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Directions for Innovative Development of E-Commerce Services Based on Econometric Modeling

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Abstract: This study analyzes the main economic and digital factors influencing the development of e-commerce services in the Samarkand region using econometric methods. Based on data for 2014–2025, the relationship between electronic payments, internet subscribers, service volume, small business, investment, and other indicators and e-commerce volume is assessed. Correlation analysis and the VIF test are used to identify relationships among the factors and the presence of multicollinearity. The ARDL-ECM model is applied to assess short- and long-term relationships, while the ARIMAX model is used to forecast e-commerce development through 2030. The results show that electronic payments, internet infrastructure, and investment are important factors in the development of e-commerce.

Keywords: e-commerce, digital economy, electronic payments, internet, investment, small business, econometric model, ARDL-ECM, ARIMAX, forecasting

1. Introduction

E-commerce is one of the fastest-growing areas of the modern digital economy, and its development dynamics depend on numerous economic and institutional factors, including internet infrastructure, electronic payment systems, entrepreneurial activity, investment, and household incomes. Therefore, identifying the factors influencing e-commerce volume and assessing the degree of interrelationship among them is of significant scientific and practical importance. In particular, studying the development trends of the e-commerce market at the regional level makes it possible to develop effective management decisions in the future and improve mechanisms for supporting this sector[1].

This study evaluates the main factors affecting e-commerce volume in the Samarkand region using econometric methods. The study analyzes the number of internet users, the volume of electronic payments, the number of active small business entities, retail turnover, investment volume, the volume of communication and information services, logistics services, household incomes, and other important indicators. Initially, the relationships among the factors were examined using correlation analysis, followed by the VIF test to identify the problem of multicollinearity.

Furthermore, the time-series properties of the selected indicators were assessed using stationarity tests, and the ARDL-ECM model was applied to identify short- and long-term relationships between e-commerce volume and the main factors. Based on the obtained results, the factors having the greatest impact on e-commerce development were identified, and forecast indicators through 2030 were developed using the ARIMAX model. The results of this analysis serve as a basis for developing scientifically grounded

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proposals aimed at the innovative development of e-commerce services in the Samarkand region and improving their efficiency[2].

In the context of the digital economy, several complementary tools of modern time-series econometrics were used in this study to scientifically assess the development patterns of e-commerce services. The central methodological framework of the analysis was based on the autoregressive distributed lag model, together with the associated bounds testing and error correction model. The advantage of the ARDL approach is that it can be applied when variables have different orders of integration, that is, when they are stationary at level $I(0)$ and at first difference $I(1)$, while also providing relatively stable results in small samples. This feature is particularly important for the relatively short time series covering 2014–2025 for the Samarkand region.

The analysis follows a two-stage logic: in the first stage, the short- and long-term effects of the factors influencing e-commerce volume are estimated within the ARDL-ECM framework; in the second stage, the statistically significant factors identified are incorporated as external regressors into the ARIMAX (Autoregressive Integrated Moving Average with exogenous variables) forecasting model, and forecasts are generated under three different scenarios through 2030. Each stage of the analysis is presented sequentially below[3].

2. Materials and Methods

This study uses econometric methods to assess the factors influencing the development of e-commerce services in the Samarkand region based on annual data for 2014–2025. The dependent variable is the volume of e-commerce (Y), while electronic payments, internet subscribers, service volume, small business entities, population, investment, employment, per capita service volume, per capita investment, and the number of small business entities per 1,000 people are used as explanatory variables. Descriptive statistical analysis, Pearson correlation analysis, and the Variance Inflation Factor (VIF) test were used to assess the statistical characteristics and multicollinearity among the variables. The stationarity of the time series was evaluated using unit-root tests. To determine short- and long-term relationships, the Autoregressive Distributed Lag–Error Correction Model (ARDL-ECM) and bounds testing approach were applied. Statistically significant factors identified in the ARDL-ECM analysis were subsequently incorporated as exogenous variables into the Autoregressive Integrated Moving Average with Exogenous Variables (ARIMAX) model. Based on this model, e-commerce development was forecast through 2030 under three scenarios. The analysis was conducted using official statistical data for the Samarkand region.

3. Results

In the econometric model, the volume of e-commerce in the Samarkand region (Y , billion UZS) was taken as the dependent outcome variable. This indicator reflects the actual economic scale of digital commerce in the region and is formed based on official statistical data and the turnover of e-commerce platforms. The set of explanatory factors was selected based on the theory of the digital economy and the concept of the e-commerce ecosystem:

- X1 – volume of electronic payments (billion UZS),
- X2 – number of internet subscribers (thousand),
- X3 – volume of services (billion UZS),
- X4 – number of small business entities,
- X5 – population (thousand people),
- X6 – volume of investment (billion UZS),
- X7 – employed population (thousand people),
- X8 – per capita volume of services (million UZS),
- X9 – per capita investment (million UZS), and
- X10 – number of small business entities per 1,000 people.

From a theoretical perspective, these factors represent three key pillars of e-commerce. First, digital infrastructure and coverage constitute the “gateway” to e-

commerce in accordance with network effects theory: as the user base expands, the value of platforms and the volume of trade increase in a nonlinear manner. Second, within the framework of transaction cost theory, the payment ecosystem improves the reliability and speed of online transactions while reducing their associated costs. Third, the entrepreneurial base determines the supply side of e-commerce, namely the number of online sellers, and is directly linked to the theory of small business development[4-8].

The remaining factors characterize the macroeconomic environment and demand potential. However, as demonstrated in the following sections, most of these factors were not directly incorporated into the final econometric model because they have high correlations with one another; instead, those with the strongest economic significance and greatest statistical stability were selected. This approach was adopted to reduce the multicollinearity problem and improve the interpretative accuracy of the model.

Table 1. Selected Dependent and Explanatory Factors for Correlation-Regression Statistical Analysis

Yil	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
2014	0.15	2,554.8	722.6	5,065.9	12,648.0	3,445.6	2,540.4	1,402.5	1.47	0.74	3.67
2015	0.30	3,295.7	833.9	5,832.9	12,860.0	3,514.8	3,237.2	1,443.9	1.66	0.92	3.66
2016	0.60	4,251.4	962.6	7,200.5	13,840.0	3,583.9	3,623.5	1,485.1	2.01	1.01	3.86
2017	1.21	5,484.4	1,116.8	8,343.2	13,981.0	3,651.7	4,384.2	1,523.1	2.28	1.20	3.83
2018	4.09	7,074.8	1,332.1	10,043.5	16,005.0	3,720.1	7,061.4	1,463.3	2.70	1.90	4.30
2019	27.53	9,126.6	1,638.6	12,786.8	19,629.0	3,798.9	10,266.7	1,455.8	3.37	2.70	5.17
2020	100.25	10,760.3	1,998.1	14,086.1	25,643.0	3,877.4	14,656.4	1,418.3	3.63	3.78	6.61
2021	597.87	11,113.7	2,298.7	18,259.0	33,114.0	3,947.7	15,641.6	1,441.3	4.63	3.96	8.39
2022	1,088.68	17,767.1	2,672.3	22,953.6	40,724.0	4,031.3	18,917.1	1,479.8	5.69	4.69	10.10
2023	1,326.38	25,471.9	3,006.1	29,023.1	47,943.0	4,118.2	25,717.1	1,504.2	7.05	6.24	11.64
2024	1,521.15	32,673.5	3,213.8	59,604.1	37,398.0	4,208.5	28,946.9	1,521.1	14.16	6.88	8.89
2025	1,745.00	46,025.9	3,435.6	72,123.2	31,470.0	4,297.5	38,281.9	1,591.2	16.78	8.91	7.32

The remaining factors characterize the macroeconomic environment and demand potential. However, as demonstrated in the following sections, most of these factors were not directly included in the final econometric model because they exhibit high correlations with one another; instead, the factors with the strongest economic relevance and statistical stability were selected. This approach was adopted to reduce the multicollinearity problem and improve the interpretative accuracy of the model.

Before starting the analysis, descriptive statistics were calculated for each indicator. Table 1 presents the mean, minimum, maximum, standard deviation, coefficient of variation (CV), and compound annual growth rate (CAGR).

The descriptive indicators were calculated using the following formulas for the mean, standard deviation, coefficient of variation, and compound annual growth rate:

$$\bar{x} = \frac{1}{n} \sum_{t=1}^n x_t \quad (1.1)$$

Where:

$\bar{x}$ - the arithmetic mean value of the indicator;

n - the number of observations (years or periods);

t - the time or observation sequence number;

x_t - the value of the indicator in period t (or year t).

$$s = \sqrt{\frac{1}{n-1} \sum_{t=1}^n (x_t - \bar{x})^2} \quad (1.2)$$

Where:

s - standard deviation;

n - number of observations;

t - time or observation sequence number;
 x_t - value of the indicator in period (t);
 $\bar{x}$ - mean value of the indicator.

$$CV = \frac{s}{\bar{x}} \times 100\% \quad (1.3)$$

Where:

CV - coefficient of variation;
 s - standard deviation;
 $\bar{x}$ - mean value.

$$CAGR = \left[\left(\frac{x_n}{x_1} \right)^{\frac{1}{n-1}} - 1 \right] \times 100\% \quad (1.4)$$

Where:

CAGR (Compound Annual Growth Rate) – compound annual growth rate;
 x_n - value of the indicator in the final period (or final year);
 x_1 - value of the indicator in the initial period (or first year);
 n - number of observation years (periods).

Table 1 data demonstrate the exceptionally high dynamics of e-commerce volume: the compound annual growth rate (CAGR) reached 134.2%, representing the highest value among all factors. At the same time, the coefficient of variation for Y was 129.2%, indicating that this indicator changed within an extremely wide range during the study period, from UZS 0.15 billion in 2014 to UZS 1,745 billion in 2025. Such a high degree of variation indicates that e-commerce in the region started from a “zero base” and subsequently went through a stage of explosive growth[9-12].

Table 2. Descriptive Statistics of the Main Indicators (2014–2025)

Ko'rsatkich	O'rtacha	Min	Maks	Std.og'ish	CV, %	CAGR, %
Y	534,43	0,15	1745,00	690,47	129,2	134,21
X1	14633,34	2554,80	46025,90	13547,89	92,6	30,06
X2	1935,93	722,60	3435,60	975,28	50,4	15,23
X3	22110,16	5065,90	72123,20	21814,57	98,7	27,31
X4	25437,92	12648,00	47943,00	12390,68	48,7	8,64
X5	3849,63	3445,60	4297,50	277,88	7,2	2,03
X6	14439,53	2540,40	38281,90	11617,67	80,5	27,97
X7	1477,47	1402,50	1591,20	52,16	3,5	1,15
X8	5,45	1,47	16,78	5,00	91,7	24,78
X9	3,58	0,74	8,91	2,68	74,8	25,38
X10	6,45	3,66	11,64	2,80	43,4	6,48

Among the factors, the highest variability is observed in electronic payments, service volume, and per capita service volume. In contrast, demographic indicators, particularly population and the employed population, are the most stable, with their growth rates remaining slow and consistent. This difference is economically logical: while indicators related to the digital sector have undergone rapid transformation, the demographic base changes naturally and more gradually. Therefore, the preliminary hypothesis can be put forward that the growth of e-commerce has occurred primarily due to technological and infrastructural factors rather than demographic factors.

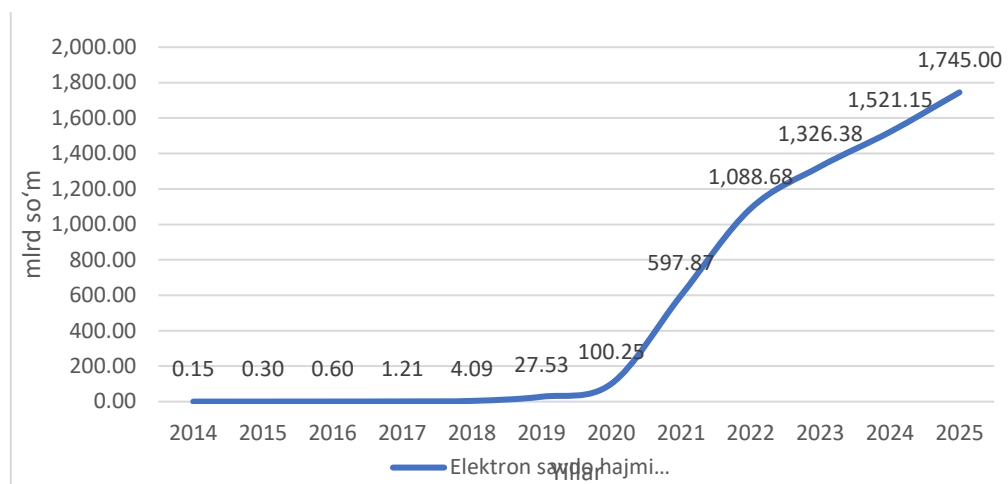


Figure 1. Dynamics of E-Commerce Volume

The growth of e-commerce volume can theoretically be explained based on the theories of the digital economy, innovation diffusion, and network effects. The increase in the indicator from 0.15 to 4.09 during 2014–2018 corresponds to the formative stage of e-commerce services. During this period, the e-commerce market had not yet become widely adopted, consumer confidence in online purchasing was low, and digital payment and logistics services were not sufficiently developed. According to the innovation diffusion theory, new technologies are initially adopted by a small group of users and subsequently begin to spread more rapidly as the number of market participants increases. Therefore, during the early years, the graph line remains relatively low and exhibits slow growth[13].

This stage is characterized by the formation of e-commerce infrastructure and the gradual development of electronic payment systems, internet coverage, and online shopping culture. From 2019 onward, the sharp increase in e-commerce volume can be explained by network effects and platform economy theory. According to network effects theory, as the number of users of a platform increases, its economic value also rises. In other words, as the number of buyers increases, access to electronic platforms becomes more beneficial for sellers; as the number of sellers increases, the range of choices available to buyers expands. As a result, e-commerce volume grows at a rapid pace. The increase in the indicator from 100.25 to 1,088.68 during 2020–2022 indicates that e-commerce entered the stage of mass adoption. During this period, digital payments, mobile applications, internet banking, delivery services, and marketplace platforms accelerated e-commerce processes. Although growth continued during 2023–2025, its pace became relatively more stable.

This situation indicates that after the initial stage of rapid market expansion, e-commerce is transitioning toward a stage of stable development. Thus, from a theoretical perspective, the dynamics of e-commerce volume demonstrate development through successive stages of formation, rapid diffusion and mass adoption, followed by stable growth[14].

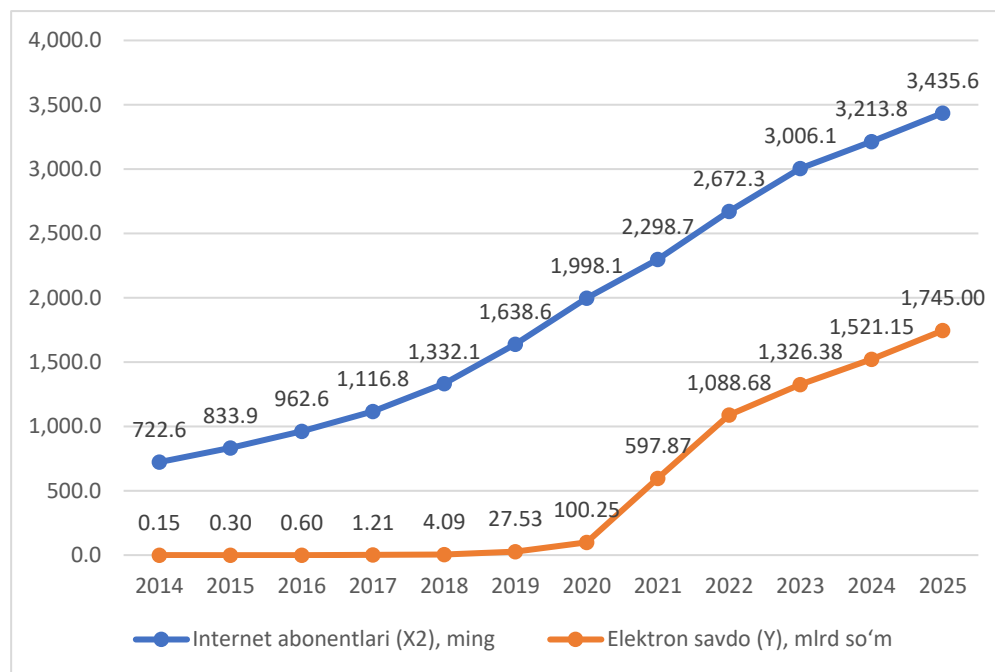


Figure 2. Comparison of Internet Subscribers and E-Commerce Volume

Figure 2 illustrates the parallel movement between the number of internet subscribers and e-commerce volume. The steady expansion of internet coverage has occurred alongside the explosive growth of e-commerce; however, e-commerce has increased at a considerably faster rate. This situation provides the economic basis for the high elasticity coefficient (with respect to internet access) that is evaluated in the following sections.

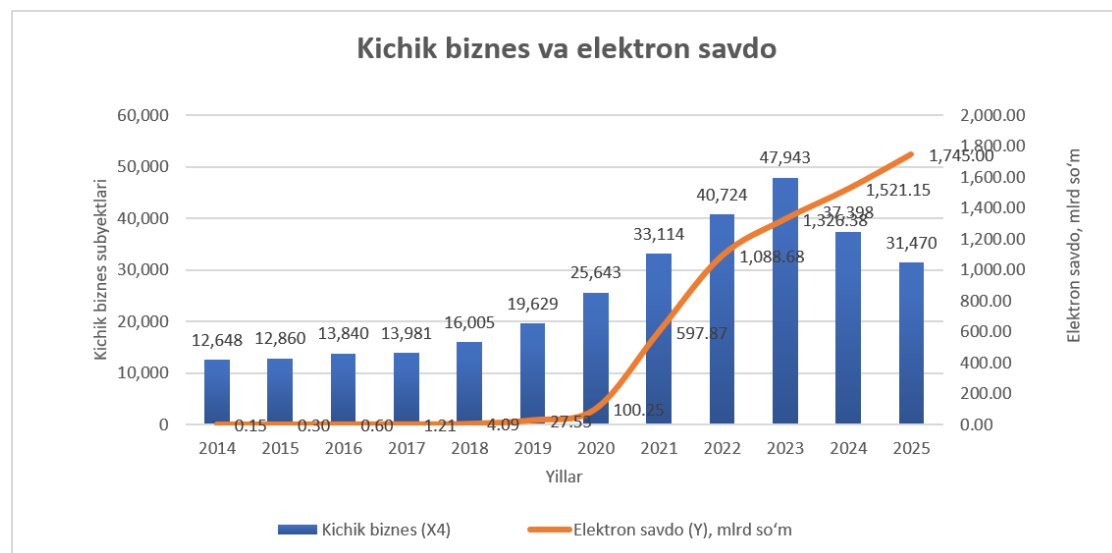


Figure 3. Dynamics of Small Business Entities and E-Commerce

As shown in Figure 3, the number of small business entities steadily increased during 2014–2023 but declined slightly in 2024–2025. Nevertheless, e-commerce continued to grow. This difference indicates that in recent years, the growth of e-commerce has been driven not by an increase in the number of new entities, but rather by the deeper integration of existing entities into digital channels and an increase in average online turnover.

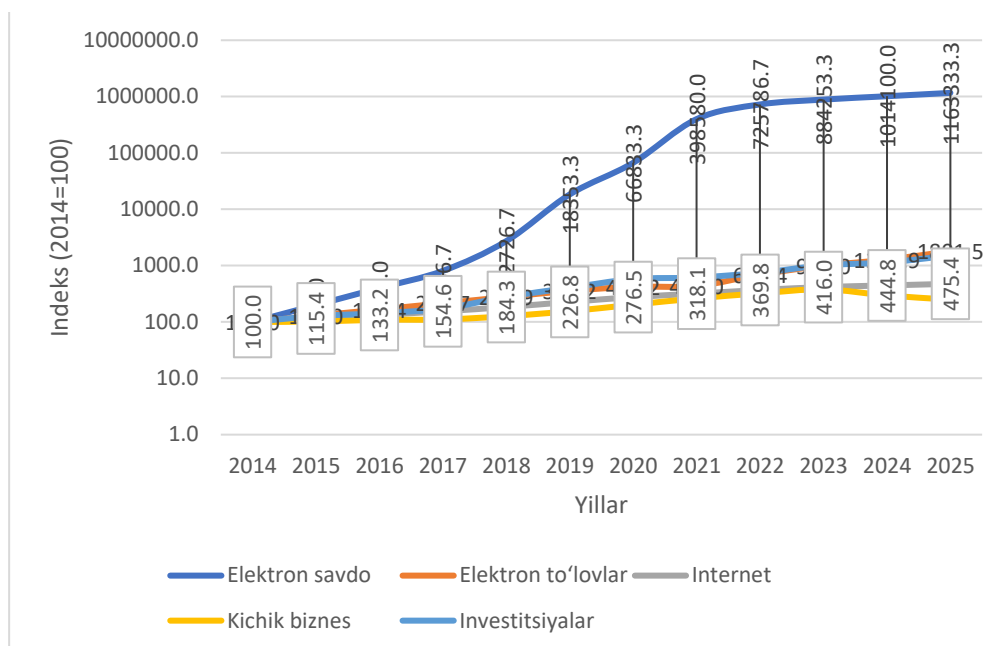


Figure 4. Indexed Growth of the Main Indicators (2014=100, Logarithmic Scale)

All major indicators are indexed relative to the 2014 base year and presented on a logarithmic scale. The e-commerce curve is positioned sharply above all other factors, with its growth magnitude reaching tens of thousands of percent. Electronic payments and investment form the second group, while internet subscribers and small business constitute the third group, showing relatively moderate growth. This visual comparison confirms that e-commerce has a distinctive “leading” growth dynamic and has developed under the combined influence of other factors[15].

Correlation Analysis and Multicollinearity Assessment

To assess the statistical relationships among the factors, a Pearson correlation matrix was calculated. The factors most strongly correlated with the dependent variable Y were investment, per capita investment, electronic payments, and internet subscribers. This result indicates that the development of e-commerce is closely associated with the payment ecosystem, digital coverage, and investment activity.

4. Discussion

The research findings show that the volume of e-commerce in the Samarkand region increased sharply during 2014–2025. E-commerce volume increased from UZS 0.15 billion to UZS 1,745.0 billion, with an average annual growth rate of 134.21%. This indicates that e-commerce in the region has moved from the formation stage to a stage of rapid development.

According to the analysis, electronic payments, internet subscribers, and investment emerged as the most important factors in the development of e-commerce. Pearson correlation analysis also showed that the strongest relationships with Y were observed for investment, per capita investment, electronic payments, and internet subscribers.

The number of internet subscribers increased from 722.6 thousand to 3,435.6 thousand, while electronic payments increased from UZS 2,554.8 billion to UZS 46,025.9 billion. Thus, the expansion of digital infrastructure and payment systems has been one of the key conditions for the growth of e-commerce.

Despite a slight decline in the number of small business entities in 2024–2025, the continued growth of e-commerce indicates that existing enterprises are becoming more actively integrated into digital platforms.

Overall, the results demonstrate the need for comprehensive support for internet infrastructure, electronic payments, investment, and the digital transformation of businesses in developing e-commerce. Assessing short- and long-term relationships

through ARDL-ECM and development scenarios through 2030 using ARIMAX makes it possible to link these findings with practical management decisions.

5. Conclusion

The research findings demonstrate that e-commerce services in the Samarkand region developed rapidly during 2014–2025. The increase in e-commerce volume from UZS 0.15 billion to UZS 1,745.0 billion confirms that its importance in the regional economy has increased significantly.

According to the results of the correlation analysis, electronic payments, internet subscribers, and investment emerged as the key factors in the development of e-commerce. Therefore, to further develop e-commerce, it is advisable to expand digital infrastructure, improve electronic payment systems, stimulate investment, and strengthen the integration of small businesses into digital platforms. The use of ARDL-ECM and ARIMAX models makes it possible to assess short- and long-term development trends in e-commerce and forecast future growth directions.

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