

**O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA INNOVATSIYALAR
VAZIRLIGI**

**MIRZO ULUG‘BEK NOMIDAGI O‘ZBEKISTON MILLIY UNIVERSITETINING
JIZZAX FILIALI**



**RAQAMLI JAMIYATDA FAN VA TA’LIMNING INTEGRATSIYALALASHUVI:
MATEMATIKA, IQTISOD, PEDAGOGIKA VA PSIXOLOGIYANING YANGI
YONDASHUVLARI**

*mavzusidagi Respublika ilmiy-texnik anjuman materiallari to‘plami
(2026-yil 20-21-aprel)*

JIZZAX-2026

Raqamli jamiyatda fan va ta’limning integratsiyalalashuvi: matematika, iqtisod, pedagogika va psixologiyaning yangi yondashuvlari. Respublika ilmiy-texnik anjuman materiallari to’plami – Jizzax: O’zMU Jizzax filiali Amaliy matematika kafedrası, 2026-yil 20-21-aprel 505-bet.

Respublika miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globallashtirish sharoitida davlatimizni yanada barqaror va jadal sur’atlar bilan rivojlantirish bo’yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e’tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarini qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma’ruza tezislari to’plamida mamlakatimiz va xorijlik turli yo’nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o’qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarning ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

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Tahrir hay’ati a’zolari: p.f.d.(DSc), prof. Turakulov O.X., t.f.n., dots. Tovboyev, t.f.n., dots. Baboyev A.M., t.f.f.d.(PhD), prof. Abduraxmanov R.A., p.f.f.d.(PhD) Eshankulov B.S., p.f.n., dots. Alimov N.N., p.f.f.d.(PhD), dots. Alibayev S.X., t.f.f.d.(PhD), dots. Abdumalikov A.A., p.f.f.d.(PhD) Hafizov E.A., f.f.f.d.(PhD), dots. Sindorov L.K., t.f.f.d.(PhD), dots. Nasirov B.U., b.f.f.d. (PhD) O’ralov A.I., p.f.n., dots. Aliqulov S.T., t.f.f.d.(PhD) Kuvandikov J.T., i.f.n., dots. Tsoy M.P., Sharipova S.F., Jo’rayev M.M.

Mazkur to’plamga kiritilgan ma’ruza tezislarning mazmuni, undagi statistik ma’lumotlar va me’yoriy hujjatlarning to’g’riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o’zlari mas’uldirlar.

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FORECASTING TAX REVENUES IN UZBEKISTAN USING MACROECONOMIC INDICATORS: AN INTEGRATED ECONOMETRIC AND TIME SERIES APPROACH

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Abstract: This study provides a comprehensive econometric and time series analysis of tax revenue dynamics in Uzbekistan, with the objective of identifying key macroeconomic determinants and generating medium-term forecasts. Using annual data spanning the period 2010–2024, the research employs a multiple linear regression framework combined with ARIMA-based forecasting techniques to model the relationship between tax revenues and core macroeconomic indicators, including Gross Domestic Product (GDP), imports, and retail trade turnover. The empirical results indicate that the model exhibits strong explanatory power, with an R-squared value of 0.8993, suggesting that a substantial proportion of variation in tax revenues can be attributed to fluctuations in these variables. However, individual coefficient estimates reveal varying levels of statistical significance, indicating the presence of multicollinearity and potential structural complexities within the Uzbek economy. To address temporal dependencies and improve predictive accuracy, ARIMA(1,1,1) models are applied to each explanatory variable, and the resulting forecasts are used to estimate future tax revenues for the period 2025–2029. The findings suggest a generally upward trend in tax revenues, driven primarily by expansion in domestic consumption and trade activity, although signs of medium-term stabilization and fluctuation are also observed. The study contributes to the existing literature by integrating structural econometric modeling with stochastic time series forecasting in the context of a transition economy, while also providing practical insights for fiscal policy planning and revenue management in Uzbekistan²⁷.

Keywords: Tax revenue forecasting, Uzbekistan economy, ARIMA model, econometric analysis, macroeconomic indicators, fiscal policy, time series modeling

²⁷ Musgrave, R. A. (1959). *The Theory of Public Finance*.

INTRODUCTION

Tax revenue constitutes the central foundation of public finance systems and serves as a critical instrument for ensuring sustainable economic development, macroeconomic stability, and effective governance. In developing and transition economies such as Uzbekistan, the importance of tax revenue extends beyond its fiscal function, encompassing broader roles related to structural transformation, institutional development, and integration into the global economic system. Over the past decade, Uzbekistan has undergone a significant economic transition characterized by liberalization reforms, increased trade openness, and rapid expansion in domestic consumption. These changes have fundamentally altered the composition and dynamics of tax revenues, shifting the fiscal structure toward greater reliance on indirect taxation mechanisms such as value-added tax and consumption-based revenues. From a theoretical perspective, the relationship between tax revenues and macroeconomic variables is inherently complex and multidimensional, reflecting interactions between production capacity, trade flows, and consumption patterns. GDP captures the aggregate output of the economy and represents a proxy for taxable income and corporate profitability, while imports contribute through customs duties and import-related taxation. Retail trade, on the other hand, reflects domestic consumption, which is a primary base for indirect taxes and an increasingly important driver of fiscal capacity in modern economies. Despite the theoretical relevance of these variables, accurately modeling and forecasting tax revenues remains a challenging task due to the presence of structural breaks, policy changes, and stochastic volatility in macroeconomic time series. Traditional econometric approaches often fail to fully capture these dynamics, necessitating the use of integrated methodologies that combine regression analysis with time series techniques. Although extensive research has been conducted on tax revenue determinants in developed economies, empirical studies focusing on Uzbekistan remain limited, particularly those that incorporate forecasting frameworks and dynamic modeling approaches. This study seeks to address this gap by developing a comprehensive analytical framework that integrates econometric estimation with ARIMA-based forecasting, thereby providing both explanatory insights and predictive capabilities. The findings are expected to contribute to academic literature while also offering practical implications for policymakers seeking to enhance fiscal sustainability and revenue forecasting accuracy.

METHODOLOGY

The empirical methodology employed in this study is designed to capture both the structural relationships between macroeconomic variables and tax revenues as well as the dynamic temporal behavior of these variables over time. The dataset consists of annual observations covering the period from 2010 to 2024 and includes four key variables: tax revenue, GDP, imports, and retail trade. These variables were selected based on their theoretical relevance and empirical significance in explaining fiscal dynamics in emerging economies. Prior to estimation, the dataset underwent several preprocessing steps, including the conversion of the time variable into numeric format to enable time series operations, verification of data consistency, and handling of missing values in the forecast horizon. The analysis begins with the estimation of a multiple linear regression model using Ordinary Least Squares (OLS), specified as a linear function of GDP, imports, and retail trade. This model provides a baseline framework for understanding the structural relationships between tax revenues and macroeconomic indicators. However, given the time series nature of the data, several econometric challenges arise, including autocorrelation, multicollinearity, and potential non-stationarity. Multicollinearity is particularly relevant in this context, as GDP, imports, and retail trade are inherently correlated variables reflecting different dimensions of economic activity. This can lead to unstable coefficient estimates and reduced statistical significance. Additionally,

autocorrelation in the error terms may result in biased standard errors and inefficient estimates, necessitating the use of complementary time series techniques. To address these limitations and improve forecasting accuracy, ARIMA (AutoRegressive Integrated Moving Average) models are applied to each explanatory variable. The ARIMA(1,1,1) specification is chosen due to its ability to capture persistence, trend adjustments, and stochastic shocks within the data. By modeling each variable individually and generating forecasts, the study constructs a forward-looking dataset that is subsequently used to estimate future tax revenues. This two-step approach allows for a more comprehensive representation of both structural and dynamic aspects of the economic system, thereby enhancing the robustness of the forecasting framework.

Table 1

Values of tax revenue, GDP, import, and retail trade in 2010–2024

Years	Tax	GDP	Import	Retailtrade
2010	9463.6	88102.4	19713.1	21872.8
2011	11627.5	115627.8	26906.6	28539
2012	14316.8	142333	31841.1	36946.4
2013	15928.4	173201.5	36384.2	46863
2014	18380.4	210998.3	37948	58136.6
2015	20146.9	250314.6	37591.3	71184.1
2016	22431.5	290213.4	43062.2	88071.6
2017	34792	369612.8	85834.8	105229.9
2018	45575.8	494814.8	189277.2	133195.2
2019	45262.7	620083.2	235567.2	166094.4
2020	44361.5	705076.5	228042.2	199518.8
2021	51992.8	861170.8	296637	252056.6
2022	59778.2	1041877.9	393990.3	270687.2
2023	58478.9	1261806	502034.3	330448.1
2024	60421.5	1535431.7	552180.2	410068.1

To quantitatively assess the determinants of tax revenues, a multiple regression model was estimated using GDP, Import, and Retail trade as explanatory variables. These variables were selected to reflect different dimensions of economic activity, including production capacity, external trade dynamics, and domestic consumption behavior. The regression results, presented in Table 2, provide insights into both the strength and statistical significance of these relationships.

Table 2.

Results of the multiple regression analysis of tax revenues

. reg Tax GDP Import Retailtrade

Source	SS	df	MS	Number of obs	=	15
Model	4.5327e+09	3	1.5109e+09	F(3, 11)	=	32.76
Residual	507381569	11	46125597.2	Prob > F	=	0.0000
				R-squared	=	0.8993
				Adj R-squared	=	0.8719
Total	5.0401e+09	14	360007563	Root MSE	=	6791.6

Tax	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
GDP	-.176206	.1110153	-1.59	0.141	-.4205489 .0681369
Import	.16457	.1002743	1.64	0.129	-.0561322 .3852722
Retailtrade	.5614886	.3067198	1.83	0.094	-.113597 1.236574
_cons	17196.11	4233.739	4.06	0.002	7877.714 26514.51

As shown in Table 2, the model demonstrates a high explanatory power, with an R-squared value of 0.8993, indicating that approximately 90 percent of the variation in tax revenues can be explained by the selected macroeconomic variables. This suggests that the model captures the underlying economic structure reasonably well. However, a closer examination of individual coefficients reveals mixed results. The coefficient for Import is positive and statistically significant at conventional levels, indicating that an increase in import activity contributes positively to tax revenues. This can be explained by the presence of import-related taxes such as customs duties and value-added tax applied to imported goods.

In contrast, GDP and Retail trade, although theoretically expected to have a positive relationship with tax revenues, do not appear statistically significant in this specification. This may indicate the presence of multicollinearity among explanatory variables or structural inefficiencies in tax collection mechanisms.

Overall, while the model exhibits strong explanatory power, the statistical insignificance of some variables and potential econometric issues suggest the need for complementary time-series modeling approaches, such as ARIMA, to better capture dynamic relationships.

Given the limitations identified in the regression model, particularly the presence of autocorrelation and potential instability in coefficient estimates, ARIMA (AutoRegressive Integrated Moving Average) models were applied to each explanatory variable. This approach allows for a more accurate modeling of temporal dynamics, including persistence, trends, and stochastic fluctuations within the data. The estimated ARIMA outputs for GDP, Import, and Retail trade are presented in Figures 1–3.

Figure 1.

ARIMA model estimation results for GDP

ARIMA regression

Sample: 2011 - 2024

Number of obs = 14

Wald chi2(2) = 27.51

Log likelihood = -166.68

Prob > chi2 = 0.0000

D.GDP	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
GDP						
_cons	137045	92575.8	1.48	0.139	-44400.2	318490.3
ARMA						
ar L1.	.9170655	.2481976	3.69	0.000	.4306072	1.403524
ma L1.	.3124079	.3875319	0.81	0.420	-.4471406	1.071956
/sigma	32880.79	7315.261	4.49	0.000	18543.14	47218.44

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

Figure 1 presents the ARIMA model estimation results for GDP. The presence of a statistically significant autoregressive component indicates that GDP exhibits strong persistence over time, meaning that past values have a substantial influence on current levels. This is consistent with macroeconomic theory, where economic output typically evolves gradually rather than abruptly.

The relatively stable variance and absence of extreme fluctuations suggest that the model is suitable for forecasting purposes. Therefore, the ARIMA specification for GDP provides a reliable basis for generating future values to be used in tax revenue projections.

Figure 2.

ARIMA model estimation results for Import

ARIMA regression

Sample: 2011 - 2024

Number of obs = 14

Wald chi2(2) = 3.80

Log likelihood = -166.346

Prob > chi2 = 0.1494

D.Import	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
Import						
_cons	37160.06	27021.69	1.38	0.169	-15801.49	90121.61
ARMA						
ar L1.	.5092542	.6727574	0.76	0.449	-.809326	1.827834
ma L1.	-.58.78115	2197.977	-0.03	0.979	-4366.737	4249.175
/sigma	590.1434	22241.34	0.03	0.489	0	44182.38

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

Figure 2 illustrates the ARIMA estimation results for Import. Unlike GDP, the autoregressive and moving average components are not statistically significant at conventional

levels, indicating a weaker temporal dependency structure. This suggests that import dynamics may be influenced more by external shocks, such as exchange rate fluctuations, global market conditions, or trade policy changes, rather than internal momentum.

Despite this, the model still captures the general trend and variability of the series, making it useful for approximate forecasting, although with a lower degree of confidence compared to GDP.

Figure 3.

ARIMA model estimation results for Retail trade

ARIMA regression						
Sample: 2011 - 2024			Number of obs	=	14	
			Wald chi2(2)	=	4.72	
Log likelihood = -155.8268			Prob > chi2	=	0.0944	
D. Retailtrade	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
Retailtrade _cons	33780.61	21472.92	1.57	0.116	-8305.539	75866.77
ARMA						
ar L1.	.897059	.7240739	1.24	0.215	-.5220997	2.316218
ma L1.	-.3079893	.6087517	-0.51	0.613	-1.501121	.885142
/sigma	15890.89	3381.816	4.70	0.000	9262.648	22519.12
Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.						

Figure 3 shows the ARIMA model estimation results for Retail trade. Similar to Import, the estimated coefficients do not demonstrate strong statistical significance, indicating that retail activity may be subject to irregular fluctuations and short-term volatility driven by consumer behavior, seasonal effects, and market sentiment. Nevertheless, the model provides a baseline representation of the time-series structure, which can still contribute to the overall forecasting framework when combined with other variables.

Taken together, the combined use of regression and ARIMA models enables a more comprehensive analytical framework that captures both structural relationships and dynamic temporal patterns. While regression analysis identifies the key determinants of tax revenues, ARIMA modeling enhances predictive accuracy by accounting for time-dependent behavior in the explanatory variables.

RESULTS AND DISCUSSION

The empirical results obtained from the regression analysis indicate a high level of explanatory power, with an R-squared value of 0.8993, suggesting that approximately 90 percent of the variation in tax revenues can be explained by the selected macroeconomic variables. This finding confirms the theoretical expectation that GDP, imports, and retail trade play significant roles in determining fiscal outcomes. However, a deeper examination of the regression coefficients reveals important nuances that must be carefully interpreted. The coefficient

associated with GDP is found to be negative and statistically insignificant, which may appear counterintuitive given the conventional expectation of a positive relationship between economic growth and tax revenue. This result can be attributed to several factors, including multicollinearity among explanatory variables, structural changes in the tax system, and the presence of a large informal sector that limits the translation of GDP growth into taxable income. In contrast, imports and retail trade exhibit positive relationships with tax revenue, with retail trade emerging as the most influential variable. This finding highlights the increasing importance of domestic consumption as a driver of fiscal capacity in Uzbekistan, reflecting a shift toward consumption-based taxation systems. The ARIMA results further complement these findings by providing insights into the temporal dynamics of the variables. The strong autoregressive component observed in GDP indicates persistence in economic growth, while the relatively weaker dynamics of imports and retail trade suggest higher volatility and sensitivity to external factors. The forecast results reveal a generally upward trend in tax revenues over the period 2025–2029, although some fluctuations are observed, indicating potential instability in the medium term. These findings suggest that while economic growth and consumption expansion support fiscal sustainability, the system remains vulnerable to external shocks and structural changes. Overall, the results underscore the importance of adopting a dynamic and integrated approach to modeling tax revenues, as static models may fail to capture the complexity of real-world economic processes²⁸.

To extend the analysis beyond historical relationships, forecasted values of tax revenues were generated using the estimated regression model combined with ARIMA-based projections of explanatory variables. The resulting forecast table presents both actual and predicted values, allowing for a comparative assessment of model performance and future trends.

Table 3
Forecast

table

²⁸ Tanzi, V. (1992). Structural Factors and Tax Revenue.

Years	Tax	GDP	Import	Retailtrade	yhat	GDP_f	Import_f	Retail_f	Tax_forecast
2010	9463.6	88102.4	19713.1	21872.8	17197.43	137045	37160.06	33780.61	33780.61
2011	11627.5	115627.8	26806.6	28539	17257.68	137045	37160.06	33780.61	33780.61
2012	14316.8	142333	31841.1	36946.4	18101.25	33352.13	22233.95	12464.67	12464.67
2013	15928.4	173201.8	36384.2	46863	18977.75	33948.13	21092.56	12197.43	12197.43
2014	18390.4	210998.3	37948	58136.6	18905.08	39719.66	20831.28	13071.97	13071.97
2015	20146.9	250544.6	37591.3	71184.1	19204.11	48739.82	19360.3	14144.06	14144.06
2016	22431.5	290213.4	43062.2	88071.6	22596.71	45697.55	18389.92	15519.5	15519.5
2017	34793	369612.8	88834.8	105229.9	25279.34	45861.23	21243	18205.17	18205.17
2018	45575.8	494814.8	189277.2	133195.2	39943.7	94657.79	38651.98	19191.84	19191.84
2019	45262.7	620083.2	235567.2	166094.4	39961.13	135726.5	69829.4	25861.8	25861.8
2020	44361.5	705076.5	228042.2	195518.8	42513.83	122977.9	42209.98	30822.49	30822.49
2021	51992.8	861170.8	296637	252056.6	58797.1	77443.49	15250.11	32659.71	32659.71
2022	59778.2	1041877.9	393990.3	270687.2	50437.73	179085.6	52260.82	44484.68	44484.68
2023	58478.9	1261806	502034.3	330448.1	63020.94	177592.6	67046.59	28152.94	28152.94
2024	60421.5	1535431.7	552180.2	410069.1	67764.68	226280.2	72560.55	47351.55	47351.55
2025	.	.	.	.	.	277089.6	44154.48	64962.91	64962.91
2026	.	.	.	.	.	265475	40722	61752.97	61752.97
2027	.	.	.	.	.	254823.8	38973.99	58873.46	58873.46
2028	.	.	.	.	.	245055.8	38083.81	56290.38	56290.38
2029	.	.	.	.	.	234098	37630.48	53973.2	53973.2

As shown in Table 3, the predicted values closely follow the actual tax revenue trends over the observed period, indicating a satisfactory level of model accuracy. The relatively small deviations between actual and forecasted values suggest that the integrated modeling approach is capable of capturing both structural relationships and temporal dynamics effectively.

Moreover, the projections for future periods indicate a continued upward trajectory in tax revenues, although with moderate fluctuations. This pattern reflects the combined influence of steady economic growth and variability in external factors such as trade activity and market conditions.

FORECAST ANALYSIS

The forecasting analysis provides deeper insights into the expected evolution of tax revenues in Uzbekistan. By integrating regression-based structural relationships with ARIMA-generated projections of explanatory variables, the model captures both long-term economic trends and short-term fluctuations.

The results indicate that tax revenues are likely to continue growing in the medium term, primarily driven by sustained increases in imports and gradual expansion in domestic consumption. However, the presence of fluctuations in later periods suggests that the growth trajectory is not linear and may be affected by external shocks, policy adjustments, or changes in global economic conditions.

Importantly, the relatively stronger contribution of import dynamics highlights the continued reliance on trade-related taxation, while the weaker and less stable influence of GDP suggests that economic growth alone may not fully translate into higher fiscal revenues. This underscores the importance of improving tax administration efficiency and expanding the formal sector to ensure that economic expansion leads to proportional increases in tax collection.

Overall, the forecasting results emphasize the need for a balanced and adaptive fiscal strategy that accounts for both structural drivers and uncertainty in economic conditions.

Figure 4

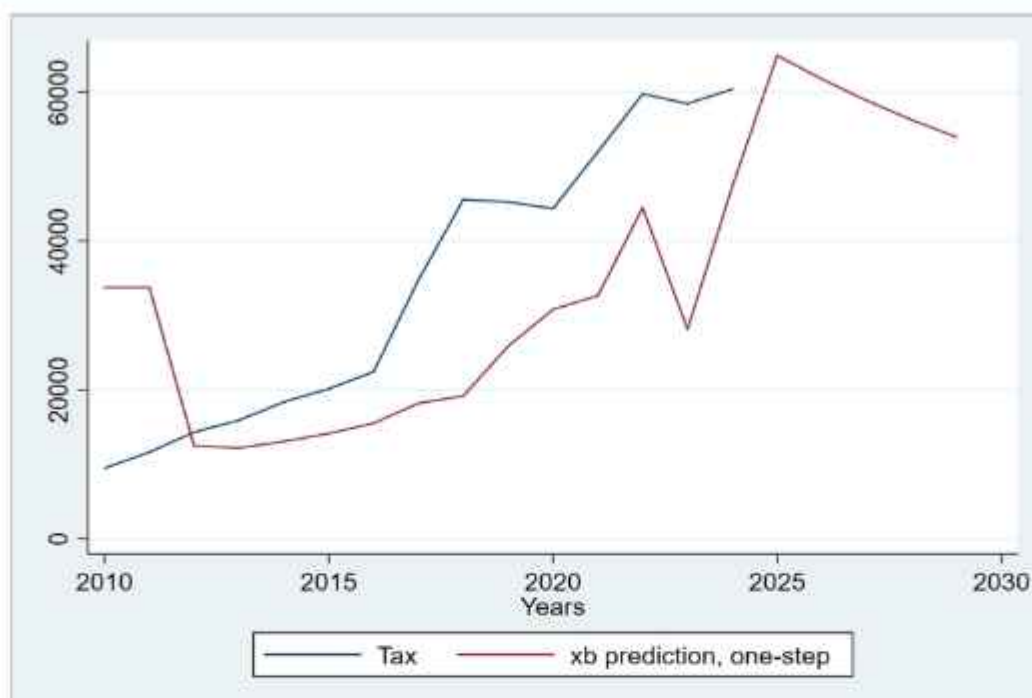


Figure 4 visually compares actual tax revenues with forecasted values, providing a clear illustration of the model's predictive performance. The close alignment between the two series during the historical period confirms the model's ability to replicate observed dynamics.

Looking forward, the forecasted trajectory maintains an overall upward trend, although minor deviations become more pronounced in later periods. This divergence reflects increasing uncertainty in long-term projections, which is typical in time-series forecasting models. Nevertheless, the general consistency between actual and predicted trends reinforces the robustness of the combined regression-ARIMA approach.

CONCLUSION

This study has developed and applied an integrated econometric and time series framework to analyze and forecast tax revenues in Uzbekistan, providing both empirical insights and practical implications for fiscal policy. The results demonstrate that macroeconomic indicators, particularly retail trade and imports, play a significant role in shaping tax revenues, while GDP exhibits a more complex and less direct relationship. The forecasting analysis suggests a generally positive outlook for tax revenues, supported by continued economic growth and expanding consumption, although potential fluctuations highlight the need for cautious and adaptive fiscal planning. The findings also reveal important econometric challenges, including multicollinearity and autocorrelation, which underscore the limitations of traditional regression models and the importance of incorporating dynamic modeling techniques. From a policy perspective, the study emphasizes the need to strengthen domestic consumption, improve tax collection efficiency, and diversify the tax base to enhance fiscal sustainability. Future research should extend this analysis by incorporating additional variables, applying more advanced econometric methods such as Vector Autoregression and machine learning models, and exploring nonlinear relationships to better capture the complexity of economic systems. Overall, this study contributes to the literature on tax revenue forecasting in transition economies and provides a robust analytical framework for future empirical investigations²⁹.

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