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INFLATION MEASUREMENT AND ITS MACROECONOMIC IMPLICATIONS

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Abstract

This study analyzes the impact of inflation on the macroeconomics of Uzbekistan based on panel and time series data for 2015–2024. Using VAR (Vector Autoregression) and ARDL (Autoregressive Distributed Lag) methodologies, the channels of inflation impact on GDP growth, investment, consumer demand, real wages, and the foreign trade balance are identified. The results show that a 1 percent increase in inflation reduces GDP growth by 0.31–0.62 percent, and reduces gross investment by 0.44–0.93 percent. The money supply (M2) and the exchange rate are identified as the main inflationary factors. The transition to inflation targeting (2021) is yielding positive results: inflation decreased from 14.5% (2019) to 8.8% (2023). The article concludes with policy recommendations to reduce inflation to 5 percent by 2026.

Keywords

inflation, macroeconomic stability, monetary policy, inflation targeting, VAR model, Central Bank of Uzbekistan, Taylor rule

INTRODUCTION Inflation—a sustained increase in the general price level—is a major macroeconomic problem for all economies, especially developing countries. Inflation slows economic growth, worsens the investment climate, reduces the value of savings, and has a direct negative impact on the standard of living of the population. [1,25] Based on the quantity theory of money, the Fisher equation (MV = PQ) explains the direct relationship between the money supply and the price level. [4]

Uzbekistan has faced persistent high inflation since independence. After experiencing a period of hyperinflation in the 1990s, the country began to reduce inflation through large-scale monetary reforms in the 2000s. [19] The liberalization of the foreign exchange market in 2015–2018 led to a sharp increase in inflationary pressures: inflation reached 14.5% in 2019. [3]

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The Central Bank of Uzbekistan (CBU) officially switched to inflation targeting (IT) in 2021. [10] The goal is to maintain inflation at 5±1.5 percent by 2023 and around 5 percent by 2026. This decision is aimed at increasing the transparency and effectiveness of monetary policy and involves actively managing the key interest rate based on the Taylor rule [6] .

It should be noted that inflationary processes in Uzbekistan are multifaceted. On the one hand, structural factors - an increase in the cost of imports, an increase in tariffs on natural monopolies, and seasonal fluctuations in agricultural prices - contribute to inflation. On the other hand, monetary factors - a rapid increase in the money supply and exchange rate fluctuations - also increase inflationary pressures. [17,1]

The main objective of the study is to identify the mechanisms of inflation's impact on the macroeconomics of Uzbekistan through econometric methods, assess the main determinants of inflationary processes, and analyze the effectiveness of the inflation targeting regime. [1,2]

The main regulatory documents regulating inflation management and monetary policy in Uzbekistan are:

PF-60 (2022) — 'Uzbekistan — Development Strategy: Reducing inflation to 5 percent by 2026 and ensuring macroeconomic stability are set as priorities.

The Law on the Central Bank of the Republic of Uzbekistan (2019) — Mandate of the Central Bank of the Republic of Uzbekistan: Ensuring price stability was established as the main constitutional objective of the Central Bank of the Republic of Uzbekistan.

Law on Currency Regulation (Amendment 2017) — Currency liberalization: Ensuring the free convertibility of the soum, which affected the manifestation of import inflation.

LITERATURE REVIEW

The theoretical framework for the inflation-growth relationship has developed in three main directions. First, the classical quantity theory of money (Fisher, 1911) [4] suggests a proportional relationship between the money supply and the price level. Friedman (1968) [5] argued that inflation is primarily a monetary phenomenon and that monetary policy is neutral in the long run.

Second, New Keynesian models (Galí, 2015) [13] explain inflation through demand management, inflation expectations, and price rigidity. This approach forms the theoretical basis of inflation targeting. Bernanke and Mishkin (1997) [20] have clearly developed an inflation targeting regime and demonstrated the possibility of "anchoring" inflation expectations through it.

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Third, the Phillips curve (Phillips, 1958) [8] describes the short-run inverse relationship between inflation and unemployment. This relationship is fundamental to analyzing the impact of domestic demand on inflation in the context of developing countries such as Uzbekistan.

Empirical studies on Central Asian countries (Umarov and Tursunov, 2023) [19] have shown that money supply growth and exchange rate are the main inflationary factors in Uzbekistan. According to the ADB (2024) [18] report, external price shocks (import inflation) also play an important role in the countries of the region.

METHODOLOGY (METHODS)

1. Database

The study used quarterly time series data for 2015–2024 (T=40 observations). Data sources: Uzbekistan Statistical Agency [3] , Monthly Statistical Bulletins of the Central Bank of Uzbekistan [1,17] , IMF Article IV Country Reports [2] , World Bank Macroeconomic Indicators Database. [14]

Key variables: inflation rate (based on the consumer price index, YoY), real GDP growth, M2 money supply growth, the key interest rate of the Central Bank of Uzbekistan, the USD/UZS exchange rate, gross domestic private investment, real wage index, import price index (UZS), and budget deficit (as a percentage of GDP). All variables were logarithmically transformed; inflation and interest rates were applied at the same level.

2. Econometric methodology

2.1. Unit root tests The augmented Dickey–Fuller (ADF) [15] and Phillips–Perron (PP) tests were used to test the stationarity of the variables . The test results confirmed that all variables were I(1) stationary in the first difference , which is a necessary condition for conducting cointegration analysis.

2.2. VAR model and impulse-effect analysis To determine the short-term dynamic impact of inflation on macroeconomic variables, the VAR model developed by Sims (1980) [11] was used:

$$\mathbf{Y}_t = \mathbf{A}_1\mathbf{Y}_{t-1} + \mathbf{A}_2\mathbf{Y}_{t-2} + \ldots + \mathbf{A}_p\mathbf{Y}_{t-p} + \mathbf{e}_t$$

Here $\mathbf{Y}_t$ is a vector of endogenous variables (inflation, GDP growth, interest rate, exchange rate, investment); A_i is a matrix of coefficients; ε_t is a vector of structural errors. The optimal lag length was determined as p=2 based on the Akaike (AIC) and Schwarz (BIC) criteria. The impulse-response functions (IRF) and forecast error variance decomposition (FEVD) were calculated based on the Cholesky decomposition. [23]

2.3. ARDL Cointegration Analysis To identify the long-run determinants of inflation, the ARDL bounds test approach of Pesaran, Shin, and Smith (2001) [12]

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was used. This model allows for the simultaneous analysis of the variables I(0) and I(1):

$$\Delta INF_t = \alpha_0 + \Sigma\beta_i \Delta INF_{t-i} + \Sigma\gamma_j D X_{t-j} + \theta_1 INF_{t-1} + \theta_2 X_{t-1} + m_t$$

Here, INF is the inflation rate; X is a vector of exogenous variables (M2, exchange rate, interest rate, import prices, budget deficit, GDP growth). Cointegration is compared with upper and lower bounds for the F-statistic and t-statistic. Short-run dynamics and the speed of return to long-run equilibrium were estimated using the error correction model (ECM).

2.4. Granger Causality Analysis The Granger (1969) [16] causality test was used to determine the directional relationships between variables . Specifically, it was tested whether the money supply, exchange rate, and budget deficit were Granger causes of inflation. All tests were evaluated at the 5 percent significance level.

RESULTS

Dynamics of inflation and macroeconomic indicators The inflation rate in Uzbekistan has undergone significant changes during 2019–2024. Table 1 shows the annual dynamics of key macroeconomic indicators. [1,3]

Table 1. Dynamics of key macroeconomic indicators of Uzbekistan (2019–2024)

Indicator	2019	2020	2021	2022	2023	2024
Real GDP growth (%)	5.9	1.9	7.4	5.7	6.3	6.5
Inflation (YoY, %)	14.5	11.1	10.8	12.3	8.8	9.8
Core inflation (%)	11.2	9.4	9.1	10.6	7.9	8.6
M2 money supply growth (%)	23.4	19.7	25.2	21.5	18.3	17.6
CBU base rate (%)	16.0	14.0	14.0	17.0	15.5	13.5
USD/UZS average exchange rate	9487	10054	10619	11050	11586	12740
Budget deficit (GDP, %)	-3.9	-4.4	-5.8	-4.4	-3.2	-2.8
Unemployment rate (%)	9.3	10.1	9.6	9.0	8.7	8.3

Note: *Inflation — Consumer Price Index (YoY); Core inflation — excluding food and energy prices; ECT — Error Correction Factor; IT — Inflation Targeting. Source: Uzbekistan Statistical Agency [3]; Uzbekistan Central Bank [1.17]; IMF [2.24].*

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The table shows that inflation is expected to decline after the transition to inflation targeting (2021): from 12.3% (2022) to 8.8% (2023) and 9.8% (2024). [17] However, the 12.3% increase in 2022 is due to the global commodity price shock caused by the Russia-Ukraine conflict and the increase in import prices. [24] It can be observed that real GDP growth has moved in the opposite direction to inflation indicators: in 2020 (the impact of COVID-19), growth fell to 1.9%, and inflation also fell; in 2022, inflation increased against the background of global price shocks, but growth slowed down. [2]

Money supply (M2) growth is positively correlated with inflation—the Granger causality test confirmed the M2 → INF direction at the 1 percent level of significance. [16] The increase in the key rate of the Central Bank of Uzbekistan to 17 percent in 2022 served to curb inflation, confirming the practical application of the Taylor rule. [6,10]

VAR model results: channels of influence of inflation

Table 2 presents the results of the impulse-response functions (IRF) of the VAR model. A 1 percent exogenous inflation shock has a statistically significant negative impact on all key macroeconomic variables. [23,11]

Table 2. VAR model: results of the impulse response of the inflation shock

Dependency (Inflation →)	1st quarter	2nd quarter	4th quarter	Importance (p)
GDP growth (%)	−0.31	−0.48	−0.62	0.003***
Private consumption (%)	−0.19	−0.33	−0.44	0.018**
Gross investment (%)	−0.44	−0.71	−0.93	0.001***
Real wage growth (%)	−0.26	−0.41	−0.57	0.012**
Export volume (%)	−0.18	−0.27	−0.39	0.041*
Exchange rate devaluation	+0.52	+0.83	+1.14	0.002***

Note: *Coefficients: percentage change of each variable (by quarter) in response to a 1 percent exogenous inflation shock. Cholesky decomposition. *** p<0.01; ** p<0.05; * p<0.10. Lag length: p=2 (AIC/BIC). Source: UzMB [1]; Author's calculations based on data from the Statistical Agency [3].*

The results show that the strongest impact of inflation is on gross investment: a contraction of −0.93 percent in the fourth quarter. This reflects the cautious attitude of investors in the face of inflationary uncertainty. [13.2] The impact on the exchange rate (+1.14 percent in the fourth quarter) demonstrates a mutually

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reinforcing mechanism between inflation and devaluation: imports become more expensive and create new inflationary pressures (import-push inflation). [17]

3. ARDL cointegration and long-run factors

Table 3 shows the ARDL bounds test results with F-statistic = 6.84 (exceeding the upper bound of 5.73, p<0.01), confirming the existence of cointegration between inflation and its determinants. [12] The ECT coefficient (−0.312) indicates that 31.2 percent of the deviation from equilibrium is returned to equilibrium per month — full adjustment occurs in about 3.2 months.

Table 3. ARDL results: Long-run determinants of inflation in Uzbekistan

Variable	Coefficient	Std. error	t-stat	Importance
M2 money supply growth	+0.342	0.081	+4.22	0.000***
USD/UZS exchange rate	+0.217	0.063	+3.44	0.001***
Import prices (UZS)	+0.189	0.071	+2.66	0.009***
Budget deficit (GDP, %)	+0.134	0.058	+2.31	0.023**
CBU base rate	−0.186	0.049	−3.80	0.000***
GDP growth (lagged)	−0.091	0.044	−2.07	0.041**
ECT (long-term adaptation)	**−0.312**	**0.087**	**−3.59**	**0.001*** **
R^2 = 0.841 | Adj. R^2 = 0.819 | F-stat = 38.6* **				

Note : *Depends variable : INF (consumer) prices index , YoY). Lag structure: ARDL(2,1,1,1,2,1,1). F-stat = 6.84 (PSS upper limit 5.73); ECT — error correction coefficient. *** p<0.01; ** p<0.05; * p<0.10. Data: 2015Q1–2024Q4 (T=40). Source: UzMB [1]; IMF [2]; Author's calculations based on the Statistics Agency [3].*

Table 3 shows that the growth of the M2 money supply (+0.342, p<0.001) is the strongest long-term factor of inflation. This empirically confirms Friedman's theory [5] in the conditions of Uzbekistan. The devaluation of the USD/UZS exchange rate (+0.217, p<0.001) is also an important factor: a 1 percent devaluation of the national currency increases inflation by 0.22 percent in the long run. [19,1]

Importantly, the increase in the key rate of the Central Bank of Uzbekistan has a statistically significant negative impact on inflation (−0.186, p<0.001). This indicates that the Taylor rule [6] is working in Uzbekistan and the effectiveness of the inflation targeting regime [7,10] . The impact of the budget deficit on inflation is also positive and significant (+0.134, p<0.05), which indicates the need to coordinate fiscal policy with monetary policy. [22,2]

Regional and international comparative analysis

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Table 4 compares Uzbekistan's inflation rates with those of neighboring countries. [24,18,21]

Table 4. Regional inflation comparison: Uzbekistan and neighboring countries (2021–2024, %)

Country	Mode	Target (%)	2021	2022	2023	2024
Uzbekistan	IT (2021~)	5.0 (2026)	10.8	12.3	8.8	9.8
Kazakhstan	IT	4–6	8.4	20.3	10.8	8.4
Georgia	IT	3.0	9.6	11.9	2.5	3.1
Russia	IT	4.0	8.4	11.9	7.4	8.6
Tajikistan	–	–	9.0	6.7	4.3	4.7
Kyrgyzstan	–	–	11.9	14.7	10.8	5.1
Asia average	–	–	3.7	5.9	4.2	3.8

Note: *IT — Inflation Targeting; ~ — partially implemented. Source: IMF WEO (2025) [24]; ADB (2024) [18]; EBRD (2024) [21]; Bank of Uzbekistan [1].*

Comparative analysis shows that Uzbekistan's inflation, while relatively high compared to Central Asian countries, is on a downward trend. Countries that have moved to a full IT regime, such as Georgia, are managing to keep inflation close to the target level. [7,20] Kazakhstan, as a result of the global shock in 2022, increased inflation to 20.3 percent, but reduced it to 8.4 percent in 2024. Uzbekistan's dynamics are following a similar path. [24]

DISCUSSION

The results of the study lead to a number of important conclusions about the impact of inflation on the macroeconomics of Uzbekistan. First, the money supply (M2) and the exchange rate were identified as the main inflationary factors. This is explained by high climatic shocks, a large share of imports, and a relatively limited financial market. [17,19]

Second, the transition to inflation targeting (2021) is yielding measurable positive results. Inflation has fallen from 14.5% (2019) to 8.8% (2023). However, we are still far from the target (5%). This confirms that the credibility of the IT regime for developing countries cannot be fully realized without institutional reforms, as Mishkin (2000) [7] has pointed out. [20]

Third, the negative impact on investment (−0.93 percent in Q4) is particularly significant. Ensuring inflation stability is crucial for improving the investment climate in Uzbekistan. IMF (2024) [2] and World Bank (2024) [14] reports also

emphasize that the investment climate in Uzbekistan is directly related to inflation uncertainty.

Fourth, exchange rate pass-through is high in Uzbekistan: a 1 percent devaluation leads to a 0.22 percent increase in inflation. This is due to the high share of imports (about 40 percent of GDP). [3,17] Therefore, the Central Bank of Uzbekistan's intervention to stabilize the exchange rate is an important additional tool of monetary policy. [1]

Social consequences of inflation , The most negative social consequence of inflation is the reduction in real wages (−0.57 percent, in the 4th quarter). In Uzbekistan, as nominal wage growth does not keep pace with inflation, real wages will fall. This is especially a serious problem for public sector employees and pensioners with fixed nominal incomes. [3,2] Inflation also erodes the real value of savings and hinders financial intermediation. [25,13]

Strengthening monetary policy: [1,6,10] The Central Bank of Uzbekistan should make its Taylor-based interest rate decisions more transparent and predictable. The quality of quarterly inflation reports should be improved to anchor inflation expectations.

Fiscal-monetary coordination: [22.2] Keep the budget deficit below 3 percent of GDP and direct public spending in areas that do not create inflationary pressures. It is necessary to completely abandon inflationary financing (seigniorage).

Import inflation management: [17,18] To reduce the impact of import price shocks, strategic commodity reserves should be formed, agricultural import diversification should be promoted, and local production should be encouraged.

Currency policy: [1,19] Preventing excessive devaluation of the exchange rate and at the same time maintaining international foreign exchange reserves at a level not lower than the equivalent of 6 months of full import costs.

Structural reforms: [9,21] Gradual implementation of tariff increases for natural monopolies (electricity, gas, water) and strengthening the competitive environment, which will reduce price rigidity and curb supply-side inflation.

CONCLUSION

This study empirically confirms that inflation has a significant negative impact on macroeconomic stability in Uzbekistan. Key conclusions:

1- A 1 percent increase in inflation reduces GDP growth by 0.31–0.62 percent, gross investment by 0.44–0.93 percent, and real wages by 0.26–0.57 percent (VAR IRF results). [23,11]

2 - Money supply (M2) growth (+0.342) and exchange rate devaluation (+0.217) are the main determinants of inflation in the long run (ARDL results). [12.5]

3 - The increase in the key rate of the Central Bank of Uzbekistan has a statistically significant negative effect on inflation with a coefficient of −0.186. This confirms that the Taylor rule [6] is working in practice and that the inflation targeting regime [7,10] is having its initial effects.

4 - To achieve the goal of reducing inflation to 5 percent by 2026, it is necessary to strengthen coordination between monetary and fiscal policies, stabilize the exchange rate, and implement structural reforms in parallel. [1,9,2]

The policy measures recommended in the article are in line with the goals of ensuring macroeconomic stability within the framework of the Uzbekistan Development Strategy "Uzbekistan - 2030" [9] . The results of the study are of practical importance in the development of monetary policy, in particular, in the effective management of inflationary processes and ensuring macroeconomic stability. It is expected that these results will serve to further improve inflationary policy in the process of political decision-making by politicians, specialists of the Ministry of Finance, and international financial organizations - the International Monetary Fund , the World Bank , and the Asian Development Bank . [2,14,18]

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