The E-Government's Influence on the Country's Economy (At the Example of Ukraine and Estonia)

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ABSTRACT

Computer technology plays a very important role for the development of institutions of modern society. The study is dedicated to finding the best way to measure the impact of electronic control on macroeconomic indicators. The methodology used is similar to the methodology for constructing the Cobb-Douglas function, as well as the Solow model (Solow-Swan), which is an exogenous model of economic growth. The proof of the hypothesis that e-government has a direct and / or indirect effect on the economy is based on group regression analysis. To do this, a model was developed and tested using the e-government development index (EGDI) and e-participation index (EPI). The results were verified using the model data panel.
Keywords: e-government, E-Government Development Index (EGDI), Gross Domestic Product (GDP), Cobb-Douglas model, panel data analysis

1. INTRODUCTION

The e-government is an important tool for the country's development, as well as a prerequisite for creating an efficient digital economy in Ukraine and further integrating it with the European Digital Single Market Strategy for the EU. However, implementing and and developing the e-government / e-democracy in any country is a complex, multifarious, costly, multi-faceted process, and therefore quite risky with regard to its defined terms and resources.

The specific steps with the goal to implement the e-government, and to increase the use of computer technology in various spheres in Ukraine have been taken since the 1990s, when a number of important regulatory documents that were adopted to develop the e-government. Of course, the information and communication technologies development provides opportunities for the e-government's introduction and creation, but the country has not yet overcome all the difficulties that have arisen during the old system formation. Given this, it is important to research and use the international experience of the leading countries.

For Ukraine, the most striking example of the e-government's introduction is Estonia, which holds the leading position among the world leaders in the introduction of the latest technologies in government. In addition, the system of electronic interaction of the state electronic information resources of Trembita is being introduced in Ukraine today, its basis is the improved Estonian X-ROAD data exchange platform, which is the foundation of the Estonian digital society. That is why in the development of the e-government system in Ukraine and in the formation of the further directions of its development, the study of the Estonian experience, as well as the comparative analysis of the impact of e-government on the economy of the countries and determining the effect of its implementation, become especially relevant.

In the academic literature, the topic of e-government is considered mainly in terms of the study of theoretical and methodological foundations, administrative and legal aspects of the implementation and development of e-government. In particular, this topic was covered in the works of I. Pogrebnyak [1], V. Eganov [2], I. Kolisnichenko [3], T. Kaganovska [4] - from the administrative and legal point of view; in the works of V. Myshchyshyn and P. Zhenzhych [5], A. Semenchenko [6], O. Golobutsky [7] - mainly from a systemic point of view. The problems of e-government in the sphere of state digitization were most completely revealed in the works of I. Dulska [8-10]. Her research covers the various aspects of implementation and the subsequent impact of e-government and innovation processes on the economy. The original analysis was done by C. Stanforth, who used Actor Network Theory, a socio-constructivist model, which basic principle is the concept of a heterogeneous network, where the latter is an actor of interactions. That is, an actor is a network that is quite dynamic. Any subject is considered as a network effect. It can be a person, a thing, an instrument, or an entire technological system or a legal entity. Each subject is connected to the system of relations with the environment and stays with them only if the integrity of these relations is preserved. Thus, the specificity of the model is that any subject is considered both as an element and as a component of the network of relations, and the disappearance or elimination of any actor disrupts the operation of the entire network, and the order in it [11]. This is a very useful method of research from a descriptive point of view, since the implementation of e-government is a complex process, both technically and

socially. However, despite the novelty and analytical ability of the method, it is difficult to use it in Ukrainian realities due to lack of data.

It is also worth to mention the works of foreign scientists who have studied the experience of Estonia, in particular: the scientific works of T. Kalvet [12], M. Ernsdorff and A. Berbec [13], which are identical by their contents. They describe the successful experience of implementing e-government in Estonia. The approach to the analysis of the experience of implementing the e-government system, which was proposed by M. Kitsing [14], and in which, this phenomenon was analyzed using the analysis of a number of social and geopolitical factors, differs most from the above studies.

Despite the considerable amount of research on this topic, only some of them are based on the analysis of the impact of digitalization processes on economic indicators, such as the scientific works of R. Katz, P. Koutroumpis and F. Martin Callorda [15]. For the study, the authors selected a digitization index as a synthetic indicator that could be used for competitive analysis. Based on the research, it has been found that since digitization also includes social transformation caused by the mass adoption of digital technologies that generate, process and transmit information, respectively, improving the economic activity and increasing the well-being of the population increase the value of the index. At the same time, the growth of profits and the improvement of ICT are the result of this change. Therefore, in order to quantify that, the authors have developed an indicator of ICT infrastructure that could be used for benchmarking. In addition, researchers have tried to identify conditions that affect the outcomes of e-government implementation in developing countries.

2. BACKGROUND

The purpose of this study is to build a model that allows to analyze of the impact of e-government on economic performance. The scientific novelty is in using the econometric approach to determine the connection between e-government and economic development, since previous studies have not paid enough attention to this aspect.

The e-government is a model of state governance through local information systems and segments of the global information network to enhance government efficiency and transparency, as well as to provide services to citizens and improve the democratic process through the use of new information and communication technologies [16]. It should be emphasized that e-government is not a mechanical combination of information and communication technologies with public administration, but is a completely new technology of public administration. This technology is provided by integrating the information resources and systems of the authorities into a single information space in order to establish a transparent and effective interaction of all subjects of the process: the state, business and citizens.

The methodology of e-government research involves the use of different approaches. For example, the United Nations systematically analyzes the effectiveness of e-government and identifies trends in e-government in the world. At the same time, 2 key indicators are used to assess the level of development: the E-Government Development Index (EGDI) and the Electronic Participation Index (EPI).

E-Government Development Index is defined as the arithmetic mean of the following 3 sub-indices (OSI, TII, HCI) [17]:

1. Online Service Index is formed of the following components:
- Emerging formation services;
- Enhanced information services;
- Transactional services;
- Connected services.

2. Telecommunication Infrastructure Index is formed of the components:
- Fixed (wired) - broad band subscriptions;
- Individuals using the Internet;
- Mobile-cellular subscriptions;
- Fixed-telephone subscriptions;
- Wireless broadband subscriptions.

3. The Human Capital Index is formed of the following components:
- Adult Literacy;
- Gross Enrolment Ratio;
- Expected Years of Schooling;
- Mean Years of Schooling.

Mathematically, therefore, EDGI is a weighted average of three normalized indices on the most important aspects of e-government, namely the broadness and quality of online services, telecommunications and human capital. At the same time, each of these sub-indices is in itself a component indicator that can be analyzed independently.

E-Participation Index (EPI) - demonstrates the effectiveness and usefulness of e-government services in involving citizens in decision-making. This index is based on three parameters:

1. E-information, which reflects the completeness of providing by government websites information on political and economic programs (budget, laws, regulations and other documents of interest to citizens).

2. E-Consultation, which shows how fully government consultation tools are available on government websites. Typically, it is possible to select an online live discussion or access to archival materials (audio or video of meetings on a particular issue). At the same time, citizens are given the opportunity to participate or comment on these meetings.

3. E-decision-making, which determines the extent to which the government provides citizens with access to decision-making and the use of a mechanism for influencing decision-making.

The above indices give an opportunity to analyze the effectiveness of e-government, to make comparative analysis by country and dynamics, but do not reflect the impact of e-government on the economy. However, the EGDI can be used in an econometric model that will

analyze the impact of e-government on economic performance, especially on GDP.

For this purpose, a panel regression equation will be developed, a regression analysis will be performed, and the results obtained will be verified using a panel data model.

Panel data analysis is a statistical method widely used in social science, epidemiology and econometrics to analyze two-dimensional panel data. Multidimensional analysis is an econometric method, in which data is collected in more than two dimensions (usually time, subjects, and third dimension).

Today, panel data is increasingly used in econometric analysis tasks: a panel-based model allows studying a sample of units over time, identify and consider the features of each sample unit.

Panel data analysis has three independent approaches: independently integrated panels; random effects models; fixed effects or first-difference models.

The choice between these methods depends on the purpose of the analysis and the problems concerning the exogeneity of the explanatory variables.

In statistics, a fixed effects model is a model in which the model parameters are fixed or non-random variables. This is why it differs from random effects models and mixed models, in which all or some of the model parameters are considered as random variables. In many applications, including econometrics and biostatistics, the fixed effects model refers to a regression model, in which group parameters are fixed (non-random) as opposed to a random effects model where group parameters are a random sample of the population. Typically, the data can be grouped by several observable factors. Group parameters can be modeled as fixed or random effects for each group. In the fixed effects model, each group represents the mean for the group.

In panel data where there are prolonged observations of the same subject, fixed effects represent subject-specific means. In panel data analysis, the term "fixed effects estimator" (also known as "bounded estimator") is used to refer to the coefficient estimator in a regression model, including such fixed effects.

Such models help to control omitted displacement variables due to unconstrained heterogeneity when this heterogeneity is constant over time. This heterogeneity can be removed from the data by identifying it, for example by subtracting the group-level average over time, or by taking the first difference that removes any invariant components of the model.

There are two general assumptions of individual-specific effects: assumptions of random effects and assumptions about fixed effects. The assumption of random effects is that the individual-specific effects do not correlate with the independent variables. The assumption of a fixed effect is that the individual-specific effects are correlated with the independent variables. If the assumption of random effects is true, the estimation of random effects is more effective than the estimation of fixed effects. However, if this assumption is not met, the random-effects estimate is not consistent. The Durbin-Wu-Hausman test is often used to distinguish between fixed and random effects models.

In econometrics, this test is used to compare models evaluated by different methods, one of which allows obtaining capable estimates for both the null and alternative hypotheses, and the other - only for the null hypothesis. In particular, the test compares the estimates of the least squares method and the instrumental variables method. The null hypothesis is that the model factors are exogenous and the alternative hypothesis is that they are endogenous. In both cases, the instrumental variable method provides relevant estimates (instruments are by definition exogenous). And the least-squares method only provides relevant estimates for exogenous factors. Thus, if the null hypothesis is fulfilled, then the estimates of the different methods are asymptotically equivalents, otherwise the differences between them will be significant. Thus, the test allows evaluating the exogeneity of the model factors.

A model like Cobb-Douglas will be used to build the model, and it will reflect the relationship between the indicators, and we will also rely on the Solow model (Solow-Swan), which is an exogenous model of growth.

In the theory of neoclassical growth, the Solow model provided the necessary mathematical basis for analyzing the rate of capital change. Despite significant disadvantages and doubts about the correspondence of the model to empirical data, a series of more complex models were subsequently created on the basis of this model. Due to its particularly attractive mathematical properties and mathematical simplicity, the Solow model has proven to be an appropriate starting point for further modifications. That is why it was advisable to take this model as a basis. The model, as noted, is based on the aggregate neoclassical production function, but it is modified by taking into account the factor of technical progress, and in fact, it is an interpretation of the classic Cobb-Douglas production function. In the light of technological advances, growth is ultimately related to the accumulation of capital or the accumulation of knowledge, which can also be referred to as innovation (for example, the development of digitization). Endogenous growth models that include capital, as well as innovations, have come to the same conclusion. In these models, the stimulus for innovation determines the speed of technological progress, which in turn determines the long-term growth rate of the economy, regardless of the amount of capital in the economy. However, since we are unable to evaluate the consequences of higher-level processes in the model, we prefer to use RE (random effects) only if the condition is fulfilled. In this case, the Durbin-Wu-Hausman test can be used to verify the RE model. The idea of the test is to compare the FE (fixed effects) model estimates with the Wald test, which works by finding the difference between the coefficients vector of each model. When comparing the FD (first difference) model panel for first type difference analysis) and FE estimation, we must consider a consistent correlation in idiosyncratic errors (uit), which is the correlation between the error term and its lagged version over different periods. When we do not have a consistent

ratio in uit, it is better to use FE rather than FD since the standard errors reported by FE are valid. If there is a consistent correlation that follows a random step, it is better to use FD since Δu_it is serially uncorrelated. If we have a negative consistent correlation in _u_it, FE is better. If we have a positive serial correlation in uit but it does not result from random fluctuation, it is very difficult to compare the performance of FE and FD estimates. Therefore, we thought it was better to include the results of both tests in our model. There are several tests to check for consistent correlations, such as the sample t-test, the Durbin-Watson test, and the Breusch-Godfrey serial correlation LM-test. This method was tested when constructing a model to investigate the effect of digitization on economic performance [18], so we also used the Durbin-Watson test. Based this theoretical basis, the modified formula of economic growth (1) and interpretation of the formula (Table 1) were constructed. The panel regression equation for this case is as follows:

$$log(GDP) \sim log(EGDI) + log(LF) + log(K) + factor(TIME) + \varepsilon \quad (1)$$

Table 1. Interpretation of formula and source

Indicator	Interpretation	Source:
GDP (PPP)	Gross Domestic Product (Purchasing power parity)	World Bank https://data.worldbank.org/
LF	Total workforce	
K	Gross fixed capital	
EGDI	E-Government Development Index	https://www.statista.com
TIME	The time factor that marks autoregressive processes or logs	-
ε	Error	-

Table 2. Indicators for regression calculations

LOCATION	TIME	EGDI	GDP	LF	K
Ukraine	2009	0.5181	334688483323.80	21737545.00	23248408460.83
Ukraine	2010	0.5181	351571236296.31	21666236.00	28390543878.22
Ukraine	2011	0.5417	378531847053.31	21621329.00	36608012450.42
Ukraine	2012	0.5653	386712328550.02	21394384.00	38171818295.58
Ukraine	2013	0.53425	393393623253.84	21540098.00	33891530088.83
Ukraine	2014	0.5032	374570934204.39	20895181.00	17884778786.37
Ukraine	2015	0.5554	341578206530.78	20885174.00	14504250458.92
Ukraine	2016	0.6076	353742534230.78	20684320.00	20280807630.14
Ukraine	2017	0.61205	369355686787.08	20505794.00	22378574705.04
Ukraine	2018	0.6165	390972933044.29	20275456.00	24556644179.33
Estonia	2009	0.5181	27488251188.56	690493.00	4124860100.03
Estonia	2010	0.6857	29021641432.58	683966.00	4234913949.92
Estonia	2011	0.7422	32895237685.69	687779.00	5953104920.71
Estonia	2012	0.7987	34642139626.11	684647.00	6759165680.47
Estonia	2013	0.80835	36432844586.01	680849.00	6828974171.68
Estonia	2014	0.818	38300194537.76	676013.00	7207890610.46
Estonia	2015	0.8257	38669190378.02	686173.00	5720610030.44
Estonia	2016	0.8334	40675286169.91	694637.00	6086025453.98
Estonia	2017	0.841	44363509176.54	702172.00	7120287088.73
Estonia	2018	0.8486	47517185746.22	700051.00	8057376431.87

Table 3. Results of the panel data model

Dependent variable:	log (GDP)				
log (EGDI)	0.201*	(0.093)			
log (EGDI)	3.212*	(0.429)			
log(K)	0.123**	(0.043)			
TIME2010	0.030	(0.024)			
TIME2011	0.075**	(0.028)			
TIME2012	0.114**	(0.032)			
TIME2013	0.157***	(0.030)			
TIME2014	0.259***	(0.029)			
TIME2015	0.210***	(0.032)			
TIME2016	0.215***	(0.034)			
TIME2017	0.259***	(0.034)			
TIME2018	0.330***	(0.036)			
Observations	20	**R2**	0.991	**Adjusted R2**	0.973
F Statistic	57.421***	(df = 12; 6)			
Note:	*p<0.1	**p<0.05	***p<0.01		

The model accounts for about 97% of the effects on the normalized coefficient determination. The indicator is fairly statistically (p <0.1) and economically (0.2) significant. Thus, if the e-government index rises by 1%, the GDP rises by 0.2%.

Although Ukraine's total GDP is larger than in Estonia, GDP growth and EGDI growth rates are much higher than in Estonia.
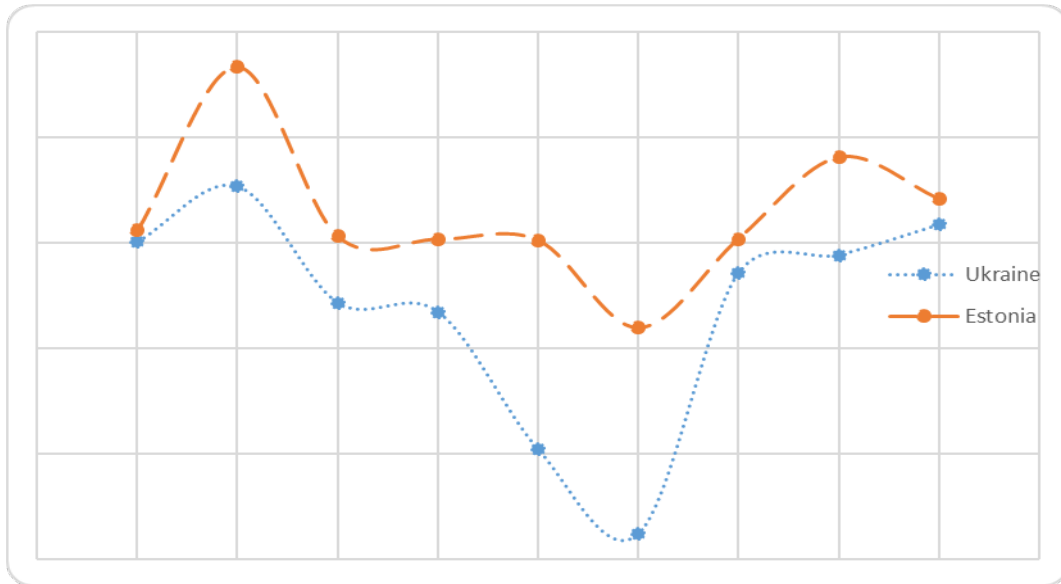

Figure 1 Ukraine's GDP index and Estonia's GDP (in 2008-2018)

It is necessary to note that, unlike in Ukraine's GDP, Estonia's GDP has been growing at a rapid rate since the 2008 crisis and did not drop significantly in 2015.
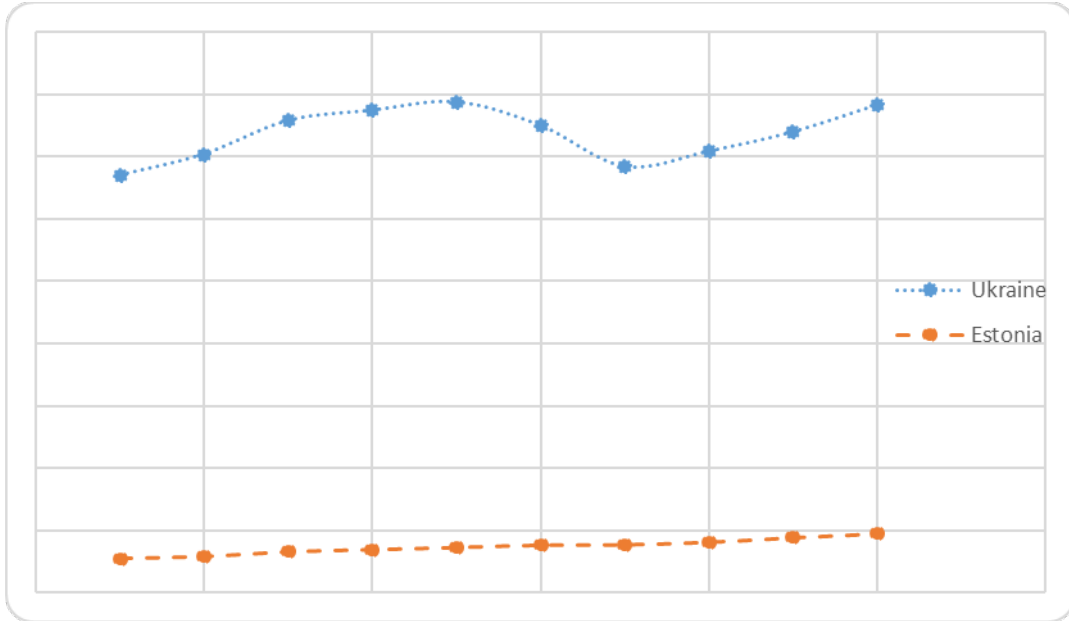
Figure 2 GDP index change from 2008 to 2018 in Ukraine and Estonia
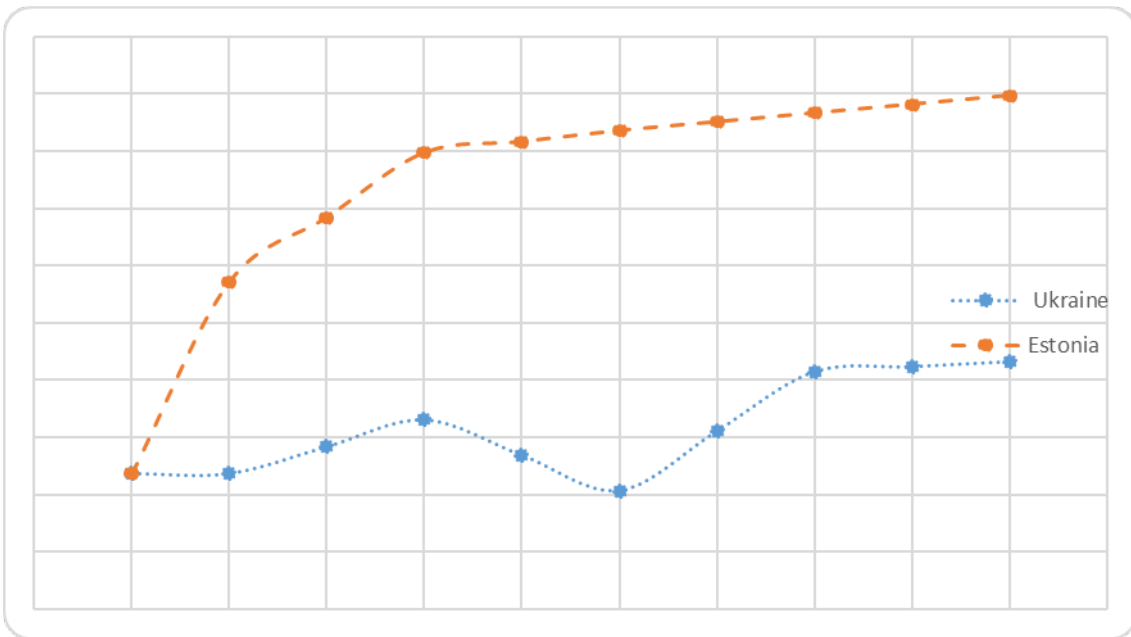

Figure 3 EGDI index change from 2008 to 2018 in Ukraine and Estonia

Using the calculations we can determine an alternate GDP in Ukraine on a logarithmic scale. If we take Estonia's EGDI value (if other parameters preserved), we obtain a possible value (Fig. 4.), which is approximately twice as big as the real value; this is reflecting the e-government's impact on the economy, and thus proves how e-government implementing in Ukraine is important.
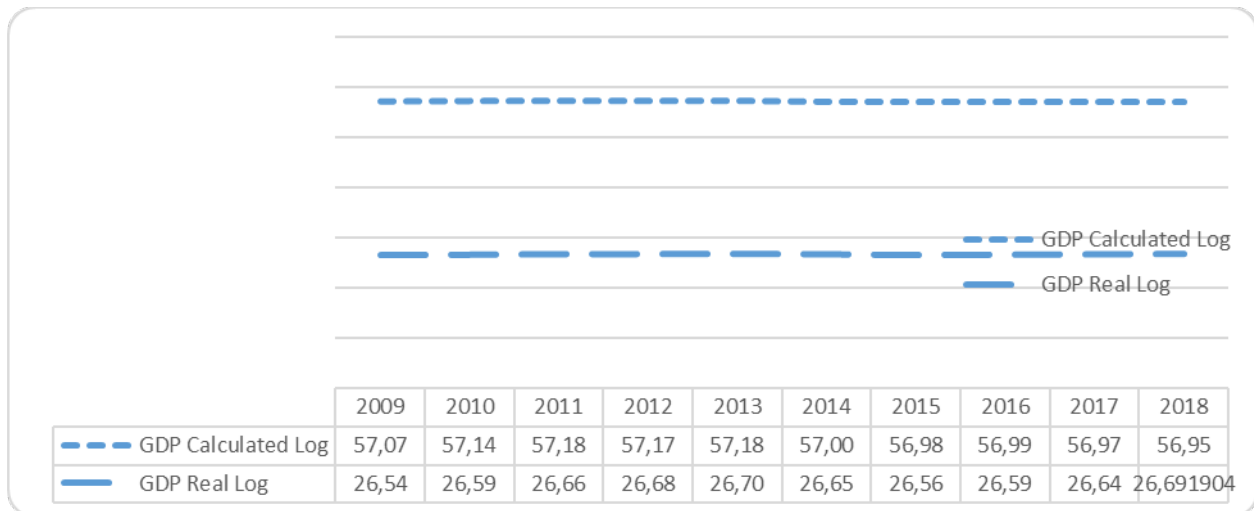
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GDP Calculated Log	57,07	57,14	57,18	57,17	57,18	57,00	56,98	56,99	56,97	56,95
GDP Real Log	26,54	26,59	26,66	26,68	26,70	26,65	26,56	26,59	26,64	26,691904

Figure 4 Logarithmic indicators of GDP of Ukraine

The Estonian economy's growth rates are much higher than the Ukrainian ones that is quite evident to illustrate the main benefits of e-government. Basing on the data resulting from the performed calculations we can determine the problem relevant to slow growth of the Ukrainian economy (among other reasons), namely, the lower level of e-government, and therefore, the e-government's impact on the economy development quantitatively proved.

3. CONCLUSION

The study's main purpose was to find a way to measure the e-governance impact on economic performance, especially on GDP. For this purpose, a model was developed and tested in which, due to the lack of necessary data, using the EGDI index was expedient. As the identification and quantification of e-governance performance is still insufficient to understand the whole process, the results obtained were verified using a panel data model. Assuming that e-government has a direct and/or indirect impact on the economy, the panel regression analysis that uses GDP index as a dependent variable provided an intuitive idea that the index developed has a potential impact on economic processes. Given that during the study a simple economic growth model was used for testing, there is an obvious opportunity for further research. However, we can already conclude that the e-government's impact can drive innovation or even be a major component in understanding how the economy is transformed due to the technology.

Given the nature of the problem such as lack of quality data, parameter calculations variety, and too heterogeneous indicators, it was difficult to choose the right analytical approach. However, the main objective of the study was achieved: there was made the analysis of the e-governance impact on the example of two countries (Ukraine and Estonia) with different ICT infrastructure; basing on econometrical data there was shown some link between the e-government and GDP, which supports the thesis about importance of the e-government's implementation and development.

The prospect of further research is promising in the condition if the new data is available, and if the capacity for their processing is sufficient. In such circumstances, we are capable to make more accurate analysis of the impacts of e-government and privatization processes on the economy. Given the lack of data on Ukraine for further research, it is recommended to collect the statistical information more frequently and to a greater extent, also to increase its structuring level and ensure its accessibility. In any case, this topic requires more attention in terms of quantitative research: it is quantitative analysis that facilitates us to formulate more clear recommendations on the future directions and pace of e-government's development in Ukraine, and to determine its impact on the economic development.

REFERENCES

[1] I. Pogrebnyak, E-Government and e-Governance: Concepts and Principles of Functioning, in Law and Innovation, vol. 3, 2014, pp. 26-35, Access mode: http://nbuv.gov.ua/UJRN/apir_2014_3_5.

[2] V. Eganov, Problems and prospects of implementation of e-government system in Ukraine, State building, vol. 2, 2012, pp. 1–10.

[3] I. Kolesnichenko, Development of e-Governance in Ukraine: Institutional Aspect, Business Inform, vol.3,

2014, pp. 52–57, Access mode:
http://nbuv.gov.ua/UJRN/binf_2014_3_9.

[4] T. Kaganovska, Electronic Governance as a Form of Public Administration in Ukraine, Forum right, vol. 2, 2014, pp. 176–182.

[5] V. Mishchishin, P.I. Zhezhnich, Analysis of features of building e-government systems in Ukraine, Bulletin of the National university "Lviv Polytechnic", vol. 699, Information systems and networks, 2011, pp. 164–175.

[6] A. Semenchenko, Organizational and legal mechanisms of public administration in the development of e-government in Ukraine: comparative analysis and scientific and methodological approaches to improvement, Bulletin of the National Academy of Public Administration under the President of Ukraine, vol. 1, 2013, pp. 55–74, Access mode:
http://nbuv.gov.ua/UJRN/Vnadu_2013_1_9.

[7] O. Golubotsky, The concept of e-government and modern needs of Ukraine, vol. 5, 2015, pp. 75-86.

[8] I. Dulska, Digital technologies as a catalyst for economic growth, Economics and Forecasting, vol. 2, 2015, pp.119-133, Access mode:
http://nbuv.gov.ua/UJRN/econprog_2015_2_11.

[9] I. Dulskaya, Priorities of nationalization of national economy, Modern problems of economy and entrepreneurship, vol.16, 2015, pp. 34-40.

[10] I. Dulska, Electronic governance as a tool of social engineering of society in Ukraine, Ukrainian society, vol.1, 2019, pp. 89-104.

[11] C. Stanforth, Using actor-network theory to analyze e-government implementation in developing countries, Information Technologies & International Development, vol. 3(3), 2006, pp-35.

[12] T. Kalvet, Innovation: a factor explaining e-government success in Estonia, Electronic Government, an International Journal, vol. 9 (2), 2012, pp. 142-157.

[13] Marc Ernsdorff and Adriana Berbec, Estonia: The short road to e-government and e-democracy, E-government in Europe, Routledge, 2006, pp. 199-211.

[14] M. Kitsing, Success Without Strategy: E-Government Development in Estonia, Policy & Internet, vol. 3 (1), 2011, pp. 1-21.

[15] R. Katz, P. Koutroumpis & F. Martin Callorda, Using a digitization index to measure the economic and social impact of digital agendas, info, vol. 16 (1), 2014, pp. 32-44.

[16] E-government: analys framework and methodology, Public Management Service, Public Management Committee, PUMA, vol.16, 2001, ANN/REV1.

[17] United Nations. E-Government Survey 2018, Gearing E-Government to Support Transformation towards sustainable and resilient, URL:
https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf

[18] Elvin Mammadli, Vsevolod Klivak, Measuring the effect of the digitalization, University of Tartu, Faculty of Economics and Business Administration, Working Paper Series, ISSN-L 1406-5967 / ISSN 1736-8995 https://majandus.ut.ee/sites/default/files/mtk/dokumendid/febawb119.pdf

[19] Bazenko, O. and Ruchynska, N. Implementation of E-government in Ukraine. Modern Economics, vol. 17(1), 2019, pp.15-19. DOI:
https://doi.org/10.31521/modecon.V17(2019)-03

[20] A. Budiati, "E-Government And E-Governance: Can Its Improve Indonesian Public Service Deliveries?", Iapa Proceedings Conference, p. 392, 2019. Available: 10.30589/proceedings.2018.212 [Accessed 8 February 2020]. DOI:
https://doi.org/10.30589/proceedings.2018.212

[21] Y. Cheong and S. Choi, "The Effect of E-government on Digital Divide", Journal of Korea Technology Innovation Society, vol. 22, no. 5, pp. 942-961, 2019. Available:
https://doi.org/10.35978/jktis.2019.10.22.5.942 [Accessed 8 February 2020]. DOI:
https://doi.org/10.35978/jktis.2019.10.22.5.942

[22] J. N.A., "Collaboration Competency and E-governance Performance", International Journal of Electronic Governance, vol. 12, no. 3, p. 1, 2020. Available: 10.1504/ijeg.2020.10026160 [Accessed 8 February 2020]. DOI:
https://doi.org/10.1504/IJEG.2020.10026160