk by limiting interconnectedness among financial institutions and by attenuating the financial accelerator, reducing procyclicality between credit and asset prices and containing unsustainable increases in leverage (Davoodi et al., 2021).

The effects of macroprudential policy on macroeconomic variables operate through specific transmission channels, which prevents these effects from being interpreted as direct relationships. For example, a tightening of the global capital ratio does not reduce GDP immediately; rather, it acts on intermediate variables: banks react to higher capital requirements by widening lending margins, retaining earnings, reducing risk-weighted assets, or restricting credit to the private sector, which

increases the cost and reduces the supply of credit and, consequently, affects consumption and investment decisions that determine economic activity (Estrada & Mencía, 2021). Similarly, the reserve requirement operates as an implicit cost on financial intermediation that is transmitted to the loan market by modifying interest rates and credit and liquidity volumes (Cantú et al., 2024). This logic is consistent with modern macrofinancial approaches: the dynamic stochastic general equilibrium (DSGE) model of a small open economy proposed by Rojaz (2017), based on García-Cicco et al. (2014), incorporates financial frictions which constitute precisely the mechanisms through which prudential tools propagate their effects to the real sector. These models also justify the causality assumption underlying the present study: macroprudential policy conditions the behavior of credit and other variables, an assumption that is tested empirically through Granger causality tests and the imposition of structural restrictions in the SVAR model.

The effects of macroprudential policies on macroeconomic and financial stability have been studied by numerous authors. Regarding the magnitude of effects on credit and output, Ampudia et al. (2021) found that restrictive measures, such as the loan-to-value ratio and capital requirements, generate significant and persistent effects in reducing credit and economic growth; however, Belkhir et al. (2020) found that a higher macroprudential policy index reduces the probability of banking crises, and its impact on economic growth is moderate, suggesting that the severity of the trade-off between stability and growth depends on the policy instrument. A contradiction arises with respect to output: while Kim & Mehrotra (2019) showed that asset- and liability-based instruments negatively affect investment and credit, Ntwaepelo (2021), analyzing BRICS economies using a panel VAR that models transmission channels, found that a contractionary macroprudential shock reduces credit and housing prices but increases output and does not affect inflation, which contrasts with the notion of an unambiguous cost to economic activity. Regarding the exchange rate and capital flows, Çelik & Binatlı (2022) showed that reserve requirements reduce exchange rate volatility in high-uncertainty environments, while Epure et al. (2017) found that restrictive policies decrease foreign currency credit and increase domestic currency credit, and Başkaya et al. (2024) documented that these policies slow capital inflows in emerging economies. Cantú et al. (2024) and Bortz (2023) highlighted the role of reserve requirements in sustaining liquidity and containing credit. These differing results reveal that the effects of macroprudential policy are sensitive to the level of financial development, institutional design, and the methodology employed, which justifies economy-specific analysis.

In the Peruvian case, the evidence points to the effectiveness of prudential instruments: Choy & Chang (2014) analyzed the main policies implemented in Peru and highlighted the solid institutional framework of the Central Reserve Bank of Peru (BCRP) and the Superintendency of Banking, Insurance and Pension Funds (SBS) in following Basel Committee recommendations, noting that countercyclical provisions mitigated the relationship between credit growth and economic cycles, while reserve requirements served to control liquidity, credit growth, and interest rate volatility, reducing the destabilizing impact of capital flows and exchange rate risk. Ribeiro (2014) and Valenzuela (2019) provided evidence that capital requirements and countercyclical provisions reduce credit volatility and promote macrofinancial stability. Salinas (2021), for his part, evaluated dynamic provisions and the reserve requirement using panel data for the 2002–2019 period, finding that both tools are effective in reducing credit growth, that the reserve requirement acts more rapidly to mitigate its procyclicality, and that foreign currency reserves are oriented primarily toward smoothing exchange rate fluctuations; he further concluded that the timing of the application of these policies is crucial to their effectiveness. However, this literature has focused on the analysis of credit volatility and has relied predominantly on panel models, leaving room for the simultaneous study of the dynamic effects of prudential shocks on a broad set of macroeconomic and financial variables through structural models — a gap that the present study seeks to fill.

In Peru, macroprudential policies aim to regulate credit in the financial sector and have a constitutional legal mandate oriented toward financial stability, although without explicitly establishing it as a macroprudential objective in the strict sense, which may limit its scope and coordination with other

economic policy instruments (Claessens et al., 2013). According to data from the BCRP, during the 2003–2022 period the country recorded average GDP growth of 4.59%; however, this performance should be interpreted with caution, given that part of this growth coincided with a favorable commodity price cycle and loose international financial conditions — exogenous factors that macroprudential policy cannot control (Cerutti et al., 2016). Since the adoption of the inflation targeting framework, the CPI averaged 3.165%, although the literature warns that the interaction between monetary and macroprudential policy can generate tensions when both operate simultaneously on variables such as credit and the exchange rate in partially dollarized economies (Agénor & Pereira Da Silva, 2016). The stock market index grew by an average of 13.94% and domestic currency credit by an average of 20% per year; however, sustained credit growth rates above 15% are typically associated with the accumulation of systemic vulnerabilities and constitute early warning signals of potential financial imbalances (Drehmann & Tarashev, 2011), introducing a tension between the observed credit dynamism and the containment objectives of macroprudential policy. Finally, while exchange rate stability and the accumulation of international reserves reflect prudent macroeconomic management, in economies with high financial dollarization exchange rate stability can generate incentives for excessive risk-taking in foreign currency — precisely the type of vulnerability that macroprudential policies seek to mitigate (Fernández et al., 2015).

The present study seeks to answer the following research question: What are the effects of macroprudential policy shocks on the macroeconomic and financial stability of Peru during the 2003–2022 period? On this basis, the objective of this research is to analyze the effects of macroprudential policy shocks on macroeconomic and financial stability. Emphasis is placed on two prudential tools: capital-based instruments (the global capital ratio) and liquidity-based instruments (the reserve requirement). The effects of shocks from these policies are analyzed, given that their primary role is to contain excessive credit growth in the Peruvian banking system, as well as their effects on capital flows, asset prices, and liquidity. Additionally, the indirect effects of these policies on GDP, inflation, and the exchange rate are examined. To achieve this objective, a quantitative approach is followed using the structural autoregressive vector (SVAR) econometric model.

2. Method and variables

The research adopts a quantitative approach, grounded in the analysis of measurable and verifiable data, with a non-experimental and longitudinal design based on the analysis of variables over time. The scope is explanatory-causal, oriented toward analyzing the effects of macroprudential policy shocks on macroeconomic and financial stability variables (Hernández et al., 2014). The study considers causality in the Granger sense, which establishes that one variable causes another if its lagged values contain predictive information about the behavior of the second beyond its own past (Hamilton, 1994). For the impulse response functions of the SVAR model to be interpreted causally, it is necessary to impose identification assumptions on the contemporaneous relationships among variables. The present study employs long-run restrictions of the Blanchard-Quah type, which support the theoretical assumption that macroprudential policy instruments do not respond contemporaneously to macroeconomic and financial variables within the same period, given that their institutional adjustment requires implementation time and effect. This assumption is consistent with the transmission channels described in the theoretical framework and with standard practice in the SVAR literature applied to macroprudential policy (Lütkepohl, 2005; Ntwaepelo, 2021). Statistical diagnostic tests are also conducted to verify the validity of the econometric model prior to its economic interpretation. The information used is drawn from bulletins, regulatory norms, resolutions, and databases of the BCRP and the SBS.

The research is conducted at the country level using secondary source data, covering the period from January 2003 to December 2022 at monthly frequency. The macroeconomic variables considered are gross domestic product (GDP), inflation measured by the CPI, and the exchange rate. The financial variables include credit, liquidity, the Lima Stock Exchange index, and short-term net foreign assets as a proxy for capital flows. The macroprudential policy tools evaluated are the global capital ratio

(GCR) and the reserve requirement (RR), analyzed within the SVAR model to interpret the effects of their shocks on macroeconomic and financial stability. Table 1 presents the operationalization of each variable.

The following research hypotheses linking relationships between variables are formulated:

General hypothesis: A contractionary macroprudential policy shock contributes positively to the preservation of macroeconomic and financial stability in Peru during the 2003–2022 period, by containing the systemic vulnerabilities accumulated in the banking system.

Specific hypotheses:

H1: A positive shock to the global capital ratio reduces credit growth in the Peruvian banking system through the channel of increased financing costs, which in turn moderates GDP expansion in the short run, generating a trade-off between financial stability and economic activity.

H2: A positive shock to the reserve requirement increases the cost of financial intermediation, reducing credit supply and short-term capital flows, while preserving liquidity levels in the banking system.

Table 1. Variable operationalization

Variables	Dimension	Indicator
Gross Domestic Product	Gross Domestic Product	Gross Domestic Product Index (base year 2009 = 100)
Inflation	Consumer Price Index	Core Consumer Price Index (base year 2021 = 100)
Tipo de cambio	Real Exchange Rate	Real Bilateral Exchange Rate Index (base year 2009 = 100)
Credit	Credit	Credit in millions of soles
Asset Prices	Financial Stock Index	Stock Market Index (base date 30/10/1998 = 100)
Capital Flow	Net external assets of the baking system	Short-term net external assets in millions of soles
Liquidity	Banking system liquidity	Banking system liquidity in millions of soles
Capital Requirements	Capital Adequacy Ratio	Capital requirement rate (percentage)
Reserve Requirements	Reserve Ratio	Reserve requirement rate (percentage)

Source: own elaboration

3. Econometric methodology

The preliminary steps for estimating the SVAR model first involve verifying the non-stationarity of the series, given the use of monthly frequency data. Subsequently, unit root tests are conducted to determine whether the series are integrated of order one. A traditional VAR model is then estimated to verify the optimal lag structure, model stability, and absence of autocorrelation in the residuals. Finally, the SVAR model is estimated, and the impulse response functions are interpreted based on the results.

The analysis employs the X-13ARIMA-SEATS method to seasonally adjust the time series, removing seasonal components while preserving the essential properties of the series, including outliers, transformation specifications, and historical data (Census-Bureau, 2024). Additionally, the variables are log-transformed to linearize nonlinear relationships and stabilize variance, using the formula $\ln x_t = \log(x_t)$ (Hamilton, 1994). Subsequently, first differences are calculated to ensure stationarity: $\Delta x_t = \ln x_t - \ln x_{t-1}$, in cases where the series are not stationary in levels.

Stationarity tests: to assess the stationarity of the variables, unit root tests are necessary. The Augmented Dickey-Fuller test (1979) and the Phillips-Perron test (1988) are applied, with the null hypothesis H_0 indicating the presence of a unit root, and the alternative hypothesis H_1 indicating

stationarity. The goal is to reject the null hypothesis by evaluating the relevant test coefficients (Hamilton, 1994).

The Granger (1969) causality test determines whether a variable contains predictive information about another beyond its own past. A variable y is said to Granger-cause x if its lagged values significantly improve the prediction of x, controlling for the effect of x's own lags. For its estimation, an autoregressive model of order p is specified whose coefficients are obtained by ordinary least squares (Hamilton, 1994).

$$x_1 = c_1 + \alpha_1 x_{t-1} + \cdots + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \cdots + \beta_p y_{t-p} + \mu_t$$

If s_1 is greater than the 1%, 5% and 10% critical values for the $F(p, T-2p-1)$ distribution, then we reject the null hypothesis H_0, which states that y does not Granger-cause x.

$$s_1 = \frac{(RSS_0 - RSS_1)/p}{RSS_1/(T-2p-1)}$$

Optimal Lag Selection: Determining the appropriate lag order p in a VAR model is essential; therefore, the likelihood ratio (LR) statistic is used for this purpose (Lütkepohl, 2005).

$$\lambda_{LR} = n\left[\ln\left|\tilde{\Sigma}_u^r\right| - \ln\left|\tilde{\Sigma}_u\right|\right] \; ; \qquad \lambda_{LR} \xrightarrow{d} \chi^2(N)$$

The magnitude of the loss in likelihood is assessed when transitioning from the unrestricted model to the restricted one.

Subsequently, the optimal lag order p is selected using information criteria such as the Akaike Information Criterion (AIC), the Hannan-Quinn Criterion (HQ), and the Schwarz Criterion (SC).

Model stability: The stability of a VAR model is verified using the characteristic root test. The model is considered stable if the roots of the associated characteristic polynomial have moduli less than one and lie within the unit circle in the complex plane (Hamilton, 1994). Therefore, the process is stable if the following condition is satisfied.

$$\det(I_k - A_1 z - A_2 z^2 - \cdots - A_p z^p) \neq 0 \qquad \text{para} \qquad |z| \leq 1$$

Autocorrelation test: Autocorrelation is tested using the Portmanteau test and the Lagrange Multiplier (LM) test. These tests are essential to verify whether the residuals are consistent with white noise—that is, whether they represent a non-predictable and purely random series.

3.1 Structural VAR

The Structural Vector Autoregressive (SVAR) model, originally developed by (Sims, 1980) and extended by (Bernanke, 1986) and (Blanchard & Watson, 1986), allows for the incorporation of restrictions to analyze the dynamics of contemporaneous relationships among variables. The SVAR model is presented in a stationary and stable form, using a system of equations in which the residuals are uncorrelated, and the specification of the relationships among variables is modified to interpret unexpected changes or shocks (Lütkepohl, 2005).

The present study adopts long-run restrictions of the (Blanchard & Quah, 1987) type, whose theoretical justification lies in the fact that macroprudential policy instruments do not generate permanent effects on real variables such as GDP, given that in the long run economic activity returns to its equilibrium path determined by structural factors. Likewise, from an institutional perspective, these instruments are not adjusted contemporaneously in response to macroeconomic and financial variables within the same period, since their implementation and effect require decision time, regulatory adoption, and transmission through the banking system. This assumption is consistent with the logic of the macroprudential policy transmission channels described in the theoretical framework and with

standard practice in the SVAR literature applied to macroprudential policy in emerging economies (Ntwaepelo, 2021).

The SVAR model is represented as follows:

$$\gamma_t = A_1\gamma_{t-1} + \cdots + A_pY_{t-p} + \mu_t$$

Where μ_t is a vector of structural error terms, and the coefficients in the matrices $A_1, \ldots, A_p$ capture the effects of the lags.

The process follows two simultaneous restrictions: first, that the residuals are not correlated with one another; and second, that the specifications of the structural relationships among the directly observed variables allow for the correct interpretation of unexpected shocks. These restrictions ensure that the impulse response functions reflect consistent changes. Thus, we have the following:

$$A\mu_t = B\varepsilon_{t'} \qquad \varepsilon_t \sim N(0, I)$$

A simultaneous equation is formulated for the reduced-form errors, rather than for the directly observed variables. This approach is used to specify the relationships between the observable variables and the innovations or shocks (Lütkepohl, 2005). Here, A and B are coefficient matrices, and ε_t represents a vector of Gaussian innovations. For this system, the reduced-form error model is expressed as follows:

$$\mu_t = A^{-1}B_{\varepsilon_t}\ ; \Sigma_\mu = A^{-1}BB'A^{-1'}\ ; vech(\Sigma_\mu) = vech(A^{-1}BB'A^{-1'})$$

This system defines $K(K+1)/2$ equations through the use of the "*vech*" function, which vectorizes the covariance matrix of μ_t under restrictions. The matrices A and B require additional restrictions to be identifiable: since each matrix contains K^2 elements, a total of $2K^2 - \frac{1}{2}K(K+1)$ restrictions must be imposed in order to determine all elements of these two matrices (Lütkepohl, 2005).

3.2 Estimation of structural VAR

The following SVAR model is specified:

$$A_{\gamma_t} = AAY_{t-1} + B_{\varepsilon_t}$$

Where $Y'_{t-1} = [\gamma'_{t-1}, \ldots, \gamma'_{t-p}]$, $A = [A_1, \ldots, A_p]$, and ε_t is assumed to be a Gaussian process with covariance matrix I_K, that is, $\varepsilon_t \sim N(0, I_K)$. The normality assumption is employed for the derivation of estimators. The reduced form of the model is expressed as $\mu_t = A^{-1}B_{\varepsilon_t}$.

The SVAR model is estimated by maximizing the likelihood function subject to structural restrictions on the matrices. We assume no restrictions on the reduced form for parameter A. Then we have the function $lnl(A, A, B,)$ it is maximized with respect to A through $\hat{A} = YX'(XX')^{-1}$ (Lütkepohl, 2005). The likelihood function to be maximized is:

$$lnl_c(A, B) = constant + \frac{T}{2}\ln|A|^2 - \frac{T}{2}\ln|B|^2 - \frac{T}{2}tr(A'B'^{-1}B^{-1}A\tilde{\Sigma}_\mu)$$

Where $\tilde{\Sigma}_\mu = T^{-1}(Y - \hat{A}X)(Y - \hat{A}X)'$. The matrices A and B are estimated using maximum likelihood subject to structural restrictions.

Blanchard-quah long-term restriction

Imposing restrictions on matrices A and B does not necessarily imply a structural break. In this regard, Blanchard & Quah (1987) identify the permanent effects of shocks. Their approach imposes zero restrictions on selected elements of the accumulated impulse response matrix, assuming that some shocks have no long-term effects (Lütkepohl, 2005). This is represented as:

$$\Xi_\infty = \sum_{i=0}^{\infty} \Theta_i = (I_K - A_1 - \cdots - A_p)^{-1} A^{-1} B$$

Estimation of Blanchard-quah long-term restriction

If the total impact matrix Ξ_∞ is restricted to be a lower triangular matrix of the Blanchard-Quah (1989) type, and assuming $A = I_K$, then using the relationship: $\Xi_\infty = (I_K - A_1 - \cdots - A_p)^{-1} B$, the estimation proceeds as follows:

$$\Xi_\infty \Xi_\infty = (I_K - A_1 - \cdots - A_p)^{-1} \tilde{\Sigma}_\mu ((I_K - \hat{A}_1' - \cdots - \hat{A}_p')^{-1})$$

Matrix B is then obtained through Cholesky decomposition of the covariance matrix of the residuals. This procedure is valid as long as the VAR process is stable and stationary (Lütkepohl, 2005).

Impulse-response function and variance decomposition

Impulse-response analysis is based on structural changes and examines the dynamic effects of structural shocks on the system's variables (Lütkepohl, 2005):

$$\Theta_j = \Phi_j A^{-1} B, \qquad j = 0, 1, 2, \ldots$$

3.3 SVAR model specification

The SVAR model follows the estimation of the matrix through maximum likelihood, guaranteeing the stability and stationarity of the model. It represents macroprudential policy, operationalized through two tools: the global capital ratio and the reserve requirement.

The recursive structure of the matrix is not an arbitrary choice, but rather responds to precise theoretical foundations. The ordering of the variables follows a logic of contemporaneous causality grounded in the transmission channels of macroprudential policy: the policy instruments are placed first in the system because, institutionally, they do not react contemporaneously to financial and macroeconomic variables within the same period, given that their adjustment requires regulatory decision-making and implementation time (Blanchard & Quah, 1987). The financial variables are placed immediately after macroprudential policy, as they constitute the intermediate channel through which prudential shocks propagate toward the real sector. Finally, the macroeconomic variables are ordered at the end of the system, reflecting the fact that they respond with a greater lag to policy shocks, in accordance with the empirical evidence for emerging economies (Ntwaepelo, 2021; Ampudia et al., 2021).. Without this theoretical grounding in the ordering, the impulse response functions would lack economic validity and would be limited to a merely statistical interpretation.

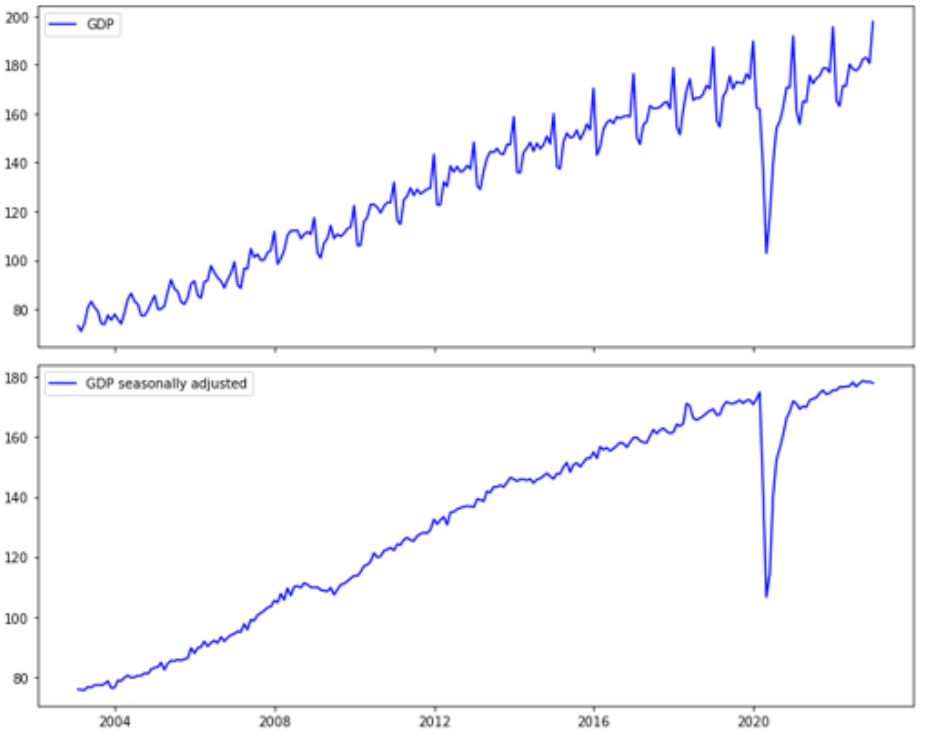
$$A_0 = \begin{pmatrix} \alpha_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & 0 & 0 & 0 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & 0 & 0 & 0 & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & 0 & 0 & 0 \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} & 0 & 0 \\ \alpha_{71} & \alpha_{72} & \alpha_{73} & \alpha_{74} & \alpha_{75} & \alpha_{76} & \alpha_{77} & 0 \\ \alpha_{81} & \alpha_{82} & \alpha_{83} & \alpha_{84} & \alpha_{85} & \alpha_{86} & \alpha_{87} & \alpha_{88} \end{pmatrix} \begin{pmatrix} MP_t \\ Cred_t \\ AP_t \\ CF_t \\ Liq_t \\ GDP_t \\ CPI_t \\ ER_t \end{pmatrix} = \begin{pmatrix} \varepsilon_{MP,t} \\ \varepsilon_{Cred,t} \\ \varepsilon_{AP,t} \\ \varepsilon_{CF,t} \\ \varepsilon_{Liq,t} \\ \varepsilon_{GDP,t} \\ \varepsilon_{CPI,t} \\ \varepsilon_{ER,t} \end{pmatrix}$$

4. Results

Only the GDP series has its seasonal component removed using the CENSUS X-13 method, as shown in Figure 1. Additionally, a sharp decline is observed during the 2020 period, which distorts the trend of the series; therefore, an average is calculated for the months of April and May.

Subsequently, all series are transformed into logarithmic form, except for the prudential tools, which are expressed as percentage rates. Unit root tests are then conducted, and in cases where the

Figure 1. GDP and seasonally adjusted GDP 2003 – 2022.



Source: own elaboration

series exhibit a unit root, first differencing is applied to enable the estimation of the Structural VAR models. For the Granger causality tests, the analysis is performed using the logarithmic form of the variables, which facilitates the definition of the three models to be estimated. Finally, the SVAR models are estimated, and the impulse response functions are interpreted to fulfill the objective of the research.

4.1 Stationarity test results

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, considering only the intercept term, as some variables were transformed into logarithms while others are expressed in percentage rates. For the decision rule, the following hypotheses were considered: H_0: the time series has a unit root (non-stationary), H_1: the time series does not have a unit root (stationary).

According to Table 2, all variables—GDP, CPI, exchange rate, credit, asset prices, capital flows, liquidity, capital adequacy ratio (CAR), and reserve requirements—are integrated of order one, I(1). This indicates that they become stationary after first differencing, which allows for the inclusion of their first differences in the econometric model. In the case of the loan-to-value (LTV) ratio, since its values are binary (0 and 1), the unit root test was not applied, and the variable is included directly in the model.

4.2 Granger causality test results

The Granger causality test was conducted, taking into account the logarithmic transformations of the variables. The analysis focused on macroprudential policy tools in relation to key indicators of

Table 2. Prueba de raíz unitaria

Time series	Augmented Dickey-Fuller		Phillips-Perron	
	ADF – Level	ADF – 1st Diff.	PP – Level	PP – 1st Diff.
Gross domestic droduct (GDP)	-1.58	-17.37***	-1.82	-17.69***
Inflation (CPI)	1.74	-11.25***	1.44	- 11.79***
Exchange rate (ER)	-1.56*	-12.05***	-1.50*	-12.01***
Credit (Cred)	-1.79	-5.25***	-2.25	-10.94***
Asset prices (AP)	-2.44*	-14.65***	-2.35*	-14.77***
Capital flow (CF)	-3.28**	-12.44***	-2.73	-12.71***
Liquidity (Liq)	-2.23	-13.61***	-1.87	-14.01***
Capital adequacy ratio (CAR)	-2.03	-15.32***	-1.78	-15.74***
Reserve requirements (RR)	-2.09	-5.08***	-1.64	-13.27***

Note: t-statistic (t), p-value (p), critical values at 1%***, 5%** and 10%*, own elaboration

macroeconomic and financial stability. The results are summarized as follows: when estimating with one lag, it was found that the capital adequacy ratio Granger-causes credit, the consumer price index, and the exchange rate at the 5% significance level; additionally, Granger causality was observed toward capital flows and gross domestic product at the 10% significance level. These findings support the specification of SVAR for the first policy tool. Moreover, considering lags of one and two periods, it was identified that reserve requirements Granger-cause credit, capital flows, asset prices, and liquidity, all at the 5% significance level, which justifies the specification of SVAR for the second policy tool.

4.3 SVAR Model Estimation by Macroprudential Instrument

In the first model, we consider the prudential instrument of the capital adequacy ratio in relation to credit, capital flow, consumer price index, gross domestic product, exchange rate. We follow the Akaike Information Criterion, which suggests the use of two lags. A dummy variable is included for error correction. The Portmanteau test for 3 lags yields a p-value of 0.1419, which allows us to reject the hypothesis of autocorrelation in the residuals. Furthermore, the Lagrange Multiplier (LM) test for 3 lags shows a p-value of 0.8131, indicating the null hypothesis of serial correlation in the residuals can be rejected. The characteristic roots lie within the unit circle, thereby ensuring model stability.

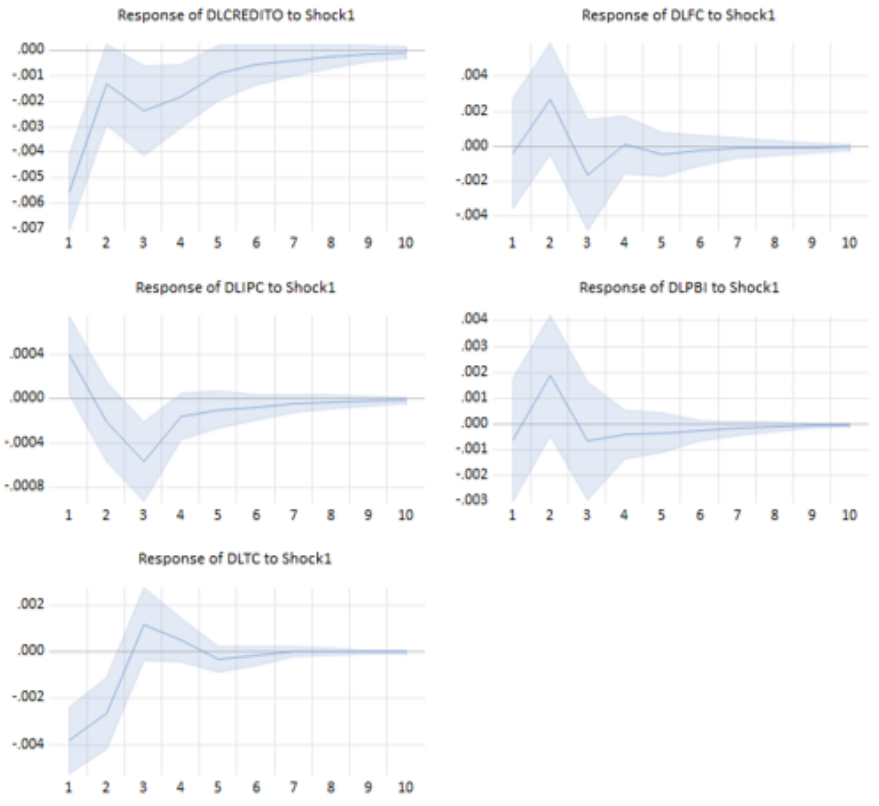
In the second model, the prudential instrument of reserve requirements is analyzed with respect to credit, capital flow, asset prices, and liquidity. According to the Hannan–Quinn criterion, the model should include one lag. A dummy variable is also included for error correction. The Portmanteau test for 2 lags yields a p-value of 0.1174, which allows us to reject the null hypothesis of residual autocorrelation. Similarly, the LM test for 2 lags returns a p-value of 0.3384, indicating that the null hypothesis of serial correlation in the residuals can be rejected. The characteristic roots are all less than one and lie within the unit circle, ensuring the stability of the model.

4.4 Effects of macroprudential policy shocks

The effects of the global capital ratio shock (Shock 1) on credit (DLCREDIT), capital flows (DLCF), consumer price index (DLCPI), gross domestic product (DLGDP), and exchange rate (DLER) are presented in Figure 2 through impulse-response functions with 95% confidence bands.

Regarding credit, the global capital ratio shock generates a negative, statistically significant, and persistent effect on credit throughout the analyzed horizon. In the short run, the maximum impact occurs in the third period with a value of -0.005538, and the 95% confidence bands confirm the statistical significance of the contractionary effect. This result is consistent with the capital-based transmission channel: faced with higher effective equity requirements as a percentage of risk-weighted assets, banks reduce their credit supply, increase the cost of credit through higher lending rates, and compress deposit rates. In the long run, the impact is transitory and does not permanently alter the long-run credit level.

Figure 2. Impulse-response function of capital adequacy ratio



Source: own elaboration

Regarding the Consumer Price Index, the effect of the shock on inflation is mixed throughout the horizon. In the short run, the initial impact is positive (0.000397 in period 1), although it is not statistically significant. This result could be explained by the transitory increase in financing costs that agents pass through to prices. From the second period onward, the effect turns negative and statistically significant until the fourth period, as the credit contraction reduces the consumption and investment incentives of households and firms, compressing aggregate demand and, with it, inflationary pressures. In the long run, macroprudential policy plays a moderating role that complements but does not substitute monetary policy.

Regarding Gross Domestic Product, the effect of the shock on GDP is mixed. In the short run, the first impact is negative (-0.000622 in period 1), although it is not statistically significant. The second period shows a positive rebound (0.001866) that is also not significant. Nevertheless, the direction of the first impact is theoretically consistent with the transmission channel: the credit contraction reduces investment and consumption, negatively affecting economic activity in the short run. In the long run, the effect converges to zero, which is consistent with the assumption of long-run neutrality of macroprudential policy on real output that underpins the model's identification restrictions.

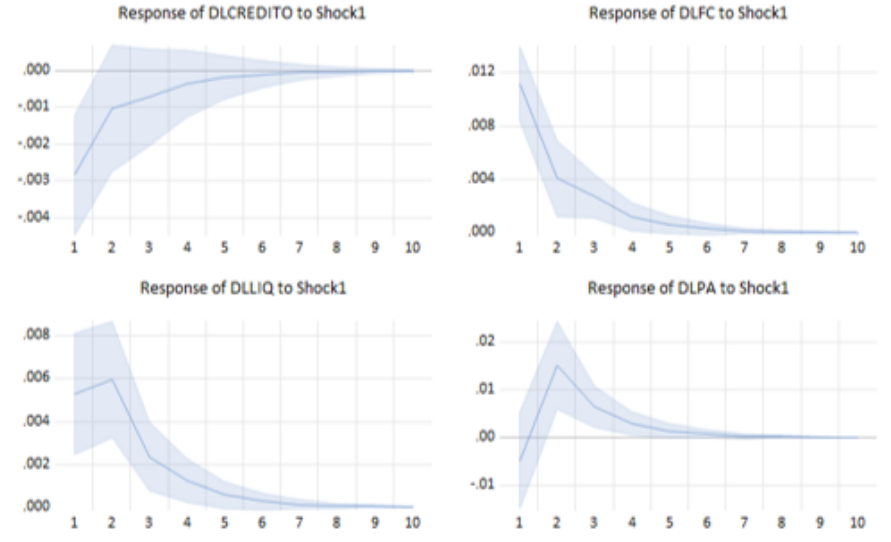
Regarding capital flows, the response of capital flows to the shock is mixed, with confidence bands crossing zero in several periods, indicating that some effects are not statistically significant. The initial impact is negative (-0.000412 in period 1), followed by a significant positive rebound in the second period (0.002732), with confidence bands above zero. This dynamic reflects that, in the short run, the tightening of the capital ratio increases the perception of soundness of the Peruvian banking system,

transiently attracting foreign capital; however, the reduction in bank profitability derived from higher capital requirements discourages short-term flows in subsequent periods, as they seek higher returns in other markets.

Finally, regarding the exchange rate, the shock generates an initial negative effect on the exchange rate (-0.003823 in period 1), statistically significant during the first two periods. This short-run exchange rate appreciation is consistent with the reduction in foreign currency demand derived from the credit contraction, which decreases imports and, therefore, the pressure on the exchange rate. From the third period onward, the effect turns positive although not significant, reflecting the gradual normalization of credit demand and imports.

The effects of the reserve requirement shock (Shock 1) on credit (DLCREDIT), capital flows (DLCF), liquidity (DLLIQ), and asset prices (DLAP) are presented in Figure 3 through impulse-response functions with 95% confidence bands.

Figure 3. Impulse-response function of reserve requirements



Source: own elaboration

Regarding credit, the reserve requirement shock generates a negative, statistically significant, and persistent effect on credit. In the short run, the largest impact is recorded in the first period (-0.002811), and the 95% confidence bands remain below zero during the first four periods. This result is consistent with the reserve requirement transmission channel: by requiring banks to hold a larger fraction of their deposits as liquid reserves, the implicit cost of financial intermediation increases, which translates into higher lending rates and a reduction in credit supply. From a financial stability perspective, this contraction is desirable as it increases the resilience of the banking system against systemic risk vulnerabilities. In the long run, the effect gradually attenuates and converges to zero from the sixth period onward.

Regarding liquidity, the shock generates a positive, statistically significant, and clearly persistent effect on financial system liquidity throughout the entire analyzed horizon. The largest impact is recorded in the first period (0.005301). This is the direct and expected effect of the reserve requirement: by requiring banks to hold higher liquid reserves relative to their liabilities, the availability of funds to meet short-term obligations is guaranteed, preventing liquidity risk episodes both during expansion and financial stress periods. In the long run, the effect progressively attenuates but remains positive through the tenth period, suggesting a more persistent impact on liquidity than on the remaining

variables, in line with the primary prudential objective of this instrument.

Regarding asset prices, the response of asset prices to the shock presents a two-phase dynamic. In the short run, the initial impact is negative (-0.004842 in period 1), with the 95% confidence bands below zero. This initial decline is consistent with the credit contraction: as available financing decreases, demand for financial and stock market assets falls, depressing their prices. From the second period onward, the effect turns positive and statistically significant through the fourth period, reaching its highest value in the second period (0.014). This recovery reflects that the greater banking solvency derived from the shock reduces the perception of financial system risk, improving the valuation of assets traded in the stock market. In the long run, the effect converges to zero from the sixth period onward.

Finally, regarding capital flows, the shock generates a positive and statistically significant effect on short-term net foreign assets during the first periods. The largest impact is recorded in the first period (0.011192), with the 95% confidence bands completely above zero during the first three periods. An increase in short-term net foreign assets reflects a capital outflow: by requiring banks to hold higher reserves and reduce their credit supply, short-term external financing becomes less attractive for banks, which reduce their exposure to external liabilities. This effect is desirable from a macroprudential perspective, as it mitigates the vulnerability of the financial system to sudden reversals of international capital flows. In the long run, the effect gradually attenuates and converges to zero from the fifth period onward.

5. Discussion

The impulse-response function results from the SVAR for the GCR and the SVAR for the RR reveal that macroprudential policy shocks generate differentiated but complementary effects on Peru's macroeconomic and financial stability variables during the 2003-2022 period. The central and most statistically robust finding is the contractionary effect on credit, present in both models, although with different magnitudes and transmission mechanisms: the global capital ratio generates a larger and more persistent impact than the reserve requirement, suggesting that capital-based instruments exert more intense pressure on credit supply than liquidity-based ones. This distinction between instruments is relevant for policy design, as it implies that their activation must be calibrated according to the type of imbalance to be corrected.

Effects on credit. The contractionary effects on credit are statistically significant in both models during the first periods and are consistent with the empirical literature. Ampudia et al. (2021) document that both capital requirements and other restrictive measures generate significant and persistent contractionary impacts on credit, in line with our results. Similarly, Belkhir et al. (2020) confirm that prudential policies are effective in moderating credit growth, although with a moderate impact on economic growth, which is consistent with the trade-off observed in the first model. In the Peruvian context, Valenzuela (2019) and Salinas (2021) show that both the global capital ratio and the reserve requirement have been effective in reducing credit growth, confirming the external validity of our results. It is worth noting, however, that the magnitude of the contractionary effect on credit observed in the present study is slightly larger than that observed in Salinas (2021) using panel models, which could be attributed to methodological differences between both approaches, tending to underestimate short-run impacts.

Effects on GDP, CPI, and exchange rate. The effects on macroeconomic variables are of smaller magnitude and in several cases statistically non-significant, which is consistent with the indirect nature of their transmission through the credit channel. The initial negative effect on GDP, although not significant, is theoretically consistent with the evidence from Kim & Mehrotra (2019) and Belkhir et al. (2020), who document that restrictive macroprudential policies can reduce economic growth in the short run. However, the finding of Ntwaepelo (2021) for BRICS economies introduces a relevant contradiction with our results, which could be explained by differences in the level of financial development and banking system structure between BRICS economies and Peru. Regarding inflation,

the negative effect from the second period onward is consistent with Çelik & Binatlı (2022), who find a slight price decrease following macroprudential shocks, reinforcing the idea that these policies have a moderating effect on aggregate demand. As for the exchange rate, the short-run appreciation effect of the first model, statistically significant during the first two periods, coincides with the findings of Cantú et al. (2024) and Ribeiro (2014) for the Peruvian case, who document that the reserve requirement contributes to reducing exchange rate volatility. This result is particularly relevant in the context of a partially dollarized economy like Peru, where exchange rate stability is an implicit objective of macroprudential policy (Agénor & Pereira Da Silva, 2016).

Effects on liquidity, asset prices, and capital flows. The positive effect of the reserve requirement on liquidity, with confidence bands above zero during the first five periods and persistence extending through the tenth period, is consistent with Bortz (2023) and Aguirre & Blanco (2015), who document the effectiveness of reserve requirements in maintaining liquidity stability and banking solvency. The greater persistence of the effect on liquidity relative to the other variables suggests that this is the primary transmission channel of the reserve requirement, in line with its institutional design as a liquidity management tool of the BCRP (Choy & Chang, 2014). Regarding asset prices, the results of the second model show a two-phase dynamic that partially differs from Kim & Mehrotra (2019), who document predominantly negative effects of macroprudential policies on asset prices. This difference suggests that the solvency signaling effect of the reserve requirement dominates over the contractionary credit effect in the medium run. Finally, the positive and significant effect on capital flows in the second model is consistent with Başkaya et al. (2024), although with an opposite direction to that observed in the first model, where the global capital ratio shock initially generates a capital inflow. This asymmetry between instruments reveals that capital flows respond differently depending on the type of macroprudential instrument activated, a result that has not been sufficiently explored in the literature for the Peruvian case.

Overall, the results confirm the general hypothesis of the study: macroprudential policy shocks contribute positively to the preservation of macroeconomic and financial stability in Peru. The global capital ratio acts primarily on credit and macroeconomic variables, while the reserve requirement operates fundamentally on liquidity, asset prices, and capital flows, evidencing a complementarity between instruments that reinforces the macroprudential architecture of the BCRP and the SBS. Nevertheless, the effects on GDP and inflation are mostly statistically non-significant, suggesting that Peruvian macroprudential policy operates predominantly on the financial system and exerts indirect and moderate effects on the real sector, in accordance with its institutional design as a complement to monetary policy (Bank for International Settlements, 2022).

6. Conclusions

The effects of macroprudential policy shocks from the global capital ratio and the reserve requirement reveal relevant findings for the management of macroeconomic and financial stability in Peru. Regarding credit, both instruments successfully contain its excessive expansion in the banking system, a desirable effect from a macroprudential perspective, albeit at the cost of a moderate contraction in economic activity as measured by GDP.

Regarding inflation, the results indicate that these policies contribute to maintaining stable inflation levels, suggesting complementarity with conventional monetary policy, although their scope in this area is moderate and should not be interpreted as a substitute for specific monetary instruments. In relation to capital flows and the exchange rate, contractionary effects are observed that reduce short-term capital inflows and contribute to exchange rate stability, which is particularly relevant in a partially dollarized economy such as Peru. Nevertheless, the magnitude of the simulated shocks may not fully reflect episodes of high external financial volatility.

For its part, the reserve requirement shows a positive effect on financial system liquidity, ensuring the sufficiency of funds in the banking sector. Regarding asset prices, both instruments present favorable effects in the capital market, although the magnitude of these effects is heterogeneous across

instruments.

In terms of economic policy implications, the results suggest that the BCRP and the SBS should continue calibrating these instruments in a countercyclical manner, intensifying their use during phases of accelerated credit expansion and easing them during periods of economic contraction. Likewise, coordination between macroprudential and monetary policy is fundamental to avoid counterproductive effects on growth.

Future research should include subsample analysis (pre-2008 crisis, post-crisis, and post-pandemic), the use of Bayesian SVAR models with sign restrictions identification, and the incorporation of the LTV ratio as a macroprudential policy instrument.

Author Contributions

Cristian Rodrigo Vilca Mamani: Investigation, conceptualization, Project administration, validation, visualization, writing-original draft, revision and edition.

Marcel Edgar Huaclla Gomez: conceptualization, methodology, visualization, revision.

Funding

Self-financing.

Conflict of interest

Authors declare that they have no conflict of interest.

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