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MACROECONOMIC SHOCKS AND THE EFFECTIVENESS OF CENTRAL BANKS' INTEREST RATE POLICIES

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Purpose: The aim of the article is to analyze the responses of selected central banks to macroeconomic shocks occurring between 2019 and 2023. The analysis focuses on the use of benchmark interest rates by the central banks of seven countries/groups of countries: Poland, the Eurozone, the USA, Japan, China, Brazil, and India in response to rising inflation triggered by the COVID-19 pandemic and the energy crisis caused by the war in Ukraine.
Design/methodology/approach: The article uses desk research, referencing data published by the central banks of selected countries regarding monetary policy conducted between 2019 and 2023. To analyze the impact of inflation rates and other economic indicators, such as unemployment rates, Lombard rates, deposit rates on benchmark interest rates levels during the study period, a Generalized Method of Moments (GMM) model was applied. This technique was chosen to effectively control for the heterogeneity of unobserved units given the dynamic nature of the dependent variables.
Findings: The article confirms the predictability and caution in the approach to monetary policy, which is crucial for economic stability. The results of the econometric model show strong inertia in the benchmark interest rate, which is typical for the cautious and well-considered decisions of central banks.
Originality/value: The article brings a new perspective to the analysis of monetary policy responses to exogenous shocks in the context of different economies. The results are relevant to both economic theorists and monetary policy practitioners.
Keywords: monetary policy, exogenous shocks, interest rates, central banks, inflation.
Category of the paper: research paper.

1. Introduction

The stability of monetary policy in the face of macroeconomic shocks is crucial for maintaining macroeconomic equilibrium and ensuring financial stability. Exogenous shocks introduce sudden and often unexpected changes in economic conditions, which require central banks to respond quickly and effectively, particularly in adjusting interest rates in response to changing inflation levels.

The years 2019-2023 were a period of significant exogenous shocks. The COVID-19 pandemic triggered a global health and economic crisis, leading to sharp declines in production and employment, and consequently, a deep recession. In response to these challenges, central banks implemented aggressive monetary policy measures, including interest rate cuts and quantitative easing programs aimed at stabilizing the economy (Guerrieri, Lorenzoni, Straub, Werning, 2020). Additionally, the energy crisis caused by the war in Ukraine led to sharp increases in energy prices, which further exacerbated inflationary pressures, forcing central banks to make difficult decisions regarding interest rate hikes to control inflation (Bachmann, Baqaee, Korinek, 2022).

These events had far-reaching impacts on the global economy, affecting inflation and unemployment in many countries. Analyzing the responses of central banks to these shocks is key to understanding how monetary policy can be effectively used to mitigate the negative effects of such events.

The object of the article is to analyze the responses of selected central banks to macroeconomic shocks occurring between 2019 and 2023. The analysis focuses on the use of benchmark interest rates by the central banks of seven countries/groups of countries: Poland, the Eurozone, the USA, Japan, China, Brazil, and India in response to rising inflation triggered by the COVID-19 pandemic and the energy crisis caused by the war in Ukraine. The selection of countries for analysis was based on their significant economic importance and diverse monetary policy strategies, which allowed for a more comprehensive and objective assessment of central banks' responses to exogenous shocks.

To achieve the formulated goal the article uses desk research, referencing monthly data published by the central banks of selected countries regarding monetary policy conducted between 2019 and 2023. To analyze the impact of inflation rates and other economic indicators, such as unemployment rates, Lombard rates, deposit rates on benchmark interest rates levels during the study period, a Generalized Method of Moments (GMM) model was applied. This technique was chosen to effectively control for the heterogeneity of unobserved units given the dynamic nature of the dependent variables.

2. Review of monetary policy of selected central banks during the crisis

The beginning of the current decade worldwide has been characterized by an extraordinary increase in prices. This occurred after years of low price growth and even periods of deflation. The causes of this phenomenon seem obvious. They are, in order:

1. The lifting of restrictions related to the COVID-19 pandemic and the unlocking of consumer demand;
2. The outbreak of the Russia-Ukraine war and the associated increases in commodity prices;

3. Local factors specific to each economy.

Each of these causes has led to the emergence of various types of inflationary phenomena. In particular, the following types of inflation can be distinguished:

- demand-pull inflation, where the cause of price increases is excessive demand relative to supply,
- cost-push inflation, where the cause of price increases is rising production costs,
- monetary inflation, where the general price level rises due to a mismatch between interest rates and the money supply relative to the current economic situation.

Currently, we are experiencing all these types of inflation simultaneously. Demand-pull inflation emerged as a result of lifting pandemic restrictions and unlocking economies; cost-push inflation is due to rising commodity prices; and monetary inflation is a consequence of the previous loose monetary policy of central banks and delays in tightening it (Wołowicz, 2023). The Figure 1 shows the annual changes in inflation rates, measured by Consumer Price Index (year-over-year) in the seven studied countries: Poland, the Eurozone, the USA, Japan, China, Brazil, and India from 2019 to 2023.

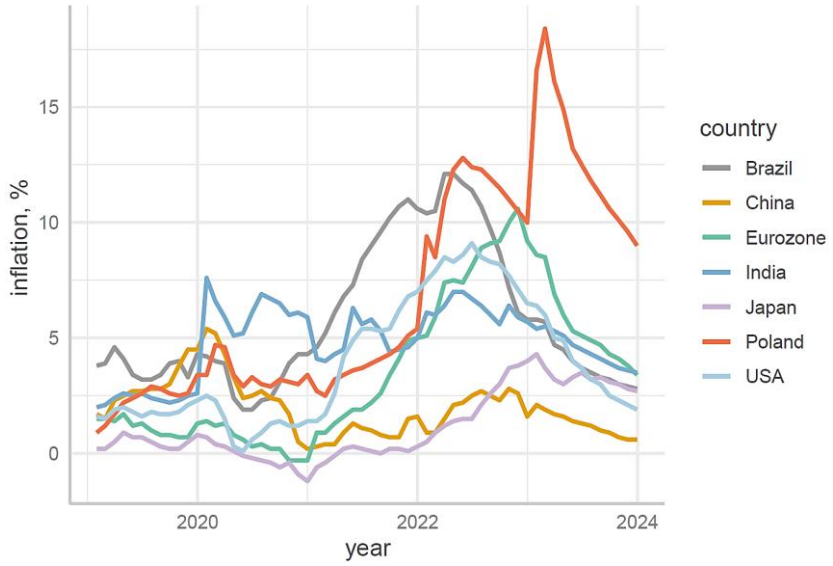

Figure 1. Temporal trends in inflation rates (%) by country, 2019-2023.

Source: own study based on: GUS, Eurostat, OECD.

This extraordinary increase in inflation prompted a response from central banks in the form of interest rate hikes. Especially since the monetary policy of the central banks in the discussed countries, to a greater or lesser extent, aims to stabilize prices in the economy. These actions were taken at different times and to varying extents. Figure 2 illustrates the changes in the benchmark interest rates of the central banks of Poland, the USA, Japan, the Eurozone, China, Brazil, and India from 2019 to 2023.

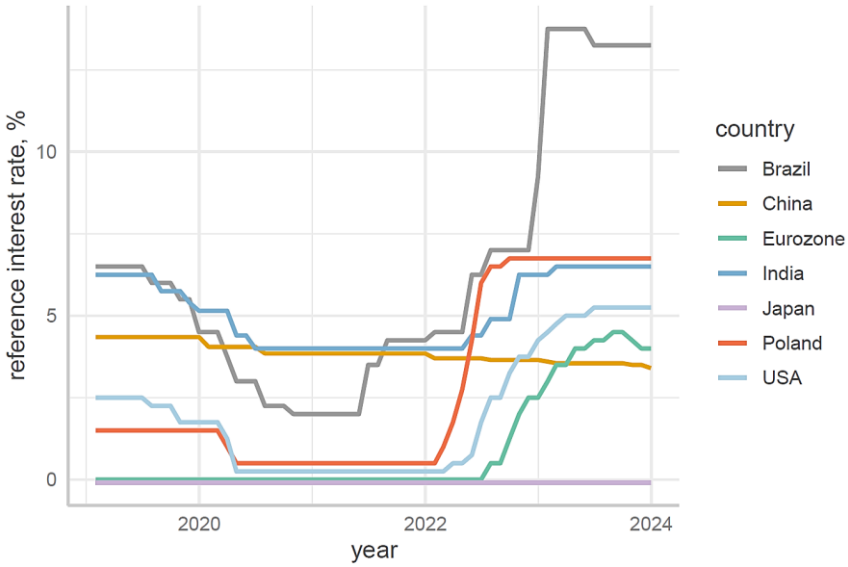

Figure 2. Temporal trends in in benchmark interest rates (%) by country, 2019-2023.

Source: own study on the basis of central banks data.

Changes in benchmark interest rates are one of the most important tools of monetary policy that central banks use to combat excessive price increases. This is a highly sensitive tool, requiring particularly precise application. Improper use of it can have negative consequences for both the pace of economic activity and the level of inflation. Therefore, it is crucial to operate it with the appropriate sensitivity, at the right time, and on the right scale, remembering that it is not the only available tool in monetary policy.

Analyzing the actions of central banks, such as benchmark interest rate hikes in response to rising inflation, allows us to assess the restrictiveness of their monetary policy during macroeconomics shocks. Of course, it must be acknowledged that the level of central bank interest rates is only one aspect of this assessment.

2.1. European Central Bank (ECB)

A key factor that prompted the ECB to ease monetary policy in the Eurozone in 2019 was the persistently low inflation, which remained below the levels consistent with its target (below, but close to 2%). Since the ECB's main interest rate had been maintained at the zero lower bound since September 18, 2019, it could not be used for further economic stimulation in 2020. In its communication policy, the ECB emphasized that interest rates would remain at this level (or lower) until inflation was projected to approach levels that are close to, but below, 2%.

The COVID-19 pandemic in 2020 caused inflation to drop to 0.3%, and the ECB introduced the Pandemic Emergency Purchase Program (PEPP) program, keeping interest rates unchanged. In 2021, inflation rose to 5.0%, but the ECB kept interest rates low and continued asset purchases. In 2022, inflation reached 10.6%, prompting the ECB to raise interest rates to 2.5% by the end of the year. In 2023, inflation fell to 2.9%, and the ECB continued raising rates, reaching 4.0% for the deposit rate. Temporal changes in main interest rate and harmonized

index of consumer prices (HICP) in the Eurozone in response to the COVID-19 pandemic and the energy crisis are presented in Figure 3.

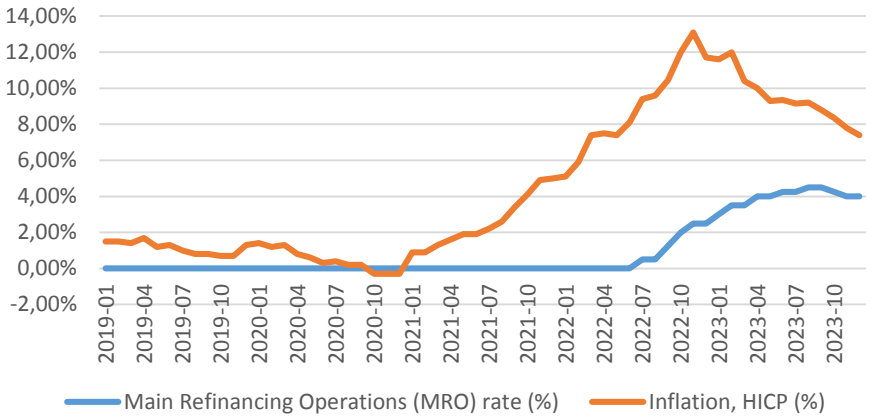

Figure 3. Temporal trends in main refinancing operations (MRO) rate (%) and HICP (%) in Eurozone, 2019-2023.

Source: own elaboration on the basis of central bank data.

2.2. Federal Reserve System (Fed)

The Federal Reserve (Fed) is the central bank of the United States, conducting monetary policy with a long-term inflation target of 2%. The key tool used by the Fed is the federal funds rate.

In 2019, inflation in the USA was 1.8%, and the Fed lowered interest rates in response to economic slowdown, ending the year at a level of 1.50-1.75%. Similarly to the ECB, in the United States, the Federal Reserve System could only respond to the crisis to a very limited extent by lowering the federal funds rate, as it stood at a low level of 1.75% at the beginning of 2020. The COVID-19 pandemic in 2020 caused inflation to further decline to 1.2%, prompting the Fed to cut interest rates to the range of 0.00-0.25% in March 2020. In August 2020, a modification of the monetary policy strategy was announced. The Fed raised its inflation target to an average inflation level to be implemented flexibly (flexible average inflation targeting). The length of the "average inflation level" was not specified. The approach to achieving the target also changed; after periods of inflation below 2%, the Fed would aim to keep inflation moderately above 2% for some time. Additionally, the Fed declared that it would consider employment shortfalls relative to its maximum level (previously deviations) from the estimated state of full employment (Bednarczyk, 2023).

In 2021, inflation rose to 4.7%, forcing the Fed to signal future rate hikes. In 2022, inflation reached 8.0%, and the Fed began aggressive rate hikes, reaching 4.25-4.50% by the end of the year. In 2023, inflation started to decrease, but the Fed continued raising rates to the level of 5.00-5.25%. Temporal changes in federal founds rate and consumer price index (CPI) in the United States in response to the COVID-19 pandemic and the energy crisis are presented in Figure 4.

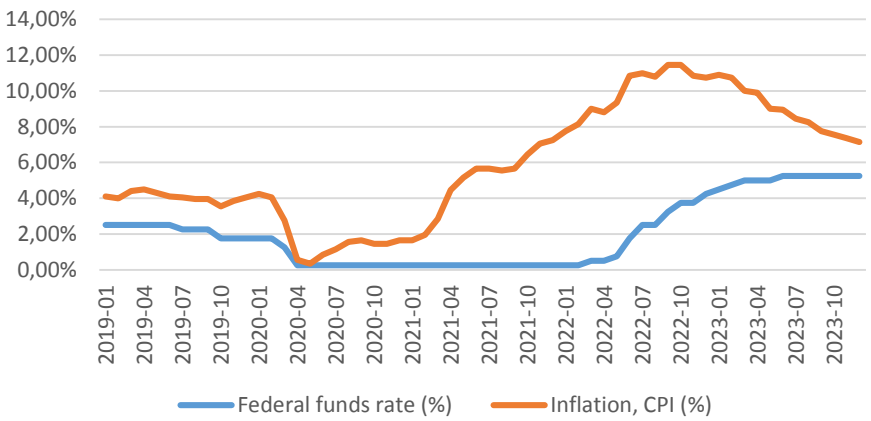

Figure 4. Temporal trends in federal funds rate (%) and CPI (%) in the USA, 2019-2023.
Source: own elaboration on the basis of central bank data.

2.3. National Bank of Poland (NBP)

The National Bank of Poland (NBP) serves as the central bank in Poland, implementing monetary policy with a primary inflation target set at 2.5% with a permissible deviation of +/-1 percentage point. The main tool used by the NBP is the reference rate. In 2019, inflation was approximately 2.3%, and the reference rate was maintained at 1.50%. In 2020, in response to the COVID-19 pandemic, inflation rose to 3.4%. In reaction to this and to support the economy, the NBP lowered interest rates to a record low of 0.10% in May 2020. However, inflation in Poland surged to 8.6% by the end of 2021, prompting the NBP to begin a cycle of interest rate hikes, reaching 1.75% by the end of 2021 and 6.75% by the end of 2022, in response to record inflation levels exceeding 15%. In 2023, inflation began to decrease to around 10%, and the NBP maintained interest rates at 6.75%. Temporal trends in NBP reference rate (%) and CPI (%) in Poland in response to the COVID-19 pandemic and the energy crisis are presented in Figure 5.

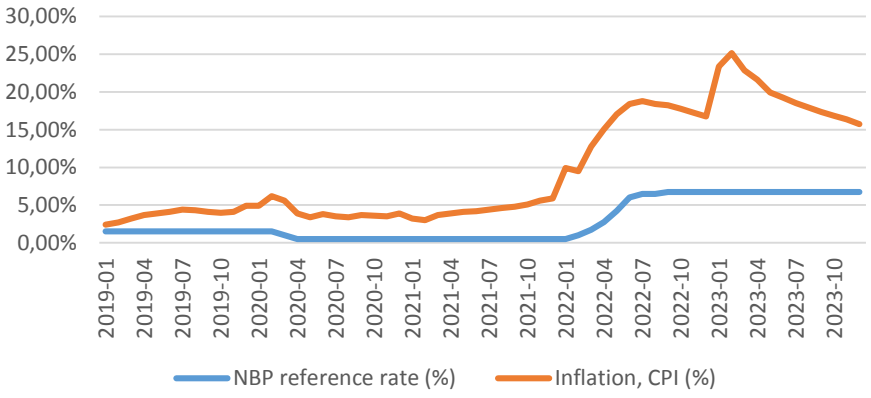

Figure 5. Temporal trends in NBP reference rate (%) and CPI (%) in Poland, 2019-2023.
Source: own elaboration on the basis of central bank data.

2.4. Bank of Japan (BoJ)

The Bank of Japan (BoJ) is responsible for monetary policy in Japan, with the goal of maintaining inflation at 2%. The BoJ has pursued a very accommodative monetary policy, featuring negative interest rates (-0.10%) and aggressive quantitative easing.

In 2019, inflation in Japan was approximately 0.5%. The Bank of Japan (BoJ) continued its loose monetary policy under the yield curve control policy by maintaining the main interest rate at a negative level of -0.1% (a level in place since January 2016) and controlling the yield on 10-year government bonds (JGBs) at around 0.0%. Additionally, the BoJ continued to purchase non-government assets in the financial market.

The COVID-19 pandemic in 2020 caused inflation to drop to -0.4%, in 2021 inflation rose to 0,1%. In 2020 and 2021, the Bank of Japan (BoJ) took actions aimed at ensuring smooth financing for businesses and maintaining stability in financial markets to prevent a deterioration in business and household sentiment. In 2020, the BoJ left interest rates unchanged at -0.1%.

Despite the increase in inflation to 2.5% in 2022, unlike other central banks in developed countries, the Bank of Japan (BoJ) did not decide to change interest rates. The main interest rate remained at -0.1% throughout 2022. The BoJ's lack of interest rate changes amid global monetary tightening by other central banks contributed to the weakening of the yen against the dollar. To strengthen the yen, the BoJ decided in September 2022 to intervene in the foreign exchange market to support the yen (the first such operation since 1998). Additionally, the BoJ continued its Quantitative and Qualitative Easing (QQE). In 2023, inflation stabilized at 2.5%, and the BoJ continued its monetary policy. Temporal trends in Short-term Policy Interest Rate (%) and CPI (%) in Japan in response to the COVID-19 pandemic and the energy crisis are presented in Figure 6.

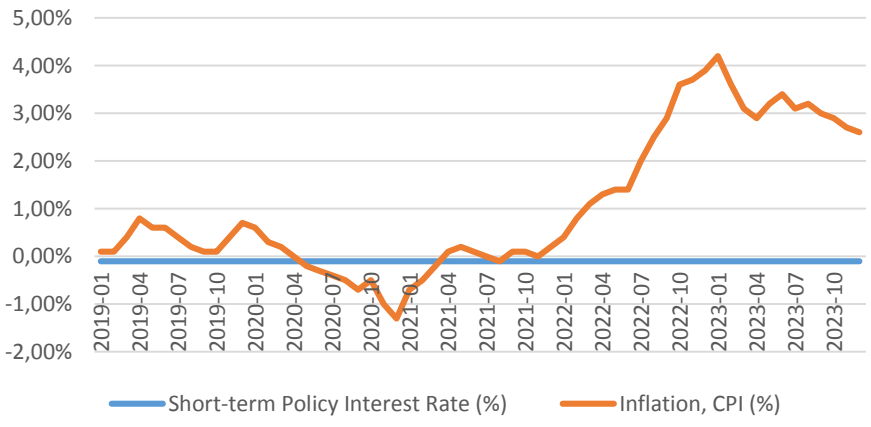

Figure 6. Temporal trends in Short-term Policy Interest Rate (%) and CPI (%) in Japan, 2019-2023.
Source: own elaboration on the basis of central bank data.

2.5. People's Bank of China (PBOC)

The People's Bank of China (PBOC) is responsible for monetary policy in China. Although the PBOC does not have an officially declared inflation target, it aims to maintain inflation at a low level.

The PBOC conducted an accommodative monetary policy, lowering interest rates in response to the pandemic. In 2019, inflation was approximately 2.9%, and the PBOC reduced the Loan Prime Rate (LPR) to 4.25% (1-year) and 4.85% (5-year). In 2020, inflation rose to 5.4%, prompting the PBOC to further lower interest rates, maintaining the LPR at 3.85% (1-year) and 4.65% (5-year). In 2021, inflation fell to 0.9%, allowing the PBOC to keep interest rates low to support the economy. In 2022, inflation rose again to 2.1%, but remained controlled, enabling the PBOC to continue its accommodative monetary policy. In 2023, inflation dropped to 0.24%, allowing the PBOC to maintain low interest rates and continue supporting economic recovery. Temporal trends in Loan Prime Rate (LPR) (%) and CPI (%) in China in response to the COVID-19 pandemic and the energy crisis are presented in Figure 7.

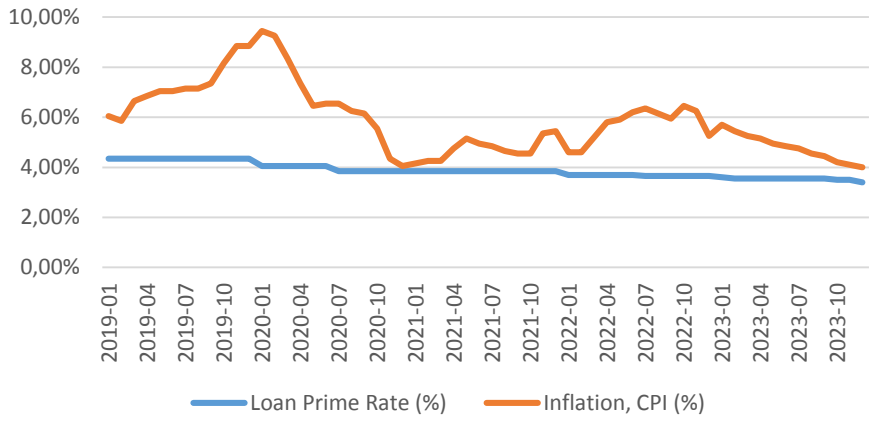

Figure 7. Temporal trends in Loan Prime Rate (LPR) (%) and CPI (%) in China, 2019-2023.
Source: own elaboration on the basis of central bank data.

2.6. Central Bank of Brazil (BCB)

The Central Bank of Brazil (Banco Central do Brasil, BCB) is responsible for monetary policy in Brazil, aiming to maintain inflation at a level of 3.75% with a permissible deviation of +/-1.5 percentage points. The official interest rate is the Special System for Settlement and Custody (SELIC) rate, which is the overnight lending rate.

In 2019, inflation was approximately 3.7%, and the BCB lowered the SELIC rate to 5.00% in response to economic slowdown. In 2020, inflation dropped to 2.1% at the onset of the pandemic, prompting the BCB to further reduce interest rates to a record low of 2.00%. However, in 2021, inflation surged to 10.1%, forcing the BCB to initiate a cycle of interest rate hikes, reaching 9.25% by the end of the year. In 2022, inflation climbed to 12.1%, leading the

BCB to continue raising interest rates, achieving 13.75% by the end of the year. In 2023, inflation fell to around 5.9%, and the BCB maintained a restrictive monetary policy to control inflation. Temporal trends in SELIC rate (%) and CPI (%) in Brazil in response to the COVID-19 pandemic and the energy crisis are presented in Figure 8.

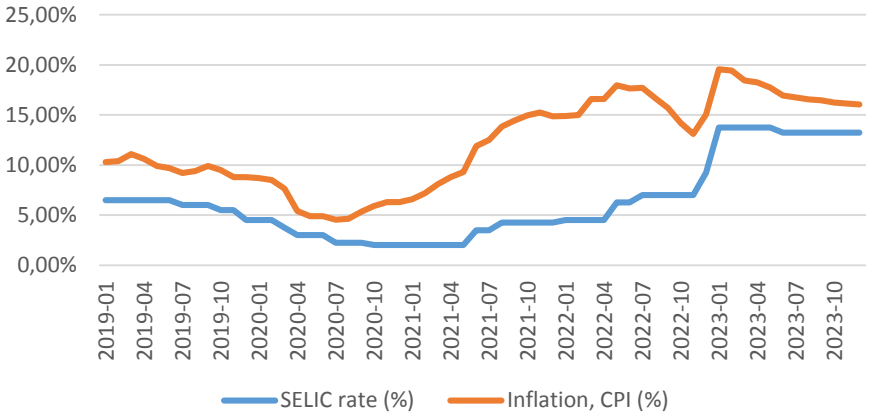

Figure 8. Temporal trends in SELIC rate (%) and CPI (%) in Brazil, 2019-2023.
Source: own elaboration on the basis of central bank data.

2.7. Reserve Bank of India (RBI)

In India, decisions regarding interest rates are made by the Central Board of Directors of the Reserve Bank of India (RBI). The official interest rate is the repo rate. In 2014, the primary goal of RBI's monetary policy became price stability, placing less emphasis on government borrowing, rupee exchange rate stability, and the need to protect exports. In February 2015, the government and the central bank agreed to set the consumer inflation target at 4 percent, with a tolerance band of +/-2 percentage points, starting from the fiscal year ending in March 2017.

In 2019, inflation in India was approximately 3.7%, and the RBI lowered the repo rate to 5.15% in response to the economic slowdown. The COVID-19 pandemic in 2020 caused inflation to rise to 6.6%, prompting the RBI to cut the repo rate to 4.00%. In 2021, inflation was around 5.1%, and the RBI maintained low interest rates to support economic recovery. In 2022, inflation increased to 6.7%, leading the RBI to raise the repo rate to 6.25%. In 2023, inflation fell to around 5.4%, and the RBI adjusted its policy based on economic conditions. Temporal trends in repo rate (%) and CPI (%) in India between 2019-2023 are presented in Figure 9.

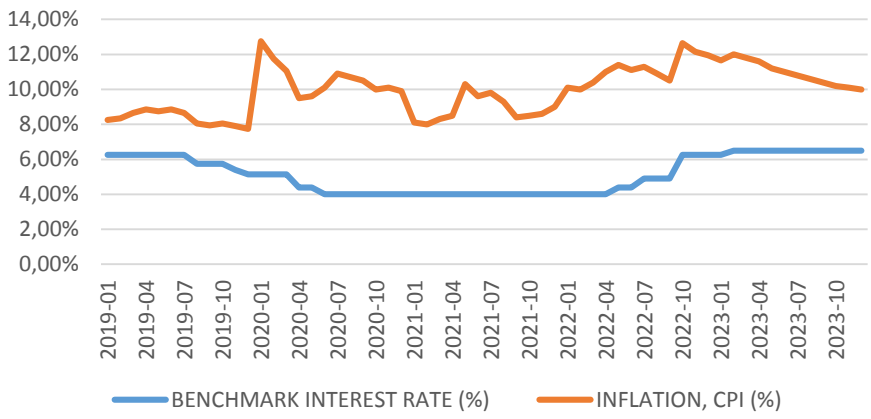

Figure 9. Temporal trends in repo rate (%) and CPI (%) in India, 2019-2023.
Source: own elaboration on the basis of central bank data.

3. Statistical analysis

The objective of the analysis was to identify the financial determinants that influence the benchmark interest rate levels in countries with major global economies during the macroeconomics shocks in 2019-2023.

3.1. Materials and method

In the analysis, we employed a one-way (individual) effect one-step system general methods of moments (GMM) model to address potential endogeneity and autocorrelation issues inherent in the panel data. This technique was chosen to effectively control for unobserved individual heterogeneity while taking into account the dynamic nature of the dependent variables.

The model was specified with the benchmark interest rate outcome variable regressed on its first lag to capture the dynamic relationships within the data. Instrumental variables such as inflation rate, unemployment rate, Lombard and deposit interest rates were selected based on their relevance and exogeneity, ensuring the validity of the GMM estimator.

The analyses were conducted using the R statistical language.

Instrument selection was critical to the model's effectiveness in addressing endogeneity. Instruments for the lagged dependent variable, in this case, the benchmark interest rate, included further lags of the dependent variable itself to mitigate weak instrument issues and reduce endogeneity bias. Specifically, the instruments used in the GMM estimator were the further lags of the benchmark interest rate, reflecting to ensure strong correlations with potentially endogenous regressors while maintaining orthogonality to the error term.

3.2. Pre-processing stage

The dependent variable (benchmark interest rate) underwent normalization through the application of the z-score technique to ensure a standard scale across all data points. This transformation aids in mitigating issues related to scale disparities and enhances the interpretability of regression coefficients. Concurrently, due to substantial variability observed in the data, the unemployment rate predictor was transformed using a logarithmic scale to stabilize the variance and reduce the impact of extreme values, thus facilitating a more reliable and accurate statistical analysis.

3.3. Model specification

The specification of the final model, as determined through rigorous sensitivity analysis, is delineated in Equation 1:

$$\textit{benchmark interest rate}_{,it} = \beta_1 \cdot \textit{benchmark interest rate}_{,it-1} + \beta_2 \cdot \textit{inflation rate}_{,it} + \beta_3\ \textit{unemployment rate}_{,it} + \beta_4\ \textit{lombard interest rate}_{,it} + \beta_5\ \textit{lombard interest rate}_{,it-1} + \beta_6\ \textit{deposit interest rate}_{,it} + \alpha_i + \epsilon_{,it}\ (1)$$

where: $\textit{benchmark interest rate}_{,it}$ represents the outcome variable at time t for unit i; $\textit{benchmark interest rate}_{,it-1}$ denotes outcome variable for unit i at time t-1 (lagged); β_1 represents the regression coefficient for outcome variable, $\beta_2 \ldots \beta_6$ denote the regression coefficients for explanatory variables; $\textit{inflation rate}_{,it}$, $\textit{unemployment rate}_{,it}$, $\textit{lombard interest rate}_{,it}$, $\textit{lombard interest rate}_{,it-1}$, $\textit{deposit interest rate}_{,it}$ these are values of the explanatory variables at time t and $t-1$ for the i-th unit; α_i represents the component accounting for unobserved individual effects for i-th unit, $\epsilon_{,it}$ – is the error term for the i-th unit at time t.

In the model's instrumentation, the benchmark interest rate was utilized as an instrumental variable, which was crucial for identifying and estimating the impact of endogenous explanatory variables.

3.4. Model validation

To ensure the robustness and validity of the model's estimates, an analysis was conducted on the distribution of the model's residuals. The Sargan-Hansen test, based on the seminal works of Hansen (1982) and Sargan (1958), was implemented to confirm the validity of the instruments used. Additionally, Arellano-Bond tests (1991) were conducted to check for the absence of first and second-order serial correlation in the differenced errors. The Wald test was employed to determine whether the selected independent variables exert a significant collective impact on the dependent variable.

3.5. Characteristics of the data sample

The dataset subjected to analysis consists of panel data capturing the dynamics of five financial parameters: benchmark interest rate, inflation rate, unemployment rate, Lombard rate, and deposit rate (all in %). This dataset encompasses monthly observations from seven countries (units) over a five-year period from 2019 to 2023, resulting in 60 records per country. The countries included in the dataset are Poland, China, Eurozone countries, India, Japan, the United States, and Brazil.

3.6. Results

The GMM model was implemented on a dataset structured as a balanced panel, comprising 7 individuals monitored over 60 time periods with one-month step, resulting in a theoretical total of 420 observations. Nevertheless, the actual number of observations used in the analysis was 814, indicating a deviation from the expected count. This variation stems from the exclusion of certain observations, necessitated by the lag structure and the transformation requirements integral to the system GMM method.

The residual analysis of the GMM model provides critical insights into its validity and reliability. With the residuals ranging from a minimum of -0.32 to a maximum of 0.33 and both the first and third quartiles concentrated below 0.01 in absolute terms, the distribution indicates a strong central tendency around the median. This tight clustering suggests that the model fits the majority of the data points well, with no evidence of large-scale deviations that would suggest systemic errors in model specification or estimation.

The mean of the residuals oscillating around zero, specifically at -0.00025, further supports the model's accuracy. A mean close to zero in residual analysis generally indicates that the model does not systematically overestimate or underestimate the dependent variable.

Overall, the residual analysis indicates that the GMM model is valid and effectively captures the complex interactions within the data. The model's estimates can be considered reliable for interpreting the effects of the independent variables on the dependent variable within the context of this study.

Starting with the Sargan test, which assesses the validity of the over-identifying restrictions and, by extension, the appropriateness of the instrumental variables used, the test statistic is remarkably low $\chi 2\ (122) = 7.00$, $p = 1.000$. The high p-value suggests that there is no evidence against the null hypothesis of the instrument's validity. In other words, the instruments used in the model are appropriate and do not correlate with the residuals, confirming that they are indeed exogenous and suitable for the GMM estimation.

Moving to the autocorrelation tests, the first autocorrelation test, which checks for first-order autocorrelation, reports a statistic of -1.73 with a $p = 0.084$. This p-value, being slightly above the conventional significance level, does not provide sufficient evidence to reject the null hypothesis of no first-order autocorrelation. However, it is borderline, suggesting a slight

possibility of autocorrelation that might warrant further scrutiny or more conservative interpretation of the model results.

The second autocorrelation test, aimed at detecting second-order autocorrelation, shows a statistic of -0.017 with a $p = 0.987$. This result comfortably supports the absence of second-order autocorrelation among the residuals, reinforcing the model's appropriateness in handling the dynamic panel data structure without introducing undue bias from autocorrelation.

Lastly, the Wald test for the significance of coefficients presents a very high chi-square statistic, $\chi 2\ (6) = 111464152.00$ with $p < 0.001$). This indicates that the model coefficients are highly statistically significant, suggesting that the independent variables included in the model have a substantial and statistically undeniable impact on the dependent variable.

In conclusion, the combination of a valid instrument set (as indicated by the Sargan test), the absence of problematic second-order autocorrelation, and the significant impact of the predictor variables (as demonstrated by the Wald test) suggests that the model is both statistically robust and theoretically sound. The slight concern raised by the first-order autocorrelation test does not substantially undermine the model but should be acknowledged in interpretations and potential further model enhancements. These results collectively affirm the effectiveness of the GMM approach in this analysis, providing a strong foundation for reliable econometric inference based on the model outputs.

The following Table 1 presents the estimated coefficients from GMM model that was employed to assess the impact of various economic indicators on the benchmark interest rate. The results serve as a basis for understanding how past values and immediate economic conditions interact to influence central bank rate decisions.

Table 1.
The coefficients of the fitted GMM model with robust standard errors

Coefficients	Benchmark interest rate (z-score)			
	B	**SE**	**z**	**p**
Lagged outcome variable				
Benchmark interest rate, lagged by one month	0.983	0.011	91.48	< **0.001**
Predictors				
Inflation rate	0.002	0.001	2.41	**0.016**
Logarithm of the unemployment rate	-0.015	0.009	-1.60	0.110
Lombard interest rate	0.324	0.012	26.33	< **0.001**
Lombard interest rate, lagged by one month	-0.317	0.014	-22.60	< **0.001**
Deposit interest rate	4.23×10^{-3}	0.002	0.27	0.791

Note. B – regression coefficient; SE – standard error (robusted); z – statistics of the Wald z test; p – p-value of statistical test.

Source: own study.

The lagged benchmark interest rate, lagged by one month, shows a near-perfect autoregressive coefficient of $B = 0.983$ with a $p < 0.001$. This finding strongly underscores the persistence of the interest rate over time, indicating that the benchmark interest rate is highly dependent on its previous month's value. The strong autoregressive coefficient for the lagged benchmark interest rate suggests a high degree of inertia in interest rate decisions, a common

characteristic in monetary policy. Central banks tend to move cautiously, adjusting rates in a gradual manner to avoid market shocks and to allow the economy time to adapt to new conditions. This inertia is also a reflection of the forward-looking nature of monetary policy, where decisions are based not only on current conditions but also on projected economic trends.

Moving to the predictors, the inflation rate shows a relatively modest but statistically significant effect on the benchmark interest rate, with a coefficient of B = 0.002 and a p = 0.016. This outcome suggests that as inflation increases, so too does the benchmark interest rate, albeit the magnitude of this effect is small, reflecting perhaps a cautious monetary policy response to inflation changes. The modest magnitude of this coefficient might indicate a tempered response to inflation, which could be due to the central bank's dual mandate to balance price stability with other economic objectives such as employment. This result also underscores the central bank's role in preemptively managing expectations to prevent runaway inflation without stifling economic growth.

In contrast, the logarithm of the unemployment rate presents a negative coefficient of -B = 0.015, although this estimate is not statistically significant (p = 0.110). This indicates a potential downward pressure on the benchmark interest rate as unemployment rises, typical of economic theory suggesting lower interest rates might be used to stimulate economic activity in the face of higher unemployment, though the data does not confirm this effect robustly.

The coefficients for the Lombard interest rate and its lagged value are particularly notable. The current month's Lombard rate has a substantial positive effect on the benchmark interest rate (B = 0.32, $p < 0.001$), while the previous month's Lombard rate exerts a nearly equal and opposite effect (B = -0.32, $p < 0.001$). The significant and contrasting coefficients for the current and lagged Lombard rates highlight the short-term adjustments and their delayed effects on the benchmark interest rate. This might reflect the transmission mechanism of monetary policy through which changes in policy rates take time to percolate through the economy, affecting various sectors differently. The immediate positive response and the delayed negative response could also indicate overshooting corrections or anticipatory adjustments by the market.

Finally, the coefficient for the deposit interest rate is positive (B = 4.23 × 10-3) but not statistically significant (p = 0.791), indicating that changes in this rate do not have a discernible impact on the benchmark interest rate within the given period. This lack of significance may point to the limited role that deposit rates play in influencing central bank benchmark rates, or it might reflect other macroeconomic factors that overshadow the influence of deposit rates. Deposit also rates often respond to changes in central bank rates rather than driving them, functioning more as a follower than a leader in the monetary policy framework.

4. Discussion

A review of central banks' actions indicates that all analyzed countries had to adjust their monetary policy strategies in response to the rapidly rising inflation caused by the COVID-19 pandemic and the energy crisis. In 2019, the discussed central banks were conducting a loose monetary policy. This was mainly due to the decline in inflation dynamics, reduced economic activity, and concerns about the effects of tightening trade policy between the United States and China. Interest rates were lowered (United States, Eurozone, China, Brazil, India) or maintained at negative levels (Japan) or at low levels (Poland). Additionally, central banks used unconventional monetary policy instruments such as asset purchases, providing liquidity to the financial market, and forward guidance on the future shape of monetary policy.

In 2020, central banks' actions worldwide aimed to counteract the negative effects of the COVID-19 pandemic. The global economic recession and low inflation dynamics prompted major central banks to implement various forms of monetary easing. The National Bank of Poland lowered the basic interest rates, while other banks maintained them at low levels (United States, Eurozone, China, Brazil, India) or negative levels (Japan), simultaneously introducing measures to increase liquidity in the banking sector and support credit activity for enterprises.

The sharp rise in energy and food prices, improvement in the economic situation due to increasing demand, and the implementation of fiscal stimulus programs by most governments in 2021 influenced the monetary policy stance of only some central banks. Despite rising inflation indicators, only Poland (from 0.1% at the end of 2020 to 1.75% at the end of 2021) and Brazil (from 2% at the end of 2020 to 9.25% at the end of 2021) decided to raise interest rates, with inflation remaining below targets only in China and Japan. The Fed in 2021 only issued a statement about the possibility of raising interest rates in the near future, while the ECB and RBI continued their low-interest-rate policies to support economic recovery after the pandemic.

The analysis shows that regulating interest rates during the period of overcoming the demand shock played a rather passive role. Interest rates became a mitigation tool only in the case of the supply shock in 2022, during the resolution of the energy crisis caused by Russia's armed aggression against Ukraine. At that time, the scale of monetary policy tightening worldwide significantly increased, associated with substantial deviations of inflation levels from the set targets in all analyzed countries. Central banks introduced changes to asset purchase programs, either ending them or gradually phasing them out. Monetary authorities decided to raise interest rates to levels unseen for a long time. The most restrictive approach was taken by Poland and Brazil, which continued raising basic interest rates (Poland: from 1.75% at the end of 2021 to 6.75% at the end of 2022; Brazil: from 9.25% to 13.75%). The USA, Eurozone, and India also responded with rate hikes but in a more moderate manner: Fed from 0.25% at the end of 2021 to 4.25% at the end of 2021 and 5.25% at the end of 2022;

ECB from 0% at the end of 2021 to 2.5% at the end of 2022 and 4.5% by mid-2023; RBI from 4% at the end of 2021 to 6.25% at the end of 2022 and 6.5% at the end of 2023. The exceptions were China and Japan, which maintained an accommodative monetary policy throughout the period, focusing on supporting economic growth.

However, the approach to using basic interest rates significantly differed from the standards and practices previously employed by central banks, especially during periods of economic recovery. The usual practice at that time was for banks to react quickly by raising interest rates as soon as signs of rising inflation expectations appeared. This reaction was stronger the more expected inflation exceeded the set inflation target (upper target range). In this way, the actions of central banks were in line with the logic of the Taylor rule, which links real GDP growth to maintaining stable price growth. The result of this policy was an increase in real interest rates preceding the rise in actual inflation, causing deflationary-stagnation processes.

During the period of overcoming the price shock caused by the energy crisis, central banks reacted with some delay to the rise in actual inflation indicators, adopting a seemingly accommodative stance towards economic growth. As a result, despite a fairly rapid increase in nominal values of official interest rates, their real values remained very low (in the case of Poland) or low (in the case of the Eurozone and the United States) (Bednarczyk, 2023).

This caution in the approach to monetary policy and the accommodative stance towards economic growth by central banks in response to recent exogenous shocks seems to be confirmed by the developed econometric model. Its results show strong inertia in the reference rate, which is typical for cautious central bank decisions. An autoregressive coefficient close to unity (0.983) with very high statistical significance ($p < 0.001$) suggests that the reference rate is highly dependent on its value from the previous month, especially during periods of supply shocks. High inertia may indicate a departure from quick reactions to rising inflation expectations, instead focusing on stabilizing the economy and avoiding additional shocks in unstable conditions.

A moderate, though significant, impact of inflation on interest rates ($B = 0.002$, $p = 0.016$) suggests that central banks were aware of the need to balance price stability with other economic goals, such as economic growth or employment, which may result from the dual mandates of central banks.

5. Summary

In light of the results presented above from the desk research conducted between 2019 and 2023, we observe various responses from selected central banks to macroeconomic shocks such as the COVID-19 pandemic and the energy crisis triggered by the war in Ukraine. The analysis reveals that monetary policy was conducted with significant caution and predictability,

which is crucial for economic stability. Specifically, the econometric model demonstrated strong inertia in the benchmark interest rate, typical of the prudent decisions made by central banks.

This study constitutes a significant contribution to the scientific discussion on monetary policy responses to exogenous shocks in the context of different economies. The findings have important implications for both economic theorists and monetary policy practitioners. An important observation is the departure from the traditional Taylor rule, indicating a shift towards more flexible and adaptive monetary policy approaches. This change reflects the need to address unprecedented economic conditions with strategies that may deviate from established norms to better manage macroeconomic shocks.

However, the study has certain limitations, primarily due to its focus on selected economies, which may affect the generalization of the results. To obtain a more comprehensive picture, future research should expand the analysis to include a larger number of countries and a variety of monetary policy tools. It would be particularly useful to explore issues related to the long-term effects of monetary policy, compare the effectiveness of different strategies in various regions, and examine the interactions between monetary and fiscal policy in the context of managing economic shocks.

References

1. Bachmann, R., Baqaee, D., Korinek, A. (2022). Inflation and Monetary Policy Responses to the Energy Crisis. *Journal of Economic Perspectives, 36(4),* pp. 23-48.
2. Banco Central do Brasil (BCB) (2019-2023). *Monthly Selic rate reports*. Brasília: Banco Central do Brasil. Available at: https://www.bcb.gov.br, 9.07.2024.
3. Bank of Japan (BoJ) (2019-2023). *Monthly policy interest rate report*. Tokyo: Bank of Japan. Available at: https://www.boj.or.jp/en, 9.07.2024.
4. Bednarczyk, J.L. (2023). *Pomiędzy inflacją a wzrostem gospodarczym. Dylematy polityki pieniężnej Narodowego Banku Polskiego*. Radom: Instytut Naukowo-Wydawniczy „Spatium", pp. 57-101.
5. Bureau of Labor Statistics (BLS) (2019-2023). *Labor Force Statistics*. Retrieved from: https://www.bls.gov/cps/, 9.07.2024.
6. Croissant, Y., Millo, G. (2018). Panel Data Econometrics in R: The plm Package. *Journal of Statistical Software, 27(2),* pp. 1-43.
7. European Central Bank (ECB) (2019-2023). *Monthly key ECB interest rates report.* Frankfurt: European Central Bank. Available at: https://www.ecb.europa.eu, 9.07.2024.

8. Eurostat (2019-2023). *Employment and unemployment*. Retrieved from: https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Employment_and_unemployment, 9.07.2024.
9. Federal Reserve Economic Data (FRED) (2019-2023). *Monthly interest rate reports*. St. Louis: Federal Reserve Bank of St. Louis. Available at: https://fred.stlouisfed.org, 9.07.2024.
10. Główny Urząd Statystyczny (GUS) (2019-2023). *Rynek pracy*. Retrieved from: https://stat.gov.pl/obszary-tematyczne/rynek-pracy/, 9.07.2024.
11. Guerrieri, V., Lorenzoni, G., Straub, L., Werning, I. (2020). Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages? *NBER Working Paper, No. 26918.*
12. GUS (2021). *Sytuacja makroekonomiczna w Polsce na tle procesów w gospodarce światowej w 2020 r.* Warszawa: ZWS.
13. GUS (2022). *Sytuacja makroekonomiczna w Polsce na tle procesów w gospodarce światowej w 2021 r.* Warszawa: ZWS.
14. GUS (2023). *Sytuacja makroekonomiczna w Polsce na tle procesów w gospodarce światowej w 2022 r.* Warszawa: ZWS.
15. Hansen, L.P. (1982). Large Sample Properties of Generalized Method of Moments Estimators. *Econometrica, 50(4),* pp. 1029-1054.
16. Instituto Brasileiro de Geografia e Estatística (IBGE) (2019-2023). *Labor Market.* Retrieved from: https://www.ibge.gov.br/en/statistics/social/labor-market.html, 9.07.2024.
17. Ministry of Labour and Employment, Government of India (2019-2023*). Ministry of Labour and Employment.* Retrieved from: https://labour.gov.in/, 9.07.2024.
18. Narodowy Bank Polski (NBP) (2019-2023). *Archiwum podstawowych stop procentowych*. Warsaw: Narodowy Bank Polski. Available at: https://nbp.pl/podstawowe-stopy-procentowe-archiwum/, 9.07.2024.
19. National Bureau of Statistics of China (NBS) (2019-2023). *Employment.* Retrieved from: http://www.stats.gov.cn/english/, 9.07.2024.
20. OECD (2023). *Consumer Price Indices (CPIs) - Complete database*. Retrieved from: https://stats.oecd.org/index.aspx?queryid=82174, 9.07.2024.
21. People's Bank of China (PBoC) (2019-2023). *Monthly loan prime rate (LPR) and benchmark interest rate reports*. Beijing: People's Bank of China. Available at: http://www.pbc.gov.cn/en, 9.07.2024.
22. Reserve Bank of India (RBI) (2019-2023). *Monthly repo rate reports*. Mumbai: Reserve Bank of India. Available at: https://www.rbi.org.in, 9.07.2024.
23. Statistics Bureau of Japan (2019-2023). *Labor Force.* Retrieved from: https://www.stat.go.jp/english/data/roudou/index.html, 9.07.2024.
24. Wołowicz, K. (2023). Stopy procentowe banków centralnych w okresie wysokiej inflacji. *Infos. Zagadnienia społeczno-gospodarcze, No. 11*, pp. 1-4.