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FORECASTING UZBEKISTAN'S GDP BY AUTOREGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA) MODEL

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Annotation. This paper is about the ARIMA (Auto-Regressive Integrated Moving Average) model to forecast Uzbekistan's GDP for the period 2025–2030, with country's economic trajectory . GDP is a critical measure of economic activity, reflecting the monetary value of all goods and services produced within a nation. The analysis emphasizes the importance of forecasting GDP for effective policymaking, resource allocation, and investment planning. Results indicate a general upward trend in Uzbekistan's GDP, with occasional fluctuations. The ARIMA model demonstrates robust predictive capabilities, aligning with historical patterns and current economic reforms. Despite its reliability, the study highlights potential improvements through hybrid approaches incorporating external factors.

Keywords: GDP forecasting, ARIMA model, Uzbekistan economy, economic policy, time series analysis, economic planning.

ARIMA (AUTOREGRESSIVE INTEGRATED MOVING AVERAGE) MODELI ASOSIDA O'ZBEKISTON YAIM KO'RSATKICHINI BASHORAT QILISH

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Annotatsiya. Ushbu maqolada O'zbekiston yalpi ichki mahsuloti (YaIM)ni 2025–2030-yillar davri uchun prognoz qilishda ARIMA (Autoregressive Integrated Moving Average) modelidan foydalanilgan. YaIM – bu mamlakat ichida ishlab chiqarilgan barcha mahsulot va xizmatlarning pulda ifodalangan umumiy qiymatini aks ettiruvchi muhim iqtisodiy ko'rsatkichdir. Tadqiqotda YaIMni prognoz qilish siyosiy qarorlar qabul qilish, resurslarni taqsimlash va investitsiya rejalashtirishda katta ahamiyat kasb etishi ta'kidlanadi. Natijalar O'zbekiston YaIMida umumiy o'sish tendensiyasi mavjudligini, biroq ba'zan nomuntazam o'zgarishlar kuzatilishini ko'rsatadi. ARIMA modeli prognozlashda yuqori aniqlikka ega bo'lib, tarixiy ma'lumotlar va hozirgi iqtisodiy islohotlar bilan mos keladi. Shu bilan birga, tadqiqotda tashqi omillarni ham inobatga oluvchi gibrid yondashuvlar yordamida modelni yanada takomillashtirish imkoniyati mavjudligi ko'rsatilgan.

Kalit so'zlar: YaIM prognozi, ARIMA modeli, O'zbekiston iqtisodiyoti, iqtisodiy siyosat, vaqt qatori tahlili, iqtisodiy rejalashtirish.

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Introduction

Uzbekistan is a developing country in Central Asia. Its GDP is stable increasing after independence with some fluctuations. Gross Domestic Product (GDP) is an important factor of economic activity and is often used by decision-makers to plan economic policy. It is a common measure that's used to represent the size of a country's economy. Gross domestic product (GDP) of a country is the monetary value of all the finished goods and services produced within a country's borders in a specific time period. It shows the aggregate statistic of all economic activity. The performance of the economy can be measured with the help of GDP and GDP per capita[12]. The issues of GDP have become the most concerned amongst macroeconomic variables and data on GDP is regarded as the important index for assessing the national economic development and for judging the operating status of the macroeconomy as a whole. [1] Forecasts of macroeconomic variables are crucial to many agents in the economy, including economic policymakers, business owners and investors [13].

Therefore, an effort is made in this report to forecast the GDP and identify factors affecting GDP in Uzbekistan. In Uzbekistan, the amount of research done so far related to GDP is not sufficient to know a country's economic condition. Only one study is done which is also much backdated. So, it is essential to forecast GDP for the prediction of the future economy as well as the advancement of a country based on the current data. On the other hand, a significant change in GDP, whether up or down, usually has an impact on the market economy. Therefore, it is necessary to realize the associated factors that affect GDP [1; 56–65].

GDP forecasting is an important tool for supporting economic growth and achieving long-term development goals. The ARIMA (Auto-Regressive Integrated Moving Average) model is widely used for economic forecasting because it is effective in analyzing and predicting time series data. It works well for short- and medium-term forecasts in different economic settings. Economists and policymakers often rely on ARIMA for predicting GDP growth, consumption, and other important indicators.

Several studies highlight the effectiveness of ARIMA models in GDP forecasting. Abonazel and Abd-Elftah (2021) used an ARIMA (1, 2, 1) model to forecast Egypt's GDP based on data from 1965 to 2016, predicting trends for the next ten years [4]. Similarly, Uddin and Tanzim (2021) applied the same model to forecast Bangladesh's GDP from 2019 to 2025, also using linear regression to identify factors influencing growth. Their analysis showed the model's accuracy using tools like Q-Q plots and ACF/PACF graphs [3].

Wabomba et al. (2018) studied Kenya's GDP (1960–2012) and identified ARIMA (2, 2, 2) as the best model using AIC values. Their predictions were close to actual GDP figures [5]. For Nigeria, Atanu et al. (2021) used GDP data from 1981 to 2019, tested for stationarity with the Augmented Dickey-Fuller test, and chose ARIMA (1, 2, 1) as the best fit. Their analysis, using EViews 11 and the Ljung-Box test, confirmed the model's reliability, with a low error rate (Theil inequality coefficient of 0.022008) [6].

These studies show that ARIMA is a dependable and flexible tool for GDP forecasting, capable of identifying economic trends across various datasets and countries.

MATHEMATICAL CONCEPTS OF THE ARIMA MODEL

Time series models like ARIMA require the data to be stationary (mean and variance constant over time). The Augmented Dickey-Fuller (ADF) test is a statistical test for stationarity.

Null Hypothesis H_0 : The time series has a unit root (non-stationary)[14].

Test Statistic:

$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_2 \Delta y_{t-2} + \cdots + \varepsilon_t$ (1)

Where $\Delta y_t = y_t - y_{t-1}$ (first difference)

γ: Determines stationarity.

ε_t: Error term.

If the p-value > 0.05, the series is non-stationary, and differencing is applied.

To remove trends and stabilize the mean we use operation below:

$y'_t = y_t - y_{t-1}$ (2)

where

y_t: Original series.

y'_t: Differenced series.

This process can be repeated if the series remains non-stationary.

ARIMA Model

The ARIMA model combines:

1. Autoregression (AR):

$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t$ (3)

Where $\phi_1, \phi_2, \ldots \phi_p$ are the AR coefficients [11].

2. Integration (I):

a. Refers to the number of differencing steps (d) needed to make the series stationary [15].

3. Moving Average (MA):

$y_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q}$ (4)

Where $\theta_1, \theta_2, \ldots \theta_q$ are the MA coefficients.

The model is specified as ARIMA(p,d,q)ARIMA(p, d, q), where: [16].

a) p: Order of AR terms.

b) d: Differencing degree.

c) q: Order of MA terms.

Our purpose is here to estimate the coefficients ϕ_i, θ_i and other parameters by minimizing the residual error according to equations above:

Minimize: $\sum_{t=1}^{n} (y_t - \hat{y}_t)^2$ (5)

Where $\hat{y}_t$ is the predicted value.

In a forecasting we have three steps:

1. Fit the model to historical data.
2. Predict future values using the model equations for y_t:

$\hat{y}_t = \phi_1 \hat{y}_{t-1} + \phi_2 \hat{y}_{t-2} + \cdots + \phi_p \hat{y}_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q}$ (6)

3. If differencing was applied, reverse the differencing:

$Forecast_t = Forecast'_t + y_{t-1}$ (7)

CODE OF THE MODEL (BY PYTHON)

```
import pandas as pd
import matplotlib.pyplot as plt
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.stattools import adfuller

data = pd.read_csv('uzbekistan1.csv', header=None, names=['Date', 'GDP'])
```

```
data['Date'] = data['Date'].str.replace('\t', '', regex=False)
data['Date'] = pd.to_datetime(data['Date'], errors='coerce')
data['GDP'] = pd.to_numeric(data['GDP'], errors='coerce')
data = data.dropna(subset=['GDP'])
data.set_index('Date', inplace=True)
result = adfuller(data['GDP'])
print(f"ADF Statistic: {result[0]}")
print(f"p-value: {result[1]}")
data_diff = data['GDP'].diff().dropna()
model = ARIMA(data_diff, order=(5, 1, 0))
model_fit = model.fit()
forecast_steps = 6
forecast_diff = model_fit.forecast(steps=forecast_steps)
last_value = data['GDP'].iloc[-1]
forecast_values = [last_value + forecast_diff[0]]
for i in range(1, forecast_steps):
forecast_values.append(forecast_values[-1] + forecast_diff[i])

forecast_dates = pd.date_range(start='2025-01-01', periods=forecast_steps, freq='Y')
forecast_df = pd.DataFrame(forecast_values, index=forecast_dates,
columns=['Forecasted GDP'])

combined_df = pd.concat([data, forecast_df])

plt.figure(figsize=(10, 6))
plt.plot(data.index, data['GDP'], label='Historical GDP', color='red')
plt.plot(forecast_df.index, forecast_df['Forecasted GDP'], label='Forecasted GDP',
color='blue', linestyle='..')
plt.title('Uzbekistan GDP Forecast (2000-2030)')
plt.xlabel('Year')
plt.ylabel('GDP in billion USD')
plt.legend()
plt.grid(True)
plt.show()

print(forecast_df)
```

Results

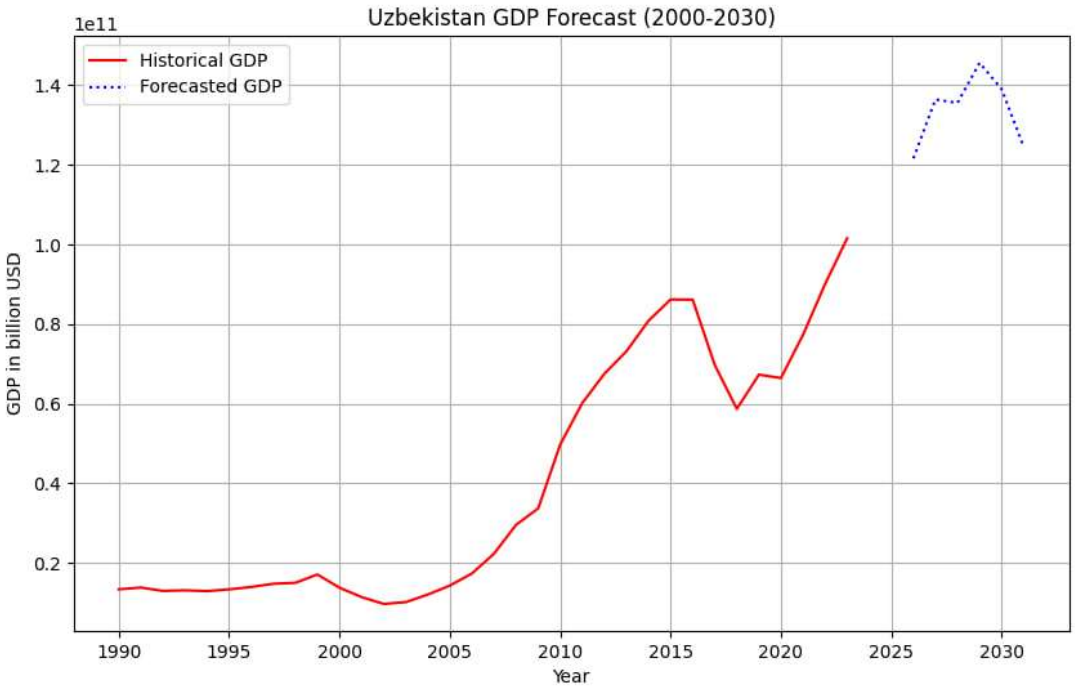
The ARIMA model effectively forecasted Uzbekistan's GDP for the period 2025–2030. The following key results were observed:

	Years	Forecasted GDP ($)
	2025-12-31	121 651 000 000
	2026-12-31	136 426 200 000
	2027-12-31	135 585 900 000
	2028-12-31	145 655 700 000

	2029-12-31	139 037 800 000
	2030-12-31	124 489 600 000

Table 1. Forecasted GDP of Uzbekistan (2025-2030)

Actual (1990-2024) and forecasted (2025-2030) GDP of Uzbekistan illustrated in the **Graph 1** according to ARIMA model by Python. It shows that general level of GDP in Uzbekistan increase but model also shows the fluctuation between 2013-2018 will also happen.



Graph 1. The result of the code

DISCUSSION

The ARIMA model has demonstrated robust forecasting capabilities for Uzbekistan's GDP. Its ability to capture the historical trend and predict future values underscores its suitability for short- to medium-term economic forecasting. Residual diagnostics suggest that the model fits the data well, with minimal prediction error. The forecasted GDP growth aligns with Uzbekistan's ongoing economic reforms and infrastructure investments. Policymakers can leverage these insights to plan fiscal policies, allocate resources, and address potential economic challenges during periods of slower growth, as observed in 2027 and 2030.

For example, the growth in 2026 and 2028 could present good opportunities for investments in key sectors. However, the forecast also points to possible GDP fluctuations, suggesting the need for strategies to manage risks and stabilize the economy, especially during potential downturns in 2029 and 2030. The ARIMA model, while useful, relies only on historical GDP data and does not account for factors like trade policies, foreign investments, or global economic trends, which can also affect GDP. Combining ARIMA with machine learning models could improve accuracy by capturing more complex patterns. Additionally, analyzing sector-specific or regional economic data could give a more detailed picture of Uzbekistan's economy.

Conclusion

The ARIMA model provides reliable GDP forecasts for Uzbekistan, helping with economic planning and decision-making. While the model is effective, adopting advanced methods could overcome its limitations and lead to more accurate and detailed predictions for the country's economic future.

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