"Financial and investment indicators for accelerating innovation development: Comparison of GII leaders and Ukraine"

| AUTHORS | Olena Dobrovolska [iD]
Ralph Sonntag [iD]
Svitlana Kachula [iD]
[R]
Olha Hubaryk [iD]
Tetiana Savanchuk [iD] |

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BUSINESS PERSPECTIVES

Olena Dobrovolska, Doctor of Economics, Professor, Department of Finance, Banking and Insurance, Dnipro State Agrarian and Economic University, Ukraine. (Corresponding author)

Ralph Sonntag, Professor, Dr., Rector of the University of Applied Sciences Stralsund, Germany.

Svitlana Kachula, Doctor of Economics, Professor, Department of Finance, Banking and Insurance, Dnipro State Agrarian and Economic University, Ukraine.

Olha Hubary, Ph.D. in Economics, Associate Professor, Department of Accounting, Taxation and Management of Financial and Economic Security, Dnipro State Agrarian and Economic University, Ukraine.

Tetiana Savanchuk, Ph.D. in Economics, Associate Professor, Department of Accounting, Taxation and Management of Financial and Economic Security, Dnipro State Agrarian and Economic University, Ukraine.

Olena Dobrovolska (Ukraine), Ralph Sonntag (Germany), Svitlana Kachula (Ukraine), Olha Hubaryk (Ukraine), Tetiana Savanchuk (Ukraine)

FINANCIAL AND INVESTMENT INDICATORS FOR ACCELERATING INNOVATION DEVELOPMENT: COMPARISON OF GII LEADERS AND UKRAINE

Abstract

The purpose of the paper is to determine the causal relationship between financial and investment indicators and the level of innovation development in GII leading countries and Ukraine. For a sample of 10 leaders in GII-2022 and Ukraine for 2011–2020, a correlation analysis was conducted based on the following indicators: the value of GII, foreign direct investment (net inflows), domestic credit to the private sector, ease of getting credit, protecting minority investors, and real interest rate. A positive relationship (with moderate/high strength) between innovation development and foreign direct investment has been proven in 7 out of 11 countries with a time lag of 0-2 years; domestic credit to the private sector – in 6 countries (lag of 0-3 years); and protecting minority investors – in 9 countries (lag of 0-2 years). For other indicators, the relationship is negative. Through VAR-modelling and Granger test, it is proven that the change in the value of foreign direct investment causes the change in the value of GII in 6 countries (bidirectional causality exists only in Ukraine); domestic credit to the private sector – in 6 countries, protecting minority investors and real interest rate – in 2 countries, and ease of getting credit – only in Switzerland. The results show that foreign direct investment and domestic credit to the private sector are the reasons for increasing the level of innovation development and have potentially the highest influence. In Ukraine, compared to GII leaders, only the factor of foreign direct investment is identified as a cause of innovation development.

Keywords	causality, credit, investment, GII, innovation development, interest rate
JEL Classification	E61, F21, O32

INTRODUCTION

Nowadays, innovation development is a significant driver for economic growth, competitiveness, capability, and sustainable development in different levels such as global, national, regional, local, company and household ones. At the same time, the levels of innovation development in Ukraine and leading countries in the Global Innovation Index (GII), as well as other countries of the world, differ significantly (WIPO, 2022). The reason is the impact of many factors that form the Global Innovation Index. Financial and investment aspect is one of them, and its significance is constantly increasing.

So, today the need for additional financing of global development goals, including innovation development, is beyond doubt. The world community of influential international organizations is constantly paying attention to the potential of financing innovation development. Responsive financing strategies, outcome-based funding mechanisms and instruments have a positive effect and benefits for innovation development.

However, the level of innovation development identified by the value of GII differs significantly in GII leading countries and Ukraine. The same gap takes place in the case of GII sub-pillars on Credit and Investment, which involves especially financial and investment indicators. In comparison, in Ukraine the values of Credit and Investment sub-pillars are positioned as weaknesses, and in many of top countries these sub-pillars are strengths.

That is why it is relevant to prove the hypothesis about the existence of relationships between a country's financial and investment indicators and the level of its innovation development, and to identify the causality direction.

1. LITERATURE REVIEW

The issue of financial and investment aspects in the context of innovation development is not new in scientific circles, and it is characterized by significant scientific development in this area. The research aspects of the financial and investment issue are closely interconnected with innovation development in many areas of social relations: 1) innovation, finance and sustainable development, including economic growth, economic development, competitiveness, entrepreneurship, commerce, financial development, financial inclusion, financial policy, financial system, financial markets, banking, investments, monetary policy, taxation, financial incentives, financial resources, financial support, financial innovation, fintech, industrial economics, innovation policies, innovation system, patents and inventions, R&D, science and technology, technology transfer, informational and knowledge management, risk management, environmental economics, alternative energy, green finance, and globalization; 2) humans, government regulation and management, including financial management, budget, policy making, organization, leadership, organizational innovations, cooperation, cooperative behavior, international cooperation, public-private partnership, education, intellectual property, health policy, marketing; and 3) decision-making and investment, including capital, foreign direct investment, efficiency, productivity, employment, and resource allocation.

Multifaceted aspects of innovation development of a country, the methodology for its analysis and evaluation, the search for ways to improve using the example of one country or cross-country data are reflected in the works of Melnyk et al. (2021, 2022).

The development of innovation activity is of great importance on the way to achieving the goals of sustainable development. Over time, most regions advance in the development of innovation development, but most regions have a heterogeneous development of innovation activity. Management decisions regarding the development of innovation activity should be complex and implemented primarily in those regions where no improvement is observed over time (Hrytsenko et al., 2021).

Considering innovation is imperative for continuity and prosperity in the international market (Huseynova & Huseynov, 2023).

Realizing the existing potential and accelerating the pace of innovation development in national economies requires the efforts of the government, business structures, and the population (Sotnyk, 2012).

Shkarupa et al. (2022) determined the dependence of economic development on indicators characterizing the potential of a country's knowledge economy and the transfer of innovations, and the impact of the potential of the country's scientific and educational activities on innovative development based on the characteristics of the "business – education – science" system in the field of innovation transfer.

In today's turbulent and constantly changing conditions, there is a growing tendency to introduce management innovations (Gallo et al., 2023). Approaches to management of innovations were analyzed by Kuzior and Zozul'ak (2019) and Kuzior et al. (2022).

Thanks to an innovation breakthrough, the digital and real economies are deeply integrated. The

digital economy has become an important driving force for transforming economic and innovation development (Chen et al., 2023). Pakhnenko and Kuan (2023) focused on the modern trend of digital innovation, the state of implementation of digital innovations in the field of public administration, as well as systematization and analysis of the main groups of ethical problems arising in connection with the use of digital technologies in public administration.

Oloveze et al. (2022) and Didenko et al. (2022) studied the impact of medicine and healthcare innovation taking into account financing these innovations. Innovations in health care are most widespread in developing countries.

Samoilikova and Artyukhov (2023) and Soumadi (2023) emphasized the moment of intellectual property and protecting rights in the context of rapid innovation development.

Liu (2023) and Kaya et al. (2023) studied the issue of fintech and technology innovation. Njegovanović (2023) discussed the multidimensionality of finance through innovation evolution, a philosophy with interdisciplinary features.

The impact of financial policy on macroeconomic indicators, macroeconomic stability and security, the current state, and barriers to its implementation was studied by many scholars. Leonov et al. (2012) analyzed the features of joint investment considering the challenges and restrictions that affect investment activity, the volume of the resource base to ensure innovation development at the macroeconomic level in general.

However, the need for financial hedging tools, effective cost management and the introduction of innovation technologies is actual at different levels of markets (Dykha et al., 2021).

Boyarko and Samusevych (2011) explored the problem of innovation development on the business level. The formation and development of the organizational and economic mechanism for the activation of innovative business development is a complex system of relations that requires state support for the activation of innovative development (Berezhnytska, 2022).

Artyukhov et al. (2021), Hryhorash et al. (2022), Nahla (2023), and Yu et al. (2023) also studied the problem of innovation development, but in connection with collaboration of business and education. The partnership between a university and a company promotes symbiosis with the economic environment through numerous gateways from the university to industrial companies, and vice versa. This contributes to the increase in investment and innovative development.

Skliar and Samoilikova (2014) and Strielkowski et al. (2022) paid attention to the multidisciplinary issue of funding innovation and investment activity in business companies, taking into account interconnections of innovation development, its financing and appearing risks.

The state of the financial sector of the economy depends on the value of credit aggregates and the existence of intersystem financial risks. The growing imbalance in the financial sector, the increase in leverage, the equity capital of business entities against the background of the expansion of speculative operations and the decrease in the share of productive investments requires its timely neutralization in order to transform free cash into productive investments, including investment in innovation development (Vasilyeva et al., 2013; Vasylyeva et al., 2014).

Konieva (2021) formalized criteria for financing policy types, moderate and conservative financing policy, and concluded that choosing the desired type of financing policy allows creating an optimal capital structure for innovation development.

The decrease in financial security and the deterioration of financial indicators causes the strengthening of financial imbalances of the territories in the conditions of an unstable economy, therefore it is important to substantiate the regional and local budget policy, the nature of inter-budgetary relations, the formation of regional development strategies, including innovative ones (Voznyak et al., 2021).

Determinants of credit sources of banks and, in particular, understanding the factors of non-per-

forming financing are also important for improving the level of innovative development, taking into account general financing, inflation, the COVID-19 pandemic, and regional aspects (Fakhrunnas et al., 2022).

The construction of networks capable of informing about the necessary financial behavior will contribute to financial integration, and there are connections between financial behavior and financial accessibility in the context of meeting banking / financial needs and innovation development (Onodugo et al., 2021).

The issue of public investment and the identification of factors that affect its effectiveness is very important to improve the management of the effectiveness of public investment, balance financial costs and promote sustainable economic and social growth (Yu, 2023).

The impact of establishing the influence of investment models (deposits, securities of the public and private sectors) of pension assets on economic growth and innovation development was also studied (Kolodiziev, 2021). Kozmenko and Vasyl'yeva (2008) analyzed the influence of investment in innovation, paying attention to specialized innovative investment banks.

Foreign investors focus on states with a high level of investment attractiveness; therefore, it is important to assess the relationship and the degree of connection between the dimensions of investment attractiveness, its internal and external dimensions, including innovative/research dimensions (Moskalenko et al., 2022).

Iastremska et al. (2023) determined the impact of investments as the basis of innovation development in modern conditions of economic development in real and virtual space.

Paz and Fontaine (2018) identified a causal mechanism of state policy of innovations that links the opening of an opportunity window with a change in public policy because of a combination of the emergence of a new policy network, the adoption of a new policy paradigm, and the selection of a new set of tools in the context of public finance.

Determining the interaction between innovation, financial development and economic growth was the subject of a study by Pradhan et al. (2018). They determined financial development and innovation as causal factors of economic growth and paid attention to focusing policy on financial development and innovation as an appropriate approach to increasing the economic efficiency of countries.

Islam et al (2018) explored the cointegration and causal relationships between economic growth, financial deepening, foreign direct investment, and innovation in the Chinese context.

Mtar and Belazreg (2021) also investigated causality of some indicators in the context of innovation or/and financial development, and economic growth.

Therefore, the identification of causality relationships between a country's macro indicators is a relevant issue to ground the possible impact for achieving strategic targets, economic growth, and sustainable development. At the same time, the causality links between financial and investment indicators and the level of innovation development were not determined.

The purpose of this paper is to determine the causality relationships between financial and investment indicators and the level of innovation development in GII leading countries and Ukraine.

2. METHODS

Research methodology is based on a systematic approach, analytical, statistical, comparative, correlation, regression, and causal analyses. The correlation analysis was conducted to confirm the existence of relationships between innovation development (the value of the Global Innovation Index) and the following financial and investment indicators: foreign direct investment (net inflows), domestic credit to the private sector, ease of getting credit, protecting minority investors, and real interest rate. Pearson and Spearman methods were applied considering the results of the Shapiro-Wilk test and possible time lags when correlation coefficients were significant and maximum

(Shapiro & Francia, 1972; Shapiro & Wilk, 1965; Pearson, 1896; Pearson & Filon, 1898; Spearman, 1904). Direction and strength were emphasized across the sample of countries.

To determine the causality relationships between certain indicators, the VAR modelling and Granger testing were built in STATA (Box-Steffensmeier et al., 2014; Lutkepohl, 2005; Rajbhandari, 2016; Rossi & Wang, 2019; Granger, 1969; Baum et al., 2022). Comparative analysis of results for Ukraine and leading countries in the Global Innovation Index was also conducted.

The information base was formed for a sample of 10 leading countries according to the Global Innovation Index 2022 (Switzerland, United States of America, Sweden, United Kingdom, the Netherlands, Republic of Korea, Singapore, Germany, Finland, and Denmark) and Ukraine (WIPO, 2022) for 2011–2020. The sources of statistics were the databases of INSEAD, WIPO, and the World bank (INSEAD, 2011; INSEAD & WIPO, 2012; WIPO, n.d., 2022; World Bank, n.d.a; World Bank, n.d.b; World Bank, n.d.c; World Bank, n.d.d).

The sample was formed for 2011–2020 due to the limited availability of data for the last 10 years for all studied indicators:

- the value of Global Innovation Index (GII) (INSEAD, 2011; INSEAD & WIPO, 2012; WIPO, n.d., 2022);

- foreign direct investment, net inflows (% of GDP) (FDI) (World Bank, n.d.c);

- domestic credit to the private sector (% of GDP) (DC) (World Bank, n.d.b);

- ease of getting credit (EGC) (World Bank, n.d.a);

- protecting minority investors (PMI) (World Bank, n.d.a);

- real interest rate (%) (RIR) (World Bank, n.d.d);

All calculations were made using STATA 18.

3. RESULTS AND DISCUSSION

Comparative analysis of innovation development level based on the values of the Global Innovation Index (GII) 2022 for ten leading countries in this rating and Ukraine demonstrates the significant difference in results, paying attention also to the
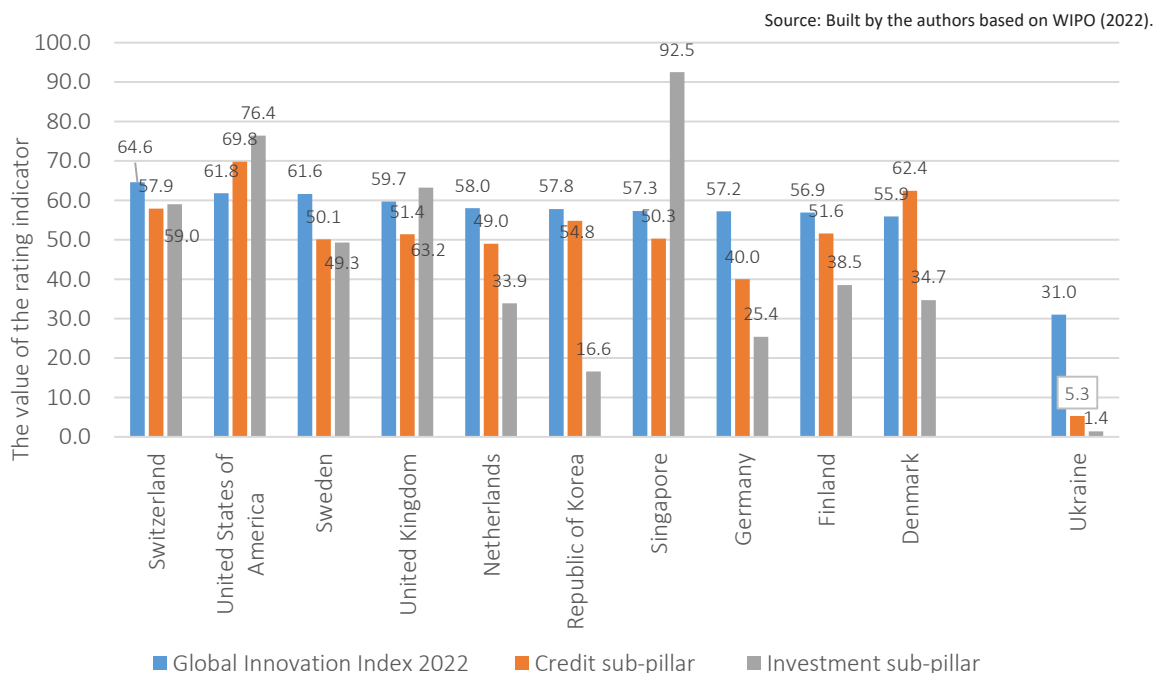
Source: Built by the authors based on WIPO (2022).

Figure 1. Comparison of the overall GII score and scores of Credit and Investment sub-pillars of GII for 10 top countries in GII and Ukraine in 2022

sub-pillars on credit and investment which involves financial indicators connected with innovation development (Figure 1).

The average value for all 132 countries included in the rating is 31,5 for the overall GII 2022score, 28,6 – for the score of Credit sub-pillar, and 18,9 – for the score of Investment sub-pillar (calculated by the authors based on (WIPO, 2022)). For Ukraine, the values of Credit and Investment sub-pillars are positioned as weaknesses. In comparison, in the United States of America, for example, Credit and Investment sub-pillars are strengths. In the United Kingdom and Singapore, the Investment sub-pillar is a strength too. And this gap between Ukraine (as other countries all over the world) and leaders is very significant.

The Shapiro-Wilk test was applied for normal data (Stata, n.d.c; Shapiro & Francia, 1972; Shapiro & Wilk, 1965). The studied data correspond to the law of normal distribution if the test result is equal or more than 0.05. The test results are given in Table 1.

If the studied data do not correspond to the law of normal distribution (the test result is less than 0.05), the Spearman method of correlation calculation will be used. In other case (normal distribution, the test result is not less than 0.05), Pearson's method of correlation calculation will be used (Stata, n.d.b, n.d.d; Pearson, 1896; Pearson & Filon, 1898; Spearman, 1904). The

results of correlation analysis to confirm the existence of relationships between innovation development and the certain financial indicators are shown in Table 2.

For this study, the following criteria for assessing the correlation between indicators were taken as a basis: $r = 0$ – no correlation; $0 < |r| \leq 0,19$ – low correlation (the relationship is not statistically significant); $0,2 < |r| \leq 0,49$ – moderate correlation; $0,5 < |r| \leq 0,79$ – high correlation; and $0,8 < |r| \leq 1$ – very high correlation.

Therefore, the relationships between innovation development and financial indicators were confirmed as follows:

1) between foreign direct investment and innovation development: in most countries (7 out of 11), there is a positive correlation with moderate or high strength and a time lag of 0-2 years;

2) between domestic credit to the private sector and innovation development: in most countries (6 out of 11), there is a positive correlation with moderate or high strength and a time lag of 0-3 years;

3) between ease of getting credit and innovation development: in most countries (6 out of 10), there is a negative correlation with moderate or high strength and a time lag of 1-3 years;

Table 1. Results of the Shapiro-Wilk test for normal data

Country	Prob>z				
	FDI	**DC**	**EGC**	**PMI**	**RIR**
Switzerland	0.34427	0.03287*	0.35240	0.37530	0.76407
United States of America	0.73079	0.02009*	n/a	0.35240	0.29870
Sweden	0.93138	0.61402	0.35240	0.12116	n/a
United Kingdom	0.00933*	0.02174*	0.35240	0.12116	0.00002*
The Netherlands	0.07392*	0.07934*	0.43597	0.18361	0.00064*
Republic of Korea	0.98365	0.01127*	0.35240	0.00571*	0.11935
Singapore	0.05129	0.59054	0.35240	0.35240	0.46459
Germany	0.31986	0.05747	0.35240	0.12116	n/a
Finland	0.21413	0.23187	0.35240	0.12116	n/a
Denmark	0.21106	0.20280	0.35240	0.12116	n/a
Ukraine	0.04512*	0.18977	0.35240	0.11106	0.31752

Note: * means the studied data do not correspond to the law of normal distribution (the test result is less than 0.05); n/a means not available due to constant data or lack of data for the time period studied for a specific country; FDI is the indicator of foreign direct investment; DC is the indicator of domestic credit to the private sector; EGC – the indicator of ease of getting credit; PMI is the indicator of protecting minority investors; and RIR is the indicator of real interest rate.

Table 2. Correlation analysis results confirming the existence of relationships between innovation development and certain financial indicators

Country	GII									
	FDI		DC		EGC		PMI		RIR	
	r	lag	r	lag	r	lag	r	lag	r	lag
Switzerland	0.41	2	0.35	1	−0.36	1	0.39	0	0.52	3
United States of America	0.20	1	0.60	0	n/a	n/a	−0.75	0	0.73	0
Sweden	0.36	0	0.39	2	−0.80	2	0.80	2	n/a	n/a
United Kingdom	−0.40	3	0.81	3	0.87	3	0.45	0	−0.79	2
The Netherlands	0.89	2	0.50	3	−0.42	3	0.43	0	−0.27	3
Republic of Korea	−0.32	2	−0.54	3	−0.91	1	0.67	1	−0.74	1
Singapore	−0.79	3	−0.63	1	0.59	0	0.59	0	−0.34	0
Germany	0.35	1	−0.90	1	−0.83	1	0.83	1	n/a	n/a
Finland	0.36	0	−0.78	1	0.64	3	−0.64	3	n/a	n/a
Denmark	0.47	1	0.42	1	0.25	1	0.50	2	n/a	n/a
Ukraine	0.61	1	−0.65	0	−0.71	3	0.72	0	−0.71	3

Note: n/a means not available due to lack of data for the time period studied for a specific country; GII is the assessment value of the Global Innovation Index; FDI is the indicator of foreign direct investment; DC is the indicator of domestic credit to the private sector; EGC is the indicator of ease of getting credit; PMI is the indicator of protecting minority investors; RIR is the indicator of real interest rate; r is correlation coefficient; lag is a time lag when the value of correlation coefficient is maximum.

4) between protecting minority investors and innovation development: in most countries (9 out of 11), there is a positive correlation with moderate or high strength and a time lag of 0-2 years;

5) between real interest rate and innovation development: in most countries (5 out of 7), there is a negative correlation with moderate or high strength and a time lag of 0-3 years.

However, to identify the causality direction, it is necessary to use VAR-modelling and Granger test.

VAR-modelling corresponds to a multivariate time series regression of each dependent variable on the lags of itself and on the lags of all other dependent variables (Stata, n.d.e; Box-Steffensmeier et al., 2014; Lutkepohl, 2005; Rajbhandari, 2016; Rossi & Wang, 2019). VAR modelling and Granger test algorithm and their interpretation, intermediate results in STATA are demonstrated in detail on the example of the first country from the sample, i.e., Switzerland. In particular, VAR modelling results are presented in Table 3.

The p-values of lag 1 of FDI, DC, EGC, PMI and RIR are significant (P>|z| is less than 0,05). And the impact on GII has been proven. R-square for the GII model (GII equation) is 0.9403 and means its adequacy. The constant for the GII model is also significant. The similar explanation is used for other equations.

After the VAR modelling, the Granger causality test is applied to detect the causality direction (Stata, n.d.a; Granger, 1969; Baum et al., 2022). The Granger test for the first country in the sample (Switzerland) is presented in Table 4.

Lagged values of FDI, DC, EGC, PMI and RIR cause the GII because the p-value is less than 0,05 (the first equation – GII). The similar explanation is used for other equations and indicators for Switzerland.

VAR modelling and Granger causality test were applied to all countries in the sample. The general results of the Granger test to determine the causality relationships between certain indicators of a country's financial policy and the level of its innovation development are presented in Table 5.

Table 3. VAR modelling on the example of the first country from the sample (Switzerland)

Equation	Parms	RMSE	R–sq	chi2	P>chi2
GII	7	.595249	0.9403*	141.8799	0.0000*
FDI	7	31.3005	0.3565	4.985815	0.5456
DC	7	.151527	0.9995*	16970.41	0.0000*
EGC	7	4.74294	0.9429*	148.5317	0.0000*
PMI	7	2.10797	0.9857*	621.1269	0.0000*
RIR	7	.568317	0.7798*	31.86417	0.0000*
	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
GII					
GII L1.	.0698571	.0996459	0.70	0.483	−.1254452 .2651594
FDI L1.	.1071394	.0134507	7.97	0.000*	.0807766 .1335023
DC L1.	.385295	.0574005	−6.71	0.000*	−.497798 −.272792
EGC L1.	.2947626	.0401308	−7.35	0.000*	−.3734174 −.2161077
PMI L1.	−.1340614	.043617	−3.07	0.002*	−.2195492 −.0485737
RIR L1.	2.934912	.3480489	−8.43	0.000*	−3.617075 −2.252748
_cons	161.4833	9.076844	17.79	0.000*	143.693 179.2736
FDI					
GII L1.	.1726608	5.239766	−0.03	0.974	−10.44241 10.09709
FDI L1.	.4846339	.7072896	−0.69	0.493	−1.870896 .9016283
DC L1.	−1.234205	3.018342	−0.41	0.683	−7.150047 4.681636
EGC L1.	−.3376733	2.110231	−0.16	0.873	−4.47365 3.798304
PMI L1.	−.1535837	2.293551	−0.07	0.947	−4.648861 4.341694
RIR L1.	22.85218	18.30176	1.25	0.212	−13.01861 58.72298
_cons	184.6869	477.2957	0.39	0.699	−750.7954 1120.169
DC					
GII L1.	.0544778	.0253659	2.15	0.032*	.0047616 .1041941
FDI L1.	.0293137	.003424	−8.56	0.000*	−.0360247 −.0226028
DC L1.	.3180594	.0146119	21.77	0.000	.2894206 .3466982
EGC L1.	.0704809	.0102157	6.90	0.000*	.0504585 .0905033
PMI L1.	.2603281	.0111032	23.45	0.000*	.2385663 .2820899
RIR L1.	1.093194	.0885995	12.34	0.000*	.9195426 1.266846
_cons	92.1392	2.310605	39.88	0.000*	87.61049 96.6679
EGC					
GII L1.	2.919383	.7939773	3.68	0.000*	1.363216 4.47555
FDI L1.	.5408367	.107175	5.05	0.000*	.3307775 .7508958
DC L1.	−3.227833	.4573668	−7.06	0.000*	−4.124256 −2.331411
EGC L1.	.6585885	.3197615	−2.06	0.039	−1.28531 −.0318675
PMI L1.	−.2501366	.3475399	−0.72	0.472	−.9313022 .431029
RIR L1.	−15.51576	2.773251	−5.59	0.000*	−20.95124 −10.08029
_cons	512.2792	72.32421	7.08	0.000*	370.5264 654.032
PMI					
GII L1.	1.297503	.3528788	−3.68	0.000*	−1.989133 −.6058737
FDI L1.	−.2403718	.0476333	−5.05	0.000*	.3337315 −.1470122
DC L1.	1.434593	.2032741	7.06	0.000*	1.036183 1.833003
EGC L1.	.1517384	.1421162	−1.07	0.286	−.4302811 .1268043
PMI L1.	.1111718	.1544622	0.72	0.472	−.1915685 .4139121
RIR L1.	6.895895	1.232556	5.59	0.000*	4.48013 9.31166
_cons	119.9019	32.14409	−3.73	0.000*	−182.9031 −56.9006
RIR					
GII L1.	−.1512036	.0951374	−1.59	0.112	−.3376695 .0352623
FDI L1.	−.1512036	.0951374	−1.59	0.112	−.0728534 −.0225132
DC L1.	.1270448	.0548035	2.32	0.020*	.019632 .2344576
EGC L1.	−.0034652	.0383151	−0.09	0.928	−.0785613 .071631
PMI L1.	.0539356	.0416436	−1.30	0.195	−.1355555 .0276843
RIR L1.	1.286161	.3323016	3.87	0.000	.6348619 1.93746
_cons	8.991273	8.666166	−1.04	0.299	−25.97665 7.994099

Note: * means the obtained value of the indicator or coefficient is significant; GII is the assessment value of the Global Innovation Index; FDI is the indicator of foreign direct investment; DC is the indicator of domestic credit to the private sector; EGC is the indicator of ease of getting credit; PMI is the indicator of protecting minority investors; and RIR is the indicator of real interest rate.

Table 4. Granger test using the example of the first country in the sample (Switzerland)

Equation	Excluded	chi2	df	Prob > chi2
GII	FDI	63.447	1	0.000*
	DC	45.056	1	0.000*
	EGC	53.95	1	0.000*
	PMI	9.447	1	0.002*
	RIR	71.107	1	0.000*
	ALL	116.34	5	0.000
FDI	GII	.00109	1	0.974
	DC	.1672	1	0.683
	EGC	.02561	1	0.873
	PMI	.00448	1	0.947
	RIR	1.5591	1	0.212
	ALL	4.6057	5	0.466
DC	GII	4.6125	1	0.032*
	FDI	73.294	1	0.000*
	EGC	47.6	1	0.000*
	PMI	549.73	1	0.000*
	RIR	152.24	1	0.000*
	ALL	1708.4	5	0.000
EGC	GII	13.52	1	0.000*
	FDI	25.465	1	0.000*
	DC	49.807	1	0.000*
	PMI	.51802	1	0.472
	RIR	31.302	1	0.000*
	ALL	58.514	5	0.000
PMI	GII	13.52	1	0.000*
	FDI	25.465	1	0.000*
	DC	49.807	1	0.000*
	EGC	1.14	1	0.286
	RIR	31.302	1	0.000*
	ALL	120.57	5	0.000
RIR	GII	2.5259	1	0.112
	FDI	13.787	1	0.000*
	DC	5.374	1	0.020*
	EGC	.00818	1	0.928
	PMI	1.6775	1	0.195
	ALL	27.798	5	0.000

Note: * means that the lagged value of the investigated indicator (Excluded) causes the result indicator (Equation) (p-value is less than or equal to 0,05); GII is the assessment value of the Global Innovation Index; FDI is the indicator of foreign direct investment; DC is the indicator of domestic credit to the private sector; EGC is the indicator of ease of getting credit; PMI is the indicator of protecting minority investors; and RIR is the indicator of real interest rate.

Thus, it was proven that changes in the value of foreign direct investment (inflows) are the reason for changes in the value of the Global Innovation Index in 6 out of 11 countries. In 4 out of 11 countries, changing the value of the Global Innovation Index causes the change in the value of the indicator of foreign direct investment (inflows). And only in Ukraine there is bidirectional Granger causality.

Changes in the value of the indicator of domestic credit to the private sector are responsible for the changes in the value of the Global Innovation

Index in 6 out of 11 countries. In 3 out of 11 countries, changes in the value of the Global Innovation Index cause the changes in the value of the indicator of domestic credit to the private sector. And there is bidirectional Granger causality is 2 countries, namely, Germany and Switzerland.

The indicator of ease of getting credit is a reason for the changes in the value of the Global Innovation Index only in Switzerland (bidirectional Granger causality). And in 4 out of 11 countries, the changes in the value of the Global Innovation Index

Table 5. General results of the Granger test to determine the causality relationships between certain indicators of a country's financial policy and the level of its innovation development

Country	FDI	DC	EGC	PMI	RIR
Switzerland	FDI → GII FDI → DC FDI → EGC FDI → PMI FDI → RIR	DC ↔ GII DC ↔ EGC DC ↔ PMI DC ↔ RIR	EGC ↔ GII	PMI ↔ GII	RIR → GII RIR → EGC RIR → PMI
United States of America	FDI → GII	DC → GII DC ↔ FDI	–	PMI ←GII PMI → FDI PMI → DC PMI → RIR	RIR ↔ FDI RIR ↔ DC
Sweden	–	DC → GII DC → FDI DC → EGC	EGC ← GII	–	–
United Kingdom	–	DC → GII DC → EGC DC → RIR	–	–	RIR → GII RIR ↔ EGC
The Netherlands	FDI ← GII FDI → DC FDI → EGC FDI → PMI FDI → RIR	DC → RIR	EGC ↔ DC EGC → RIR	PMI ←GII PMI ↔ DC PMI ↔ EGC PMI → RIR	RIR ←GII
Republic of Korea	FDI ← GII	DC → FDI	EGC ← GII EGC ↔ FDI	PMI → GII PMI → FDI PMI → DC PMI → EGC	RIR → FDI
Singapore	FDI → GII FDI → DC	DC → EGC	EGC ← GII	–	RIR → EGC
Germany	FDI ↔ GII	DC ↔ GII DC → FDI	–	PMI ↔ DC	–
Finland	–	DC → GII DC → EGC	–	–	–
Denmark	FDI → GII FDI → DC	DC ← GII	EGC ↔ DC	–	–
Ukraine	FDI ↔ GII FDI → DC FDI → EGC	DC → FDI DC ↔ PMI	EGC → DC EGC → RIR	PMI → FDI PMI → DC	RIR ←GII RIR → FDI RIR ↔ DC RIR → EGC RIR → PMI

Note: → is causality direction; GII is the assessment value of the Global Innovation Index; FDI is the indicator of foreign direct investment; DC is the indicator of domestic credit to the private sector; EGC is the indicator of ease of getting credit; PMI is the indicator of protecting minority investors; and RIR is the indicator of real interest rate.

cause the changes in the value of the indicator of ease of getting credit.

The indicator of protecting minority investors is a cause of changing the value of the Global Innovation Index in 2 out of 11 countries. Reverse causality is in two countries in the sample. And there is bidirectional Granger causality in Switzerland.

The indicator of real interest rate is a cause of changing the value of the Global Innovation Index in 2 out of 11 countries. And reverse causality exists in two countries of the sample.

Also, among them, causality links were identified for financial and investment indicators (Table 5) to understand the possibilities of impacting financial indicators and innovation development in general.

Summarizing the results of both the regression-correlation analysis and the Granger test, it is substantiated that the volume of foreign direct investment inflows and domestic credit to the private sector should be increased to increase the level of innovation development. Accordingly, the inverse positive effect of improving innovation development on financial indicators in the state has been proven too.

Co-integrating relationship between financial development, innovation, and economic growth based on the experience of 49 European countries was confirmed by Pradhan et al. (2018), who explained financial development as causative factors of economic growth, but not in relation to innovation development as in this study.

Paz and Fontaine (2018) explored causality in the context of innovation policy. Their constructive approach was based on Bayesian statistics and involved 11 tests on the cause-and-effect mechanism. At the same time, their study focuses exclusively on political innovation only in Colombia, covering the importance of treasury processes. And in this study, the financial and investment factors examined are broader and cover more countries.

Causality links between financial development, innovation, and economic growth based on data from OECD countries were analyzed by Mtar and Belazreg (2021). The authors establish cause-and-effect relationships between three important macro-elements, but the article concludes primarily about the importance of regulating financial systems and improving the quality of financing to promote economic development. They also confirmed the hypothesis about the neutrality between financial development and innovation. Instead, the obtained results of the current study confirm the causality of individual financial and investment indicators and their direct and positive impact on the innovative development.

Islam et al. (2018) showed the causal relationships between innovation, foreign direct investment, financial deepening, and economic growth based on the ARDL bounds test for cointegration and Granger causality VECM. The authors also recommended improving the financial system to increase the potential for innovative development through direct foreign investment. But they made their conclusions based only on China's case, while in this study, the sample involves 11 countries.

At the same time, some limitations of the results obtained may be related to the sample of countries. In further research, it is advisable to expand the panel of countries and include not only the 10 leaders in innovation development (and Ukraine), but also other countries from the Global Innovation Index rating that are less influential in this direction.

CONCLUSIONS

The purpose of the paper was to determine the causality relationships between financial and investment indicators and the level of innovation development in GII leading countries and Ukraine. The results both of the regression-correlation analysis and the Granger test showed that foreign direct investment inflows (positive relationship in 7 out of 11 countries with moderate/high strength and a time lag of 0-2 years; a cause of GII – in 6 out of 11 countries, including bidirectional causality in Ukraine) and domestic credit to the private sector (positive relationship in 6 out of 11 countries with moderate/high strength and a time lag of 0-3 years; a cause of GII – in 6 out of 11 countries) are the reasons for increasing the level of innovation development and have potentially the highest influence. Protecting minority investors and real interest rate have a third less impact. And the ease of getting credit is a cause of changing the value of GII only in Switzerland. Accordingly, the inverse positive effect of improving innovation development on financial and investment indicators in the state has also been proven. In Ukraine, compared to GII leading countries, only the factor of foreign direct investment inflows was identified as a cause of innovation development. The factors of domestic credit to the private sector and ease of getting credit were not confirmed as a causal factor for Ukraine over the time period studied.

Therefore, it is recommended to shift the emphasis of state policy towards increasing the volume of foreign direct investment inflows and domestic credit to the private sector to increase the level of innovation development. These strategic directions should be reflected in programs to support foreign investors and domestic creditors, including tools for improving the national legal framework, preferential tax tools, etc.

The results obtained have some limitations related to the selected sample of countries and the period studied. In further research, it is advisable to expand the panel of countries and include not only the 10 leaders in innovation development (and Ukraine), but also other countries from the Global Innovation Index rating that are less influential in this direction. In further research, it is planned to formalize and numerically evaluate the impact of selected indicators of financial policy (foreign direct investment inflows and domestic credit to the private sector) on the level of innovation development through regression modeling and the construction of an econometric model.

AUTHOR CONTRIBUTIONS

Conceptualization: Olena Dobrovolska, Ralph Sonntag.
Data curation: Olena Dobrovolska, Olha Hubaryk, Tetiana Savanchuk.
Formal analysis: Ralph Sonntag, Olha Hubaryk.
Investigation: Olena Dobrovolska, Tetiana Savanchuk.
Methodology: Olena Dobrovolska, Svitlana Kachula.
Project administration: Ralph Sonntag, Svitlana Kachula.
Supervision: Olena Dobrovolska, Olha Hubaryk.
Validation: Olena Dobrovolska, Tetiana Savanchuk.
Visualization: Svitlana Kachula , Olha Hubaryk, Tetiana Savanchuk.
Writing – original draft: Olena Dobrovolska, Olha Hubaryk, Tetiana Savanchuk.
Writing – review & editing: Olena Dobrovolska, Ralph Sonntag, Svitlana Kachula, Olha Hubaryk, Tetiana Savanchuk.

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