EXCELLENCIA
INTERNATIONAL MULTI-DISCIPLINARY JOURNAL OF EDUCATION
Volume 02, Issue 10, 2024 ISSN (E): 2994-9521

Forecasting the Digital Economic Indicators of the Republic of Uzbekistan Using Arima Models

Kinjaev Kattakul Nurmatovich [1], Turaev Baxtiyor Ergashevich [2]

[1] Master of Termez State University

[2] Senior lecturer at Termez University of Economics and Service

Annotation:

The digital economy in Uzbekistan has been gaining significant traction in recent years, driven by government initiatives aimed at transforming the national economy through the integration of digital technologies. In this article, the indicators of the digital economy of the Republic of Uzbekistan are forecasted using ARIMA models . First, the stationarity of the time series was checked and SARIMA (3; 2; 0) (1; 2; 0) 4 model is constructed. The significance of the model was assessed by MAPE , and the statistical significance of its parameters was assessed by Fisher's Z test. It was studied that the residuals obey the normal distribution law and that they do not have autocorrelation. As a result, a forecast until 2028 was developed.

Key words: ADF test , ACF, PACF , model, ARIMA, SARIMA, MAPE, Fisher, stationary.

Introduction: Digitalization allows developing the economy and one of the main indicators that determine the state of the digital economy in the Republic of Uzbekistan is the indicator of communication and information services. This indicator shows the results of the activities of enterprises operating in the communication and information network, and in 2023 it amounted to 3226.6 billion sums. Compared to the previous period, the increase was 131.5%. This indicates that the network is developing rapidly.

Main part: Forecasting the future values of this indicator is important for making important management decisions in the network, and for enterprises to reduce risk, manage resources, attract

investments, and improve the level of service quality. Therefore, the indicator of communication and information services of the Republic of Uzbekistan (Figure 1)[1] was projected.

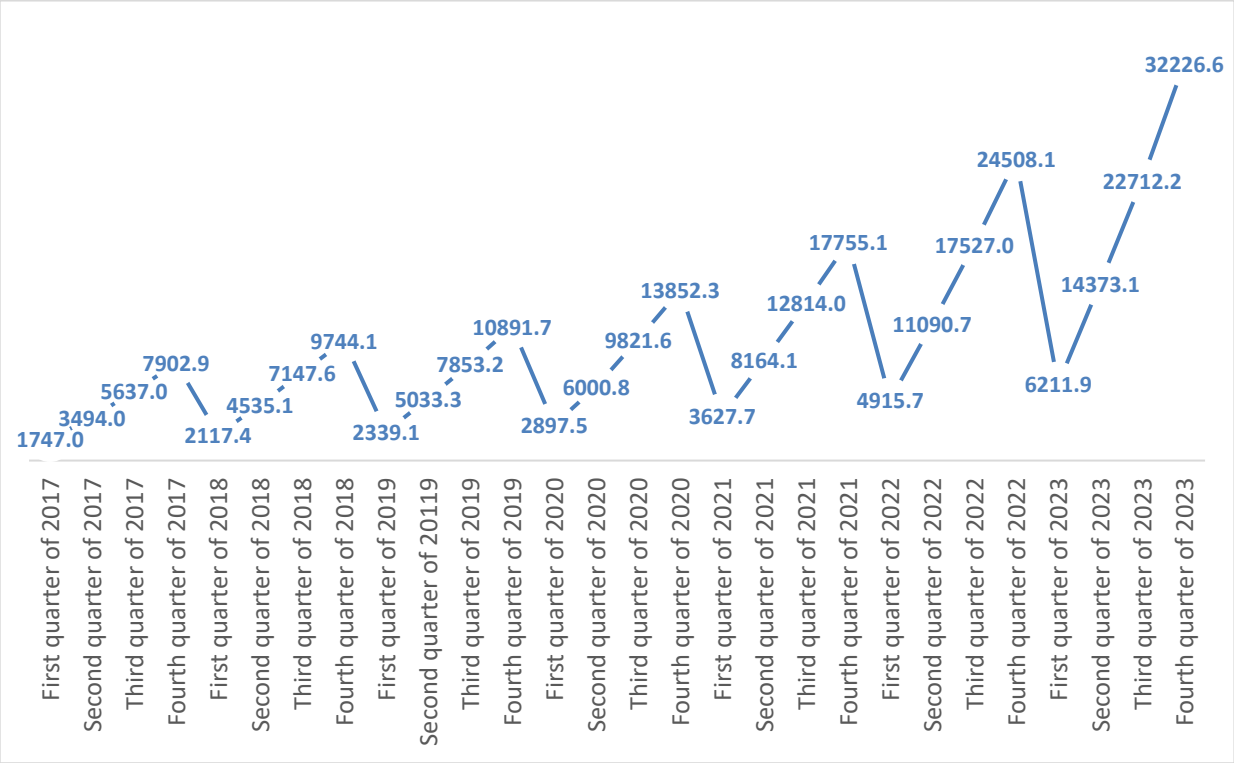

Figure 1. Indicator of communication and information in the Republic of Uzbekistan (in billion sums).

It is known that modeling consists of the following stages:

1. Specification stage. At this stage, the order of ARIMA model p, q, d is determined. In here, p is the autoregressive order, d is the degree of integration and q is the moving average order. In the next, we check the stationarity of the time series is checked. To achieve stationarity, given data can usually be differentiated up to two times. If I (0), then the stationary series is "zero integrated". If the given series is differentiated once or twice until it becomes stationary, it is expressed as I (1) or I (2) respectfully. After that, the remaining actions are performed.
2. Identification stage. At this stage, model parameters are estimated. An overview of ARIMA models is as follows[2]:

$$\Delta^d y = a + \sum_{i=1}^{p} \varphi_i \Delta^d y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon \qquad (1)$$

3. Verification stage. Parameter estimation according to Fisher's Z criterion, model significance estimation according to MAPE, checking the absence of autocorrelation in the residuals, checking whether the residuals obey the normal distribution law, etc. are performed.
4. Forecasting. First, the stationarity of the time series of the indicator of communication and information in the Republic of Uzbekistan was checked. Stationary time series averages are usually constant. Figure 1 shows that the averages of the series are not constant. Therefore, the stationarity of the first differences, i.e., the level of integration of the model is d=1, was tested (Table 1).

[1] www.stat.uz – Information from the State Statistics Agency under the President of the Republic of Uzbekistan.
[2] Turaev B.E. Correlation and regression analysis of the share of construction works in the gross regional product of the Surkhandarya region // Economics and innovative technologies. - 2021. - No. 6. - P. 205-214.

Analyzing the test results from Table 1 below, the p-value in the Dickey-Fuller test should always be greater than the 0.1, 0.05, 0.01 significance levels. For us, this value was equal to 0.9885 in the variable state and 1 in the fixed state. Hence, the p-values are greater than the significance level. Since these values are greater than the significance levels, we can see in the correlogram below (Figure 2) that the time series is not stationary when I(1).

Table 1 Results of the augmented Dickey-Fuller[3] test[4]

Augmented Dickey-Fuller test for y
testing down from 8 lags, criterion AIC
sample size 23
unit-root null hypothesis: a = 1
test without constant
including 4 lags of (1-L) y
model: (1-L) y = (a-1) *y (-1) + ... + e
estimated value of (a-1): 0.108891
test statistic tau_nc (1) = 1.95803
asymptotic p-value 0.9885
1st-order autocorrelation coeff. for e: -0.020
lagged differences: F (4, 18) = 886.797 [0.0000]
test without constant
including 4 lags of (1-L) y
model: (1-L) y = b0 + (a-1) *y (-1) + ... + e
estimated value of (a-1): 0.209725
test statistic: tau_c (1) = 2.24655
asymptotic p-value 1
1st-order autocorrelation coeff. for e: 0.032
lagged differences: F (4, 17) = 762.985 [0.0000]

Analyzing the test results from Table 1, it is verified that the p-value is always greater than the significance levels of 0.1, 0.05, 0.01 in the Dickey-Fuller test. In our case, this value was equal to 0.9885 in the variable state and 1 in the fixed state. Hence, the p-values are greater than the significance level. Since these values are greater than the significance levels, it is concluded that the time series is not stationary when I(1). It is known that to determine the order of p and q of the model, the correlogram below is examined (Figure 2).

[3] https://en.wikipedia.org/wiki/Dickey–Fuller_test.
[4] Author development.

According to Figure 2 below, the process is characterized by autoregression. Also, 4-lag seasonality is observed. However, it is difficult to identify any model order. For this reasons, various models were tested and as a result, the following model order was achieved.

ARIMA (3; 2; 0) (1; 2; 0) (2)

(2) the following results were obtained when evaluating the model.

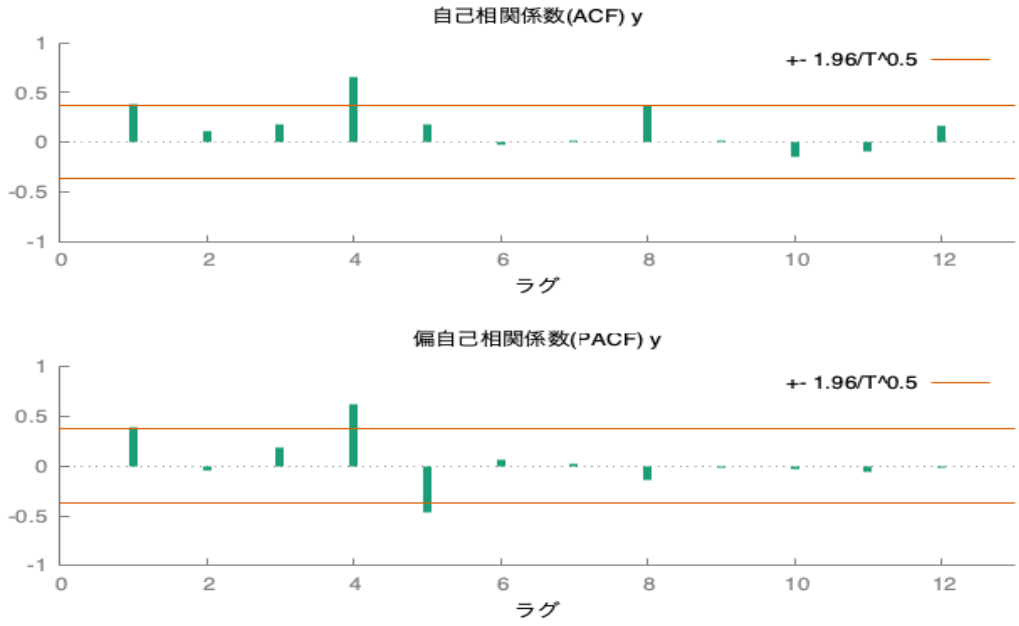

Figure 2. Time series correlogram[5]

Table 2 Regression analysis results [6]

Model 2: ARIMA, using observations 2019:3-2023:4 (T = 18)

Dependent variable: (1-L) ^2(1-Ls) ^2 y

Standard errors based on Hessian

	Coefficient	Std. Error	z	p-value	
phi_1	−0.880247	0.107487	−8.189	<0.0001	***
phi_2	−0.852409	0.112471	−7.579	<0.0001	***
phi_3	−0.909178	0.0753702	−12.06	<0.0001	***
Phi_1	−0.849541	0.112529	−7.550	<0.0001	***

Mean dependent var	49.30556	S.D. dependent var	1586.340
Mean of innovations	2.343345	S.D. of innovations	707.3550
R-squared	0.991805	Adjusted R-squared	0.990048
Log-likelihood	−147.3849	Akaike criterion	304.7698

[5] Author development.
[6] Author development.

Schwarz criterion		309.2216	Hannan-Quinn		305.3836
		Real	Imaginary	Modulus	Frequency
AR					
	Root 1	-1.0321	0.0000	1.0321	0.5000
	Root 2	0.0473	-1.0313	1.0323	-0.2427
	Root 3	0.0473	1.0313	1.0323	0.2427
AR (seasonal)					
	Root 1	-1.1771	0.0000	1.1771	0.5000

From Table 2, the general view of the model is as follows:

$$\Delta^2 y = -0{,}880247\Delta^2 y_{t-1} - 0{,}852409\Delta^2 y_{t-2} - 0{,}909178\Delta^2 y_{t-3} - 0{,}849542\Delta^2 y_{t-4} + \varepsilon \quad (3)$$

Table 2 shows that the parameters of the model are significant according to Fisher's z test. Also, when we checked the approximation error of the model, it turned out that MAPE=8.1%.

Besides that, no autocorrelation was observed in the residuals of model (3), and it was found that the p-value of the Chi-square[7] test for normal distribution of the residuals is greater than 0.05. Thus, the model is suitable for the economic process.

Predicted values were developed using model (3).

Table 3 Forecast values and confidence intervals of the indicator of communication and information in the Republic of Uzbekistan [8]

Years	Forecast values	The lower bound of the confidence interval	The upper bound of the confidence interval
First quarter of 2024	8177.4	6791.0	9563.8
Second quarter of 2024	18167.4	16086.0	20248.7
Third quarter of 2024	29014.2	26382.3	31646.1
Fourth quarter of 2024	42205.8	39154.5	45257.1
First quarter of 2025	10389.8	5048.9	15730.7
Second quarter of 2025	22199.8	14972.5	29427.2
Third quarter of 2025	35511.5	26686.9	44336.1
Fourth quarter of 2025	53010.6	42927.5	63093.6
First quarter of 2026	13292.0	-1064.5	27648.5
Second quarter of 2026	26596.7	8336.0	44857.4
Third quarter of 2026	42655.6	20942.3	64369.0
Fourth quarter of 2026	65508.3	41002.2	90014.5
First quarter of 2027	16538.8	-14647.0	47724.5

[7] Chi-square is a statistical test used to examine the differences between categorical variables from a random sample in order to judge the goodness of fit between expected and observed results.
[8] Author development.

Second quarter of 2027	31166.8	-6524.4	68857.9
Third quarter of 2027	49772.6	6102.0	93443.2
Fourth quarter of 2027	78603.5	29965.2	127241.9
First quarter of 2028	20405.4	-38206.5	79017.3
Second quarter of 2028	36000.6	-32627.3	104628.5
Third quarter of 2028	57182.2	20887.5	135252.0
Fourth quarter of 2028	92869.5	6791.5	178947.5

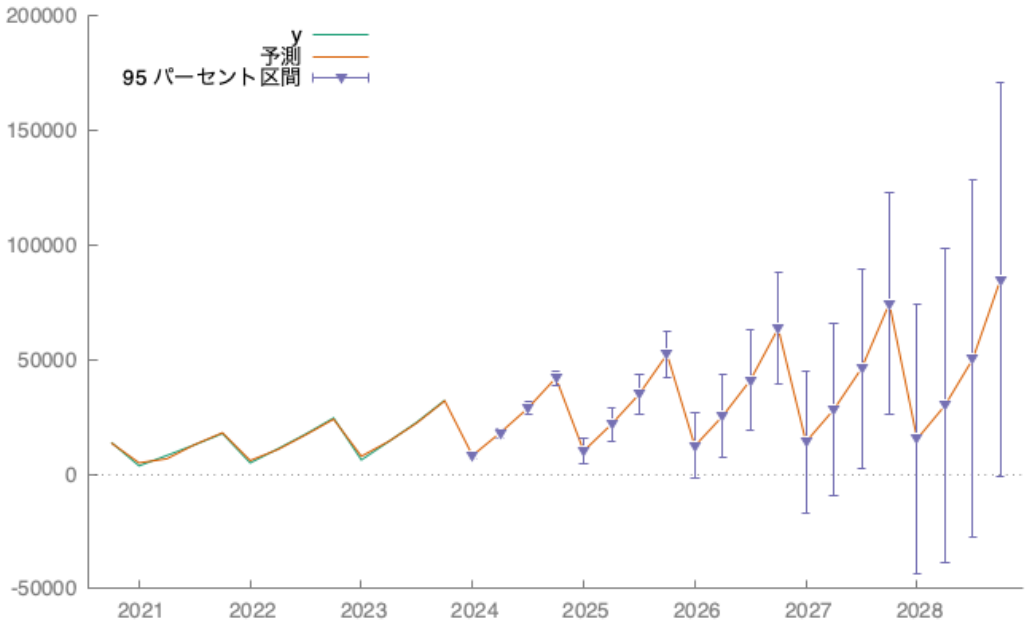

Figure 3. Forecast of the indicator of communication and information in the Republic of Uzbekistan[9].

Conclusion: the indicator of communication and information in the Republic of Uzbekistan amounted to 32,226.6 billion sums in the 4th quarter of 2023 is expected to reach 92,869.5 billion sums by the 4th quarter of 2028. This means that it will increase by 3 times from the current period. The future of the digital economy in Uzbekistan looks promising, with ongoing investments in technology and infrastructure development. As more sectors embrace digital transformation, Uzbekistan aims to position itself as a regional hub for technology and innovation.

REFERENCES

1. www.stat.uz – Information from the State Statistics Agency under the President of the Republic of Uzbekistan.
2. https://en.wikipedia.org/wiki/Dickey–Fuller_test.
3. Turaev B.E. Correlation and regression analysis of the share of construction works in the gross regional product of the Surkhandarya region // Economics and innovative technologies. - 2021. - No. 6. - P. 205-214.

[9] Author development.