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INDICES OF INNOVATION ACTIVITY AS COMPONENTS OF MACROECONOMIC STABILITY ASSESSMENT: HOW DOES THE SHADOWING OF INVESTMENT FLOWS AFFECT?

Abstract. *The article focuses on the study of causal links between the level of innovation development and the shadow economy on the example of 10 European countries. Based on the analysis of existing approaches to determining the level of innovation activity in the country, a linear model for evaluating the Complex Innovative Activity Index is proposed. The main hypothesis of the paper was the assumption that the increase in the level of the shadow economy is accompanied by a decrease in the country's innovative development, deteriorating access to financial resources, and so on. The purpose of the paper is to analyze the correlation between the level of the shadow economy and the indicators of innovative development of the country as components of its macroeconomic stability using Panel data analysis from 2007 to 2018. Unlike previous studies, this research considered that level of innovative development increasingly depends on the level of the shadow economy. The results confirm the relationship between factor and result indicators for all analyzed countries. To test the hypotheses about the negative impact of the shadow economy on the level of innovative activity of the country was presented the linear model with Complex Innovative Activity Index as an integral indicator of 8 international indexes (Global Competitiveness Index, Digital Readiness Score, Digital Economy and Society Index, Knowledge Economic Index, The European Innovation Scoreboard, Bloomberg Innovation Index, The International Innovation Index, Global Innovation Index) characterizing the level of innovative development of the country. In the second stage: testing of the data series for stationarity by the Dickey-Fuller and Philips Perron test Statistics, calculation of the optimal lag length from the maximum possible selected by the Akaike criteria, the Hannan-Quinn Information Criterion and the Schwartz Information Criterion, verification of*

cointegration of data series using Johansen test are performed. Empirical calculations have proved the high impact of the shadow economy on the innovative development of the country. All indices are statistically significant at the level of 1% and 5% and 10% respectively. It is substantiated that the state should take into account interdependencies as a basis for the development and implementation of measures aimed at increasing the innovative activity of economic entities, increasing the innovation potential of the country, and so on.

Keywords: innovative activity, investment flows, macroeconomic stability, shadow economy, indices.

Introduction. Stability is the basis of any successful efforts for the development of the private sector and economic growth of the country, serves as a guarantee of stability of business operations, growth of investment in the official sector of the economy. One of the most generalizing indicators that determine the level of economic development of the country is macroeconomic stability, which is a complex indicator that reflects the efficiency of certain sectors of the economy.

In the context of the exacerbation of the global economic crisis, the shortage of resources in most countries, one of the most studied modern phenomena of the national economy is shadowing. The shadow economy is a complex phenomenon, which is characterized by multiple influences on individual components of the economy, a set of negative manifestations and undesirable consequences for both the country and society.

One of the most threatening consequences of the shadowing of the economy is a significant deterioration in its economic development, in particular: reduction of budget revenues, increasing its deficit, significant reduction of tax revenues, reduction of investment and innovation potential of the country, and so on. To date, the share of the shadow economy fluctuates within 10-40% of GDP. In Advance Economies the level of the shadow economy is 10-20% of GDP, in Emerging economies – 30-35 percent of GDP, in CIS countries these values exceed 40% (Schneider, 2015; IFFR, 2018). According to the United Nations Office on Drugs and Crime (2018), 2 to 5% of the world GDP is formed in the shadow economy.

The propensity of economic agents to participate in shadow operations is often studied by scientists as the greatest threat to the country's economic security and stable functioning. Governments and international organizations are constantly developing measures to reduce the level of the shadow economy, the whole set of which can be divided into stimulating and restrictive. If restrictive measures provide for coercive influence on economic entities, stimulating measures - reduction of shadow operations due to the growth of economic and social development of the country.

Literature Review. The essence of macroeconomic stability, its indicators, their relationship with the level of the shadow economy investigated by scientists from around the world.

Given the multicomponent indicator of the stability of the national economy, today there are a significant number of approaches to its evaluation.

For example, Kendiukhov and Tvaronaviciene (2011) proposed to assess the level of macroeconomic stability with the help of five indicators: GDP growth, unemployment, inflation, the state budget balance to GDP, the balance of current turnover to GDP. The author considered the integrated indicator in the form of a pentagon, the lines of which characterize the degree to which countries have achieved the set macroeconomic goals.

A. Subramanian and S. Satyanath (2004) defined the institutional environment as the main indicator of macroeconomic stability, the catalyst for the growth of economic shadowing. Scientists have identified effective institutions of power as a prerequisite for reducing the level of shadowing in the country.

M. Varudakis-Veganzones (2001) to the basic indicators of macroeconomic stability, the variable value of which most leads to an unstable macroeconomic situation and imbalances in the economy, include:

inflation and the share of government deficit in GDP. These indicators lead to various distortions in the economy and the existence of a parallel foreign exchange market.

C. Lovell (1995) used methods of mathematical programming to measure economic stability. They allow to determine the limit values of macroeconomic indicators and further evaluate the economic results through the analysis of their effectiveness. The author studied the level of their macroeconomic stability for the period from 1970 to 1988 on the example of 10 Asian countries and 17 OECD countries. According to the study, Lovell established a scalar indicator of macroeconomic stability, which takes into account the following indicators: GDP growth, employment, trade balance and price stability.

The analysis reveals a significant number of indicators of macroeconomic stability that are directly related to the level of shadowing of the economy, in particular: the share of government deficit in GDP, inflation, real interest rates, nominal rates, savings and investment in the country.

Thus, the generalization of the results of empirical research (Formankova et al., 2018; Zarutska et al., 2020; Bobenic et al., 2018; Bilan et al., 2019) showed that most often scientists study the impact of the shadow economy on the following components of macroeconomic stability:

1. The volume of gross public debt as an indicator of the state of the national economy and an inhibitor of its economically sustainable development.

2. The volume of real GDP as an indicator that reflects the performance of economic entities of the country.

3. Inflation rate - a characteristic of the purchasing power of the population.

4. Unemployment rate - an indicator that reflects the effectiveness of government social policy.

5. The number of tax revenues

6. The exchange rate of the national currency to the US dollar.

At the same time, in our opinion, the connection of the shadow economy with the indicators of innovative development of the country as one of the main components that determine the potential for growth of production capacities, development of scientific researches, etc. is the least studied.

Some aspects of this phenomenon are investigated by scientists from around the world (Bakari et al, 2018; Kapidani and Luci, 2019; Loukil, 2016; Sekhar and Gudimetla, 2013; Tiutiunyk et al, 2019; 2020). A large share of budget resources is used to stimulate innovative development in most countries. Despite many incentives in the field of innovation development, today the level of innovation activity in most countries remains low. One of the reasons for this situation is the presence of the shadow sector of the economy.

Given that significant amounts of financial resources, including innovation, are derived from the official sector of the economy, and stable economic development of the country is impossible without funding innovative measures, it would be appropriate to analyze the statistical significance between innovative activity and the level of the shadow economy.

Most previous studies focus mainly on a more general analysis of the relationship between indicators of macroeconomic stability of individual countries in the context of inflation, GDP, exchange rates, foreign investment and the level of the shadow economy. At the same time, a considerable amount of our work is devoted to the study of the shadow economy and its impact on the indicators of innovative activity of the European countries, developing an approach to assessing the level of innovation development.

Thus, researchers consider the growing level of innovative development of the country as a prerequisite for de-shadowing the economy. Thus, some researchers consider innovative technologies as a tool for increasing the transparency of financial transactions and withdrawing cash flows from the shadows.

One group of scientists claimed the stimulating effect of innovative activity on the level of the shadow economy. Digitization of the economy, the growing share of Internet business is an additional mechanism for shadowing incomes, increasing the share of informal employment, illegal withdrawal of funds abroad,

and so on. This problem becomes especially relevant in the context of the growing share of electronic financial transactions. In this context, digital operations are seen as an integral part of the shadow sector of the economy, a tool of cybercrimes, tax evasion, money laundering and more.

According to the second approach, innovative development, which is manifested in the digitalization of the economy, the emergence of electronic payments, financial innovations leads to a decrease in the level of the shadow economy and increased control over cash flow.

Levchenko et al. (2018) claimed that innovative financial technologies are the most important instrument for ensuring macroeconomic stability of the country and withdrawing funds from the shadows.

Muhammad et al. (2020) considers innovation as an integral part of economic sector development and an important determinant of the economic stability of the country. Mane researches confirm that innovation activity is a driver of economic stability and growth (Bara and Calvin, 2016; Beck et al., 2012; Błach, 2011; Bara et a.l, 2016; Kozubikova and Kotaskova, 2019).

According to Chou and Chin (2011), the demand for innovation can result from economic reforms, which can be beneficial for companies and have the potential for improving their business model. Effective stimulation of innovation is dependent not only on the form of regulation but also on the flexibility, understood as openness and transparency of economic policy.

The purpose of the paper is to empirically substantiate the causal links between the level of the shadow economy and the indicators of innovative development of the country as components of its macroeconomic stability.

Methodology and research methods. The research of causal links between the levels of the shadow economy and indicators of innovative development of the country will be carried out using the STATA software package for the sample from 10 European countries for 2007-2018. The limitation of the period is due to the lack of data for individual indices of innovative development in the databases of the World Bank, IMF, World Economic Forum, European Commission, Boston Consulting Group.

The nexus between macroeconomic stability and shadow economy has not been unleashed through empirical investigation before. Literature produced evidence proving the correlation between shadow economy and macroeconomic stability variables, such as GDP, tax revenues, interest rate, foreign direct investments, the share of profitable companies and so on.

Given the important role of innovative development of the country in ensuring its economic stability, it can be presumed that there is a relationship between the levels of innovative activity and the shadow economy in the country.

Given the significant variety of indicators that characterize the level of innovative development of the country, the study of communication will be carried out using the Complex Innovative Activity Index, which combines 8 indicators characterizing the level of innovative technologies and financial development. The calculation of the index is based on a linear model in which the individual components are weighted by the weighting coefficients. The characteristics of the subindexes used for the calculation are presented in Table 1.

Table 1. Indexed Components of Complex Innovative Activity Index

Index	Methodology	Source
Sub-index «Innovation capability» of the Global Competitiveness Index (GCI)	Includes five components: Entrepreneurial Culture, Interaction And Diversity, Research And Development, Commercialization, Administrative Requirements	World Economic Forum

Continued Table 1

Digital Readiness Score (DRS)	Includes seven components: Basic Needs, Human Capital, Ease Of Doing Business, Business And Government Investment, Start-Up Environment, Technology Infrastructure, Technology Adoption	Cisco Corporate Affairs
Digital Economy and Society Index (DESI)	Includes six components: Connectivity, Human Capital/Digital Skills, Use of Internet, Integration of Digital Technology, Digital Public Services, Research and Development ICT	European Commission
Sub-index «Innovation» of the Knowledge Economic Index	Reflects the effectiveness of innovation system of firms, research centers, universities, consultants and other organizations in attracting the growing stock of global knowledge, assimilating and adapting it to local needs; creating new technology.	World Bank
The European Innovation Scoreboard	Includes the following indicative components: «human resources», «research systems», «innovation-friendly environment», «finance and support», «enterprise investment», «innovators», «communications», «intellectual assets», «impact on employment», «impact on sales».	European Commission
Bloomberg Innovation Index	Includes seven metrics: Research and Development Intensity; Manufacturing Value-added, Productivity, High-tech Density; Tertiary Efficiency; Researcher Concentration; Patent Activity.	Bloomberg
The International Innovation Index BCG	The index measured both innovation inputs and outputs. Innovation inputs includes: government and fiscal policy; education policy and the innovation environment. Outputs included: patents, technology transfer, and other R&D results; business performance (labor productivity and total shareholder returns); the impact of innovation on business migration and economic growth.	Boston Consulting Group, USA
Global Innovation Index (GII)	Includes two groups of indicators: Innovation Input Index (Institutions, Human Capital and Research, Infrastructure, Market Sophistication, Business Sophistication) and Innovation Output Index (Research and Technology Output, Creative Outputs).	Cornell University, INSEAD, the World Intellectual Property Organization

Source: developed by the authors by the authors on the basis of (World Bank ,2020; The Global Innovation Index, 2019; Bloomberg Innovation Index, 2020; Cisco Global Digital Readiness Index,2019; European Commission, 2020; Global Competitiveness Report, 2020).

The evaluation of the Complex Innovative Activity Index will be carried out according to the following formula:

$$CIAI = w_{GCI} \cdot GCI + w_{DRS} \cdot DRS + w_{DESI} \cdot DESI + w_{KEI} \cdot KEI + w_{EIS} \cdot EIS \qquad (1)$$
$$+ w_{BII} \cdot BII + w_{BCG} \cdot BCG + w_{GII} \cdot GII$$

where, w_i – a weighting coefficient of indicator i.

The rating of sub-indices of the Complex Innovative Activity Index will be performed using the Fishburne formula, which has the following form:

$$w_n = \frac{2 \cdot (N-n+1)}{N \cdot (N+1)} \qquad (2)$$

where, N is the total number of sub-index; n - the rank of the sub-index.

The priority of sub-indices will be determined by Expert Assessment Methods.

The hypothesis on the impact of shadow investment flows on the country's innovative development indicators will be tested using economic and mathematical modeling tools.

In the first stage, the correlation analysis of the relationship between the defined indicators will be performed using the Multiple regressions method (OLS model), which has the following form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon \qquad (3)$$

where, the betas (β_k) are the parameters that OLS estimates; epsilon (ε) is the random error.

Scientists have developed a significant toolkit to study the causal links between the level of the shadow economy and indicators of macroeconomic stability in the country. The Dickey-Fuller and Philips Perron test will be used to test the hypothesis of stationarity of the studied data set. Data cointegration will be determined using the Johansen test. The optimal duration of the lag will be determined by the Akaike criteria, the Hannan-Quinn Information Criterion and the Schwartz Information Criterion.

At the last stage of the study to test the dependencies between the levels of the shadow economy and innovative component of macroeconomic stability index will use the approach proposed by Granger based on the construction of time series and regression equation to the following:

$$y_t = \beta_0 + \sum_{j=1}^{m} \beta_j \, y_{t-j} + \sum_{j=1}^{m} \beta_j \, x_{t-j} + e_t \qquad (4)$$

The application of this approach will allow checking the existence of a causal link between the shadow economy and the innovative development of the country in terms of the following hypotheses:

1. The presence of a one-way causal relationship between the analyzed indicators. The change in the level of the shadow economy causes a change in the level of innovation activity, but not vice versa.

2. The presence of a two-way relationship between factor and result indicators growth of the shadow economy causes a change in the level of innovation activity in the country and vice versa:

$$\sum_{j=1}^{n} \tau_j \neq 0 \qquad (5)$$

$$\sum_{j=1}^{m} \rho_j \neq 0 \qquad (6)$$

3. Lack of relationship between the analyzed indicators.

Results. Based on formula 2, the weights coefficient for sub-indices of Complex Innovative Activity Index were determined, the values of which are given in Table 2.

Table 2. Weighting coefficients for sub-indices of Complex Innovative Activity Index

Sub-index	The rank	Weighting coefficient
Global Competitiveness Index	8	0,027778
Digital Readiness Score	6.5	0,069444
Digital Economy and Society Index	6.5	0,069444
Knowledge Economic Index	5	0,111111
The European innovation scoreboard	4	0,138889
Bloomberg Innovation Index	3	0,166667
The International Innovation Index BCG	2	0,194444
Global Innovation Index (GII)	1	0,222222

Source: developed by the authors.

Table 3. Complex Innovative Activity Index for European countries

	BEL	CZE	DEU	DNK	ESP	FRA	GBR	HRV	EST	AUT
2007	47.02	46.30	54.12	55.06	43.64	51.35	57.21	35.67	46.20	47.97
2008	47.27	46.55	54.41	55.35	43.87	51.63	57.52	35.86	46.45	48.23
2009	47.58	46.86	54.77	55.72	44.17	51.97	57.90	36.10	46.76	48.55
2010	48.08	47.34	55.34	56.30	44.62	52.51	58.50	36.47	47.24	49.05
2011	48.08	47.34	55.34	56.30	44.62	52.51	58.50	36.47	47.25	49.06
2012	47.94	47.21	55.18	56.14	44.50	52.36	58.34	36.37	47.11	48.92
2013	48.22	47.48	55.50	56.46	44.75	52.66	58.67	36.58	47.38	49.20
2014	48.25	47.52	55.54	56.50	44.79	52.70	58.71	36.60	47.42	49.24
2015	48.47	47.73	55.79	56.76	44.99	52.94	58.98	36.77	47.63	49.46
2016	48.95	48.20	56.34	57.31	45.43	53.46	59.56	37.13	48.10	49.94
2017	48.80	48.05	56.17	57.14	45.29	53.30	59.38	37.02	47.95	49.79
2018	48.47	47.73	55.79	56.76	44.99	52.94	58.98	36.77	47.63	49.46

BEL – Belgium, CZE – Czech Republic, DEU – Germany, DNK – Denmark, ESP – Spain, FRA – France, GBR - United Kingdom, HRV – Croatia, EST – Estonia, AUT – Austria,

Source: developed by the authors on the basis of World Economic Forum, Cisco Corporate Affairs, European Commission, World Bank, European Commission, Bloomberg, Boston Consulting Group, Cornell University, INSEAD, the World Intellectual Property Organization Data.

The values of the Complex Innovative Activity Index allow us to conclude about the average level of innovative activity of the analyzed countries. During 2007-2018, its average value does not exceed 50.44.

Germany (55.36), Denmark (56.32) and United Kingdom (58.52) have the highest average level of innovation activity for the analyzed period. The lowest rates are typical for Croatia (36.48), Czech Republic (47.36) and Estonia (47.26).

One of the reasons for this situation, in our opinion, is the high level of the shadow economy of these countries, which significantly limits their innovation and investment potential.

The correlation analysis carried out using the Multiple regressions method indicates the causal links between the level of the shadow economy and the Complex Innovative Activity Index for 10 European countries. Most results are statistically significant at 0.05%. Indicators of the Multiple regressions model are shown in Table 4.

Table 4. Indicators of the Multiple regressions model for Complex Innovative Activity Index and level of shadow economy for European countries

Country	Indicator	Constanta
BEL	-1.306529** (0.249661)	-1.165245** (0.101118)
CZE	-2.432964* (0.557564)	-2.315414* (0.125491)
DEU	-2.473821** (0.588984)	-2.021179** (0.171629)
DNK	-3.584366** (3.836912)	-2.877324** (0.726841)
ESP	-1.306529* (0.249661)	-1.165245* (0.101118)
FRA	-1.393482** (0.266277)	-1.242795** (0.107848)
GBR	-2.594883** (0.594671)	-2.46951** (0.133842)
HRV	-2.638459** (0.628183)	-2.155694** (0.183052)
EST	-3.822913** (4.092268)	-3.068816** (0.775214)
AUT	-1.393482** (0.266277)	-1.242795** (0.107848)

$*p<.05$ ** $p<.01$ ***$p<.001$. Standard errors within parentheses

Source: developed by the authors.

At the next stage, in order to build a model of the dependence of indicators of innovative development of the country on the level of its shadow economy, using the Dickie-Fuller test to identify additional lags.

According to the results, most indicators are stationary. The calculated value is more than the critical value at 1%, 5%, and 10% levels of significance. For example, the value of the ADF test statistic for CIAI for Belgium is more than the critical value (-2.66) and indicates the stationarity of the data analyzed. The results of the Philips Perron Test Statistics allow us to accept the unit root null hypothesis for stationary of majority indicators at the 10% level of significance.

For data series with the rejected the null hypothesis about the presence of a single root in the time series, the first differences of the data series for stationarity were checked. The absolute value of the calculated value of t-statistics in the first differences exceeds the critical values for the significance level

of 1%, 5%, and 10%. It allows us to reject the null hypothesis about the nonstationarity of the first differences of the data series with a minimum probability of error.

Table 5. The results of testing the data series for stationarity by the Dickey-Fuller and Philips Perron test Statistics

Variables	ADF Test Statistics		Philips Perron Test Statistics		Decision
	Test statistic	lag	Test statistic	lag	
BEL					
CIAI	-4.15207***	1	-4.15207***	0	Stationary
SE	-1.22883	1	-1.31788	0	Non-stationary
CZE					
CIAI	-2.76393**	1	-3.01192**	1	Stationary
SE	-2.41319	2	-1.58543	0	Non-stationary
DEU					
CIAI	-3.79763**	1	-3.79763**	1	Stationary
SE	-2.92572**	0	-2.92572**	0	Stationary
DNK					
CIAI	-0.4656	0	0.339073	1	Non-stationary
SE	-2.98225**	0	-3.13773***	0	Stationary
ESP					
CIAI	-5.72299***	1	-4.52449**	1	Stationary
SE	-2.12297**	1	-2.12297**	1	Stationary
FRA					
CIAI	0.58045	1	0.58045	0	Non
SE	-3.79763**	2	-3.18542**	1	Non
GBR					
CIAI	-5.53033***	1	-2.96754*	2	Stationary
SE	-3.11537**	0	-2.3841	2	
HRV					
CIAI	-2.18225**	1	-2.82913**	2	Stationary
SE	-1.63267	2	-1.43708	1	Non-stationary
EST					
CIAI	-1.33998	0	-1.33998	2	Non
SE	-0.74594	1	-0.74594	1	Non
AUT					
CIAI	-3.55116**	1	-3.55116**	1	Stationary
SE	-3.47089**	0	-3.47089**	1	Stationary
p<.05 ** p<.01 ***p<.001. Standard errors within parentheses					

Source: developed by the authors.

Table 6 shows the results of calculating the optimal lag length from the maximum possible selected by the Akaike criteria, the Hannan-Quinn Information Criterion and the Schwartz Information Criterion.

Table 6. The results of the calculation of the length of the lag (fragment)

Country	Lag	LR	FPE	AIC	HQIC	SBIC
				CIAI		
	0	NA	18.61166	5.591037	5.388641	5.51562
	1	2.31021	26.08154	6.551595	6.789472	7.119967
	2	4.220343	9.709415	5.065806	4.557065	4.938011
	3	5.666294	9.844871*	4.467596*	3.671272*	4.072544*
	4	315.9395*		-57.7132	-60.1524	-58.8209
BEL	5	-2.3256		-54.7128	-57.3622	-52.6707
				SE		
	0	NA	0.29776	1.59184	1.39167	1.51725
	1	3.56776	0.22380	1.28295	0.87800	1.13206
	2	16.75243	0.00985	-1.75067	-2.33282	-1.96758
	3	11.38601	0.00487*	-4.14590*	-5.19665*	-4.53740*
	4	246.56544*		-51.78964	-52.68208	-52.12211
	5	-1.37027		-32.36061	-32.92297	-32.57011
				CIAI		
	0	NA	0.01364	-1.37852	-1.58100	-1.45396
	1	4.71661	0.00787	-1.92823	-2.33021	-2.07800
	2	2.44136	0.01010	-2.28091	-2.98062	-2.54161
	3	8.91811	0.00705*	-3.97109	-5.08272	-4.38527
	4	424.10280*		-88.08748*	-89.40192*	-88.57717*
DEU	5	1.25624		-85.31280	-86.58583	-85.78706
				SE		
	0	NA	21.67890	6.51245	6.27670	6.42461
	1	2.30414	26.01303	7.29702	6.77164	7.10126
	2	4.04242	13.72828	4.94652	4.36494	4.72983
	3	5.51805	9.53691*	4.25734	3.47541	3.96600
	4	315.92957*		-58.44621*	-59.44678*	-58.81902*
	5	1.12145		-13.74708	-13.98242	-13.83477
				CIAI		
	0	NA	18.47671	5.55050	5.21578	5.34957
	1	1.77474	20.03626	5.62045	5.31280	5.47563
DNK	2	4.92024	16.70940	6.02066	4.22103*	5.46967
	3	6.70191	11.58298*	5.17072*	-	5.75692
	4	448.505*		-82.97234	84.39279	4.81687*
	5	0		-75.53239	- 76.82485	-83.50160
						-76.01419

Countinued Table 6

		SE			
0	NA	0.61061	3.26438	2.85388	3.11142
1	6.03062	0.37829	2.16858	1.48408	1.91353
2	28.01363	0.01647	-2.92749*	-3.90097*	-3.29020*
3	12.41193	0.00531*	-4.51946	-5.66489	-4.94624
4	366.54672*		-76.99101	-78.31772	-77.48527
5	-3.15534		-74.51686	-75.81180	-74.99928

Source: developed by the authors.

Calculations allow us to conclude that the optimal lag length for Belgium and Denmark is 3 years, for Germany – 4 years. For the rest of the analyzed countries, the length of the lag ranges from 3 (Czech Republic, Estonia, Austria, Croatia) to 4 (Spain, France, United Kingdom) years.

The next stage of calculations is to test the hypothesis of cointegration of data series. To do this, we calculate the Johansen cointegration test, which is based on assumptions about the linear deterministic trend and the delay interval in the first differences from 3 to 4. The results of the calculations are shown in table 7.

Table 7. The results of the calculation of the Johansen test (fragment)

Lag	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
			BEL			
1	-0,07396	0,016733	-5,15018	0	-0,10675	-0,04116
2	-0,10751	0,018318	-6,83972	0	-0,14341	-0,0716
3	-0,09724	0,01526	-7,42232	0	-0,12715	-0,06733
4	-0,08115	0,019984	-4,72802	0	-0,13875	-0,03891
			CZE			
1	-0,07968	0,018028	-5,54887	0	-0,11502	-0,04435
2	-0,11583	0,019736	-7,3692	0	-0,15451	-0,07715
3	-0,10477	0,016441	-7,9969	0	-0,13699	-0,07255
4	-0,08744	0,021531	-5,09402	0	-0,14949	-0,04192
			DEU			
1	-0,06255	0,014151	-4,35547	0	-0,09028	-0,03481
2	-0,09092	0,015491	-5,7843	0	-0,12128	-0,06055
3	-0,08224	0,012905	-6,277	0	-0,10753	-0,05694
4	-0,06863	0,016901	-3,99845	0	-0,11734	-0,03291
			DNK			
1	-0,12602	0,028511	-8,77547	0,100	-0,1819	-0,07014
2	-0,18318	0,031212	-11,6543	0,185	-0,24435	-0,12201
3	-0,16569	0,026001	-12,647	0,053	-0,21665	-0,11473
4	-0,13828	0,034052	-8,05614	0,053	-0,23642	-0,0663

Countinued Table 7

			ESP			
1	-0,09829	0,022238	-6,84455	0,046	-0,14187	-0,0547
2	-0,14287	0,024344	-9,08993	0,183	-0,19059	-0,09516
3	-0,12923	0,02028	-9,8642	0,086	-0,16898	-0,08949
4	-0,09829	0,022238	-6,84455	0,182	-0,14187	-0,0547

Source: developed by the authors.

The results of the calculation of the Johansen cointegration test indicate a stable relationship of long-term equilibrium and allow us to conclude that there is a unilateral impact of the shadow economy on the Complex Innovative Activity Index in all analyzed European countries.

Table 8 shows the results of the calculation of causal links between shadow investment flows and innovative development of European countries indicate the presence of a unilateral impact of shadow transactions with time lags in 1 (Belgium, Denmark, Croatia, Estonia), 2 (Czech Republic, Austria, Spain, Germany) and 3 (France, United Kingdom) years.

Table 8. Results of calculation causal link with the test Granger

Country	Equation	F	df	df_r	Prob > F
BEL	CIAI → SE	8,9127	1	6	0,0438
	SE → CIAI	0,8608	2	3	0,2738
CZE	CIAI → SE	16,7158	1	6	0,0113
	SE → CIAI	4,7249	2	3	0,2193
DEU	CIAI → SE	0,8217	1	6	0,2159
	SE → CIAI	2,1319	2	3	0,4979
DNK	CIAI → SE	1,7567	1	6	0,2137
	SE → CIAI	1,1239	2	3	0,4004
ESP	CIAI → SE	2,0412	2	3	0,2527
	SE → CIAI	1,4044	1	6	0,2585
FRA	CIAI → SE	7,0492	1	6	0,0332
	SE → CIAI	3,7780	2	3	0,1376
GBR	CIAI → SE	11,9996	1	6	0,0134
	SE → CIAI	5,1140	2	3	0,0347
HRV	CIAI → SE	4,1003	1	6	2,2448
	SE → CIAI	9,5914	2	3	0,1240
EST	CIAI → SE	2,7111	1	6	0,2560
	SE → CIAI	2,1929	2	3	0,3250
AUT	CIAI → SE	1,2233	1	6	0,1395
	SE → CIAI	1,0080	2	3	0,1226

Source: developed by the authors.

Conclusions. The analysis concludes that there is a link between the level of the shadow economy and the country's innovative development. The presence of shadow investment flows leads to a decrease in the country's investment potential, the ability to finance research, technological renewal of production and more. Often it is the high level of the shadow economy that is a deterrent to foreign partners investing in the real sector of the economy.

The established interdependencies should serve as a basis for the development and implementation of measures aimed at increasing the innovative activity of economic entities, increasing the innovation potential of the country, and so on.

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Індекси інноваційної діяльності як складові макроекономічної стабільності: дослідження впливу тіньових інвестиційних потоків?

Стаття зосереджена на дослідженні причинно-наслідкових зв'язків між рівнями інноваційного розвитку та тінізації економіки на прикладі 10 європейських країн. На основі аналізу існуючих підходів до визначення рівня інноваційної активності в країні пропонується лінійна модель оцінки комплексного індексу інноваційної діяльності. Основною гіпотезою статті було припущення, що підвищення рівня тінізації економіки супроводжується зниженням інноваційного розвитку країни, погіршенням доступу до фінансових ресурсів тощо. Метою статті є аналіз співвідношення між рівнем тіньової економіки та показниками інноваційного розвитку країни як складових її макроекономічної стабільності за допомогою аналізу рядів даних з 2007 по 2018 рр. На відміну від попередніх досліджень, дане дослідження обґрунтовує гіпотезу, про те, що рівень інноваційного розвитку країни залежить від обсягу тіньового сектору економіки. Результати підтверджують взаємозв'язок між факторною та результуючими показниками для всіх аналізованих країн. Для підтвердження гіпотези про негативний вплив тіньової економіки на рівень інноваційної діяльності країни була побудована лінійна модель оцінювання Індексу комплексного інноваційного розвитку країни як інтегрального показника 8 міжнародних індексів (Індекс глобальної конкурентоспроможності, Цифрова оцінка готовності, Цифрова економіка та Індекс суспільства, Економічний індекс знань, Європейський індекс інновацій, Індекс інновацій Bloomberg, Міжнародний індекс інновацій, Глобальний індекс інновацій), що характеризує рівень інноваційного розвитку країни. На другому етапі здійснено: тестування рядів даних на стаціонарність за допомогою статистичного тесту Дікі-Фуллера та Філіпса Перрона, розрахунок оптимальної довжини лага, обраної за критерієм Акакайке, інформаційним критерієм Ханнана-Квінна та інформаційним критерієм Шварца, перевірка коінтегрованості рядів даних за допомогою тесту Йогансена. Емпіричні розрахунки довели високий вплив тіньової економіки на інноваційний розвиток країни. Усі показники є статистично значущими на рівні 1% та 5% та 10% відповідно. Обґрунтовано, що держава повинна враховувати встановлені взаємозалежності як основу для розробки та реалізації заходів, спрямованих на підвищення інноваційної активності суб'єктів господарювання, збільшення інноваційного потенціалу країни тощо.