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CONTENTS

CONTENTS

FORECASTING EXPORT AND IMPORT INDICATORS OF BUKHARA REGION

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Abstract. This study analyzes and forecasts the export and import dynamics of Bukhara region for the period 2016–2024 using quarterly time series data. The ARIMA (Autoregressive Integrated Moving Average) modeling approach, based on the Box–Jenkins methodology, is applied to examine the behavior of foreign trade indicators and to generate forecasts for 2025–2030. The stationarity of the time series is evaluated through ACF and PACF analyses, confirming that the variables do not require seasonal adjustment and allowing the use of non-seasonal ARIMA models. Model selection is performed using statistical criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and log-likelihood values. The results indicate that the ARIMA(3,0,1) model is the most appropriate for export forecasting, while the ARIMA(4,0,1) model provides the best fit for import dynamics. The forecast results show a steady increase in exports alongside relatively higher and more volatile import levels, leading to a persistently negative trade balance over the forecast horizon. These findings provide important insights for regional trade policy and economic planning in Bukhara region.

Keywords: ARIMA model; Box–Jenkins approach; time series analysis; export forecasting; import forecasting; Bukhara region; stationarity; ACF; PACF; foreign trade dynamics; econometric modeling.

Аннотация. В данном исследовании проведён анализ и прогнозирование динамики экспорта и импорта Бухарской области за период 2016–2024 гг. на основе квартальных данных временных рядов. Для изучения поведения показателей внешней торговли и формирования прогнозов на 2025–2030 гг. применён метод моделирования ARIMA (Autoregressive Integrated Moving Average), основанный на методологии Бокса–Дженкинса. Стационарность временных рядов оценивалась с использованием функций автокорреляции (ACF) и частной автокорреляции (PACF), что подтвердило отсутствие необходимости сезонной корректировки данных и позволило использовать несезонные модели ARIMA. Выбор оптимальной модели осуществлялся на основе статистических критериев, включая информационный критерий Акаике (AIC), байесовский информационный критерий (BIC) и значения функции правдоподобия. Результаты исследования показали, что модель ARIMA(3,0,1) является наиболее подходящей для прогнозирования экспорта, тогда как модель ARIMA(4,0,1) обеспечивает наилучшее описание динамики импорта. Прогнозные оценки свидетельствуют об устойчивом росте экспорта при сохранении более высоких и относительно волатильных объёмов импорта, что обусловливает сохранение отрицательного сальдо внешнеторгового баланса в прогнозируемом периоде. Полученные результаты имеют практическое значение для формирования региональной внешнеторговой политики и совершенствования экономического планирования в Бухарской области.

Ключевые слова: модель ARIMA; методология Бокса–Дженкинса; анализ временных рядов; прогнозирование экспорта; прогнозирование импорта; Бухарская область; стационарность; ACF; PACF; динамика внешней торговли; эконометрическое моделирование.

INTRODUCTION

Global experience demonstrates that promoting economic development, improving public welfare, and reducing income inequality are of crucial importance. In addressing these issues, foreign economic relations play a highly significant role. Therefore, countries around the world are striving to participate more actively in international trade. According to data published by the United Nations (UN) in 2025, foreign trade played an important role in the economies of developing countries in 2024. Exports from Asian countries increased by an average of 2.3 percent compared with the previous year, reflecting a trend similar to global export growth. Developing economies such as Vietnam (5.9%) and Hong Kong (14.0%) made particularly notable contributions to export expansion [1].

Of total global exports, USD 13.3 trillion originated from developed countries, while USD 11.1 trillion came from developing economies. Developing countries accounted for approximately 46 percent of total global exports. Global exports reached USD 24.4 trillion in 2024, representing an increase of USD 474 billion compared with 2022. Economic growth in developing countries, particularly in Asia and Oceania, where exports and imports expanded by 5.6 percent, contributed substantially to the growth of international trade. Exports from developing countries in the Americas increased by 4.3 percent, while those from Africa grew by 1.1 percent. Meanwhile, export levels in developed countries remained relatively stable [2].

Currently, countries around the world are seeking to strengthen their participation in international trade. The efforts of developed economies to expand trade relations highlight the strategic importance of foreign trade activities. The development of foreign trade serves as a key factor in ensuring economic stability and sustainable growth.

According to the United Nations Conference on Trade and Development (UNCTAD), global trade reached a record value of USD 31 trillion in 2022. Despite the effects of the COVID-19 pandemic and the conflict in Ukraine, international trade in goods and services experienced substantial growth. Trade in goods increased by 10 percent, reaching USD 24.2 trillion, mainly due to rising energy prices. Trade in services reached USD 6.8 trillion, representing a 15 percent increase compared with the previous year. However, due to growing geopolitical tensions, a slowdown in global trade growth was expected in 2023.

According to UNCTAD, the largest bilateral merchandise trade flows in the world were observed between the People's Republic of China and the United States, as well as between these countries and their neighboring economies. In 2022, the United States imported goods worth USD 576 billion from China, while China imported goods worth USD 179 billion from the United States. China's total trade turnover with Hong Kong, Japan, Taiwan, and the Republic of Korea amounted to USD 1.47 trillion. Similarly, trade between the United States, Mexico, and Canada reached USD 1.59 trillion [23, 24, 68].

LITERATURE REVIEW

The scope of international merchandise trade statistics is determined by both general and specific recommendations outlined in the IMTS guidelines. The general recommendations address the following aspects [3]:

- the characteristics and classification of goods;
- the specific and complex nature of trade transactions;
- practical considerations related to data collection and reporting.

As a general principle, international merchandise trade statistics recommend recording all goods that enter or leave a country's economic territory and thereby contribute to changes in its stock of material resources.

Specific recommendations apply to particular categories of goods and provide additional clarification regarding their treatment in statistical records. These recommendations are essential for the compilation of balance of payments statistics, national accounts, and other macroeconomic indicators. To ensure consistency and international comparability, such goods should be recorded separately and classified according to whether they:

- should be included in international merchandise trade statistics; or
- should not be included in international merchandise trade statistics.

The statistical study of foreign trade constitutes a specialized branch of external economic statistics that characterizes the current state and development trends of foreign trade relations at both national and regional levels. Foreign trade enables economic entities to create and realize value, as goods considered of limited value in one region may possess greater economic significance in another. Consequently, the development of foreign trade relations facilitates the efficient allocation of resources and contributes to regional economic development.

Numerous academic studies demonstrate that the development of foreign trade positively influences the welfare of a country's population. For example, K. K. Reddy argues that exports and imports stimulate economic growth, while G. T. Karamanaj emphasizes that imports can help address resource constraints within a region. Furthermore, S. Yuksel and S. Zengin note that although imports may increase foreign currency expenditures, their impact on economic growth depends on the overall structure and balance of trade. At the same time, S. Bakari and M. Mabrouki contend that imports serve as an important driver of economic growth by facilitating investment activities and providing access to valuable resources, technologies, and production inputs [4, 5, 6].

Based on the existing literature, two main hypotheses regarding the relationship between foreign trade and economic growth can be formulated.

The first hypothesis is the export-led growth hypothesis, which considers exports as a major driving force of economic development. According to this perspective, a causal relationship exists from exports to production expansion and economic growth. Therefore, the contribution of foreign trade can be assessed through its impact on a region's Gross Domestic Product (GDP).

The second hypothesis suggests that imports also provide significant opportunities for countries and regions by facilitating the exchange of goods, services, technologies, and resources. The positive effects of imports can be sustained when they complement domestic production capacities and support the development of national industries.

RESEARCH METHODOLOGY

The compilation of foreign trade statistics is based on the recommendations set forth in the United Nations publication *International Merchandise Trade Statistics: Concepts and Definitions (IMTS)*. Likewise, the organization and compilation of merchandise foreign trade statistics in the Republic of Uzbekistan are carried out in accordance with the standards and guidelines established by the IMTS framework. According to this manual, International Merchandise Trade Statistics (IMTS) represents a specialized and multipurpose system of official statistical information concerning the recording and presentation of data on the movement of goods between countries and territories.

ANALYSIS AND RESULTS

According to the results of the study, the country's exports declined significantly in 2020; however, they remained nearly 8 percent higher than the export volume recorded in 2018. The export trend of Bukhara region differed somewhat from the overall export dynamics of Uzbekistan. During the study period, the region's exports reached their lowest level in 2018, amounting to USD 187.2 million. By 2024, however, exports from Bukhara region had increased substantially, reaching nearly USD 300 million (Figure 1).

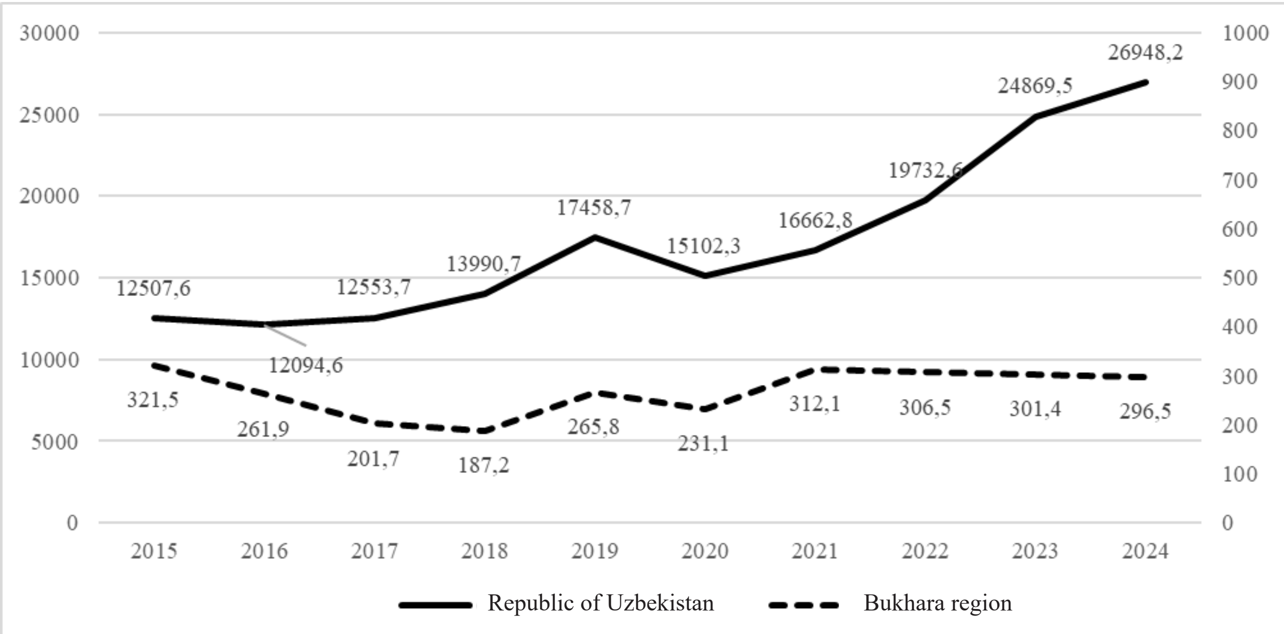

Figure 1. Trends in Export Performance of the Republic of Uzbekistan and the Bukhara Region (USD million)[1]

The export and import indicators of Bukhara region for 2016–2024 were analyzed and forecasted based on quarterly data using the ARIMA model. The ARIMA model is one of the most widely used forecasting techniques for predicting future values in time series analysis. This time series modeling approach is also known as the Box–Jenkins methodology [7, 8, 9, 10] (Figure 2).

1 author's development

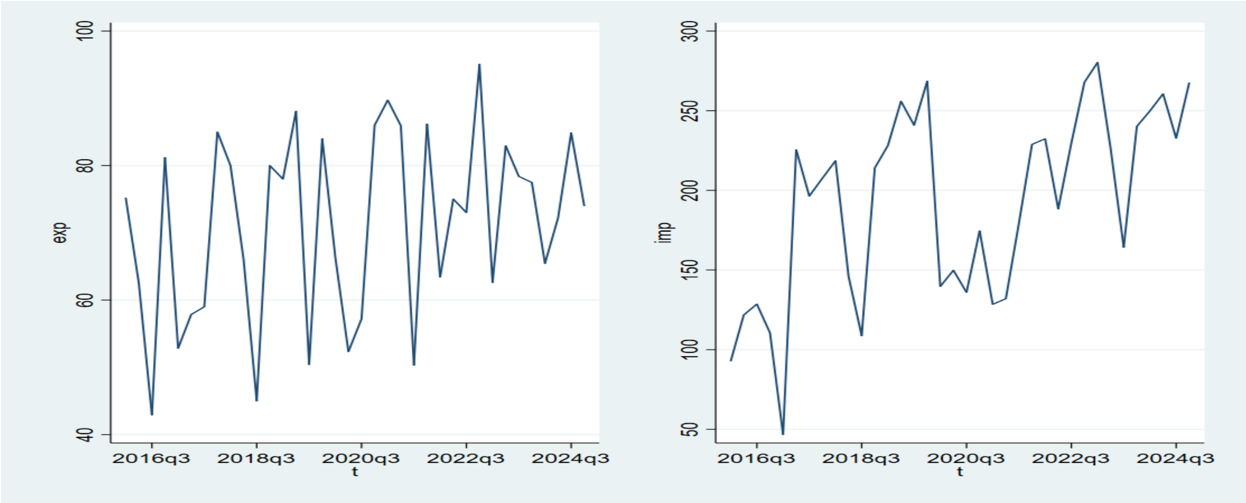

Figure 2. Variations in export and import indicators of Bukhara region based on data for 2016–2024[2]

Most time series data are non-stationary. However, the ARIMA model can be applied only to stationary time series. A stochastic process is considered stationary if its mean and covariance remain constant over time. If the data do not exhibit seasonal variations, a non-seasonal ARIMA(p,d,q) model is used in the study (Figure 3).

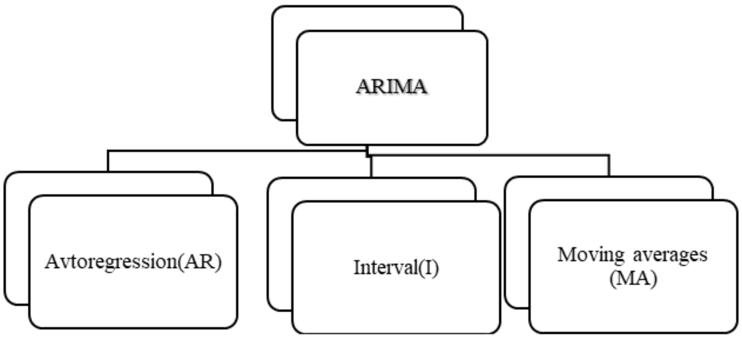

Figure 3. Structural components of the ARIMA model[3]

The ARIMA model consists of three components. The first is the autoregressive (AR) process, which represents the relationship between an observation and its lagged values, and it is expressed as follows:

$$Y_t = a_1 Y_{t-1} + a_2 Y_{t-2} + \cdots + a_p Y_{t-p} a_1 + e_t \quad (1)$$

where
Y_t – the variable under study,
t –time.

The second component is the differencing order (I), which is represented by the parameter *d* in the model. The degree of differencing refers to how many times the original observations are differenced. If the data are non-stationary, they should be transformed into a stationary form through first differencing.

The third component is the moving average (MA) process. It is a model that uses the relationship between observations and the residual errors from a moving average model, applied to lagged observations. It can be expressed as follows:

$$Y_t = e_t + B_1 e_{t-1} + B_2 e_{t-2} + \cdots + B_q e_{t-p} \quad (2)$$

where
Y_t – the variable under study,
t –time.

2 Research results obtained by the author using STATA 17 software.
3 author's development

Accordingly, the model consists of a combination of components represented by the parameters p, d, and q. The ARIMA model was developed and further advanced by G. Box and G. Jenkins in 1970. They applied this model to forecast financial market indicators [11, 12, 13].

The identification stage is one of the most important steps in ARIMA modeling. At this stage, in addition to determining the order of differencing or integration I(d), the autoregressive parameter AR(p) and the moving average parameter MA(q) are also identified. The value of AR(p) is determined using the partial autocorrelation function (PACF), while the value of MA(q) is determined using the autocorrelation function (ACF). These values can be obtained in STATA 17 software using the PACF and ACF commands (Figure 4).

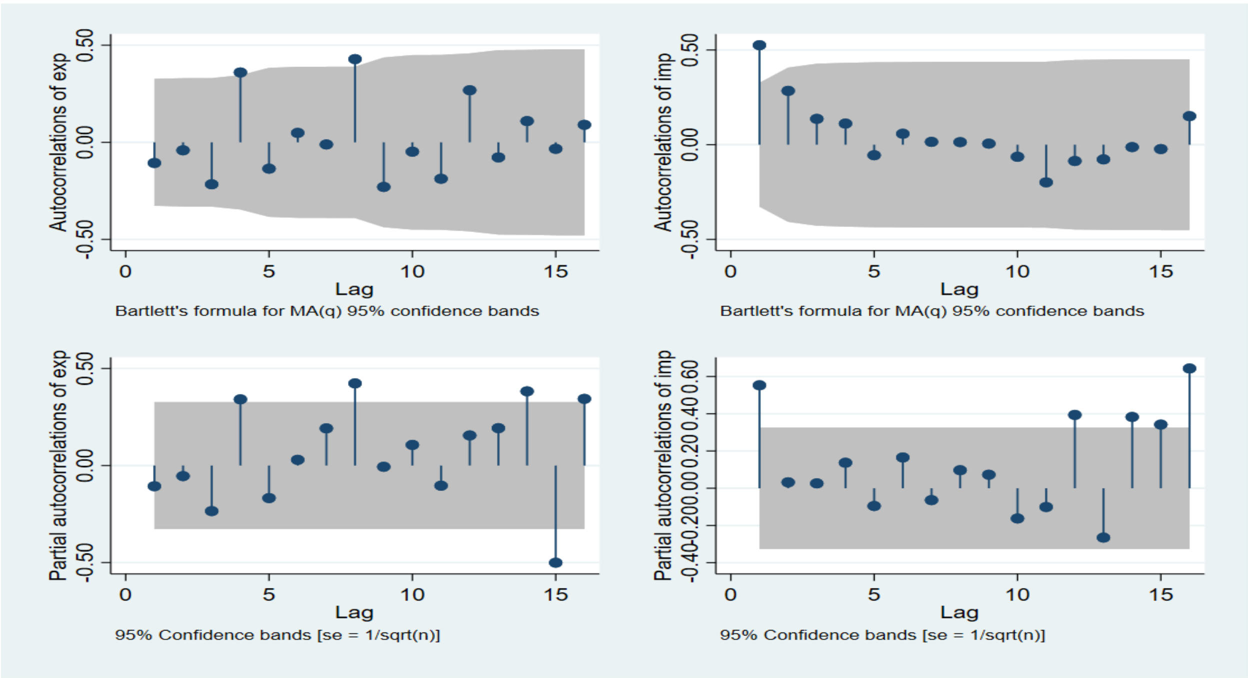

Figure 4. ACF and PACF results for stationary values of export and import volumes (at the 5% significance level)[4]

The ACF and PACF graphical results shown in Figure 3.7 for the export and import values of Bukhara region further confirm the stationarity of the data. As can be seen from the graph, both the ACF and PACF lines exceed the significance bounds at certain lags for both the import and export series. If the ACF plot demonstrates a rapid decay, the time series can be considered stationary. Since the time series data used in this study are stationary, their statistical properties, such as mean and variance, remain stable over time.

At the next stage of the study, it is necessary to determine the p, d, and q parameters of the ARIMA model. Since the indicators are stationary and there is no need for first-order differencing, d = 0 is assumed. The next step is to determine the values of p and q. According to the Box–Jenkins approach, the main tools for identifying the orders p and q in ARIMA models are the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

The ACF measures the correlation between the current and past values of a series. The x-axis represents the lag, while the y-axis shows correlation coefficients ranging from −1 to +1, indicating both positive and negative correlations. Positive correlations indicate that increases in current observations are associated with increases in lagged values, whereas negative correlations indicate an inverse relationship. In general, the ACF reflects how closely the current values of a time series are related to its past values. Similarly, the PACF describes the relationship between the current values and their lagged values after removing the effects of intermediate lags. Both the ACF and PACF play an important role in explaining the behavior of time series data. The moving average order, denoted by q, is determined using the ACF plot, while the autoregressive order, denoted by p, is determined using the PACF plot. In such cases, the decision to include or exclude points beyond the significance bounds is made based on optimal model selection criteria.

4 Research results obtained by the author using STATA 17 software.

Accordingly, four possible models were identified for exports: AR(3) MA(1), AR(5) MA(1), AR(3) MA(2), and AR(5) MA(2) (Table 1).

Table 1
Criteria for selecting ARIMA models for exports of Bukhara region[5]

Model selection criteria					
Kriteriyalar	Model				The best model
	Model A ARIMA (3 0 1)	Model B ARIMA (3 0 2)	Model C ARIMA (5 0 1)	Model D ARIMA (5 0 2)	
SigmaSQ	11,84325	11,86477	12,31	12,44	A
Log likelihood	-140,3645	-140,3303	-141,6696	-142,2	B
Akaike	288,729	289,0605	291,3391	292,4114	A
Bayeseian	295,0631	295,3946	297,6732	298,7459	A

The best model is A.

According to the model selection criteria, the most appropriate model is the one that exhibits the lowest values of the information criteria while maintaining satisfactory goodness-of-fit statistics. Based on these criteria, the ARIMA(3,0,1) model was identified as the most suitable specification for the data under analysis (Table 2).

Table 2
ARIMA model selection for imports of Bukhara region.

Model selection criteria			
Kriteriyalar	Model		The best model
	Model A ARIMA(3 0 1)	Model B ARIMA(4 0 1)	
SigmaSQ	48.92	48.31	B
Log likelihood	-191.22	-190.84	B
Akaike	390.45	389.68	B
Bayeseian	396.78	396.01	B
The best model			B

Based on the graphical analysis results, the polynomial roots of the autoregressive (AR) and moving average (MA) components for the import series of Bukhara region lie within the unit circle. This confirms the stability and adequacy of the ARIMA(4,0,1) model and indicates that it can be reliably used for analyzing and forecasting import dynamics. The regression results of the ARIMA(4,0,1) model used for forecasting imports in Bukhara region are presented in the following table.

Based on the results of the study, forecast estimates of export and import volumes for Bukhara region were developed for the period 2025–2030. The forecasted values of exports and imports are presented in Table 3.

5 Research results obtained by the author using STATA 17 software

Table 3
Forecast indicators of export, import, and trade balance (saldo) volumes of Bukhara region for 2025–2030 (in million USD)[6]

Years	Export	Import	TSA	Balance (saldo)
2025	309,240	902,529	1211,771	-593,289
2026	314,683	879,956	1194,640	-565,272
2027	318,925	887,481	1206,407	-568,556
2028	323,594	899,750	1223,346	-576,156
2029	328,334	912,767	1241,102	-584,433
2030	333,062	925,894	1258,957	-592,832

The results of this study demonstrate that the ARIMA modeling approach is an effective tool for analyzing and forecasting foreign trade dynamics in Bukhara region. The application of the Box–Jenkins methodology enabled the systematic identification, estimation, and diagnostic checking of appropriate time series models for both export and import indicators.

Stationarity analysis based on ACF and PACF plots confirmed that the selected time series exhibit stable statistical properties after transformation, thereby justifying the use of non-seasonal ARIMA models. The absence of a need for differencing (d = 0) indicates that the export and import series are stationary or become stationary after minimal transformation, which strengthens the reliability of the modeling process.

Model selection based on information criteria, including AIC, BIC, and log-likelihood values, revealed that the ARIMA(3,0,1) specification is the most appropriate model for export dynamics, while the ARIMA(4,0,1) model provides the best fit for import behavior. These results indicate that export dynamics are relatively stable and can be explained by a simpler autoregressive structure, whereas import dynamics require a slightly more complex autoregressive component to capture their variability.

The forecast results indicate a steady upward trend in exports of Bukhara region during 2025–2030, reflecting gradual improvements in production capacity and external demand conditions. In contrast, imports are projected to remain at a relatively higher level with moderate fluctuations, suggesting a continued need for imported goods and production inputs. As a result, the trade balance remains negative throughout the forecast period, although exports demonstrate a consistent growth trend.

From a policy perspective, these findings suggest that regional economic development strategies should focus on enhancing export competitiveness, diversifying export markets, and strengthening domestic production capacity to gradually reduce import dependency. At the same time, the persistence of a negative trade balance highlights the importance of structural measures aimed at expanding value-added production within the region.

Overall, the study confirms that ARIMA-based forecasting provides reliable short- and medium-term projections for regional trade indicators and can serve as a useful analytical tool for policymakers and researchers in evaluating trade performance and designing economic development strategies.

CONCLUSION AND RECOMMENDATIONS

When modeling data using ARIMA models, it is sometimes useful to plot inverse characteristic roots. In STATA software, model reliability is assessed by examining the inverse roots of the AR and MA components. The arroots function returns the autoregressive roots from the AR characteristic polynomial, while the maroots function returns the moving average roots from the MA characteristic polynomial. The inverse roots must lie inside the complex unit circle for the model to be considered stable.

Based on the ARIMA regression results, it can be concluded that the ARIMA(4,0,1) model has statistically significant AR and MA components for forecasting imports in Bukhara region. The t-statistic is high (10.02), and the p-value is 0.000, indicating that the coefficient is statistically significant. The AR(L4) component equals 0.1576, with a p-value of 0.0457, which is close to the 0.05 significance threshold. Thus, this component is statistically significant at the 5 percent level. The MA(L1) component equals 0.3652, with a p-value of 0.011, indicating that it is also statistically significant. Therefore, the model is suitable for forecasting import volumes.

According to the results of the study, the forecast indicators describe the foreign trade dynamics of Bukhara region. By the end of 2025, exports in the region are expected to exceed USD 309 million, while imports are projected to reach USD 902.5 million. In the following years, export volumes are expected to grow steadily, whereas import trends are expected to show relatively higher variability. By 2030, exports are forecasted to

6 Research results obtained by the author using STATA 17 software.

exceed USD 333 million, while imports are expected to reach USD 926 million. As a result, the trade balance is projected to reach USD -592.8 million. In relative terms, exports are expected to grow by nearly 9 percent compared with 2024, while imports are expected to increase by more than 1.5 percent. The trade balance is projected to remain relatively stable due to faster export growth and moderate fluctuations in import dynamics.

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