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ASSESSMENT OF TRANSMISSION EFFECTS BETWEEN "CORRUPTION-DIGITIZATION-ECONOMIC GROWTH"

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ABSTRACT

The last decade has seen the rapid development of digital information technology, the intellectualization of control systems, the increase in the number and capacity of mobile and computer devices, and the accumulation of large amounts of data and its processing through machine learning algorithms, which inevitably leads to new opportunities for economic development. Rapid digitalization and its penetration into various spheres of public life contributed to increasing the level of transparency of public administration, strengthening public control, and reducing the bureaucratization of society. Hence, digital technologies can serve as tools to fight corruption and create conditions for intensive economic growth. Therefore, the topic based on the study of transmission effects in the chain "corruption-digitization-economic growth" is relevant. The work aims to develop methodological tools for assessing the transmission effects between digitalization, corruption level decrease, and economic growth. The following methods were used for the study: Levin-Lin-Chu, Hadri, Pesaran, and Chin tests, Dickey-Fuller tests - to check stationary variables; statistical criterion Kao - to check the existence of cointegration relationship between variables; modified least-squares method - to estimate regression coefficients based on panel data; coefficient of determination and Jarque-Bera test – to verify the adequacy of the econometric model. An empirical study confirmed the hypothesis of the presence of transmission effects between indicators that characterize the level of corruption in the economy, digitalization, and economic growth. It has been proven that the reduction of corruption and the growth of digitalization in studied countries contributes to economic growth.

Keywords: digitalization, corruption, economic growth, panel regression model

JEL Classification: D73, O32, C23, F43

INTRODUCTION

The last decade has seen the rapid development of digital information technology, the intellectualization of control systems, the increase in the number and capacity of mobile and computer devices, and the accumulation of large data sets and their processing by machine learning algorithms. Digitalization has led to improved performance in various areas. For example, the level of transparency of public administration increased, public control strengthened, and bureaucratization was reduced. Therefore, digital technologies and artificial intelligence algorithms can serve as tools to combat corruption and business misconduct by expanding access to public information, monitoring the activities of public administration and local government, digitizing administrative services, and providing opportunities to report corruption. The United Nations estimates that about 1 trillion USA dollars are paid annually as bribes, and $ 2.6 trillion is stolen because of worldwide corruption [26].

LITERATURE REVIEW

The study of corruption as a national phenomenon is carried out in legal, political, social, and economic aspects, which indicates its comprehensive nature of the impact on various spheres of society.

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Anti-corruption measures must be systemic, must aim at improving the effectiveness of anti-corruption activities, and involve state, public, political, professional, and other organizations in this process. Over the past five years, the number of publications in the Scopus scientometric database on this issue has almost doubled. In 2021, 279 publications were published, while in 2017 - 198 publications, which indicates the relevance of the chosen field of study worldwide. Half of the scientific work on the impact of digitalization on the fight against corruption belongs to scientists from four countries (USA, China, India, and the UK).

Many publications are devoted to the evolution of corruption, its features, external and internal determinants of its spread, and mechanisms for its prevention in the national economy [20, 28]. For instance, the incidence of bribes in customs/imports, courts, and taxes/tax collection were examined in the paper [7] The paper [27] substantiates the destructive impact of corruption on the pace of economic development and business activity of economic entities. Milova et al. analyzed the long-term cause-and-effect relationships between corruption and the country's brand using the Augmented Dicker-Fuller test and the granger casualty test [11].

The authors of the paper empirically have confirmed that corruption tends to increase with low levels of state regulations [12]. Nguedie has empirically improved that sensitivity of growth to investment is higher in countries with a low degree of corruption [13].

Systematization of scientific literature suggests that the main causes of corruption are a lack of strict social and legal control over the activity of authorities, imperfect legal systems, low wages, and social services in the civil service, as well as low tolerance of society to corruption. According to V. Terziev, M. Nichev, S. Bankov [22] the main reason for corruption existence: the weakness of moral and ethical principles, where legislation and legal prohibitions are not a sufficient obstacle to obtaining illegal income in the form of bribes or gifts; low professional qualification of business entities and civil society; lack of effective control over the activities of civil servants by the public and the media; bureaucracy and excessive power of individuals; failure to strike a balance between law, morality, and justice.

One of the key factors which systemically impact the economic and social sphere is digitalization [8, 14, 19]. There are a lot of practical cases where using AI, Big Data, blockchain technologies, and the Internet of Things have improved the efficiency of health funding [9, 18].

Brazil has developed a software product based on machine learning, which allows assessing the risk of corrupt behavior among civil servants based on data on criminal records, education, political affiliation, and business relationships [25].

IBM specialists with the Government of Kenya cooperated to optimize the administrative procedures required to start a business (from 11 to 3 steps). The usage of artificial intelligence has allowed Kenya to rise from 92 to 61 place in the ranking of "Ease of doing business" [5].

In Britain, the tax authorities have used computer technology for digital transformation and data collection to reduce the tax gap. As a result, the Connect system analyzes taxpayers' data to identify potential tax evaders. The algorithm identifies people who are most likely to commit tax fraud and helps to develop precautionary measures. From 2008 to 2014, thanks to the system, an additional 3 billion pounds of tax revenue were received [15].

Ukrainian Transparency International office empirically proved that the interdependence between corruption and economic growth is strong for a group of countries as the former Soviet Union countries, Latin American and African regions [16]. In addition, it has been established that reducing the level of corruption stimulates the inflow of foreign investment into the country [6].

Despite the large scientific achievements and interest of both domestic and international organizations in this issue, the impact of modern innovations in the development of digital technologies on the prevention and identification of signs of corruption in public administration remains insufficiently studied.

AIMS

The article aims to develop methodological tools for assessing the transmission effects between digitalization, corruption reduction, and economic growth.

METHODOLOGY

An econometric model based on balanced panel data was chosen to assess the link between economic growth, corruption, and digitalization. Panel data combines the benefits of spatial data and time series, allowing you to analyze and isolate changes at the individual level of each object. Panel data provide more informative data, greater variability, less collinearity, more degrees of freedom, and greater efficiency. Because panel data usually describe the results of individuals, firms, states, and countries over a while, there is heterogeneity in these units. Panel data evaluation methods can take into account such heterogeneity, taking into account subject-specific variables [1, 21].

In this paper, we described the analysis of the presence of transmission effects between digitalization, corruption level, and economic growth. In addition, we analyzed the relationship between the studied processes in the example of two groups of countries: high and middle income. The paper proposes a scientific and methodological approach to assessing the relationship between corruption, digitalization, and economic growth of the country, which involves the gradual implementation of the following steps:

- the formation of panel data to characterize digitalization, corruption, and economic development of the country;
- checking variables for multicollinearity;
- verification of stationary data using Levin-Lin-Chu, Hadri, Pesaran, and Chin, Dickey-Fuller tests;
- determination of the presence of integration between the studied variables based on the Kao`s cointegration test;
- estimation of parameters according to the econometric model using the modified least-squares method;
- verification of the adequacy of the constructed model (coefficient of determination and Jarque-Bera test);
- conducting economic interpretation of the results obtained by the model.

Economic growth is one of the most important indicators of an effective economic system, which contributes to the creation of conditions for increasing national wealth, stable functioning of the financial sector, and improving overall living standards and welfare.

Corruption is one of the key factors that have a destructive effect on the pace of economic development, and business activity. It also leads to the growth of the shadow sector of the economy. Corruption Perceptions Index (CPI) was used to conduct a comparative analysis of different countries in the world on the level of corruption risk. In 2012, Transparency International changed the methodology for calculating the corruption perception index in Estonia, Latvia, and Croatia in the context of two periods: 1999-2011 (scale from 0 to 10) and 2012-2020 (scale from 0 to 100) (fig. 1).

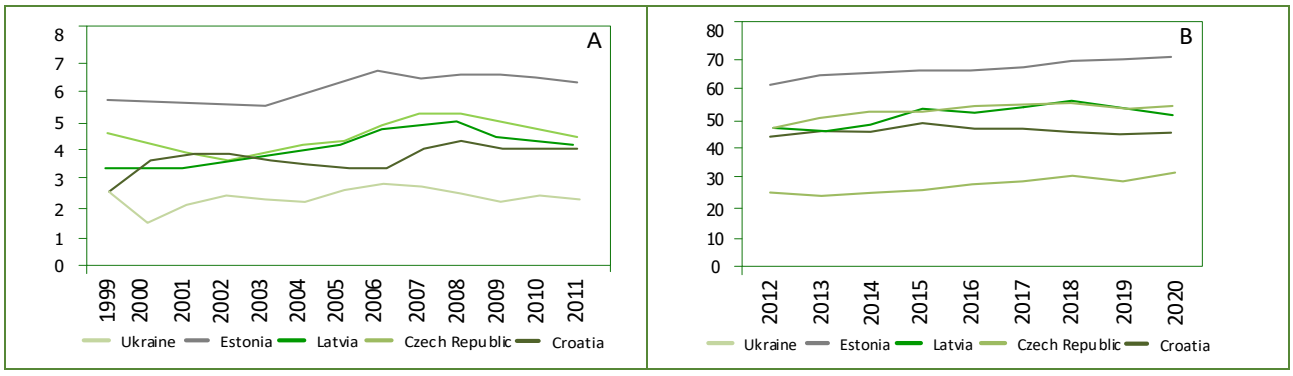

Figure 1. Dynamics of the Corruption Perceptions Index for Some European Countries, units. Notes: "A" – 1999-2011, "B" – 2012-2020. (*Source: Transparency International [24]*)

Thus, according to the chart in Figure 1A, the corruption perception index for the analyzed countries is growing from 2003 to 2006, which indicates a decrease in corruption. However, during the global financial and economic crisis (2008-2009), there was a sharp decline in the value of the Corruption Perceptions Index, which indicates an increase in corruption. Figure 1B, for the Czech Republic, Ukraine, and Estonia, data generally shows a declining trend in corruption due to an increase in the CPI. The value of the Corruption Perceptions Index in Latvia has been declining since 2018.

Along with the study of corruption in the country, we analyze one of the key indicators of economic development – GDP per capita in terms of the above analyzed European countries (Ukraine, Czech Republic, Estonia, Latvia, Croatia) (fig. 2).

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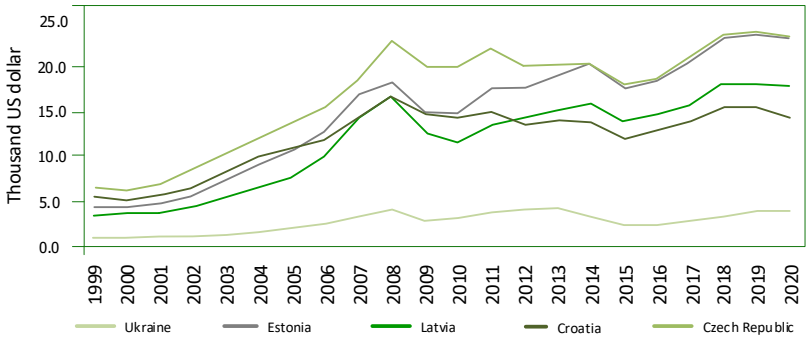

Figure 2. Dynamics of GDP per capita for some European countries from 1999 to 2020, thousand US dollars. *(Source: World Bank data [30])*

Figure 2 shows a graph of changes in GDP per capita (thousands of US dollars) for the five countries analyzed above (Ukraine, the Czech Republic, Estonia, Latvia, and Croatia). Thus, we see that in the period 2008-2009, the volume of GDP per capita decreased significantly for all five countries analyzed. Note that in the same period, according to Figure 1.1 A, the level of corruption increased. For example, in Latvia and Croatia, since 2018, GDP per capita has been declining, while compared to the graph in Figure 1B, the value of the corruption perception index remains stable or decreases, which may indicate an increase in corruption. Yes, there is an indirect link between the indicator of economic development - GDP per capita and the index of perception of corruption. This hypothesis needs further analysis to be confirmed.

It is worth noting that corruption schemes are cross-sectoral in nature and permeate various economic activities in the country. Figure 3 shows the main consequences of corruption on the country's economic system.

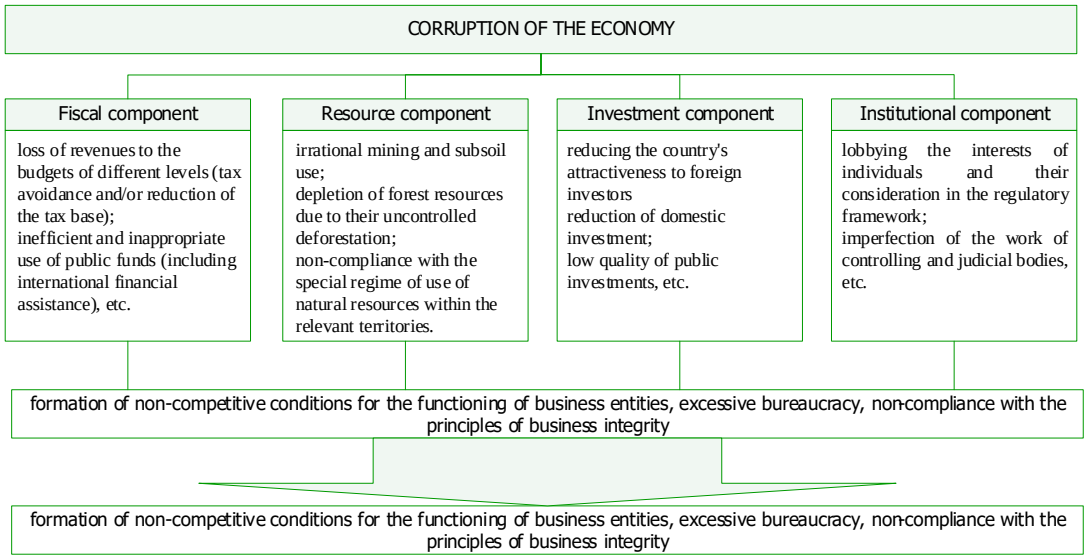

Figure 3. The main manifestations of corruption and their impact on the country's economy.

Artificial intelligence technologies, machine learning, and big data analysis are increasingly used to improve anti-corruption systems globally. Establishing international standards and cooperation at the international level allows forming a basis for reducing the manifestations of business misconduct in the global dimension. Innovative methods and algorithms for processing big data allow identifying anomalies, establishing patterns of informal relationships, as well as minimizing the role of change to humans in the system of decision support for corruption.

A panel regression model was used to estimate the transmission effects in the corruption-digitalization-economic growth chain. The Corruption Perceptions Index (CPI) was chosen to represent the level of corruption. The following indicators characterize digitalization: secure Internet servers (SIS), fixed broadband subscription (FBS), and individuals using the Internet (IU). We propose to characterize the level of economic development with the use of indicators: GDP per capita (GDP), general government final consumption (GCE), gross capital formation (GCF), and foreign direct investments (FDI).

The object of the study selected two groups of countries depending on their gross domestic income per capita according to the World Bank classification:

- high-income countries (Finland, Sweden, Norway, Germany, Great Britain, Estonia, Austria, Chile, Japan, Denmark, Ireland, the Netherlands, Canada, Australia, Singapore, Croatia, Spain, Italy, Poland, Portugal);
- middle-income countries (Albania, Armenia, Philippines, Ecuador, Egypt, Moldova, Vietnam, Belarus, Georgia, Pakistan, Azerbaijan, Ukraine, Kyrgyzstan, Tunisia, Uzbekistan, Tajikistan, Bolivia, Bangladesh, Nepal, Kenya).

Based on this, two sets of statistics for high- and middle-income countries for the period 2012-2020 were generated. Note that all indicators that will be included in the econometric model have been pro-logarithmized, which will reduce the balances on the model and increase their compliance with the normal distribution law. To check the multicollinearity between the selected factor variables, a correlation matrix was constructed, which allowed us to determine the combinations of indicators with a close linear relationship. It is established that within the group of high-income countries there is a close relationship between IU and CPI indicators, IU, and FBS, so we exclude the variable IU from further calculations. Regarding the group of middle-income countries, there is multicollinearity between IU and FBS, GCE and GCF, and therefore it is suggested not to take into account FBS and GCF.

The next step is to check the variables for stationarity. Since we work with the panel data, the following criteria can be used to check the presence of individual roots: Levin-Lin-Chu, Hadri, Pesaran and Chin, and Dickey-Fuller tests. All mathematical calculations are performed in the EViews program. The result of the verification of stationary variables are given in Annex B. Based on the analysis of the results of the above tests, the following conclusions can be drawn:

- for middle-income countries, all indicators are non-stationary, so it is necessary to take their first differences;
- for high-income countries: the IU and GCF indicators have the first level of integration, and all others have no integration.

As there is integration for both groups of countries, it is necessary to check for cointegration between variables, i.e. to check the assumption that there is a long-term relationship between them. The statistical criterion Kao was used for testing, which involves testing the null hypothesis and the absence of cointegration relationships between variables. Because the data of both groups of countries p-value <0.05, we can say that there is a cointegration and long-term relationship between variables (Table 1).

Table 1. Results of checking variables for cointegration.

	t-Statistic	Prob.
I model – high-income countries	-4.560644	0.0000
II model – middle-income countries	-3.638579	0.0001

The next stage of the proposed approach is to build a panel regression model, the general form of which is as follows:

$$GDP_{i,t} = \alpha CPI_{i,t} + \beta SIS_{i,t} + \gamma FBS_{i,t} + \delta IU_{i,t} + \zeta GCE_{i,t} + \lambda GCF_{i,t} + \tau FDI_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $GDP_{i,t}$ – the logarithmic volume of GDP per capita in the i-country in the period t; $\alpha, \beta, \gamma, \delta, \zeta, \lambda, \tau$ – regression coefficient characterizing the impact of the corresponding indicator on $GDP_{i,t}$ in the long run; $\varepsilon_{i,t}$ – regression residues.

Fully modified least squares were used to determine the regression coefficients. The results of the calculation of regression parameters for two groups of countries are shown in Table 2.

Table 2. The results of identifying the long-term link between economic development, digitalization, and corruption (dependent variable – $GDP_{i,t}$). Note: * – statistically significant indicator.

Independent variables	High-income countries			Middle-income countries		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
CPI	1.208	5.090	0.000*	0.822	4.736	0.000*
FBS	1.329	5.311	0.000*	X	X	X
IU	X	X	X	0.821	8.525	0.000*
SIS	-0.046	-1.563	0.120	0.069	-2.660	0.009*
FDI	-0.048	-1.018	0.310	-0.042	-0.794	0.429
GCF	0.827	3.771	0.000*	X	X	X
GCE	-0.428	-2.190	0.030*	0.106	4.437	0.000*
Coefficient of determination	0.672			0.706		

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For high-income countries, 4 out of 7 independent variables are statistically significant: Corruption Perceptions Index (CPI), High-Speed Internet Access (FBS), General Government Expenditure (GCE), and Gross Domestic Investment (GCF). In the developed world, increasing access to high-speed Internet (FBS) has the greatest impact on economic growth. The growth of the corruption perception index (actually reducing the risk of corruption in the country) is stimulating GDP per capita in the long run. The only indicator that has a negative impact on GDP per capita is the volume of total government spending.

For middle-income countries, 5 out of the 6 indicators are statistically significant: Corruption Perceptions Index (CPI), number of Internet users (IU), number of secure Internet servers (SIS), and total government spending (GCE). Calculations show that there is a direct and statistically significant relationship between the level of corruption perception and GDP per capita. At the same time, digitalization indicators also have a positive impact on economic growth in middle-income countries.

To confirm the validity of the above conclusions, we note that the regression models based on panel data are adequate. The coefficient of determination for high- and middle-income countries is 0.672 and 0.706, respectively, i.e. the independent variables included in the econometric models describe the change in the performance indicator by 67.19% and 70.64%.

The histogram of the distribution and the Jarque-Bera test were used to estimate the normality of the distribution of the regression model residues (fig. 4).

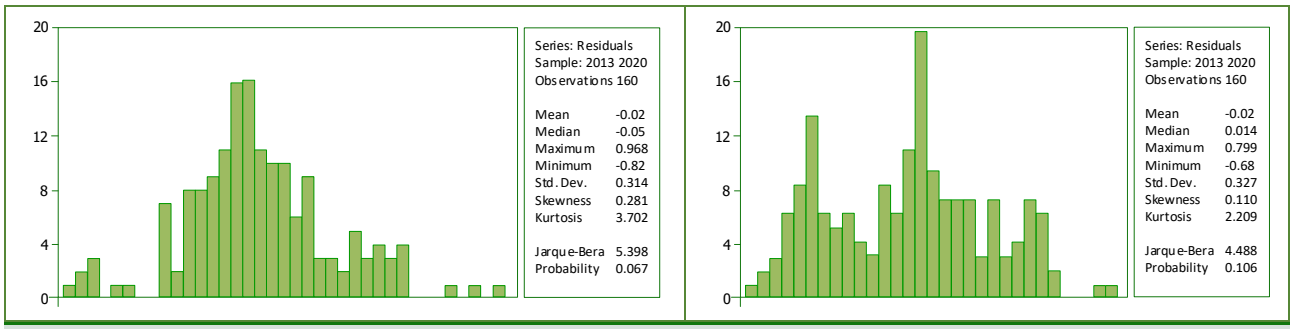

Figure 4. Histogram of the distribution of balances. Notes: figure on the left – for the group of high-income countries, figure on the right – for the group of middle-income countries.

The data in Figure 4 show the presence of a normal distribution of residues in the constructed models. Because the level of significance of the Jarque-Bera criterion is 0.067 and 0.106, which is greater than 0.05.

Thus, the empirical study confirmed the hypothesis of the presence of transmission effects between indicators that characterize the corruption level in the economy, digitalization, and economic growth. In addition, it has been proven that reducing corruption and increasing digitalization in the studied countries contributes to economic growth.

Improving business integrity and combating corruption will have a synergistic effect on the development of the national economy by increasing transparency of public authorities, increasing foreign investment, and rising social welfare [3].

CONCLUSIONS

Foreign experience in the use of digital information technology to combat corruption has shown that the use of computer automated software and algorithms for artificial intelligence is the most effective tool for simplifying the administrative process and monitoring the transparency of the company and government. The digitalization of bureaucratic procedures reduces the number of people involved and, consequently, the opportunities for bribery. Artificial intelligence eliminates the human factor in decision-making processes and can track the threat of crime without human intervention. According to the study, the authors propose urgent measures to combat corruption in the face of digital innovation and rapid development of information technology such as expanding the list of administrative services that can be provided electronically, which will reduce bureaucracy and the likelihood of corruption; introducing legislative reforms to increase control over the process of accountability and severe punishment in case of concealment of material goods; introduction of an electronic system capable of tracking the mismatch between the income and expenses of accountable persons, indicating illegal activities (theft, bribery, money laundering); improving infrastructure / establishing a body for regular collection of statistics from various sectors of the economy; open privatization of property by persons uninterested in politics, for efficient use of resources.

ADDITIONAL INFORMATION

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ОЦІНЮВАННЯ ТРАНСМІСІЙНИХ ЕФЕКТІВ У ЛАНЦЮЗІ «ДЕКОРУМПІЗАЦІЯ-ЦИФРОВІЗАЦІЯ-ЕКОНОМІЧНЕ ЗРОСТАННЯ»

Протягом останнього десятиліття спостерігається інтенсивний розвиток цифрових інформаційних технологій, інтелектуалізація систем управління, збільшення кількості та потужності мобільних і комп'ютерних пристроїв, акумулювання великих масивів даних та їх обробка алгоритмами машинного навчання, що неодмінно призводить до появи нових можливостей для економічного розвитку країн світу. Стрімка діджиталізація та її проникнення в різні сфери суспільного життя посприяло підвищенню рівня транспарентності публічного управління, посиленню громадського контролю, зменшення бюрократизації суспільства. І тому цифрові технології можуть слугувати інструментами боротьби з проявами корупції та створення умов для інтенсивного економічного зростання країни. Тож тема наукової роботи, присвячена дослідженню трансмісійних ефектів у ланцюзі «декорумпізація-цифровізація-економічне зростання», є актуальною. Мета роботи – розробка методичного інструментарію оцінювання трансмісійних ефектів між цифровізацією, декорумпізацією та економічним зростанням. Для дослідження використано наступні методи: тести Левіна-Ліна-Чу, Хадрі, Песаран і Чін, Дікі-Фуллера – для перевірки змінних на стаціонарність; статистичний критерій Као – для перевірки наявності коінтеграційного зв'язку між змінними; модифікований метод найменших квадратів – для оцінювання коефіцієнтів регресії на основі панельних даних; коефіцієнт детермінації та критерій Жарка-Бера – для перевірки адекватності економетричної моделі. Проведене емпіричне дослідження підтвердило гіпотезу щодо наявності трансмісійних ефектів між індикаторами, що характеризують декорумпізацію економіки, цифровізацію та економічне зростання. Доведено, що зменшення обсягів корупції та зростання діджиталізації в досліджуваних країнах сприяє економічному зростанню.

Ключові слова: : цифровізація, корупція, економічне зростання, панельна регресійна модель

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