INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS

ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

# Macroeconomic Determinants of Economic Growth in Uzbekistan: An Empirical Analysis

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**Abstract**

Gross domestic product (GDP) is one of the most important indicators used to assess a country's economic performance and overall macroeconomic conditions. Macroeconomic indicators play a significant role in analyzing national economic development and identifying the factors that influence economic growth. This study examines the relationship between four macroeconomic variables – gross domestic savings, unemployment, population growth, inflation – and GDP growth in Uzbekistan. Using annual data covering the period from 1991 to 2025, the study applies multiple linear regression to evaluate the relationship between these variables and GDP growth. The findings will provide insights into the macroeconomic factors associated with Uzbekistan's economic performance and contribute to a better understanding of the determinants of its economic growth. The results of this study reveal that gross domestic savings has a positive relationship with GDP growth in Uzbekistan, while unemployment, population growth and inflation exhibit negative relationship with GDP growth (see estimated regression model). According to the findings of this study, policymakers should focus on promoting domestic savings, reducing unemployment, managing inflation and supporting sustainable population growth to foster sustained economic development in Uzbekistan.

***Keywords***

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

Gross Domestic Product (GDP), Unemployment, Economic Growth, Population growth, Gross Domestic Savings, Inflation, Multiple Linear Regression, Uzbekistan.

## 1. INTRODUCTION

Gross domestic product (GDP) is one of the most widely used indicators for assessing a country's economic performance and level of development. According to the System of National Accounts (SNA), GDP measures the market value of all final goods and services produced within a country's domestic territory during a specified period. It provides an overview of economic activity and is commonly used to evaluate economic growth, compare economic performance across countries and support the formulation of economic policies. Analyzing the factors that influence economic growth has long been a central topic in economic research. Understanding their relationship with GDP growth is important for developing effective economic policies and promoting sustainable economic development. According to Keynesian theory, GDP can be measured using the expenditure approach, which expresses total output as the sum of consumption (C), investment (I), government expenditure (G) and net exports (NX). These components represent the main sources of aggregate demand and play an important role in driving economic activity.[1]

Meanwhile, modern economic growth theories emphasize the importance of capital accumulation, technological progress and improvements in productivity in expanding an economy's productive capacity over the long term. A country's gross domestic product is influenced by a range of macroeconomic factors and numerous researchers have investigated the relationships between these variables and economic performance. Commonly examined determinants include interest rate, domestic savings, unemployment, foreign direct investment and international trade. Mehmood examined the effects of 13 independent variables on GDP in Pakistan and Bangladesh.[2] The findings indicated that gross national expenditure, merchandise exports, gross savings and final consumption expenditure were positively associated with GDP in

[1] J.M. Keynes, "The general theory of employment, interest and money" Macmillan Cambridge University Press, for Royal Economic Society in 1936.
[2] S, Mehmood, "Effect of different factors on gross domestic product: A comparative study of Pakistan and Bangladesh", Academy of Contemporary Research Journal, 2012,1(1), 11-22.

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

Pakistan. In Bangladesh, gross national expenditure, total external debt, merchandise imports and merchandise exports were also reported to have positive relationships with GDP. Similarly, Anghelache and Anghel emphasized the role of employment, labor productivity, workforce skills, investment, foreign direct investment, imports, exports, net exports and total consumption in shaping GDP dynamics.[3]

Some studies have also focused on the individual effects of specific macroeconomic variables on economic growth. Jangili examined the relationship between savings, investment and economic growth in India from 1951 to 2008 at both aggregate and sectoral levels, employing the Granger causality test.[4] The findings indicated a reciprocal relationship between private – sector savings, investment and economic growth. In contrast, Budha investigated the relationship between gross domestic savings, investment and economic growth in Nepal using annual time – series data from 1975 to 2010. The study found no short – run causal relationship between domestic savings and GDP.[5]

Other researchers have examined the determinants of GDP in specific national contexts. Anghelache et al. analyzed Romania's GDP using multiple regression model and found that final consumption expenditure and total investment were significant determinants of GDP.[6] Similarly, Villanueva investigated the factors influencing Romania's GDP between 1994 and 2014, identifying final consumption expenditure and total investment as the principal contributing factors during the period.[7] Khan and Chhapra analyzed 30 years of economic data from Pakistan and reported a long-run relationship between GDP and macroeconomic variables, including unemployment and inflation.[8] However, Singh's study of India, based on data from 2011 to 2018, found that the relationship between unemployment and GDP was not statistically

[3] Anghelache and M.G. Anghel, "Econometric methods and models used in the analysis of the factorial influence of the gross domestic product growth", Network Intelligence Studies, Volume V, Issue 9 (1/2017), pp 67-78.
[4] R. Jangili, "Casual Relationship between Saving, Investment and Economic Growth for India – what is the Relationship?" Reverse Bank Solow of India Occasional Papers, 2011, 32(1).
[5] Budha, "A multivariate analysis of savings, investment and economic growth in Nepal" MPRA Paper 2012, No.43346.
[6] Anghelache, A. Manole and M.G. Anghel, "Analysis of final consumption and gross investment influence on GDP – multiple linear regression model" Theoretical and Applied Economics, Volume XXII (2015), No. 3(604), autumn, pp, 137-142.
[7] I. Villanueva, "Analyzing Romania GDP: Final consumption, gross investment and net exports influence compared to previously published models". Theoretical and Applied Economics Volume XXVII (2020), No.4(625), Winter, pp. 169-176.
[8] S. Khan and I. Chhapra, "Analysis of GDP and macroeconomic Variables on economic Growth of Pakistan". Journal of management, Business and Economic Research, 11(1), 2016, pp. 2-9.

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

significant, suggesting that unemployment may not be a significant determinant of economic performance in that particular context.[9]

Sher et al. empirically examined the impact of population growth on Pakistan's economic development between 1975 and 2008.[10] Their findings suggested that population growth can affect economic development both directly and indirectly. While population growth may contribute positively by increasing the utilization of a country's demographic potential, its indirect effects may be negative when rapid population growth leads to higher unemployment. Similarly, Alana et al. analyzed data from seven countries dating back to 1820 and found that GDP growth and population growth were highly persistent and shared a long-run equilibrium relationship.[11] Giovanni and Shambaugh investigated the relationship between foreign interest rates and annual real output growth across several industrialized economies.[12] Their results indicated that, in countries with fixed exchange rates, higher foreign interest rates were associated with lower annual real GDP growth.

Guo and Zhang examined the relationship between Australia's GDP growth and gross savings, the consumer price index, unemployment, the real interest rate and population over the period 1981-2019.[13] Building on their research, the present study investigates the relationship between GDP growth and population growth, unemployment, gross domestic savings and inflation over the period 1991-2025.

Overall, previous studies suggest that the determinants of economic growth are complex and context – dependent. The effects of a given macroeconomic variable may differ across countries and periods, while variations in data and econometric methods may produce different empirical findings.

## 2. METHODOLOGY

[9] R. Singh, "Impact of GDP and Inflation on Unemployment Rate: A Study of Indian Economy in 2011-2018". International Journal of Management, IT & Engineering, Volume 8, 2018, pp. 329-340.
[10] S. Ali, A. Ali and A. Amin, "The impact of population growth on economic development in Pakistan". Middle-East Journal of Scientific Research, 18(4), 2013, pp. 483-491.
[11] L. Gil-Alana, C. Font and A. Gil-Lopez, "GDP and population growth: Evidence of fractional cointegration with historical data from 1820 onwards". Journal of Economic Studies, JES-06-2020-0307. R2.
[12] J. di Giovanni and J. Shambaugh, "The Impact of Foreign Interest Rates on the Economy: The Role of the Exchange Rate Regime". Journal of International Economics 74 (2), 2008, pp. 341-361.
[13] Guo, H., Zhang, Z. (2022). "An empirical study of factors influencing Australia's GDP". In Proceeding of the 2022 International Conference on Mathematical Statistics and Economic Analysis (MSEA 2022) (pp. 581-586) Atlantis Press.

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INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS
ISSN: 2690-2265
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This section describes the sample, variables and econometric model used to examine the relationship between the independent variables and gross domestic product (GDP) growth in Uzbekistan. The study considers four macroeconomic variables: gross domestic savings, population growth, unemployment, inflation. Annual time-series data covering the period from 1991 to 2025 are used in the empirical analysis. The study applies multiple linear regression using the Ordinary Least Squares (OLS) method to estimate the relationship between GDP growth and the selected explanatory variables. In addition, descriptive statistics, correlation analysis, stationarity tests and multicollinearity diagnostics are employed to evaluate the characteristics of the data and the reliability of the estimated model.

### 2.1. Data and Variable Descriptions

The study uses annual time-series data for Uzbekistan covering the period from 1991 to 2025. The dependent variable is GDP growth, measured as an annual percentage rate. The independent variables include gross domestic savings, population growth, unemployment and inflation. Gross domestic savings is measured in billions of US dollars, while population growth, unemployment and inflation are expressed as annual percentages.

These variables are selected to examine their relationship with GDP and to assess their relevance to Uzbekistan's macroeconomic performance. More detailed information about the variables, their abbreviations, data sources and units of measurement is presented in Table 1.

**TABLE 1.** DESCRIPTIONS OF DATA

| Variables | Abb | Resources | Unit |
|---|---|---|---|
| Gross Domestic Product growth | GDPG | World Bank | percent |
| Gross Domestic Savings | GDS | World Bank | $ billions |
| Population growth | POPG | World Bank | percent |
| Unemployment | UNEM | MacroTrends | percent |
| Inflation | INF | World Bank | percent |

SOURCE: AUTHOR'S COMPILATION BASED ON WORLD BANK DATA

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INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS
ISSN: 2690-2265
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The table clearly shows that all the five variables except unemployment are obtained from the World Bank website,[14] while unemployment data are sourced from Macrotrends.[15] Gross domestic savings is expressed in relatively large numerical values. Therefore, natural logarithmic transformations are applied to this variable to facilitate interpretation and account for differences in scale.

In Figure 1, the graphs illustrate the trends in GDP growth and the selected macroeconomic variables in Uzbekistan over the period from 1991 to 2025.




**FIGURE 1.** TRENDS IN GDP GROWTH AND SELECTED MACROECONOMIC INDICATORS IN UZBEKISTAN, 1991-2025

[14] World Bank. World Development Indicators. Retrieved October 25, 2026, from https://data.worldbank.org/country/uzbekistan
[15] Macrotrends. Uzbekistan unemployment rate. Retrieved October 25, 2026, from https://www.macrotrends.net/global-metrics/countries/uzb/uzbekistan/unemployment-rate

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
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SOURCE: AUTHOR'S COMPILATION BASED ON WORLD BANK DATA

GDP growth fluctuated considerably during the early 1990s, reaching negative levels before recovering and remaining mostly positive from the late 1990st onward. Growth generally remained positive throughout the 2000s and 2010s, although fluctuations occurred, including a noticeable decline around 2020, followed by a recovery in subsequent years.

Gross domestic savings increased substantially over the period, particularly after the mid-2000s, despite some temporary declines. Inflation, measured by the GDP deflator was extremely high in the early 1990s but fell sharply in the mid-1990s and remained comparatively low thereafter. Unemployment rose significantly during the 1990s, peaked toward the end of that decade and then generally declined, stabilizing at a lower level in later years. Population growth decreased from the early 1990s to the early 2000s before gradually recovering in the following years.

Overall, the graphs demonstrate substantial changes in Uzbekistan's macroeconomic conditions over the period. However, these descriptive trends alone cannot establish the direction, magnitude or statistical significance of the relationships between the explanatory variables and GDP growth. Therefore, further econometric analysis is required to evaluate these relationships. Given the visible trends and fluctuations in the time-series data, it is also important to assess stationarity, multicollinearity and the potential risk of spurious regression before interpreting the estimation results.

### 2.2. Model Specification

To examine the relationship between GDP growth and its explanatory variables in Uzbekistan, this study specifies a multiple linear regression model using the Ordinary Least Squares (OLS) method. The model incorporates four explanatory variables and natural logarithmic transformations are applied to gross domestic savings to account for differences in scales and facilitate the interpretation of the estimated coefficients. The econometric model is specified as follows:

$$GDPG_t = \beta_0 + \beta_1 \ln(GDS_t) + \beta_2 POPG_t + \beta_3 UNEM_t + \beta_4 INF_t + \varepsilon_t \quad (1)$$

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Where $t$ represents the year; the coefficients $\beta_0, \beta_1, \ldots \beta_4$ are the parameters to be estimated and $\varepsilon_t$ is the error term. Since the study uses numerical data, a quantitative research approach is adopted to estimate the relationship between these variables and GDP growth. The regression results are used to assess the direction and statistical significance of each variables, association with GDP growth.

### 2.3. Hypothesis

This study develops four hypotheses to examine the relationship between GDP growth and the selected economic variables in Uzbekistan:

$H_1$: Gross domestic savings (GDS) has a positive and statistically significant relationship with GDP growth.

$H_2$: Population growth (POPG) has a positive and statistically significant relationship with GDP growth.

$H_3$: Unemployment (UNEM) has a negative and statistically significant relationship with GDP growth.

$H_4$: Inflation (INF) is negatively correlated with GDP growth and has statistically significant relationship with GDP growth.

These hypotheses will be tested in this study.

### 2.4. Descriptive Statistics

This section examines the strength and direction of the linear relationship between GDP growth and the explanatory variables using Pearson's correlation coefficient. The correlation matrix presented in Table 2 provides an initial overview of the relationships among the variables included in the model. The correlation coefficients indicate whether the relationships between GDP growth and gross domestic savings, unemployment, population growth and inflation are positive or negative, as well as the strength of these associations. In addition, the correlation among the explanatory variables are examined to identify potential multicollinearity issues that may affect the reliability of the regression estimates. However, correlation analysis alone cannot establish causality or determine whether the observed relationships are statistically significant within the multiple regression model.

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INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS
ISSN: 2690-2265
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Therefore, the correlation results are interpreted as a preliminary step before conducting further econometric analysis.

**TABLE 2.** CORRELATION COEFFICIENTS

| | GDPG | POPG | UNEM | ln(GDS) | INF |
|---|---|---|---|---|---|
| GDPG | 1 | | | | |
| POPG | -0.5974 | 1 | | | |
| UNEM | -0.0349 | -0.5309 | 1 | | |
| ln(GDS) | 0.5436 | 0.0188 | -0.5298 | 1 | |
| INF | -0.7762 | 0.5435 | -0.0813 | -0.4543 | 1 |

SOURCE: AUTHOR'S COMPILATION BASED ON WORLD BANK DATA

The results indicate that GDP growth has a moderate negative correlation with population growth (-0,59738) and a strong negative correlation with inflation (-0,77618). These findings suggest that higher population growth and inflation values are associated with lower GDP growth values in the sample. In contrast, the correlation between GDP growth and the logarithm of gross domestic savings, ln(GDS), is positive (0,5436), indicating a moderate positive relationship. The correlation between GDP growth and unemployment is very weak and negative (-0,0349), suggesting almost no linear relationship between the two variables. The correlation matrix also reveals relationships among the explanatory variables. Population growth is negatively correlated with unemployment (-0,53089), while its correlation with inflation is positive (0,543458). Unemployment has a moderate negative correlation with ln(GDS) (-0,52977), and inflation is negatively correlated with ln(GDS) (-0,4543). The correlation between population growth and ln(GDS) is negligible (0,01881), while the relationship between unemployment and inflation is also very weak and negative (-0,08134).

Overall, the correlation results provide an initial understanding of the direction and strength of the linear relationship among the variables. Although some explanatory variables exhibit moderate correlations, none of the pairwise correlation coefficients exceeds 0,8 in absolute value, suggesting that severe multicollinearity may not be evident from the correlation matrix alone. However, further diagnostic tests, such as the variance inflation factor (VIF), are needed to assess multicollinearity more reliably.

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

## 3. RESULTS AND DISCUSSION

Multiple regression analysis using the Ordinary Least Squares (OLS) method is employed to estimate the relationship between GDP growth and the selected macroeconomic variables in Uzbekistan. Since time – series data may exhibit non – stationarity, which can lead to spurious regression results, the Augmented Dickey – Fuller (ADF) test is conducted to examine the stationarity of each variable. The Variance Inflation factor (VIF) is used to assess potential multicollinearity among the explanatory variables. Furthermore, diagnostic tests for autocorrelation and heteroskedasticity are performed to evaluate whether the estimated model satisfies the relevant assumptions of the Classical Linear Regression Model (CLRM). These procedures help assess the reliability of the regression estimates and support the interpretation of the relationships between the explanatory variables and GDP growth.

### 3.1. Ordinary Least Square Method

Table 3 presents the estimated coefficients of the regression model examining the determinants of GDP growth in Uzbekistan. The results indicate that population growth (POPG), the logarithm of gross domestic savings – ln(GDS) and inflation (INF) are statistically significant in explaining GDP growth in Uzbekistan, although their levels of significance differ. Population growth is statistically significant at the 1 % level, gross domestic savings is significant at the 5 % level and inflation is significant at the 1 % level. In contrast, unemployment (UNEM) is not statistically significant at the 10 % level. It can also be observed that the logarithm of gross domestic savings has a positive impact on GDP growth in Uzbekistan, which is consistent with our expectations. In contrast, unemployment, inflation and population growth are negatively associated with GDP growth. Based on our initial hypotheses, the results are broadly consistent with our expectations, except for population growth, whose negative relationship with GDP growth was not consistent with the hypothesized relationship.

**TABLE 3.** OLS REGRESSION RESULTS

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -11.053547  15.037858  -0.735  0.46802
x1           -6.035821   1.691253  -3.569  0.00123 **
x2           -0.257260   0.201107  -1.279  0.21063
x3            1.256783   0.602110   2.087  0.04546 *
x4           -0.006151   0.001952  -3.151  0.00367 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.301 on 30 degrees of freedom
Multiple R-squared:  0.755,     Adjusted R-squared:  0.7223
F-statistic: 23.11 on 4 and 30 DF,  p-value: 8.5e-09
```

SOURCE: AUTHOR’S CALCULATIONS BASED ON WORLD BANK DATA

The coefficient of population growth is negative (-6,03582) and statistically significant at the 1 % level, with p – value of 0,00123. This suggests that, holding other variables constant, a one-percentage-point increase in population growth is associated with a 6,03582 % point decrease in GDP growth, assuming both variables are measured in percentage points. The coefficient of unemployment is also negative (-0,25726), but it is not statistically significant (p=0,21063). Therefore, the results do not provide sufficient evidence of a statistically significant relationship between unemployment and GDP growth in this model. Gross domestic savings, expressed in logarithmic form, has a positive coefficient of 1,25678 and is statistically significant at the 5 % level (p=0,04546). Since GDP growth is measured in percentage points and GDS is logged, a 1 % increase in gross domestic savings is associated with an approximate 0,01257 % point increase in GDP growth, holding the other variables constant. The coefficient of inflation is negative (-0,00615) and statistically significant at the 1 % level (p=0,00367). Thus, a 1 % increase in inflation is associated with a 0,00615 % point decrease in GDP growth, holding all other variables constant.

The estimated regression model:

$$GDPG_t = -11{,}0535 - 6{,}0358 \cdot POPG_t - 0{,}2573 \cdot UNEM_t + 1{,}2568 \cdot \ln(GDS_t) - 0{,}0062 \cdot INF_t \quad (2)$$

Figure 2 compares the actual GDP growth rates with the estimated values obtained using the regression model presented in equation (2) for the period 1991-2025. The estimated values, represented by the red line, are calculated by substituting the observed values of the explanatory variables into the estimated regression equation.

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INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS
ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

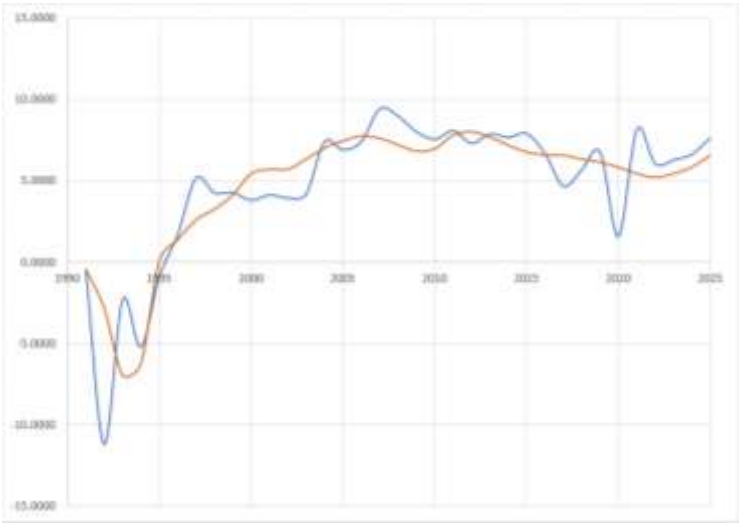


**FIGURE 2.** ACTUAL AND FITTED GDP GROWTH RATES (1991-2025) (blue line – Actual GDP growth rate; orange line – Estimated GDP growth rate)

SOURCE: AUTHOR'S COMPILATION BASED ON WORLD BANK DATA

Overall, the estimated values follow the general pattern of actual GDP growth, although noticeable differences occur in several years, particularly during periods of sharp fluctuations. These differences represent the regression residuals and indicate that the model captures the general trend in GDP growth but does not fully explain all year – to – year variations.

Table 4 presents the regression statistics used to evaluate the goodness of fit and overall significance of the model. The coefficient of determination (R squared) is 0,75496, indicating that approximately 75,5 % of the variation in GDP growth can be explained by the four independent variables included in the model. The adjusted R squared is 0,7223, suggesting that the model explains approximately 72,23 % of the variation in GDP growth after adjusting for the number of explanatory variables and the sample size.

The overall statistical significance of the regression model was assessed using the F – test. The results show an F – statistic of 23,10669 and a corresponding p – value (significance F) of $8{,}5 \cdot 10^{-9}$. Since this p – value is below the 1 % significance level ($p < 0{,}01$), the null hypothesis that all explanatory variable coefficients are jointly equal to zero is rejected. Therefore, the regression model is statistically significant overall, indicating that the independent variables are jointly

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ISSN: 2690-2265
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associated with GDP growth. (The definitions and abbreviations of all variables are provided in Table 1).

**TABLE 4.** R SQUARED AND F STATISTIC RESULTS

| Results | Value |
|---|---|
| $R^2$ | 0.75496 |
| Adjusted $R^2$ | 0.72228 |
| F Statistic | 23.1067 (df=4;30) |

SOURCE: AUTHOR'S CALCULATIONS BASED ON WORLD BANK DATA

Overall, the estimated coefficients for population growth and inflation have negative signs, while gross domestic savings has a positive sign. The results are consistent with the hypotheses concerning gross domestic savings, population growth and inflation, while the hypothesis concerning unemployment is not statistically supported by the regression results. These findings describe statistical associations and do not, by themselves, establish causality.

### 3.2. Stationarity

The stationarity of the time-series variables was examined using the Augmented Dickey-Fuller (ADF) test to determine whether their statistical properties remain stable over time. The test evaluates the null hypothesis ($H_0$) that a series contains a unit root and is therefore non-stationary, against the alternative hypothesis ($H_1$) that the series is stationary. At the 5 % significance level, the ADF statistic must be more negative than the critical value to reject the null hypothesis.

**TABLE 5.** UNIT ROOT TEST RESULTS

| Variables | Level | | | | | |
|---|---|---|---|---|---|---|
| | Constant | | | Constant & Trend | | |
| | $\tau_{2_critic}$ | Critical value | | $\tau_{3_critic}$ | Critical value | |
| | | 5% | 10% | | 5% | 10% |
| GDPG | -4.0809 | -2.93 | -2.60 | -3.5041 | -3.50 | -3.18 |
| POPG | -3.2748 | -2.93 | -2.60 | -4.2975 | -3.50 | -3.18 |
| UNEM | -2.8874 | -2.93 | -2.60 | -3.4665 | -3.50 | -3.18 |
| ln(GDS) | -0.2782 | -2.93 | -2.60 | -3.0239 | -3.50 | -3.18 |
| INF | -70.9808 | -2.93 | -2.60 | -72.6755 | -3.50 | -3.18 |

SOURCE: AUTHOR'S CALCULATIONS BASED ON WORLD BANK DATA

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ISSN: 2690-2265
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As shown in Table 5, the null hypothesis of a unit root was rejected at the 5 % significance level for GDP growth, population growth and inflation under the constant specification. Therefore, these variables can be considered stationary at levels. For unemployment, the null hypothesis could not be rejected at the 5 % significance level but rejected at the 10 % level, providing weaker evidence of stationarity. In contrast, the null hypothesis could not be rejected for the logarithm of gross domestic savings at either 5 % or 10 % significance level, indicating that further testing is required to determine its order of integration.

### 3.3. Multicollinearity

Since the independent variables in a multiple regression model may be correlated with one another, multicollinearity can arise. To examine the presence of multicollinearity among the explanatory variables in this study, the Variance Inflation Factor (VIF) was employed.

Variance Inflation Factor formula is following

$$VIF_j = \frac{1}{1 - R_j^2}$$

Where $VIF_j$ is the variance inflation factor for explanatory variable *j,* and $R_j^2$ is the coefficient of determination obtained by regressing that variable on all the other explanatory variables.

For example, for population growth (POPG):

$$POPG_t = \alpha_0 + \alpha_1 UNEM_t + \alpha_2 \ln(GDS_t) + \alpha_3 INF_t + u_t$$

Then calculate:

$$VIF_{POPG} = \frac{1}{1 - R_{POPG}^2}$$

The same procedure is repeated for UNEM, ln(GDS) and INF.

As a general rule of thumb, a VIF value exceeding 10 indicates potentially serious multicollinearity. The VIF values for all explanatory variables were calculated and compared with this threshold.

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**TABLE 6.** MULTICOLLINEARITY ANALYSIS OF SELECTED VARIABLES

| Test | POPG | UNEM | ln(GDS) | INF |
|---|---|---|---|---|
| VIF | 2.1463 | 2.2448 | 2.1277 | 2.0569 |

SOURCE: AUTHOR'S CALCULATIONS BASED ON WORLD BANK DATA

As shown in Table 6, the VIF values for all independent variables are below 10, ranging from 2,0569 to 2,2448. Therefore, the results suggest that the regression model does not suffer from severe multicollinearity among its explanatory variables.

### 3.4. Autocorrelation

Autocorrelation occurs when the error terms of a regression model are correlated across different time periods. It is particularly common in time – series data, such as annual GDP observations, because economic shocks may persist over time. Figure 3 presents a time – series plot of the regression residuals, illustrating how the differences between actual and predicted GDP growth values vary over time.

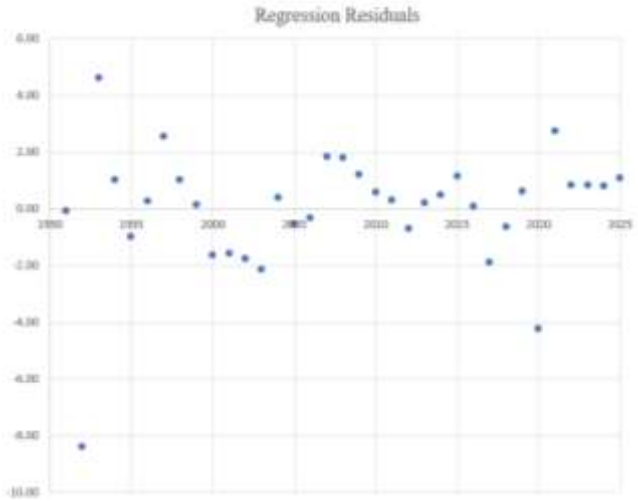



**FIGURE 3.** REGRESSION RESIDUALS OVER TIME SOURCE: AUTHOR'S COMPILATION BASED ON WORLD BANK DATA

Autocorrelation can lead to inefficient OLS estimates and unreliable standard errors, affecting the validity of statistical inference. To detect this problem, the Durbin – Watson and Breusch – Godfrey tests are commonly used.

The Durbin – Watson (DW) test is used to detect first-order autocorrelation in the residuals of a regression model. The test statistic is calculated as:

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$$DW = \frac{\sum_{t=2}^{n}(\widehat{\varepsilon_t} - \widehat{\varepsilon_{t-1}})^2}{\sum_{t=1}^{n}\widehat{\varepsilon_t}^2}$$

Where DW represents the Durbin-Watson statistic, $\widehat{\varepsilon_t}$ denotes the estimated regression residual in period $t$, $\hat{\varepsilon}_{t-1}$ represents the estimated residual in the preceding period and $n$ is the total number of observations, which is 35 in this study.

The Durbin-Watson statistic ranges approximately from 0 to 4. A value near 0 indicates positive autocorrelation, a value near 2 suggests little or no first-order autocorrelation, and a value near 4 indicates negative autocorrelation.

The test yielded a Durbin-Watson statistic of 2,3231 and a p-value of 0,7297. Durbin-Watson statistic is relatively close to 2 and suggests no strong first-order autocorrelation. Since the p-value exceeds 5 % significance level, the null hypothesis of no first-order autocorrelation cannot be rejected. Thus, the results indicate no statistically significant evidence of first-order autocorrelation in the model's residuals.

The Breusch – Godfrey test was also conducted to examine the presence of autocorrelation in the residuals of this regression model. The test produced an LM test statistic of 1,6205 and p-value of 0,8051 for autocorrelation up to order 4. Since the p – value exceeds the 5 % significance level, the null hypothesis of no autocorrelation up to order 4 cannot be rejected. Therefore, the results indicate no statistically significant evidence of autocorrelation in the regression residuals.

### 3.5. Heteroscedasticity

In some regression models, the variance of the error term may not remain constant across observations, a phenomenon known as heteroscedasticity. The presence of heteroscedasticity can reduce the efficiency of ordinary least squares (OLS) estimation and lead to biased standard errors, resulting in unreliable statistical inference. Therefore, it is important to detect heteroscedasticity to ensure the validity of regression results. One of the most widely used methods for detecting heteroscedasticity is the White heteroscedasticity test. In this study, the White

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

heteroscedasticity test was applied to examine whether the error variance in the regression model is constant.

We constructed an auxiliary model as follows, using the squared OLS residuals as the dependent variable and the explanatory variables, their squared terms and pairwise interaction terms as independent variables.

$$\widehat{\varepsilon_t^2} = \alpha_0 + \sum_{i=1}^{4} \alpha_i X_{it} + \sum_{i=1}^{4} \gamma_i X_{it}^2 + \sum_{i<j} \delta_{ij} X_{ij} X_{jt} + \vartheta_t$$

Here, $X_{it}$ represents the four explanatory variables and $\vartheta_t$ is the auxiliary regression error term. The test statistic is:

$$LM = nR_{aux}^2$$

The null hypothesis $(H_0)$ assumes that the error terms are homoscedastic, meaning that their variance is constant, whereas the alternative hypothesis $(H_1)$ indicates the presence of heteroscedasticity, meaning that the error is non – constant.

If $LM > \chi_{critical}^2$, reject the null hypothesis $(H_0)$ and conclude that there is evidence of heteroscedasticity. $\chi_{critical}^2$ means the critical value of the chi-square distribution. For our model, with 14 degrees of freedom and a 5 % significance level:

$$\chi_{critical}^2 = \chi_{0.05,14}^2 = 23{,}685$$

From Table 7, the $R_{aux}^2$ value is used to calculate the LM statistic. The calculated LM statistic is the compared with the critical value of the chi-square distribution.

$$LM = 35 \cdot 0.9425 = 32.9875$$

Since $LM > \chi_{critical}^2$, the null hypothesis of homoscedasticity is rejected, indicating the presence of heteroscedasticity in the regression model.

**TABLE 7.** AUXILIARY REGRESSION RESULTS OF THE WHITE HETEROSCEDASTICITY TEST

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INTERNATIONAL JOURNAL OF STATISTICAL ANALYSIS

ISSN: 2690-2265
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```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -2.237e+01  1.991e+03  -0.011   0.9911
x1          -4.876e+01  2.034e+02  -0.240   0.8130
x2          -1.167e+01  3.939e+01  -0.296   0.7701
x3           9.050e+00  1.564e+02   0.058   0.9544
x4          -3.605e-01  5.574e-01  -0.647   0.5252
I(x1^2)     -1.475e+01  2.930e+01  -0.503   0.6202
I(x2^2)     -2.221e-01  2.365e-01  -0.939   0.3588
I(x3^2)     -5.205e-01  3.053e+00  -0.170   0.8664
I(x4^2)      1.563e-05  3.402e-05   0.459   0.6509
x1:x2       -6.420e-01  3.037e+00  -0.211   0.8347
x1:x3        4.980e+00  9.726e+00   0.512   0.6143
x1:x4       -1.872e-02  2.174e-01  -0.086   0.9322
x2:x3        7.976e-01  1.556e+00   0.513   0.6137
x2:x4       -2.362e-02  1.898e-02  -1.245   0.2276
x3:x4        2.530e-02  1.007e-02   2.513   0.0206 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.876 on 20 degrees of freedom
Multiple R-squared:  0.9425,    Adjusted R-squared:  0.9023
F-statistic: 23.42 on 14 and 20 DF,  p-value: 2.287e-09
```

SOURCE: AUTHOR’S CALCULATIONS BASED ON WORLD BANK DATA

To address this issue, heteroscedasticity-robust standard errors were employed to obtain more reliable statistical inference. Specifically, the HC1 estimator was used.

$$\widehat{Var_{HC1}}(\hat{\beta}) = \frac{n}{n-k}\widehat{Var_{HC0}}(\hat{\beta})$$

HC1 adjusts the estimated covariance matrix according to the sample size (n) and the number of estimated parameters (k), improving the reliability of standard errors when heteroscedasticity is present. The adjustment does not change the OLS coefficient estimates but may affect their standard errors, t-statistics and p-values. Consequently, the final conclusions regarding the statistical significance of the explanatory variables are based on the regression results obtained using HC1 robust standard errors.

**TABLE 8.** ADJUSTED OLS RESULTS

```
t test of coefficients:

               Estimate  Std. Error t value  Pr(>|t|)
(Intercept) -11.0535466  10.5764875 -1.0451 0.3043225
POPG         -6.0358214   1.4350848 -4.2059 0.0002162 ***
UNEM         -0.2572602   0.1372748 -1.8741 0.0706920 .
lnGDS         1.2567832   0.3855052  3.2601 0.0027725 **
INF          -0.0061509   0.0019848 -3.0990 0.0041950 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
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SOURCE: AUTHOR'S CALCULATIONS USING OLS WITH HC1 ROBUST STANDARD ERRORS

After applying HC1 heteroscedasticity-robust standard errors, the results in Table 8 indicate that population growth has a negative and statistically significant association with GDP growth at the 1 % level. Gross domestic savings exhibit a positive and statistically significant association at the 1 % level, while inflation has a negative and statistically significant association at the same level. Unemployment has a negative coefficient and is statistically significant at 10 % level, although it is not significant at the 5 % level.

The findings of this study indicate that inflation, gross domestic savings and population growth may play important roles in influencing Uzbekistan's economic growth. Therefore, policymakers should consider these macroeconomic factors when designing and implementing economic policies aimed at promoting sustainable and stable economic growth.

## 4. CONCLUSION

Sustained and stable economic growth is a major objective of economic policy in many countries, as it contributes to improvements in living standards, national economic strength and long – term development. Therefore, identifying the factors that influence economic growth is essential for designing effective economic policies.

This study examined the determinants of GDP growth in Uzbekistan using a multivariate econometric regression model. Compared with previous studies, the influencing factors studied here are more comprehensive and diverse, establishing that economic growth is significantly affected by various factors. The findings highlight the importance of considering macroeconomic conditions when formulating policies to promote sustainable economic growth. Policymakers should pay particular attention to maintaining price stability, supporting employment, encouraging productive savings and investment, and developing policies that respond to demographic changes. Such measures may help strengthen economic resilience and reduce the adverse effects of external shocks, including global crises, pandemics and geopolitical conflicts.

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ISSN: 2690-2265
ACCEPTED: 04.11.2026
PUBLISHED: 05.10.2026

However, the estimated relationship should be interpreted in light of the model's statistical results and limitations. The direction and statistical significance of each explanatory variable should guide specific policy recommendations. Further research could improve the analysis by incorporating additional macroeconomic indicators and applying alternative econometric methods to assess the robustness of the findings.

Overall, this study contributes to understanding the macroeconomic factors associated with GDP growth in Uzbekistan and provides an empirical basis for further research and evidence – based economic policymaking.

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