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ORIGINAL CONTRIBUTION

Empirical Assessment of the Relationship Between Conventional and Unconventional Monetary Policy Instruments and Macroeconomic Indicators in Uzbekistan

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Abstract— The effect of conventional monetary policy on macroeconomic indicators has been studied in many countries, but unconventional monetary policy has received far less attention, particularly in developing economies. This paper assesses the relative effectiveness of conventional and unconventional monetary policy instruments in Uzbekistan. Central bank total assets are used as the indicator of unconventional monetary policy, and the policy rate as the conventional instrument. The analysis applies the Johansen cointegration test, a vector error correction model with four lags, impulse response and forecast error variance decomposition analysis, and the Toda-Yamamoto augmented vector autoregression causality test. One cointegrating vector was identified. Solved for each variable in turn, the results show that a larger central bank balance sheet is associated in the long run with higher inflation, a weaker exchange rate, and lower output growth. In contrast, the policy rate does not enter the relation. Adjustment takes place through the output equation. Joint Wald tests show no short-run effect of the balance sheet on any macroeconomic variable, whereas the Toda-Yamamoto test finds predictive causality from the balance sheet to inflation and output growth, and from the policy rate to all three. Monetary transmission in Uzbekistan operates mainly through the interest rate instrument, while the influence of the balance sheet appears over longer horizons rather than the short run. Because central bank total assets also reflect operations that are not policy decisions, the estimates are reported as associations rather than as identified policy effects.

Index Terms— Unconventional monetary policy, Central bank total assets, Policy rate, Vector error correction model, Uzbekistan

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Introduction

This paper examines the macroeconomic effects of conventional and unconventional monetary policy measures carried out by the Central Bank of the Republic of Uzbekistan. Although the Central Bank does not apply Quantitative Easing (QE) or Qualitative Easing (QaE) as models of unconventional policy, some instruments used in practice influence the economy through liquidity management and produce results close to QE

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mechanisms. The study therefore uses central bank total assets (CB_TA) as the indicator of unconventional monetary policy, since it reflects the cumulative effect of the applied instruments on the balance sheet. In the literature, central bank total assets are regarded as a general measure of the intensity and scale of unconventional policy (Boeckx et al., 2025; Stone et al., 2009).

The indicator is the sum of the four main components of the asset side of the balance sheet, each corresponding to a type of operation: net foreign assets (foreign exchange intervention), claims on other depository corporations (refinancing and liquidity provision), net claims on the central government (open market operations and transactions in government securities), and claims on other sectors (credit support). Since the instruments that change the size of the balance sheet all pass through this single aggregate, central bank total assets are studied as an independent variable.

Total assets are an outcome measure and not a policy shock. They move with foreign exchange operations that are conducted for reserve management purposes and with the purchase of domestically produced gold, which is a long-standing feature of the Bank's operations; they move with refinancing operations that respond to the liquidity position of the banking sector; and they move with the government's own transactions on its accounts at the central bank. Only a part of this movement represents deliberate monetary easing or tightening. A decomposition of the balance sheet into policy-driven and non-policy components would clearly be preferable, but the monthly breakdown of central bank operations that such a decomposition requires is not published for Uzbekistan over the whole of our sample period. We therefore treat every estimate that involves CB_TA as a conditional association, avoid describing balance sheet movements as exogenous policy impulses, and return to this question in conclusion.

In addition, to assess the relative effectiveness of monetary policy instruments, the policy rate (PR) is studied in the model as an independent variable alongside central bank total assets. The policy rate represents the conventional, price-based instrument, while central bank total assets reflect the quantitative dimension of unconventional policy. Interest rate policy affects mainly the cost of credit and investment decisions, whereas policy expressed through balance sheet indicators affects the economy through liquidity conditions, asset prices, and credit allocation channels (Ardian et al., 2025; Gertler & Karadi, 2011). Including both types of instruments in one model makes it possible to identify the differences between them empirically and to assess their relative effectiveness.

Existing empirical work on Uzbekistan has dealt only with the conventional side of policy. Hespeler (2012) estimated a vector error correction model for the period before the 2017 liberalization and found the exchange rate channel to be stronger than the interest rate channel, but his system was built on M2 under a crawling peg and tight capital controls, so it describes a regime that no longer exists. Al Rasasi and Cabezon (2022) assessed the transition to inflation targeting with Vector AutoRegression (VAR) models and linked weak transmission to institutional gaps and the large role of the state in the financial sector. Davlatov and Sági (2026) showed with structural VAR models that a recursive ordering produces price and exchange rate puzzles in Uzbek data, and Wang and Zhao (2025) studied the macroeconomic impact of monetary policy without separating the price-based from the quantity-based instrument. None of these studies use the size of the balance sheet, none estimates the two instruments jointly, and none separates long-run associations from short-run dynamics and predictive causality. This is the gap the paper addresses.

The study contributes to the literature in three ways. First, it compares the transmission mechanisms of the two instruments within a single system rather than in separate models estimated on different samples. Second, research on unconventional policy has concentrated on financial stability (Krishnamurthy & Vissing-Jorgensen, 2011; Remache et al., 2024), whereas macroeconomic effects have been studied less, and most evidence relates to advanced economies; this paper examines a developing economy in which the zero lower bound has never been binding, so balance sheet policy is not a substitute for an exhausted interest-rate policy. Third, it states what each method can establish and separates long-run associations, error correction adjustment, and predictive causality.

The paper is organized as follows. Section 2 presents the theoretical foundations and the research background. Section 3 describes the data and the methodology. Section 4 analyses the empirical results. Section 5 discusses the findings, presents the conclusions and policy implications, and sets out the limitations of the study.

Theoretical Foundations and Research Background

Research on unconventional monetary policy developed mainly after the global financial crisis of 2008, and the definitions used in the literature still differ. Therefore, it is useful to state which one this paper follows.

In the broadest formulation, unconventional monetary policy covers any central bank instrument that does not depend on changing the current or expected risk-free nominal interest rate, and includes balance sheet policies connected with asset purchases, such as quantitative easing, credit easing, emergency lending and, in some classifications, macroprudential policy (Angelia, Samuel, et al., 2026; Sheedy, 2017). Other authors interpret unconventional policy from the standpoint of expanding credit intermediation to address disruptions in private financial intermediation, and argue that the central bank can use such instruments to counteract financial crises and to widen access to credit (Gertler & Karadi, 2011). A third strand treats unconventional policy as a credit and liquidity support mechanism whose potential transmission channels are the portfolio rebalancing channel and the risk-taking channel (McMahon et al., 2018), while a fourth defines it as the set of instruments not associated with the management of short-term interest rates and applied when conventional policy can no longer hold the interest rate above the zero lower bound (Bindseil & Fotia, 2021; Riaz, 2026).

Unconventional monetary policy also includes ”macroprudential” policy instruments, which impose restrictions on borrowing that are independent of interest rates (Bavardi, 2024; Sheedy, 2017). Developing countries often seek alternative ways of tightening credit conditions by using macroprudential instruments, such as reserve requirements, in order to achieve financial stability (Glocker & Towbin, 2015). Macro-prudential instruments such as capital buffers, loan-to-value limits, or reserve requirements differ from balance sheet policy in their objective: they target the resilience of the financial system rather than the monetary stance, are usually assigned to a different decision-making body, and do not work by changing the size or composition of the balance sheet. They are therefore not treated here as unconventional monetary policy. Throughout the paper, unconventional monetary policy means balance sheet policy: the measures taken when the capacity of conventional instruments to manage liquidity, interest rates, and other monetary indicators at the desired level is constrained under economic instability, and that are reflected in the size and structure of the central bank balance sheet.

How the stance of unconventional policy should be measured is itself unsettled. Anderl and Caporale (2023) show that shadow rates, the most widely used single-number summary of the stance once the interest rate stops moving, behave differently across countries and are sensitive to how they are estimated. In an economy where the zero lower bound has never been reached, a shadow rate has little to add, and an observable balance sheet aggregate is the more natural indicator.

Gambacorta et al. (2014), using a VAR model and monthly data for 2008-2011, assessed the macroeconomic effects of unconventional monetary policy in eight advanced economies. They found a temporary increase in economic activity and prices following these measures, and confirmed that unconventional policy carried out through the expansion of central bank assets affects output in a way comparable to that of conventional policy; although the countries used different instruments, no significant difference between the effects was detected.

Evidence for the euro area over 2001-2016 shows that both conventional and unconventional policy support economic and financial stability and have a positive effect on the general price level (Fiorelli & Meliciani, 2019). Boeckx et al. (2025) demonstrate that an exogenous expansion of central bank total assets leads to a significant but temporary increase in output and prices, which confirms that the central bank can affect the real economy through balance sheet expansion without changing the policy rate. Weale and Wieladek (2016) find that asset purchases equal to 1% of GDP raised GDP by 0.58% and the consumer price index by 0.62% in the United States, while purchases of the same relative size in the United Kingdom raised GDP by 0.25% and the price index by 0.32%.

More recent work qualifies these findings. Ballabriga and Davtyan (2025) compare the two regimes within one framework for the euro area and the United States and report that the effect of policy on prices was stronger in the conventional period. Evgenidis and Papadamou (2020) find that the transmission of European Central Bank balance sheet policies to output and prices is present but modest and depends on the state of the financial system. Budová et al. (2026) show that inflation persistence in the euro area changed measurably under the unconventional regime, and Coccia and Russo (2026) note that the estimated size of balance sheet effects is sensitive to the identification strategy adopted. What emerges is that balance sheet policy works, but its measured effect is smaller and less stable across regimes than the crisis-period studies suggested.

The evidence for emerging economies is thinner and is dominated by studies of spillovers from advanced-economy policy rather than studies of domestic balance sheet policy. and Bhattarai et al. (2015) show that United States quantitative easing had significant effects on exchange rates, asset prices, and capital flows in emerging markets, and Andreou et al. (2021) find that unconventional policy abroad is an important determinant of equity capital flows into these markets. Goto (2023) shows that balance sheet expansion shocks reduce uncertainty in financial markets, lead to depreciation of the domestic currency, and raise both output and the price level. Nam (2018) examines quantitative easing and inflation in Korea, Lau and Yip (2023) find that the effect of Japanese balance sheet policy differs across sub-periods, and Xiang et al. (2024) show for China that the response to quantity-based instruments depends on the structure of the financial system. Work on balance sheet operations conducted by emerging market central banks themselves is more recent. Beirne and Sugandi (2023) examine the asset purchase programs launched by fourteen such central banks after 2020 and find that they lowered domestic bond yields without the currency depreciation that the earlier literature had led authors to expect. Rao and Kumar (2023) reach a similar conclusion for India and make the point that matters here: these operations were carried out with policy rates well above zero, so balance sheet policy in emerging markets is not a substitute for exhausted conventional policy that it was in the advanced economies.

Two features of this literature deserve attention. First, the sign of the exchange rate response is not uniform across studies: balance sheet expansion is associated with depreciation in some settings and with appreciation in others, depending on whether the confidence and capital-inflow effect or the liquidity effect dominates. Second, studies that examine domestic balance sheet policy in economies where the zero lower bound is not binding are very few, and this is exactly the situation in Uzbekistan.

Two studies come close to the exercise attempted here. and Sejko and Tanku (2024) estimate a cointegrated structural VAR for Albania, a small and heavily euroized open economy, and find that a shift in the composition of the central bank balance sheet acts as a monetary shock in its own right, with its strongest effect on prices running through the exchange rate. Ybrayev (2022) shows for Kazakhstan, the nearest comparable economy to Uzbekistan, that the strength of transmission depends on the state of the credit cycle. Neither study uses the size of the balance sheet as the policy indicator, and neither places it alongside the policy rate within one system.

Uzbekistan changed its monetary policy framework substantially after the liberalization of the currency market in 2017, and the Central Bank has operated an inflation-targeting regime since the beginning of 2020 (Al Rasasi & Cabezon, 2022). The transition has not been easy: dollarisation remains high, financial markets are shallow, a considerable share of credit is still directed, and the economy is exposed to world commodity prices and remittance inflows, while the target date for reaching 5% inflation has been postponed more than once (International Monetary Fund, 2025). These features weaken the interest rate channel and, in principle, raise the relative importance of quantity-based instruments.

Three questions remain unresolved in this work. All of these studies measure policy either by an interest rate or by a monetary aggregate, and none uses the size of the balance sheet, even though in Uzbekistan the balance sheet is the aggregate through which foreign exchange intervention, refinancing, and directed credit support all pass. None estimates the two instruments jointly, so it is not known whether the balance sheet carries information beyond the policy rate. Furthermore, none distinguishes between long-run equilibrium relations, short-run dynamics, and predictive causality. The present study addresses these three questions.

Methodology

Data and variables

The independent variables of the model are Central Bank Total Assets (CB_TA) and the Policy Rate (PR); the dependent variables are the growth rate of the Consumer Price Index (CPI), the nominal Exchange Rate (ER), and the growth rate of Gross Domestic Product (GDP). The classification of the variables, their units, their frequency, and their sources are given in Table I.

Table I
Data classification

No.	Variable	Definition and unit	Frequency	Source
		Independent variables		
1	CB_TA	Central bank total assets = net foreign assets + claims on other depository corporations + net claims on central government + claims on other sectors, billion UZS	Monthly, end of period	Central Bank of the Republic of Uzbekistan
2	PR	Policy rate, % per annum	Monthly, end of period	Central Bank of the Republic of Uzbekistan
		Dependent variables		
3	CPI	Growth of the consumer price index, % change on the same month of the previous year	Monthly	Statistics Agency under the President of the Republic of Uzbekistan
4	GDP	Growth rate of gross domestic product, % change on the same period of the previous year	Quarterly, converted to monthly (Section method-olgy)	Statistics Agency under the President of the Republic of Uzbekistan
5	ER	Nominal exchange rate (UZS/USD), monthly average	Monthly	Central Bank of the Republic of Uzbekistan

The sample covers the period from January 2020 to June 2025, which gives 66 monthly observations. After the logarithmic transformation described in methodolgy, first differencing, and the inclusion of four lags, the estimation sample of the vector error correction model runs from May 2020 to June 2025 and contains 62 observations; the augmented VAR used for the Toda-Yamamoto test runs from June 2020 to June 2025 and contains 61 observations. All the calculations were carried out in Stata. The sample begins in January 2020 because the Central Bank adopted the inflation-targeting framework at that point; extending it backward would mean pooling two different policy regimes.

Four of the five series are observed monthly; GDP is quarterly. To bring it into the system, each quarterly year-on-year growth rate was carried unchanged into the three months of that quarter, a constant-within-quarter allocation implemented in Stata by expanding each quarterly record threefold and merging it with the monthly series on the date variable. No indicator series and no Chow-Lin, Litterman, or Denton-type procedure were used: the aim was to keep the quarterly figure exact rather than to import an indicator series whose own properties would then need defending. The cost is that the monthly output series is piecewise constant, which shows up later as added persistence in the output equation, most visibly in the size of the error-correction coefficient discussed in short-run results of the vector error correction model.

CB_TA and ER enter the model in natural logarithms. Both trend upward with variability that grows with their level, which the logarithm corrects for, and in log form the cointegrating coefficients read as elasticities rather than as responses to a billion soum or a single exchange-rate point, which is the more natural scale for a balance sheet and a nominal exchange rate. CPI, GDP, and PR are left as reported, since they are already rates and, in the case of GDP, occasionally reach zero, as in the second quarter of 2020.

The sample includes the pandemic, the commodity and food price shock of 2021-2022, the war in Ukraine and its effect on remittances and regional trade, and the energy price adjustment of 2024-2025. No dummy variables are included, and no formal tests are performed to identify the causes of the outliers. The residual diagnostics in Section 4.7 indicate a few large, isolated disturbances rather than a shift in the underlying relationship, which is encouraging but does not replace a proper test.

Stationarity is tested using the Augmented Dickey-Fuller test (Dickey & Fuller, 1979) and the Phillips-Perron test (Phillips & Perron, 1988), both with and without a trend, with two additional lags in the ADF level regressions and the Newey-West bandwidth for PP. The VAR lag order is chosen from the LR, FPE, AIC, HQIC, and SBIC statistics, and cointegration is determined from the Johansen trace test (Johansen, 1991) with a constant restricted to the cointegration space. The VECM is then estimated using the maximum likelihood method at the specified rank. Therefore, model adequacy is tested using Lagrange multiplier tests for residual autocorrelation, the Jarque-Bera test (Jarque & Bera, 1987), and the inverse root test for the cointegration matrix.

The impulse responses use a Cholesky ordering of LnCB_TA, PR, CPI, LnER, GDP, so that the two policy variables are assumed not to react within the month to inflation, the exchange rate, or output, in line with the lag between a Board decision and the publication of price index and national accounts data. This is a common ordering but not the only defensible one - Davlatov and Sági (2026) show for Uzbekistan that a recursive scheme of this kind can generate price and exchange rate puzzles that a non-recursive one avoids. Therefore, the responses below are interpreted as the dynamics implied by this particular recursive structure rather than as identified structural effects.

The Toda and Yamamoto, 1995 is run on the levels VAR with the $p = 4$ lags selected in Table V, plus one extra lag for the maximum order of integration established in unit root tests, and the modified Wald statistics restrict only the first four lags, so the test has four degrees of freedom.

Data Analysis

Descriptive statistics

The exchange rate and central bank assets have low dispersion: the exchange rate followed a steady path, and the balance sheet expanded at an even pace. Output growth is far more variable, with a mean of 5.67% and a standard deviation of 2.24, reflecting the fall of growth to zero in the second quarter of 2020. Inflation averaged 10.86%, and the policy rate is stable, with a standard deviation of 0.83. The low dispersion of the output series is partly a consequence of the disaggregation procedure of Methodology, since the series is constant within each quarter by construction.

Table II
Descriptive statistics of the variables

Variable	Observations	Mean	Std. dev.	Minimum	Maximum
LnCB_TA	66	12.4820	0.2978	11.9246	13.1627
PR	66	14.4042	0.8296	13.5000	17.0000
CPI	66	10.8596	1.5963	7.9800	14.5000
LnER	66	9.3350	0.0899	9.1610	9.4695
GDP	66	5.6651	2.2404	0.0000	8.8000

The correlation of 0.945 between LnCB_TA and LnER in Table III deserves attention. Net foreign assets are the largest component of the balance sheet and their value in soum depends mechanically on the exchange rate, so the two series carry a large amount of common information. The coefficients associated with them in the cointegrating vector should not be given a strong structural interpretation individually.

Table III
Correlation matrix

	LnCB_TA	PR	CPI	LnER	GDP
LnCB_TA	1.0000				
PR	-0.4786	1.0000			
CPI	-0.6310	0.6045	1.0000		
LnER	0.9454	-0.5212	-0.7325	1.0000	
GDP	0.4232	-0.3934	-0.5441	0.4742	1.0000

Unit root tests

To identify the appropriate models for the following stages of the analysis, the variables were subjected to stationarity tests. Table IV reports the ADF and PP results with the specification described in methodology.

The ADF and PP tests disagree about one variable: the ADF test finds the policy rate stationary at the 5% significance level, while the PP test finds it stationary at the 10% significance level. The more conservative reading is adopted here, and PR is treated as I (1), for three reasons. The ADF rejection is marginal and therefore sensitive to the number of augmenting lags used.

Table IV
Unit root test results

Variable	ADF	ADF	PP	PP
	Level	First difference	Level	First difference
LnCB_TA	0.571 (0.9869)	-8.756 (0.0000)	0.316 (0.9781)	-8.931 (0.0000)
PR	-2.906 (0.0446)	-5.612 (0.0000)	-2.594 (0.0943)	-5.492 (0.0000)
CPI	-2.026 (0.2755)	-7.254 (0.0000)	-2.163 (0.2199)	-7.265 (0.0000)
LnER	-2.116 (0.2380)	-4.844 (0.0000)	-1.656 (0.4542)	-4.685 (0.0001)
GDP	-1.643 (0.4606)	-7.886 (0.0000)	-1.856 (0.3530)	-7.934 (0.0000)

The policy rate takes only a small number of discrete values in this sample, changing on five occasions, and unit root tests can perform poorly on step-like series. Moreover, a stationary variable inside a cointegrated system implies only an additional trivial cointegrating relation involving that variable alone, and does not affect the consistency of the remaining estimates. The Toda-Yamamoto procedure applied in Joint tests and causality analysis is in any case valid regardless of the order of integration, which is a further reason for using it alongside the VECM.

For the other variables, the two tests agree: the *p*-values in levels exceed 0.05, while after first differencing they are effectively zero. The variables are therefore integrated of order one, which justifies the use of the Johansen procedure.

Selection of the lag order

Results of this kind are sensitive to lag length, so the lag order is settled first. Table V reports the five criteria.

Table V
VAR lag order selection

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	-152.407		0.00011	5.07766	5.14501	5.24920
1	180.598	666.01	5.4e-09	-4.85799	-4.45388*	-3.82873*
2	210.958	60.721	4.6e-09	-5.03091	-4.29003	-3.14393
3	237.838	53.760	4.5e-09	-5.09156	-4.01392	-2.34687
4	283.611	91.545*	2.5e-09*	-5.76164*	-4.34725	-2.15924

The AIC, FPE and LR criteria reach their optimum at lag four, while the HQIC and SBIC favor the more parsimonious specification of one lag. The specification estimated below uses four lags. The transmission mechanisms of monetary policy, including liquidity provision, the management of expectations, and portfolio rebalancing, operate gradually and require a relatively longer lag structure; in a short sample, a low lag order may fail to capture important dynamic adjustments and may bias the subsequent impulse response and variance decomposition analyses. The Lagrange multiplier tests reported in diagnostic tests and stability do not reject the absence of residual autocorrelation under this specification.

Four lags in a five-variable system yield seventeen parameters per equation estimated using 62 observations, so individual coefficients are estimated with low precision; this is the reason for the joint tests of lag blocks in Table X, on which more weight is placed. The artificial persistence introduced by the disaggregation procedure also biases the criteria towards longer lag orders, so the divergence among them may partly reflect the data-construction procedure. The lag order is therefore a source of specification uncertainty rather than a settled matter.

Cointegration test

After determining the lag length, the Johansen trace test was applied to examine the presence of long-run equilibrium relationships among the variables. Table VI presents the cointegration test results obtained using four lags, in accordance with the VAR specification.

Table VI
Johansen Cointegration test results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value (0.05)
None	-	83.3148	68.52
At most 1	0.46739	44.2568*	47.21
At most 2	0.29671	22.4338	29.68
At most 3	0.18168	10.0030	15.41
At most 4	0.12034	2.0531	3.76

Note. Decisions are stated at the 5% critical values. The asterisk marks the rank selected by the trace test, that is, the first row in which the statistic falls below its critical value.

The trace statistic of 83.31 exceeds the 5% critical value of 68.52, so the null of no cointegration is rejected; the null of at most one vector is not, since 44.26 falls below 47.21. One cointegrating relation is therefore confirmed, so a stable long-run equilibrium relation links the monetary policy instruments to the macroeconomic variables. The second statistic is not far below its critical value, so the evidence for one vector rather than two is not overwhelming.

Long-run results of the vector error correction model

Table VII sets out the estimated cointegrating vector together with the adjustment coefficients of the five equations. The vector is normalized on LnCB_TA, with the normalization applied by default in the estimation routine. Its four free coefficients are jointly different from zero: the Wald statistic is 134.06 on four degrees of freedom, with a *p*-value below 0.001.

Table VII
Long-run estimation results of the VECM

Panel A. Cointegrating vector (beta), normalised on LnCB_TA				
Variable	Coefficient	Std. error	Z	*p*-value
LnCB_TA	1.0000	-	-	-
PR	0.0312	0.0526	0.59	0.554
CPI	-0.1311	0.0319	-4.11	0.000***
LnER	-4.8858	0.4586	-10.65	0.000***
GDP	0.0578	0.0147	3.94	0.000***
Constant	33.6895	-	-	-
Panel B. Adjustment coefficients (alpha) on the error correction term				
Equation	Coefficient	Std. error	Z	*p*-value
D.LnCB_TA	-0.0793	0.0432	-1.84	0.066*
D.PR	0.8530	0.2887	2.95	0.003***
D.CPI	0.3880	0.5131	0.76	0.449
D.LnER	0.0051	0.0052	0.96	0.335
D.GDP	-1.9641	0.5360	-3.66	0.000***

Note. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Wald test of the cointegrating equation: chi-square(4) = 134.06, *p*-value < 0.001.

The estimated long-run relation may be written as:

$$\text{LnCB}_{TA} + 0.031 \times PR - 0.131 \times CPI - 4.886 \times \text{LnER} + 0.058 \times GDP + 33.689 = 0$$

How the coefficients are read depends on the normalization. Since the expression is normalized on LnCB_TA, each coefficient describes the response of the balance sheet to the variable beside it, and its sign reverses once the expression is solved for LnCB_TA. Obtaining the long-run response of inflation, the exchange rate or output to the balance sheet requires solving the relation for that variable, which alters the magnitude of the coefficient as well as its sign. Solved in this way, a balance sheet 1% larger is associated with inflation higher by about 0.076 percentage points, a nominal exchange rate weaker by about 0.205%, and output growth lower by about 0.173 percentage points. The policy rate carries a coefficient indistinguishable from zero (*p*-value = 0.554), so once the balance sheet is in the relation, the conventional instrument adds nothing further to it in the long run.

Three qualifications limit how far these figures can be taken. The standard errors in Table VII belong to the vector as normalized on LnCB_TA, whereas the rearranged coefficients are ratios of estimated parameters whose standard errors would have to be obtained by the delta method, so no significance is attached to them. What does carry over is the test of whether a variable enters the relation at all, since that hypothesis is invariant to the normalization, and on this basis CPI, LnER, and GDP enter it, while PR does not. Finally, a single cointegrating vector does not allow separate structural long-run equations to be identified: the figures above are alternative ways of writing one relation rather than three effects, and none of them may be read as the causal effect of the balance sheet on the variable concerned.

Panel B shows where the adjustment takes place. The error correction coefficient is significant only in the output equation (-1.9641) and the policy rate equation (0.8530); it is insignificant in the inflation and exchange rate equations and reaches only the 10% level in the balance sheet equation. Deviations from the long-run relation are thus corrected mainly through output and the policy rate, while inflation and the exchange rate behave as weakly exogenous with respect to that relation over the sample period.

Short-run results of the vector error correction model

The error correction coefficient in the output equation is negative and significant at the 1% level, which establishes that output growth adjusts towards the long-run relation, but its magnitude calls for care. An adjustment coefficient larger than one in absolute value does not mean that more than the whole of the disequilibrium is removed smoothly. It means that the correction overshoots, so that a deviation is more than fully offset within one month and reappears with the opposite sign, and the return to equilibrium is a damped oscillation rather than monotone convergence. Convergence still holds, since any value between -2 and 0 is consistent with stability, but the estimate lies close to that boundary.

Table VIII
Short-run estimation results of the VECM

Dependent Variable	ΔCPI	ΔLnER	ΔGDP
ECTt-1	0.3880	0.0051	-1.9641***
ΔLnCB_TAt-1	-1.4730	-0.0307*	-2.6860
ΔLnCB_TAt-2	-1.7224	-0.0270	-1.3535
ΔLnCB_TAt-3	-4.0920**	-0.0190	1.9243
ΔPRt-1	-0.1233	-0.0020	0.4029
ΔPRt-2	0.5066**	-0.0054**	-0.1985
ΔPRt-3	0.1393	-0.0037	0.5749**
ΔCPIt-1	0.1134	0.0008	-0.0187
ΔCPIt-2	0.0050	-0.0024*	-0.5035***
ΔCPIt-3	0.0438	-0.0011	0.1871
ΔLnERt-1	-7.1338	0.4216***	-5.6903
ΔLnERt-2	18.1800	-0.4171***	3.4706
ΔLnERt-3	-16.0552	0.2874**	-5.4148
ΔGDPt-1	0.0179	-0.0016*	0.0523
ΔGDPt-2	-0.1548*	-0.0034***	0.0383
ΔGDPt-3	-0.0734	0.0003	0.5862***
Constant	0.1354	0.0042***	-0.0012
R-squared	0.3583	0.7115	0.5868
chi-square	25.1232	110.9772	63.8960
p-value	0.0920	0.0000	0.0000

Note. n = 62 for each equation. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Log likelihood 261.4825; AIC -5.5640; SBIC -2.5105; HQIC -4.3651 for the system. Results for the ΔLnCB_TA and ΔPR equations are available from the author; the adjustment coefficients of those equations appear in Panel B of Table VII

A second reason for caution concerns the data. As methodolgy explains, the monthly output series is constant within each quarter, so its first difference is zero in two months out of three and takes a single large value in the third. Regressing a series of this kind on a lagged level term tends to produce a large negative coefficient by construction, and the significant coefficient on the third lag of the output change, which corresponds exactly to the quarterly frequency of the source data, points in the same direction. The size of the error correction coefficient is therefore treated as partly an artifact of the disaggregation procedure, and no economic conclusion is drawn from it; what survives is the sign and the significance.

Turning to the individual coefficients, the third lag of the balance sheet change is negative in the inflation equation at the 5% level, and its first lag is negative in the exchange rate equation at the 10% level. The second lag of the policy rate change is positive in the inflation equation and negative in the exchange rate equation, while its third lag is positive in the output equation. The second lag of the inflation change is negative in the output equation, which is consistent with the possibility that elevated inflation raises uncertainty and discourages investment in the short run. The exchange rate equation shows marked persistence, with significant coefficients on all three of its own lags. Explanatory power varies considerably across equations: the inflation equation reaches an R-squared of only 0.36, and its joint statistic is significant only at the 10% level, so important determinants of inflation evidently lie outside the system.

Coefficients estimated one at a time in a system of this size are imprecise, and little weight is placed on any of them individually. The complete blocks of policy lags are tested jointly in Joint tests and causality analysis, where the results can be considered alongside the causality tests in levels.

Diagnostic tests and stability

The Lagrange multiplier test does not reject the absence of serial correlation at lag one or lag two at the 5% level, so the chosen lag structure appears to capture the dynamics adequately, although the result at lag two is marginal.

Table IX
Diagnostic tests of the VECM

Panel A. Lagrange multiplier test for residual autocorrelation				
Lag order	chi-square	df	*p*-value	*p*-value
1	21.575	25	0.6601	0.6601
2	34.718	25	0.0934	0.0934
Panel B. Jarque-Bera normality test, by equation				
Equation	chi-square	*p*-value	Skewness	Kurtosis
ΔLnCB_TA	1.022	0.6000	-0.146	2.443
ΔPR	64.931	0.0000	1.239	7.358
ΔCPI	192.383	0.0000	1.191	11.295
ΔLnER	18.713	0.0001	0.848	5.091
ΔGDP	24.391	0.0000	-0.275	6.023
All equations	301.440	0.0000	-	-
Panel C. Eigenvalue stability condition				
Moduli of the companion matrix			Value	
Unit moduli imposed by the rank restriction			4	
Largest remaining modulus			0.845	
Moduli lying outside the unit circle			0	

Note. Panel A reports the Lagrange multiplier test for the null of no residual autocorrelation at the stated lag. Panel B reports the Jarque-Bera test by equation and for the system as a whole. Panel C reports the moduli of the companion matrix, whose position in the complex plane is shown in Figure 1.

The Jarque-Bera statistic for the system is 301.44, with a *p*-value of 0.000, so normality of the residuals is rejected. What follows from this should be stated precisely. The Johansen estimator is a quasi-maximum-likelihood estimator, so consistency of the estimates and the asymptotic distribution of the trace statistic do not require Gaussian errors, and non-normality does not invalidate the point estimates. Finite-sample inference is another matter. With 62 observations and seventeen parameters per equation, Wald statistics computed under normality may be poorly sized when the residuals have heavy tails, and asymptotic impulse response bands may be too narrow. The *p*-values reported here should accordingly be read as approximate, and results with p-values between 0.01 and 0.10 should be interpreted as suggestive rather than established.

Panel B locates the problem. The residuals of the balance sheet equation are close to normal, and the rejection comes from the policy rate equation and, above all, from the inflation equation, whose residuals have a kurtosis coefficient of 11.30 and whose skewness coefficient is 1.19. Heavy tails of this kind, in a short sample containing the pandemic, a commodity price shock, and administered price adjustments, are what a few large isolated disturbances would produce rather than a sign of a mis-specified dynamic structure. The remedies are impulse dummies for these episodes and the use of bootstrap rather than asymptotic inference. Neither is implemented here, and both are recorded in Section conclusion.

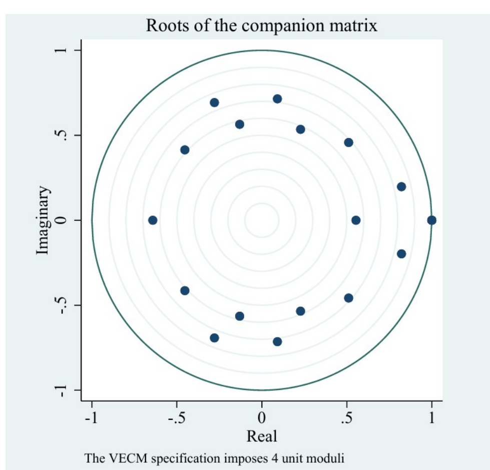

Fig. 1 *VECM stability: Roots of the companion matrix*

Panel C reports the stability condition, assessed from the position of the inverse roots of the companion matrix in the complex plane, shown in Figure 1. Apart from the four unit moduli imposed by the rank restriction, all roots lie inside the unit circle, the largest having a modulus of 0.845. The estimated VECM is therefore dynamically stable and suitable for the impulse response and variance decomposition analyses that follow.

Impulse response analysis

Impulse response functions were used to trace the dynamic reaction of the macroeconomic indicators to shocks in the policy variables over a horizon of twelve months. What follows describes the direction and shape of the point responses. None of them is claimed as a statistically significant effect: over most of the horizon the confidence bands include zero, which is unavoidable in a five-variable system with four lags estimated on 62 observations. A movement away from zero in the figure is not by itself evidence of an effect.

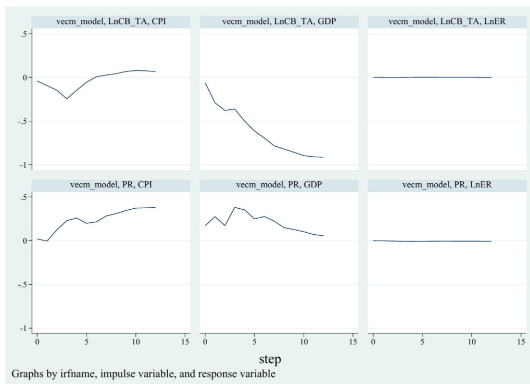

Fig. 2 *Impulse response functions to monetary policy shocks*

A positive shock to central bank assets is followed at first by a slight decline in inflation, but from the third period onwards the response turns positive and stays positive to the end of the horizon. The delay is what would be expected if the pass-through from liquidity expansion to aggregate demand and prices is gradual, and the sign agrees with the positive long-run association reported in Table VII. A positive shock to the policy rate is also followed by an increase in inflation over much of the horizon, contrary to the standard prediction; Section 5.1 returns to this.

The response of output growth to a shock in central bank assets is predominantly negative across the horizon, consistent with the negative long-run association in Table VII, so the two pieces of evidence are in agreement rather than in conflict. Output growth responds positively to a policy rate shock initially, and that response fades over time. The exchange rate shows little response to either shock, remaining close to zero in virtually all periods, which may be attributed to exchange rate management practices, central bank interventions, or a low degree of exchange-rate transmission.

Forecast error variance decomposition

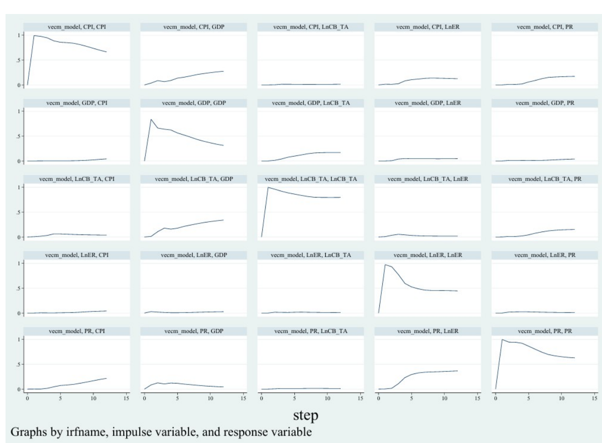

Fig. 3 *Forecast error variance decomposition*

In the early periods, each variable is explained mainly by its own innovations, and the contributions of the other variables grow gradually. Inflation is explained mainly by its own shocks throughout, reflecting its inertia, while the contributions of output and policy-rate shocks rise later in the horizon. For output growth, the contribution of balance sheet shocks increases steadily. The balance sheet depends heavily on its own shocks, and the rising contributions of output and policy rate shocks suggest that the monetary authority adjusts balance sheet operations in response to economic conditions. The exchange rate is explained predominantly by its own innovations throughout, in agreement with the impulse responses.

Joint tests and causality analysis

Because individual coefficients in a system of this size are estimated imprecisely, the policy variables are better assessed through their complete lag blocks. Table X reports two such assessments. Panel A restricts the three lagged differences of each policy variable jointly to zero within the short-run part of the VECM. Panel B applies the Toda-Yamamoto procedure to the augmented VAR in levels, which examines whether past values of one variable improve the forecast of another. The second test is a test of Granger causality, not of structural causality, and it does not identify a policy shock, so its results are described in terms of predictive content.

Table X

Joint tests on the predictive content of the policy variables

	Policy rate (PR)	Policy rate (PR)	Central bank total assets (LnCB_TA)	Central bank total assets (LnCB_TA)
Dependent variable	chi-square	*p*-value	chi-square	*p*-value
Panel A. Joint Wald tests on the lagged differences within the VECM, chi-square(3)				
ΔCPI	5.39	0.1455	5.53	0.1368
ΔLnER	10.77	0.0130**	5.12	0.1630
ΔGDP	6.83	0.0775*	4.87	0.1818
Panel B. Toda-Yamamoto tests on the augmented VAR in levels, chi-square(4)				
CPI	12.97	0.0114**	11.12	0.0252**
LnER	13.73	0.0082***	6.52	0.1636
GDP	11.08	0.0257**	17.67	0.0014***

Note. ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Panel A restricts the three lagged difference terms of the stated policy variable jointly to zero in the equation named in the first column; $n = 62$. Panel B is based on an augmented VAR estimated in levels with five lags, with modified Wald tests applied to the first four lags; sample June 2020 - June 2025, $n = 61$.

Panel A gives a more cautious picture than the individual coefficients of Table VIII. The block of lagged policy rate changes is jointly significant in the exchange rate equation and, at the 10% level, in the output equation, but not in the inflation equation. The block of lagged balance sheet changes is not jointly significant in any equation, and the individually significant coefficient on its third lag in the inflation equation does not survive a test of the whole block. Within this specification, the balance sheet channel has no short-run effect that can be detected statistically.

Panel B is more favorable to both instruments. The policy rate has significant predictive content for all three macroeconomic variables: for inflation and output growth at the 5% level, and for the exchange rate at the 1% level. The balance sheet indicator has significant predictive content for inflation and output growth, but not for the exchange rate, which may reflect the greater sensitivity of the exchange rate to external factors such as foreign trade, capital flows, and intervention operations.

The contrast between the two panels calls for comment. The balance sheet lag blocks are jointly insignificant within the short-run part of the VECM, yet the balance sheet has significant predictive content in the augmented VAR in levels. The two results are not contradictory, because they test different hypotheses using different transformations of the data. The tests in Panel A concern the lagged first differences alone, in isolation from the long-run relation captured by the error correction term, while those in Panel B concern four lags in levels and pick up the cumulative influence of both. The reading is that the balance sheet acts on inflation and output through the long-run relation and through cumulative distributed lags rather than through an immediate month-to-month adjustment.

Discussion of the Main Findings

The four sets of results have different logical status, and it is worth stating where they agree. The long-run relation and the impulse responses give the same sign for the association between the balance sheet and output growth, both negative, and for the association with inflation, both positive once the initial periods have passed. The impulse responses, the variance decomposition, and the Toda-Yamamoto tests agree that the exchange rate is comparatively insulated from domestic policy shocks. They disagree on one point: the short-run block tests find no detectable effect of the balance sheet, while the Toda-Yamamoto tests find predictive content for inflation and output. As explained in Joint tests and causality analysis, this supports the reading that the balance sheet channel works cumulatively rather than on a month-to-month basis, as would be expected of a channel operating through liquidity conditions and directed credit rather than through a market price.

The finding that inflation rises after a positive shock to the policy rate is contrary to the standard prediction. The most likely explanation is a price puzzle produced by the endogeneity of the policy instrument rather than by a perverse transmission mechanism. The Central Bank raises the policy rate in response to inflationary pressure that it observes or anticipates, and if the information on which it acts is not fully contained in four lags of the five variables, the estimated policy shock is contaminated by that information, so the subsequent rise in inflation reflects the pressure that provoked the tightening rather than a consequence of it. Two considerations support this reading: Davlatov and Sági (2026) obtain exactly this puzzle for Uzbekistan under recursive identification and find that it disappears under a non-recursive scheme, and the policy rate moved on only five occasions in this sample, each in response to a well-identified inflationary episode. The puzzle is not peculiar to Uzbekistan: Ha et al. (2025) find it throughout emerging market data, attribute it to the endogeneity of the policy instrument and to the weight of exchange rate and commodity shocks in these economies, and show that it weakens once the policy shock is identified more carefully than a recursive scheme allows. The result is therefore not interpreted as evidence that monetary tightening raises inflation in Uzbekistan.

The negative long-run association between central bank total assets and output growth, and the negative output response in the impulse responses, run against the results of Gambacorta et al. (2014), Weale and Wieladek (2016) and Fiorelli and Meliciani (2019) for advanced economies. Three explanations are plausible and not mutually exclusive. The first, and in the author's view the most important, is reverse causation: the balance sheet expands most rapidly when the authorities support the economy through liquidity provision, refinancing, and directed credit, and these operations intensify precisely when growth is weak, as in 2020. A negative association would then be observed even if balance sheet expansion had no adverse effect on output, and the adjustment coefficients in Panel B of Table VII, where the balance sheet is close to weakly exogenous while output carries the adjustment, are consistent with this. The second is composition: net foreign assets, the largest component, expand through reserve accumulation and gold purchases largely unrelated to domestic demand management. The third is that liquidity expansion generates imbalances that weigh on output over the medium term, which cannot be excluded but is the least well identified. The negative sign should therefore be read as evidence that the balance sheet is endogenous in this system, not as a statement that its expansion damages growth.

The exchange rate deserves a final remark, since it carries a large coefficient in the cointegrating vector while responding very little to policy shocks. The two facts are reconciled if the exchange rate and the balance sheet share a common long-run trend without the exchange rate responding to short-run impulses. Net foreign assets are valued in soum, so a depreciation mechanically raises the soum value of the balance sheet, and both series rise together; this accounting link is a further reason for caution in giving the exchange rate coefficient a behavioral interpretation. Beyond this, the weak short-run response is consistent with active exchange rate management, since interventions dampen precisely the responses that impulse response functions are designed to detect. In Albania, an economy comparable in its degree of currency substitution, and Sejko and Tanku (2024) find the opposite configuration, with the exchange rate carrying most of the effect of the balance sheet on prices; the difference is consistent with what more active exchange rate management would produce. Gürkaynak et al. (2023) document a third case in Turkey, where a policy rate held below the level implied by inflation left the exchange rate to determine the price level, which is a reminder that the exchange rate response says as much about the policy regime as about the transmission mechanism.

Conclusion

The Johansen test confirmed a single stable long-run equilibrium relation among central bank total assets, the policy rate, inflation, the exchange rate, and output growth. Adjustment towards this relation is carried by output growth and by the policy rate, while inflation and the exchange rate behave as weakly exogenous with respect to it. When the cointegrating vector is solved for each variable in turn, a larger balance sheet is associated in equilibrium with higher inflation, a weaker exchange rate, and lower output growth, and the policy rate does not enter the relation independently.

In the short run, joint tests show that changes in the policy rate are associated with movements in the exchange rate and, more weakly, with output growth, while changes in the balance sheet have no jointly significant association with any macroeconomic variable. In the augmented VAR in levels, by contrast, both instruments have predictive content for inflation and output growth, and the policy rate has predictive content for the exchange rate. The interest rate instrument is therefore the more consistently informative of the two across specifications, and the influence of the balance sheet appears over longer horizons rather than through immediate adjustment.

Several structural features help to explain this. Reliance on inflation targeting and interest rate signaling since 2020 has strengthened the influence of the policy rate on demand, expectations, and financial conditions. Shallow capital markets, limited financial intermediation, administrative interventions, and directed lending all weaken the market channels through which balance sheet expansion would otherwise work.

Two implications follow, both stated narrowly so as not to exceed what the estimates support. The first is that the policy rate should remain the primary operational instrument, since it is the instrument for which the evidence of a systematic relationship with macroeconomic outcomes is consistent across methods. The second is that the size of the balance sheet should not be treated as an independent instrument of demand management on the basis of these results: it aggregates foreign exchange operations, refinancing, and credit support, and the estimates suggest that it responds to macroeconomic conditions rather than driving them.

A third implication concerns measurement. If balance sheet policy is to be evaluated seriously in Uzbekistan, a published monthly decomposition of central bank operations into policy and non-policy components would be of considerable value, since it would allow a measure of the monetary stance to be constructed that is not contaminated by reserve management and fiscal operations.

The study has several limitations. Central bank total assets are a proxy that aggregates foreign exchange interventions, reserve and gold operations, refinancing, government transactions, and credit support, so only part of the variation reflects a deliberate change in the monetary stance, and every result involving CB_TA is conditional on this measurement. The monthly output series is obtained by a constant-within-quarter allocation, which introduces artificial persistence and affects both the lag selection and the magnitude of the error correction coefficient. The sample spans a period that includes the pandemic, a global commodity shock, the war in Ukraine, and administered energy price adjustments, yet no structural break tests were carried out, and no break dummies were included.

Three further limitations concern inference and identification. The Jarque-Bera test rejects normality, which does not affect consistency but does affect finite-sample inference, so the reported p-values are approximate. The impulse responses depend on the Cholesky ordering, and the price puzzle discussed in discussion of the main findings indicates that the recursive scheme does not isolate an exogenous policy impulse; the Toda-Yamamoto results establish predictive rather than structural causality, and no claim of structural causal identification is made in this paper. Finally, important determinants of Uzbek inflation and output, such as remittance inflows, world commodity prices, the fiscal stance, and dollarisation, are omitted, which is consistent with the low explanatory power of the inflation equation.

Four extensions would address these limitations: estimation of the same system at quarterly frequency, where no disaggregation is required, and comparison of the resulting long-run vector with the one reported here; the inclusion of formal structural break tests and impulse dummies for the identified episodes; re-estimation of the impulse responses under an alternative Cholesky ordering and with generalised impulse responses in the sense of Pesaran and Shin (1998), together with bootstrap confidence bands; and the construction of a narrower measure of unconventional policy based on the refinancing and credit support components alone, which would exclude the reserve management operations that appear to account for much of the association between the balance sheet and the exchange rate.

Conflict of Interest

The author declares that there is no conflict of interest.

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