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Predictive Models For Efficient Commerce Management In A Virtual Environment

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Abstract: Digitalization is an integral feature of the development of the modern world economy. By attracting digital technologies, the quality of customer service improves, risks are reduced, costs are reduced, trading becomes more efficient, as well as the fight against fraud and money laundering. E-commerce's priority is to seamlessly interact with the customer, for which they are launching a new analytics platform that collects and processes customer data in real time and allows you to create relevant and timely personalized offers.

Keywords: mathematical model, predictions seem reasonable, electronic trading, pandemic, German market, characteristics.

Introduction

At the end of 2019, 14.1 percent of all global retail sales are e-commerce sales. At the same time, there are about 1.92 billion digital buyers in the world today. The largest e-commerce market, worth $740 billion, is in China. Alibaba, the world's largest online retailer, has goods with a gross value of $768 billion [1].

According to the German market and consumer data company Statista, the current percentage of retail sales in e-commerce is around 15. This number is growing every year, and Statista predicts that it will reach 22% in 2023. With a quarter of the world's population now shopping online, these predictions seem reasonable.

In Uzbekistan, largely due to the expansion of the Internet and electronic trading platforms in the country, the indicators for the development of electronic commerce in 2019 increased by 6.7 times, The volume of trade via the Internet in 2019 amounted to 275.3 billion soums (growth rate - 6.7 times), which is 0.11 percent of the total trade volume of the republic (in 2018 - 0.02 percent). In 2021, especially the volume of e-commerce has grown, given the conditions of the pandemic.

For the purposes of analyzing the factors affecting the quality of public administration of e-commerce in the context of the transition to a digital economy in Uzbekistan, we will conduct an econometric analysis, where we will take Government Effectiveness as an effective factor.

The table shows all the factors that we include in the model in the form of time series. The factors are selected based on the characteristics of their influence on the efficiency of the government in the field of e-commerce

Table 1 Description of variables (Compiled by the author)

Designation	Factor	Variable
y	Government performance	Government Effectiveness
x1	Public Administration Efficiency	Efficiency of public administration
x2	Regulatory Impact	Regulatory impact
x3	Corruption control	Control of corruption

x4	Innovation Index	Innovation Index

The study is based on time series relating to the period from 2012 to 2021. In total, four feature factors were borrowed in the model, the total number of observations is 55. All indicators (both regressors and regressors) are presented as coefficients (indices) (see Appendix 1).

We investigate the degree of stochastic dependence between variables. To do this, we construct a correlation matrix (see Table 2).

Table 2 Correlation matrix (Compiled by the author.)

	Y	X4	X3	X2	X1
Y	1.00	0.43	0.77	0.87	0.57
X4	0.43	1.00	0.49	0.50	0.63
X3	0.77	0.49	1.00	0.95	0.71
X2	0.87	0.50	0.95	1.00	0.73
X1	0.57	0.63	0.71	0.73	1.00

According to the calculations presented in the correlation matrix, it can be seen that there is a positive relationship between all factors, with the closest being between the government performance indicator and the regulatory impact index (r=0.87), as well as the corruption control index (r= 0.77). This means that the growth of the above indicators can potentially significantly improve the efficiency of the government.

Carrying out descriptive statistics based on the ADF test made it possible to conclude that the Y series is stationary by the first difference, since with a probability p=0.002 we are forced to reject the hypothesis of the presence of a unit root (see Table 3).

Table 3 Augmented Dickey-Fuller test (Compiled by the author)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(Y(-1),2)	-2.785467	0.177830	-15.66363	0.0006
D(Y(-1),3)	0.909747	0.104553	8.701332	0.0032
C	-0.009733	0.004191	-2.322224	0.1029
@TREND("2011")	0.002131	0.000574	3.709901	0.0340
R-squared	0.992208	Mean dependent var		-0.002857
Adjusted R-squared	0.984415	S.D. dependent var		0.024300
S.E. of regression	0.003034	Akaike info criterion		-8.462601
Sum squared resid	2.76E-05	Schwarz criterion		-8.493510
Log likelihood	33.61910	Hannan-Quinn criter.		-8.844624
F-statistic	127.3298	Durbin-Watson stat		1.798630
Prob(F-statistic)	0.001165			

Let us construct a multivariate linear regression model in which the dependent variable Y is the efficiency of the government (see Table 4).

Таблица 4 Multiple regression metrics (модель 1) (Compiled by the author**)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X4	0.000797	0.002966	0.268641	0.7972
X3	-0.001997	0.002114	-0.944731	0.3813
X2	0.081461	0.032164	2.532659	0.0445

X1	-0.020128	0.035228	-0.571360	0.5885
C	0.209284	0.090599	2.310005	0.0603
R-squared	0.804216	Mean dependent var		0.237273
Adjusted R-squared	0.673694	S.D. dependent var		0.017939
S.E. of regression	0.010248	Akaike info criterion		-6.020610
Sum squared resid	0.000630	Schwarz criterion		-5.839748
Log likelihood	38.11335	Hannan-Quinn criter.		-6.134618
F-statistic	6.161509	Durbin-Watson stat		1.928350
Prob(F-statistic)	0.025611			

The approximation error of the constructed model is within the normal range:

$$\bar{A} = \frac{1}{n} \cdot \sum_{i=1}^{n} \left|\frac{y-\hat{y}}{y}\right| \cdot 100\,\% = 2{,}81\% \qquad (1)$$

Let's check the model for quality and adequacy. The coefficient of determination R-square = 0.80, which means that 80% of the variation of the dependent variable is explained by four explanatory variables included in the model, and only about 20% is due to the influence of factors not taken into account in the model or random factors. In accordance with the Fisher-Snedekor criterion for , we can recognize the model as adequate. In our case, F_{obs} = 6.16, and F_{tabl}=4.53 with degrees of freedom $f_1 = m = 4$, $f_2 = n - m - 1 = 11 - 4 - 1 = 6$, which confirms the possibility of rejecting the null hypothesis and thus Thus, the reliability of the regression model is at a significance level of 0.05. According to the Fisher criterion, this model is adequate.

Tabular value of the Student's criterion, corresponding to the confidence probability γ = 0,95 and the given number of degrees of freedom $t_{крит} = t_{0,05;6} = 2{,}45$. Comparing the calculated t-statistics of the coefficients of the equation with the table value, we conclude that only the coefficient of the regression equation at x2 is statistically significant.

In order to make the most correct forecast, we will construct another economic and mathematical model, the explained and explanatory variables of which are presented in Table 5.

Table 5 Description of variables(Compiled by the author)

Designation	**Factor**	**Variable**
y	Government Effectiveness	Government Effectiveness
x1	Regulatory and legislative framework in the digital economy	Regulatory and legislative framework in the digital economy
x2	Regulatory quality	Regulatory quality
x3	E-Government Development Index	E-Government Development Index
x4	Global Cybersecurity Index	Global Cybersecurity Index

The use of correlation analysis methods shows the presence of a close direct relationship between the efficiency of the government and all explanatory variables, and based on the correlation matrix, one can make an assumption about the multicollinearity of the regressors (see Table 6).

Table 6 Correlation matrix (Compiled by the author **)**

	Y	X4	X3	X2	X1
Y	1.000000	0.808838	0.749727	0.910017	0.873102
X4	0.808838	1.000000	0.939300	0.830962	0.943209
X3	0.749727	0.939300	1.000000	0.813106	0.940481
X2	0.910017	0.830962	0.813106	1.000000	0.856715

X1	0.873102	0.943209	0.940481	0.856715	1.000000

Based on the data described in Table 5, we construct a multiple regression linear model (see Table 7) and test the regression coefficients for statistical significance.

Table 7 Multiple regression metrics (model 2)(Compiled by the author **)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X4	0.004078	0.027109	0.150420	0.8854
X3	0.146285	0.086035	1.700301	0.1400
X2	0.050602	0.019337	2.616797	0.0398
X1	0.051410	0.024820	2.071358	0.0837
C	0.370801	0.050516	7.340332	0.0003
R-squared	0.911283	Mean dependent var		0.237273
Adjusted R-squared	0.852139	S.D. dependent var		0.017939
S.E. of regression	0.006898	Akaike info criterion		-6.812171
Sum squared resid	0.000286	Schwarz criterion		-6.631310
Log likelihood	42.46694	Hannan-Quinn criter.		-6.926179
F-statistic	15.40772	Durbin-Watson stat		2.303285
Prob(F-statistic)	0.002607			

The coefficient of determination $R^2 = 0{,}91$ shows a close functional relationship between the factors. Fisher criterion $F_{набл.} = 15{,}41$, $F_{крит.} = 4{,}53$. According to the Fisher criterion, this model is adequate. The probability of accepting the null hypothesis H_0 for the entire model as a whole is 0.003, which indicates the need to accept an alternative hypothesis and the significance of the model as a whole.

Tabular value of the Student's criterion, corresponding to the confidence probability $\gamma = 0{,}95$ and the number of degrees of freedom v $v = n - m - 1 = 11 - 4 - 1 = 6$; $t_{крит} = t_{0{,}05;6} = 2{,}45$. Comparing the calculated t-statistics of the coefficients of the equation with the tabular value, we conclude that the most statistically significant are the coefficients for the variables x1 and x2 of the regression equation. It should be added that the probability of accepting the null hypothesis for the coefficients for the above variables takes a value below 0.05, which confirms their significance and the correctness of the constructed model.

The approximation error is an acceptable value (less than 15%):

$$\bar{A} = \frac{1}{n} \cdot \sum_{i=1}^{n} \left|\frac{y-\hat{y}}{y}\right| \cdot 100\,\% = 1{,}25\% \quad (2)$$

Check the residuals for autocorrelation. To do this, we write out the value of the Durbin-Watson statistics from Table 7: DW = 2.30. Using special tables, we determine the significant points dl and du for the 5% significance level. For m = 4 and n = 11: dl=0.444; du=2.283. Since dl≤DW ≤du, then, therefore, there are reasons to believe that the test for the presence of autocorrelation does not give a definite answer to the question.

Let's check for autocorrelation using the Breusch-Godfrey test. It is based on the following idea: if there is a correlation between neighboring observations, then it is natural to expect that in the equation:

$$e_t = \rho \times e_{t-1}, \quad t = 1, \dots, n \quad (3)$$

where e_t are the regression residuals obtained by the ordinary least squares method), the coefficient ρ will be significantly different from zero.

The results of the Breusch-Godfrey test are presented in Table 8.

Таблица 8 Breusch-Godfrey Serial Correlation LM Test (Compiled by the author)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X4	0.009347	0.028417	0.328920	0.7555

X3	-0.000525	0.085520	-0.006136	0.9953
X2	-0.005107	0.019843	-0.257346	0.8072
X1	-0.007237	0.025641	-0.282237	0.7891
C	-0.008056	0.050811	-0.158543	0.8802
RESID(-1)	-0.583356	0.563226	-1.035741	0.3478
R-squared	0.176651	Mean dependent var		-2.51E-17
Adjusted R-squared	-0.646698	S.D. dependent var		0.005343
S.E. of regression	0.006857	Akaike info criterion		-6.824728
Sum squared resid	0.000235	Schwarz criterion		-6.607695
Log likelihood	43.53601	Hannan-Quinn criter.		-6.961538
F-statistic	0.214552	Durbin-Watson stat		2.007988
Prob(F-statistic)	0.941760			

The results of the Breusch-Godfrey test indicate that the probability of accepting the null hypothesis of the absence of autocorrelation is Prob=0.94 and, therefore, there is no autocorrelation in the model.

Let us establish the presence (absence) of heteroscedasticity of random deviations of the model using the Glaser test for this (see Table 9).

Table 9 Heteroskedasticity Test: Glejser (Compiled by the author**)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.012419	0.017901	0.693752	0.5138
X4	0.005704	0.009606	0.593747	0.5744
X3	-0.005480	0.030487	-0.179738	0.8633
X2	0.004883	0.006852	0.712658	0.5028
X1	-0.000164	0.008795	-0.018596	0.9858
R-squared	0.544393	Mean dependent var		0.004336
Adjusted R-squared	0.240655	S.D. dependent var		0.002805
S.E. of regression	0.002444	Akaike info criterion		-8.887055
Sum squared resid	3.59E-05	Schwarz criterion		-8.706193
Log likelihood	53.87880	Hannan-Quinn criter.		-9.001062
F-statistic	1.792309	Durbin-Watson stat		2.959294
Prob(F-statistic)	0.249030			

Glaser's test showed that since the probability of accepting the null hypothesis is higher than 5%, this indicates the absence of heteroscedasticity.

Let us check the constructed model for heteroscedaticity of residuals using the Breusch-Pagan test (see Table 10).

Table 10 Heteroskedasticity Test: Breusch-Pagan-Godfrey (Compiled by the author**)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.55E-05	0.000229	0.154717	0.8821
X4	2.33E-05	0.000123	0.189181	0.8562
X3	2.57E-05	0.000391	0.065762	0.9497
X2	3.02E-05	8.78E-05	0.343553	0.7429
X1	2.92E-05	0.000113	0.259258	0.8041
R-squared	0.487637	Mean dependent var		2.60E-05
Adjusted R-squared	0.146061	S.D. dependent var		3.39E-05
S.E. of regression	3.13E-05	Akaike info criterion		-17.60121

Sum squared resid	5.89E-09	Schwarz criterion	-17.42035
Log likelihood	101.8067	Hannan-Quinn criter.	-17.71522
F-statistic	1.427611	Durbin-Watson stat	3.120072
Prob(F-statistic)	0.331270		

The Breusch-Pagan test showed that the probability of accepting the null hypothesis for the whole model is 33.1% and, therefore, we can accept the alternative hypothesis about the absence of heteroscedasticity of the model residuals.

Thus, the study showed that there is no autocorrelation between variables in the model and the model is homoscedastic. The coefficient of determination and the Fisher criterion also confirm the high quality of the model, while the approximation error of the second model is slightly lower than the first one (see (1) and (2)), the Akaike information criterion also confirms the need to choose the second model:

$$\mathrm{AIC}_1 = -6{,}02,\ \mathrm{AIC}_2 = -17{,}60 \quad (4)$$

In addition, based on the fact that in the first constructed model, only one of the four coefficients for variables are statistically significant, and in the second model, two out of four are statistically significant, we conclude that it is necessary to build a forecast based on the second model.

As follows from the data obtained using the EViews program using the least squares method (see Table 7), the resulting multivariate model will look like:

$$\mathrm{Y} = 0{,}371 + 0{,}051 \cdot \mathrm{x}_1 + 0{,}051 \cdot \mathrm{x}_2 + 0{,}015 \cdot \mathrm{x}_3 + 0{,}004 \cdot \mathrm{x}_4 \quad (5)$$

(t) (7,34) (2,07) (2,62) (1,70) (0,15)

Equation (5) expresses the dependence of the government performance indicator (Y) on the indicator of the regulatory and legislative framework in the CE (x1), the indicator of regulatory quality (x2), the e-government development index (x3) and the global cybersecurity index (x4). The coefficients of the equation show the quantitative impact of each factor on the performance indicator, while others remain unchanged. In our case, the government performance indicator is:

- grows by 0.051 units. with an increase in the efficiency of the regulatory and legislative framework in the CE by 1 unit. (provided that other factors remain unchanged);
- tends to increase by 0.051 units. with an increase in the indicator of regulatory quality by 1 unit. (provided that other factors remain unchanged);
- increases by 0.015 units. with an increase in the indicator of the e-government development index by 1 unit. (provided that other factors remain unchanged);
- increases by 0.004 units. with an increase in the global cybersecurity index by 1 unit. (assuming other factors remain unchanged).

Thus, the greatest increase in the indicator of the effectiveness of the government's work is given by the indicator of the effectiveness of the regulatory and legislative framework in the CE and the indicator of regulatory quality.

The study showed that model (5) can be used to make a forecast based on it, having previously predicted explanatory variables based on trends (see Table 10).

Таблица 10 Characteristics of temporal models of explanatory variables [2]

Variable	**model type**	**Relationship equation**	$\mathbf{R^2}$
x1	Linear	$\mathrm{x}_1 = 0{,}0912 \cdot \mathrm{t} - 0{,}175$	0,8752
x2	Polynomial	$\mathrm{x}_2 = -0{,}0011 \cdot \mathrm{t}^3 + 0{,}0376 \cdot \mathrm{t}^2 - 0{,}26773 \cdot \mathrm{t} - 1{,}1073$	0,9592
x3	Linear	$\mathrm{x}_3 = 0{,}0217 \cdot \mathrm{t} + 0{,}43$	0,7313

x4	Linear	$x_4 = 0{,}0741 \cdot t - 0{,}0925$	0,7964

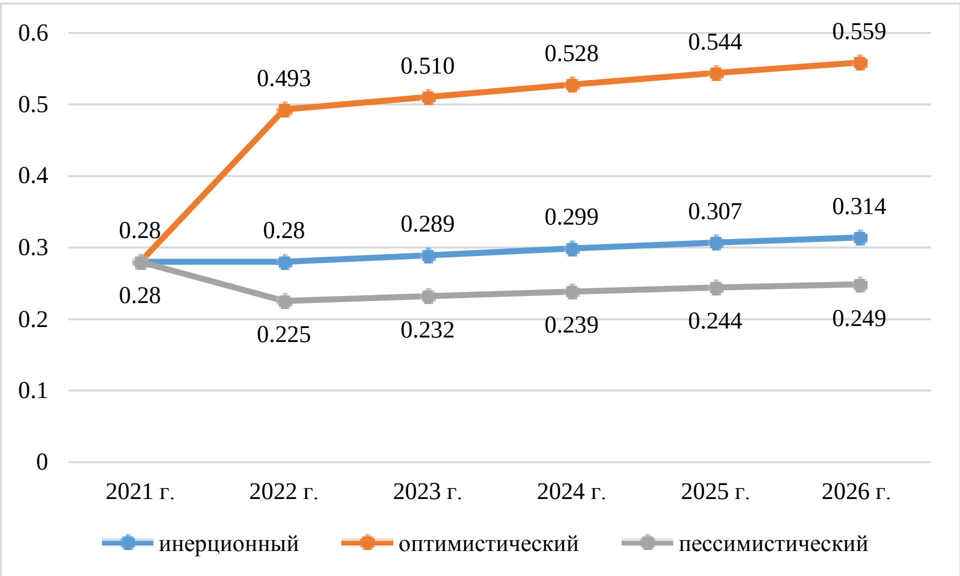
Based on the trends and model (5), we construct the predictive values of the explanatory and explained variables (see Table 11).

Table 11 Forecast values of exogenous model variables up to 2026.[3]

years	Government efficiency	Regulatory and legislative framework in the CE	Regulatory quality	eGovernment Development Index	Global Cyber Security Index
2021 г. (факт)	0,280	0,931	-1,030	0,672	0,725
2022 г.	0,280	0,919	-0,801	0,690	0,797
2023 г.	0,289	1,010	-0,645	0,712	0,871
2024 г.	0,299	1,101	-0,498	0,734	0,945
2025 г.	0,307	1,192	-0,369	0,756	1,019
2026 г.	0,314	1,283	-0,264	0,777	1,093

Based on the forecast obtained, it can be concluded that over the next five years, the performance index of the government of the Republic of Uzbekistan will, albeit slightly, grow steadily.

Let's build several scenario forecasts - inertial (assuming that all processes will be carried out within the planned boundaries), pessimistic (assuming a decrease in the growth rates of all explanatory variables by 10%) and optimistic (based on the assumption that the growth rates of all explanatory variables will increase by 10%). In the latter case, the effectiveness of the government will increase significantly (see Fig. 1).



Rice. 1. Forecast values of the performance index of the government of Uzbekistan in 2022-2026.[4]

Thus, in accordance with the built model and the inertial forecast, by 2026 the index of the efficiency of the government of the Republic of Uzbekistan in the field of e-commerce will grow slightly, which may mean the need to take effective measures to improve the efficiency of all influencing factors, including the regulatory and legislative framework in digital economics, regulatory quality, e-government development index, global cybersecurity index.

Based on the study, the main goal of the state policy of Uzbekistan for the future in the field of improving the efficiency of the government should be the development of a state program to improve the quality of public administration, regulatory impact, and provide a system of measures to simplify doing business and introduce innovations. The implementation of strategic goals in the field of improving the effectiveness of government measures will lead to an increase in the democratization of society, an increase in the availability and quality of information resources, a decrease in the level of corruption, and, ultimately, will achieve the most important goals of sustainable development of Uzbekistan.

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