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MODELING OF THE IMPACT OF E-COMMERCE ON R&D

Introduction

The global e-commerce market is one of the largest dynamic and growing markets. It is expected to reach 16.1% of the global Internet retail network; E-commerce developed rates outpaced overall product development rates. The e-commerce market of Ukraine is, perhaps, the most diverse market in Ukraine at all. This is the only industry whose growth has been the highest in Europe in the last 2 years, generating very optimistic forecasts and attracting more participants. Therefore, the question arises of research and assessment of the parameters of development of this sector at the present stage.

As a consequence, both the estimates of Ukraine's e-commerce situation and its forecastings present many contradictions. In addition, despite the large number of publications, there is no work on analyzing the success of individual e-market players, but of business models and strategies for e-commerce development, which complicates the choice of appropriate tools.

Also, the problem of development and management of Internet commerce in modern conditions in Ukraine has fundamental importance due to the intensification of the processes of concentration of trade objects; development and emergence of new technologies, models of Internet usage in activity of trading enterprises; market dynamics in its various segments; increased competition from foreign entities; modification of forms and types of competition, including intensification of online marketing activities of trading enterprises.

Literature review

Anvari, R. and Norouzi, D. [1], investigated the impact of the e-commerce and R&D, health expenditure and government size on the GDP per capita in twenty one selected

countries, namely, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, and United Kingdom. The panel model with GLS method was used to investigate the period of 2005-2013. The results showed that the explanatory variables in the selected countries played a significant role in the per capita income. In other words, it was revealed that e-commerce and R&D expenditure with GDP per capita had a long run impact based on the cointegration test results; also, both e-commerce and R&D expenditure were found to have a positive impact on GDP per capita, but e-commerce had a stronger development enhancing effect. In addition, other variables such as government size and health expenditure also had a positive influence on GDP per capita. According to these findings, the level of government activity has led to a growing interest in the positive analysis of the size of government.

Liu et al. [2] investigated the impact of e-commerce and R&D on productivity, using a unique panel dataset obtained from Taiwanese manufacturing firms for the period of 1999 to 2002. They found that both e-commerce and R&D capital had a positive influence on productivity, while R&D exhibited a larger productivity- enhancing effect. Over the past four decades, the role of R&D in productivity growth has been well recognized as a large number of economic research centers have been developed, showing the importance of public investment in the public politics.

Based on the study of modelling in three countries conducted by Zatonatska, T., Rozhko, O. and Tkachenko, N. [3] it has been determined that the value of e-commerce and R&D expenditures is more significant for GDP per capita growth in Ukraine and Poland, due to the higher level of ICT development in Austria and its approximation to the saturation point relative to the growth rates of innovation industries. Also, expenditures on R&D and e-commerce has a significant impact on the country's economic development and contributes to increasing the volume of the gross domestic product and productivity of manufacture, which will further enhance the research in this direction.

Terzia N. [4] investigated the impact of e-commerce on international trade and employment and showed that Internet will promote international trade much as lifting other trade barriers would. Thus, the volume of international trade will increase via e-

commerce. The countries open to imports from high-income economies will benefit from knowledge spillovers. E-commerce can also have a significant impact on trade in services.

The results of the development of Internet commerce in Ukraine are published in the works of Glinenko, L. and Daynovsky, Y. [5], Marusey, T. [6], Kozlov V. and Tomashevskaya, T. [7] and other Ukrainian scientists. The state of online retail was determined with the widest variety of employees - widespread turnover, the penetration of online commerce, share of online shoppers among other internet users, the average people on people, the commodity structure of purchases and a number of people. At the same time, they used the reports of domestic and foreign researchers who conducted independent studies of electronic markets.

Objective

Conducting a scientific-statistical analysis of the impact of e-commerce on research and development (R&D) and constructing a mathematical model with additional factors to describe the impact.

Results

Data were used from various statistical resources during the period from 2009 to 2018. All calculations were made in the RStudio software environment.

Table 1

Basic data

Year	*GDP per Capita, $*	*R&D, $mln*	*Internet Penetration, %*	*E-sales, $mln*
2009	2546	1041	0.27	139
2010	2974.4	1133	0.29	266
2011	3570.8	1203	0.4	347
2012	3856.8	1320	0.43	477
2013	4030.3	1367	0.49	731
2014	3014.6	860	0.54	877
2015	2115.4	559	0.57	999
2016	2185.9	451	0.62	1298
2017	2640.3	503	0.65	1717
2018	3104	523	0.68	1852

Source: [8-11]

The unit root test is tested to examine whether the variables contain a panel unit root. If the variables contain a unit root, the cointegration test is used to examine whether the long run relationships present between the variables. If the long run relationship is present, the OLS method is tested to find out the relationship between the variables.
The Dickey–Fuller test tests the null hypothesis that a unit root is present in an autoregressive model. The alternative hypothesis in our case is presence of stationarity.

Table 2

Dick-Fuller test

	Level		*First difference*	
Variable	*ADF*	*P-value*	*ADF*	*P-value*
GDPP	0.0212	0.641	-0.3564	0.533
RD	-0.958	0.327	-1.039	0.299
IP	3.628	0.990	1.723	0.976
ES	4.47	0.990	1.38	0.953

Source: compiled by the author based on test results

As we can see from the table above time series are not stationary, because p-value of each variable is greater than 0.1, so we accept the null hypothesis that unit root is present.

The Engle-Granger test can check for multiple linear combinations of time series for forming stationary portfolios. The null hypothesis means that there is no cointegration at all. Alternative hypothesis means that there is a cointegrating relationship between two or possibly more time series.

Table 3

Engle-Granger test (linear trend)

Variables	*Lag*	*EG statistics*	*P-value*
RD~GDPP	2.00	-1.84	0.1
RD~IP	2.00	0.0633	0.1
RD~ES	2.00	-0.806	0.1

Source: compiled by the author based on test results

So, cointegration relationship between variables is present whereas p-values equal to 0.1, so it’s a critical value to reject the null hypotheses.

Since it is necessary to determine the influence of several factors on a dependent variable, the model equation takes the following form:

$$RD_t = \beta_0 + \beta_1 GDPP_t + \beta_2 IP_t + \beta_3 ES_t + \varepsilon_t$$

(1.1)

where β_0 - constant; $\beta_1, \beta_2, \beta_3$ - model parameters; t - time period; $GDPP$ - GDP per capita, in millions dollars; IP - share of the population that using Internet, % from the country population; ES - e-commerce market volume, in millions dollars; ε_t - stochastic fluctuations.

Results of the conducted modelling the following:

Table 4

Regression results

Coefficients	***Estimate***	***Std. Error***	***t-value***	***Pr(>|t|)***
Intercept	2.901e+08	1.430e+08	2.028	0.0889
GDPP	3.365e+05	2.853e+04	11.795	2.24e-05 ***
IP	-2.684e+08	4.059e+08	-0.661	0.5330
ES	-3.124e-01	9.962e-02	-3.135	0.0202 *
Multiple R-squared	*0.9857*			
Adjusted R-squared	*0.9786*			
F-statistic	*138.2 on 3 and 6 DF*			
P-value	*6.315e-06*			

Source: compiled by the author based on modelling results

The final equation is:

$$RD_t = 2.901 \cdot 10^8 + 3.365 \cdot 10^5 GDPP_t - 2.684 \cdot 10^8 IP_t - 0.312 ES_t$$

(1.2)

As we can see in Figure 1, the model is adequate, since the p-value is less than 0.01, it can be argued that it describes the available data qualitatively. The R-squared rate is quite high and indicates a high relationship between the variables. E-commerce market volume has a negative impact on research and development, with a $1 increasing of the first variable in the causing the decreasing of the second one by of $ 0.312. While the overall welfare of the population, expressed as a GDP per capita, it has a slightly larger impact and its increasing by $1 raises R&D expenditures by $33,650. It should be noted that Ukraine has a tendency of reducing the R&D expenditures and for the last 10 years it have decreased almost twice. At the same

time, the e-commerce market, on the contrary, has grown very rapidly and increased more than 10 times, accompanying the growth of internet users. That is why the model describes this inverse relationship by the negative coefficients next to the corresponding variables.

Separately was calculated indicator VIF (variance inflation factor) that is a measure of multicollinearity, which allows to estimate the increase in variance due to the linear dependence of the i-th variable from others.

Table 5

VIF indicator for the first model

	VIF
GDDP	1.134238
IP	10.995043
ES	11.408976

Source: compiled by the author based on modelling results

Since VIF exceeds 10 for two variables, indicating that there are multicollinearity, it will be advisable to remove one and construct another model. The equation for the second model is:

$$RD_t = 2.221 \cdot 10^8 + 3.335 \cdot 10^5 GDPP_t - 0.375 ES_t \quad (1.3)$$

As we can see, the obtained result is slightly different from the initial results, but in general the results of the model remained the same. Multicollinearity indicators for the selected variables do not exceed 1.2 which indicates its absence.

Conclusion

This study investigated the impact of the e-commerce, GDP per capita, Internet penetration on R&D expenditures in Ukraine. The regression model with was used to investigate the period of 2009-2018. Since, autocorrelation was detected in the first model, it was eliminated in the next one, though, results remain the same. The results showed that the several variables played a significant role in R&D expenditures. It was revealed that GDP per capita had a positive impact based on the model coefficient; also, e-commerce volume had a negative impact on R&D, because of decreasing tendency of the last one.

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