Tiutiunyk, I., Drabek, J., Antoniuk, N., Navickas, V., & Rubanov, P. (2021). The impact of digital transformation on macroeconomic stability: Evidence from EU countries. *Journal of International Studies, 14*(3), 220-234. doi:10.14254/2071-8330.2021/14-3/14

Journal of International Studies

The impact of digital transformation on macroeconomic stability: Evidence from EU countries

Inna Tiutiunyk
Department of Finance and Entrepreneurship, Sumy State University, Ukraine
i.karpenko@finance.sumdu.edu.ua
ORCID 0000-0001-5883-2940

Josef Drabek
Faculty of Wood Sciences and Technology
Technical University in Zvolen, Slovakia
josef.drabek@tuzvo.sk
ORCID 0000-0001-6855-6919

Nataliia Antoniuk
Department of Finance and Entrepreneurship, Sumy State University, Ukraine
n.antoniuk@finance.sumdu.edu.ua
ORCID 0000-0001-8610-3219

Valentinas Navickas
Alexander Dubcek University of Trencin, Trencin, Slovakia
valentinas.navickas@ktu.lt
ORCID 0000-0002-7210-4410

Pavlo Rubanov
Department of Finance and Entrepreneurship, Sumy State University, Ukraine
p.rubanov@finance.sumdu.edu.ua
ORCID 0000-0002-9415-8786

Abstract. The article deals with investigating the role of digital transformation in achieving competitive advantages of the economy. The paper identifies the benefits and risks of the digital transformation for macroeconomic stability of the economy. The comparison of the average level of the digital transformation and indicators of macroeconomic stability of EU countries for the period 2001–2020 allowed the authors to distinguish clusters of countries by the nature and direction of the relationship between the analyzed indicators. The results of VAR

Received: February, 2021
1st Revision: June, 2021
Accepted: September, 2021

DOI: 10.14254/2071-

modelling on the example of EU countries proved the relationship between the level of digitalization of the economy and indicators of its macroeconomic stability. The paper simulates the responses of macroeconomic stability parameters to single and accumulated shocks of digital transformation. The results show the bidirectional causality between the digital transformation of the economy and indicators of its macroeconomic stability. The findings of the study are beneficial for authorities to form competitive advantages of the economy and its sustainable development.

8330.2021/14-3/14

Keywords: macroeconomic stability, digital transformation, competitive advantages, sustainable development, financial innovation

JEL Classification: H20, H71, F49, K34

1. INTRODUCTION

Transformational processes in the economy, one of the manifestations of which is the COVID-19 pandemic, exacerbate the existing problems of the economic development of countries and only increase their negative impact on indicators of macroeconomic stability. In the context of COVID-19, in most countries, the need to transform models of doing business through the implementation of online economic transactions has become urgent. At the same time, the implementation of these processes required, in addition to the appropriate IT support, a certain level of knowledge and skills of working in the information environment, both among consumers and business entities. Digitalization is large-scale, and affects the areas from individuals' lifestyle and micro-business activity till large enterprises functioning and state police regulation. Today, the EU countries have developed and adopted many legislative documents that regulate the processes of digitalization of the economy at both individual entities and the country level. International organizations, governments of individual countries are guided by the provisions defined in The Digital Europe Program, Digital Education Action Plan, 2030 Digital Compass: the European way for the Digital Decade, and others. However, most developing countries were unprepared for these challenges, which had many economic (significant decline in GDP, business bankruptcy (especially SMEs)) and social (deterioration of living standards, social security) effects. The businesses of most countries with a low level of digital literacy are not ready to quickly reorient their activities to an online format. This has led to significant economic losses at both the micro and macro levels. This situation highlighted the need to minimize the gap between the existing and necessary for the stable development of the economy levels of digital development of all economic entities and increase their readiness to operate with the digital technologies.

2. LITERATURE REVIEW

Macroeconomic stability of the countries constitutes a constant search for ways to achieve the desired level of their economic growth, which implies a high economic potential for financing programs and activities, brings up and holds its position within the world. Some scientists consider macroeconomic stability as the ability to quickly adjust to market turbulence, changes in business conditions, crises in the economy through combinations of economic and managerial measures. This contributes to achieving competitive advantages in investing and starting a business in the country. In this sense, governments seek to identify specific properties and combinations of instruments and state programs that increase their economic stability.

Today there is a significant amount of papers exploring the role of digital transformation of the economy in the macroeconomic stability of the country. Nowadays, there is no unified understanding of the link between the digitalization of the economy and the indicators of its macroeconomic stability. According to the results of the paper's analysis, it can be concluded that the diffusion of digital innovation in the economy has a lot of manifestations (Shkarlet et al., 2020; Bilan et al., 2019; Wolnicki and Piasecki, 2019; Vasilyeva et al., 2021; Novikov, 2021; Skrynnyk, 2020). Lyon (1996) considers the digitalization of the economy as a new stage in the historical development of society, which is the result of the second industrial revolution and is based mainly on microelectronic technology. Kozubikova and Kotaskova (2019) concluded the significant role of digital innovation in the efficiency of public administration and their huge influence on its social development indicators. A similar opinion has Miller (1986), who claimed that digital innovations are one of the most important ingredients for economic progress. Countries that implement digital innovation can produce financial instruments aimed at minimizing or transferring financial risks.

According to Bacik et al. (2020), Cwiklicki and Wojnarowska (2020), Karaoulanis and Karaoulanis (2020), Kaya (2021), Mokhtar et al. (2020), the digitalization of the economy changes economic relations, the process of production, exchange, distribution, and consumption, affecting the economic policy of the government, the strategy of economic development of the state, and its economic security. Sekhar (2013) claimed that the higher level of digital innovation activity of the country is, the higher levels of its macroeconomic stability are. According to the author's calculations in the context of digitalization of the economy, a significant share of gross domestic product is provided by activities for the production, processing, storage, and transmission of information and knowledge.

The digitalization of the economy has a significant impact on the development of the country's financial market. Thus, Basri (2018), Redda et al. (2017), Njegovanović (2018), Brychko et al. (2021) argued that the active use of digital technologies has a significant impact on the share of non-cash payments, contributes to the diversification of financial services, the development of online and mobile banking in the country.

A direct link between the digitalization of the economy and the stability of the financial sector was proved by Bhatt (1989). Based on empirical calculations, the author proved the impact of digitalization of the economy on the level of risk in the country's financial market, the degree of diversifying investments.

In general, digital transformation of the economy influence the level of GDP (Chou and Chin, 2011; Vasylieva et al., 2020; Obeid et al., 2020; Melnyk et al., 2018; Tiutiunyk et al., 2021), the competitive advantage of business (Bondarenko et al., 2020; Petroye et al., 2020; Chigrin and Pimonenko, 2014), its investment potential (Kliestik et al., 2020; Zolkover and Georgiev; 2020; Kotenko & Bohnhardt; 2021; Kuzmenko et al., 2020), indicators of its financial (Kuek et al., 2021; Leonov et al., 2019) and labor (Smiianov et al., 2020; Didenko et al., 2021) markets, ecology security (Vasylieva et al., 2019; Lyeonov et al., 2019) etc.

Frolov and Lavrentyeva (2019), Kolosok et al. (2018), Lopez and Alcaide (2020), Vasilyeva et al. (2020), Skvarciany et al. (2021), Vorontsova et al. (2020); Lyeonov et al. (2021) emphasized the significant role of digitalization in the effectiveness of public policy. The link between the digitalization and the social and ecological development of the country was investigated by Didenko et al. (2020), Petrushenko et al. (2020), Pimonenko et al. (2021), Samusevych et al. (2021).

Thus, according to the Press Releases of Gartner, the results of the companies that have implemented artificial intelligence in their business in turnovers over the last four years is increased by 270%. According to Eurostat, the share of European companies that sell their products through e-commerce in 2016 reached 20%. At the same time, this indicator varies significantly in terms of countries and types of enterprises by size. Thus, in 2016, the highest share of companies involved in e-commerce was in Ireland, Denmark, Germany, Belgium, the Netherlands, Sweden, and the Czech Republic (over 25%), and the lowest (less than 10%) - in Latvia, Bulgaria and Romania. According to the report of the International Federation of Robotics, the robotics market is forecasted to grow by 175% over the next decade. However, at the same time, the

effects of digital transformation are not always positive. First of all, despite the significant advantages of introducing digital technologies in the activities of economic entities in developed countries, for developing countries today there are some undeniable strengths and certain barriers. Thus, while creating new jobs digitalization destroys or changes existing ones (workforce) greatly increasing the necessity for professional labor. It results in becoming jobless by many people and leading to inequality in wages. Moreover, the more governments and businesses rely on digital technologies the more they become vulnerable to attack, which brings up a threat of cyber terrorism. Furthermore, low indicators of economic development of developing countries and the lack of financial resources form the preconditions for determining the latest raw material bases for the leading countries. Digital processes and transformation within economic and financial sectors provide the intensive increase of shadow transactions. Everything mentioned above is just some challenges developing countries will have to face during their attempts at digitalization. Given that the production of most goods and services in a pandemic is impossible without digital resources it would be appropriate to analyze the statistical significance between macroeconomic stability and the level of digitalization of the country.

Some authors argue that the digitalization of the economy leads to financial malpractice, increasing the level of the shadow economy and reducing the level of macroeconomic stability in the country (Brychko, 2019; Koibichuk et al., 2021; Limba et al., 2020; Lydeka and Karaliute, 2021; Kobushko et al., 2021; Papík and Papíková, 2021; Bilan et al., 2020b; Samoilikova et al., 2021; Lyulyov et al., 2021). Authors based on indicators of the development of the banking sector substantiated the link between the growth of the banking sector and its fragility and level of digitalization of the economy. At the same time, the authors emphasized the existence of a two-way relationship between the indicators. The level of economic development of the country determines the degree of spread of digital technologies in the economy. Countries with higher GDP growth rates, financial and investment potentials tend to have a higher level of digitalization of the economy.

It should be noted that our previous studies focus mainly on a more general analysis of indicators of macroeconomic stability of the countries in the context of economic and social determinants of its achievement. The analysis concludes that some economic indicators (tax revenues, tax rates, the level of shadow economy) harm the macroeconomic stability of the country and achieving its economic sustainable goals. Lyeonov et al. (2021), based on OLS and GMM estimators for 32 countries, conclude a positive and significant relationship between global growth opportunities of a country and a higher level of financial innovation.

At the same time, a considerable amount of our paper is devoted to the investigation of the digitalization of the economy and its impact on the indicators of economic and development of EU countries.

This paper aims to investigate the link between macroeconomic stability and the level of the digitalization of the economy based on the hypothesis about the linear relationship between these indicators.

3. METHODOLOGY

Given that the level of readiness of individual countries for digitalization differs significantly, the issues of ensuring the comparability of indicators between individual countries are relevant to conduct an interstate comparative analysis of the digitalization of the economy of these countries. Existing studies demonstrate attempts to conduct such an intergovernmental analysis, but most of them are based on individual indicators (Afonasova et al., 2019), which complicates the qualitative interpretation of the results, providing a generalized assessment and ranking of countries according to the relevant criteria. Instead, using the index method or the method of integrated assessment helps to avoid these shortcomings and to conduct a

comparative assessment of the degree of development of certain economic phenomena in different countries.

Comparative analysis of the theoretical basis for assessing the level of digitalization of the economy (Biegun and Karwowski, 2020; Roszko-Wójtowicz and Grzelak, 2020; Zolkover and Renkas, 2020; Yarovenko et al., 2021) testified that the simplest and most effective way to accumulate information about the country's digital transformation is to use international indices developed by leading rating agencies. One of the most popular indexes is the Digital Evolution Index (DEI). This index provides a comprehensive assessment of the level of the digital transformation for 90 economies based on 160 indicators into four key drivers: Supply Conditions, Demand Conditions, Institutional Environment, and Innovation and Change. The calculation of this index is based on 35 aspects of digitalization.

In addition to international indices that directly characterize the level of digitalization of the economy, there are a significant number of indices, some sub-indices of which reflect the level of digitalization of the economy. Systematization of indices that reflect the level of digitization of the economy is carried out in table 1.

Table 1

Indexes of Digital Transformation of economy

	Sub-index	**Source**
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)	DESI is a composite index that summarizes relevant indicators on digital performance and tracks the evolution of countries in digital competitiveness. Includes 6 index groups: Connectivity, Human Capital/Digital Skills, Use of Internet, Integration of Digital Technology, Digital Public Services, Research and Development ICT	European Commission
Financial Development Index (FDI)	FDI is aggregate of the Financial Institutions index (Financial Institutions Depth index, Financial Institutions Access index, Financial Institutions Efficiency index) and the Financial Markets index (Financial Markets Depth index, Financial Markets Access index, Financial Markets Efficiency index)	International Monetary Fund
Global Innovation Index (GII)	The Global Innovation Index is based on 80 indicators within these categories: political environment, education, infrastructure and business sophistication.	Cornell University, the World Intel-lectual Property Organization
Digital Competitiveness Index (DCI)	Knowledge (Talent Training and Education Scientific Concentration), Technology (Regulatory Framework Capital Technological Framework) and Future Readiness (Adaptive Attitudes Business Agility IT Integration).	World Competitiveness Center
Digital Evolution Index (DEI)	Supply Conditions, Demand Conditions, Institutional Environment, and Innovation and Change	Tufts University
ICT Development Index (ICTDI)	ICT readiness (reflecting the level of networked infrastructure and access to ICTs); ICT intensity (reflecting the level of use of ICTs in the society); ICT impact (reflecting the results/outcomes of more efficient and effective ICT use).	International Telecommunication Union

*Source***:** developed by the authors based on Cisco Corporate Affairs, European Commission, International Monetary Fund, Cornell University, INSEAD, The World Intellectual Property Organization, World Competitiveness Center, Tufts University, International Telecommunication Union data

The Digital Transformation Index will be estimated by the following formula:

$$DTI = w_{DRS} \times DRS + w_{DESI} \times DESI + w_{FDI} \times FDI + w_{GII} \times GII + w_{DCI} \times DCI + w_{DEI} \times DEI + w_{ICTDI} \times ICTDI \quad (1)$$

where, w_i – a weighting coefficient of sub-index *i*.

The weighting coefficients for sub-indices will be performed using the Fishburne formula.

Table 2

Weighting coefficients for sub-indices of Digital Transformation Index

	The rank	**Weighting coefficient**
Digital Readiness Score (DRS)	1,50	0,232143
Digital Economy and Society Index (DESI)	5,00	0,107143
Financial Development Index (FDI)	7,00	0,035714
Global Innovation Index (GII)	3,50	0,160714
Digital Competitiveness Index (DCI)	3,50	0,160714
Digital Evolution Index (DEI)	1,50	0,232143
ICT Development Index (ICTDI)	6,00	0,071429

Source: developed by the authors.

The assessment of the level of macroeconomic stability of the country will be carried out using a model of the pentagon of macroeconomic stability "Macroeconomic stabilization Pentagon". This model is one of the most common in assessing the level of macroeconomic stability (Lyulyov et al., 2021) because it most fully achieves the goals of public policy to stabilize the country's economic development.

This model was developed by the director of the Institute of Finance in Warsaw, Professor of Economics Kolodko G. W. (1993) as a response to the need to stabilize the economy under the influence of internal and external imbalances. The basis for building this model is to consider 5 key indicators that characterize certain components of economic development:

$$MSP = [(\text{GDP} \times U) + (U \times \text{IR}) + (\text{IR} \times \text{SBB}) + (\text{SBB} \times CA) + (CA \times \text{GDP})] \times \text{k} \quad (2)$$

where GDP is the level of GDP growth; U – unemployment rate; IR – inflation rate; SBB – state budget balance to GDP; CA – current account; $k = 1/2 \sin 72°$

Graphical interpretation of the obtained results is carried out using a pentagon, the vertices of which reflect the stability of individual indicators of macroeconomic stability. The area of the pentagon reflects the overall level of macroeconomic stability of the country.

All information and data appearing in the article correspond to 2001-2020. They were obtained through Cisco Corporate Affairs, European Commission, International Monetary Fund, Cornell Uni-versity, INSEAD, The World Intel-lectual Property Organization, World Competitiveness Center, Tufts University, International Telecommunication Union data.

The practical implementation of the proposed approach to the analysis of the link between the level of digitalization of the economy and the level of macroeconomic stability was carried out based on statistics for EU countries: Croatia, Germany, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.

The selection of such a sample of countries and the study period is due to the limited statistical data for calculating the digital transformation index and level of macroeconomic stability.

4. EMPIRICAL RESULTS AND DISCUSSION

According to the results of the analysis conducted in Table 3, the levels of macroeconomic stability and digitalization of economies have different rates of change. Most indicators are characterized by significant variability in their values. The levels of macroeconomic stability of the country are characterized by the greatest variability. During the period 2001-2020, the lowest levels of macroeconomic stability were in the Netherlands (20.15) and Romania (25.64). Significant fluctuations in the levels of macroeconomic stability of countries indicate the lack of effective and consistent policy to achieve a high level of macroeconomic stability of the country. Spain, Germany and Poland, as countries with high annual GDP growth rates, showed the best levels of macroeconomic stability.

In contrast to macroeconomic stability, the index of digitalization of the economy is characterized by greater stability. Sweden (35.91) and Germany (38.96) have the highest values, while the Netherlands (30.10) and Slovenia (29.85) have the lowest Index of Digital Transformation.

Table 3

Descriptive statistics of variables for the period from 2001 to 2020

	Variable	Mean	Std. Dev.	Max	Min
Croatia	MEC	30.47	5.12	40.90	24.50
	DTI	31.74	2.41	33.85	28.96
Germany	MEC	41.98	6.48	56.78	31.78
	DTI	36.54	1.98	38.96	34.38
Netherlands	MEC	27.85	5.96	36.98	20.15
	DTI	28.25	1.94	30.10	26.85
Poland	MEC	41.01	8.32	55.70	31.24
	DTI	36.17	2.17	34.26	29.04
Portugal	MEC	31.44	6.85	37.89	28.22
	DTI	35.06	2.23	32.96	37.95
Romania	MEC	30.95	7.05	35.98	25.64
	DTI	33.28	1.96	35.96	30.25
Slovakia	MEC	32.74	6.95	38.98	27.41
	DTI	31.07	1.25	33.69	28.96
Slovenia	MEC	34.96	6.72	40.85	26.84
	DTI	27.85	1.03	29.85	26.24
Spain	MEC	40.25	5.47	47.98	32.52
	DTI	30.42	1.57	32.65	28.74
Sweden	MEC	38.65	7.98	46.52	30.87
	DTI	31.62	2.08	35.91	29.12

Source: Authors' calculations

The correlation between the macroeconomic stability and the Digital Transformation Index is carried out by the Ordinary Least Squares method. The results showed the link between the indicators of macroeconomic stability and the Digital Transformation Index in terms of EU countries. Most results are statistically significant at 0.05%. For all EU countries, the link between the level of macroeconomic stability and the Digital Transformation Index has been confirmed. The correlation between MEC and GE is presented in table 4.

Table 4

OLS test for MEC and DTI

	Value	Statistic	cons
Croatia	Critical Value	3.7132	2.7845
	Prob.	3.4688**	0.7034*
Germany	Critical Value	2.3545	2.2407
	Prob.	0.5396*	0.1214**
Netherlands	Critical Value	2.3940	1.9560
	Prob.	0.5700**	0.1661**
Poland	Critical Value	1.2644	1.1277
	Prob.	0.2416**	0.0979**
Portugal	Critical Value	0.7811	3.2391
	Prob.	0.2873*	0.4216**
Romania	Critical Value	0.8275	2.7696
	Prob.	0.5288***	0.6869*
Slovakia	Critical Value	0.4534	0.7795
	Prob.	0.3013***	0.6986**
Slovenia	Critical Value	1.0765	3.1126
	Prob.	0.0860**	0.2020**
Spain	Critical Value	2.5156	6.4705
	Prob.	1.1526**	2.0056**
Sweden	Critical Value	0.9789	3.1861
	Prob.	0.3761	0.5731

Source: Authors' calculations

The link between the macroeconomic stability and the Digital Transformation Index can be estimated by checking the all-time series for stationarity using the Dickey-Fuller test. The findings in table 4 allowed rejecting the hypothesis of stationary of most indicators. Thus, the absolute value is less than the critical value at 1%, 5%, and 10% levels of significance. The study of stationarity of all-time series based on the Dickey-Fuller test is shown in table 5. The absolute value of MEC for Croatia (0.0089) is less than the critical value that indicates the non-stationarity of the analyzed indicators. The results of using the Philips Perron Test reject the null of stationary of time series for all countries at the 1%, 5%, and 10% levels of significance.

Table 5

Dickey-Fuller test

	Variables	ADF Test Statistics*			Philips Perron Test Statistics		
		Prob.	lag	Test statistic	Prob.	lag	Test statistic
Croatia	MEC	0.0089	1	-2.9198**	0.0089	1	-2.9198**
	DTI	0.0633	1	-2.3078**	0.6097	0	-0.9436
Germany	MEC	0.8260	0	0.0897	0.8260	1	0.0897
	DTI	0.0001	1	-3.9608**	0.0001	1	-3.9608***
Netherlands	MEC	0.3603	2	-1.4693*	0.4227	2	-1.3488
	DTI	0.0067	3	-2.9984**	0.0362	2	-2.5018**
Poland	MEC	0.0734	2	-2.2522*	0.0400	2	-2.4676**
	DTI	0.8410	2	0.4017	0.8410	2	0.4017
Portugal	MEC	0.0244	1	-2.6283**	0.0171	1	-2.7351*
	DTI	0.1289	1	-2.0249**	0.1199	1	-2.0556**
Romania	MEC	0.0002	2	-3.8275**	0.0278	2	-2.5873
	DTI	0.0007	2	-3.5403***	0.0007	1	-3.5403**
Slovakia	MEC	0.0141	1	-2.7915**	0.3633	1	-1.4633
	DTI	0.0094	3	-2.9061**	0.3253	3	-1.5385

Slovenia	MEC	0.1970	2	-1.8257	0.1970	2	-1.8257*
	DTI	0.6163	2	-0.9274	0.0089	2	-0.9274
Spain	MEC	0.7436	2	-0.5163	0.7784	1	-0.3393
	DTI	0.7811	3	-0.3222	0.7837	2	-0.3060
Sweden	MEC	0.3393	3	-1.5103	0.3613	3	-1.4667
	DTI	0.5292	4	-1.1300	0.6494	4	-0.8393

Source: Authors' calculations

Since all series are nonstationary, and there may be a cointegration relationship between them. To select a model of the relationship between the macroeconomic stability and Digital Transformation Index we will test the hypothesis of the cointegration of data series by Johansen tests. The data in Table 6 indicate the co-integration of the analyzed data series. For all EU countries, the absolute values for 0 rank are more critical. For example, for Poland, the trace statistic (24.0t2) is more than 5% (15.41) and 1% critical value (20.04). It means that the series of variables MEC and DT are non-stationary and allows to accept the hypothesis of co-integration of the data series.

Table 6

Johansen tests for cointegration

	Rank	**5% critical value**	**1% critical value**	**Trace statistic**
Croatia	0	15.41	20.04	28,853
	1	3.76	6.65	8,345
Germany	0	15.41	20.04	25,703
	1	3.76	6.65	8,115
Netherlands	0	15.41	20.04	14,163
	1	3.76	6.65	1,655
Poland	0	15.41	20.04	13,613
	1	3.76	6.65	1,451
Portugal	0	15.41	20.04	37,819
	1	3.76	6.65	10,938
Romania	0	15.41	20.04	33,690
	1	3.76	6.65	10,636
Slovakia	0	15.41	20.04	18,564
	1	3.76	6.65	2,169
Slovenia	0	15.41	20.04	17,844
	1	3.76	6.65	1,902
Spain	0	15.41	20.04	27,496
	1	3.76	6.65	7,953
Sweden	0	15.41	20.04	24,494
	1	3.76	6.65	7,733

Source: Authors' calculations

The data in Table 6 indicate the causality of the data series with high statistical significance. That is, increasing the level of digitalization of the economy could increase the level of macroeconomic stability of the country, and conversely, reducing the level of macroeconomic stability could increase the level of digitalization of the economy. The stationary and the cointegration of the data series indicate the causality expediency of build the VAR model of the relationship between the level of digitalization of the economy and macroeconomic stability.

To determine the optimal lag structure in the VAR model, we use tests for maximum lag and exclusion. According to the tests for maximum lag and exclusion the maximum lag for Croatia is 2 years, Poland – 2

years, Slovakia – 3 years. The Akaike, Hannan-Quinn, Schwarz Bayesian criteria for the VAR model are shown in Table 7.

Table 7

The Akaike, Hannan-Quinn, Schwarz Bayesian criteria for VAR model

Lag	LL	LR	df	p	FPE	AIC	HQOC	SBIC
Croatia								
0	87.52		25		1.2e-12	-36.25	-36.45	-36.95
1	.	.	25		-1.1e-74*	-102.32	-110.36	-114.25
2	1458.36	.	25	0.985	.	-265.25*	-277,55*	-275,26*
3	1462.32	-9.874	25	0.478	.	-231.25	-236,21	-233,22
4	1458.21	7.859	25	0.857	.	-189.24	-177,09	-174,71
5	1452.27	21.589	25	-	.	-98.51	-99,96	-98,67
6	1468.32	15.658	25	-	.	-87.58	-87,86	-86,58
Germany								
0	102.32		25		3.2e-14	-20,45	-20,80	-20,48
1	452.32	1548.4	25	0.000	1.1e-63*	-132,45	-134,53	-132,62
2	689.32	1325.1*	25	0.125	.	-268,63	-271,05	-268,83
3	1125.32	9.854	25	0.756	.	-269,90*	-272,32*	-270,10*
4	1365.58	-11.256	25	.	.	-268,20	-270,62	-268,40
5	1587.74	12.546	25	0.912	.	-250,12	-252,54	-250,32
6	1598.96	1.325	25	.	.	-219,71	-222,13	-229,90

Source: Authors' calculations

The results of the assessment allow us to build a VAR model that confirms the existence of a link between the level of macroeconomic stability and the Digital Transformation Index in EU countries. To visualize the responses of the model parameters to single and accumulated shocks of the Digital Transformation Index we build a graph of single shocks (Figure 1).

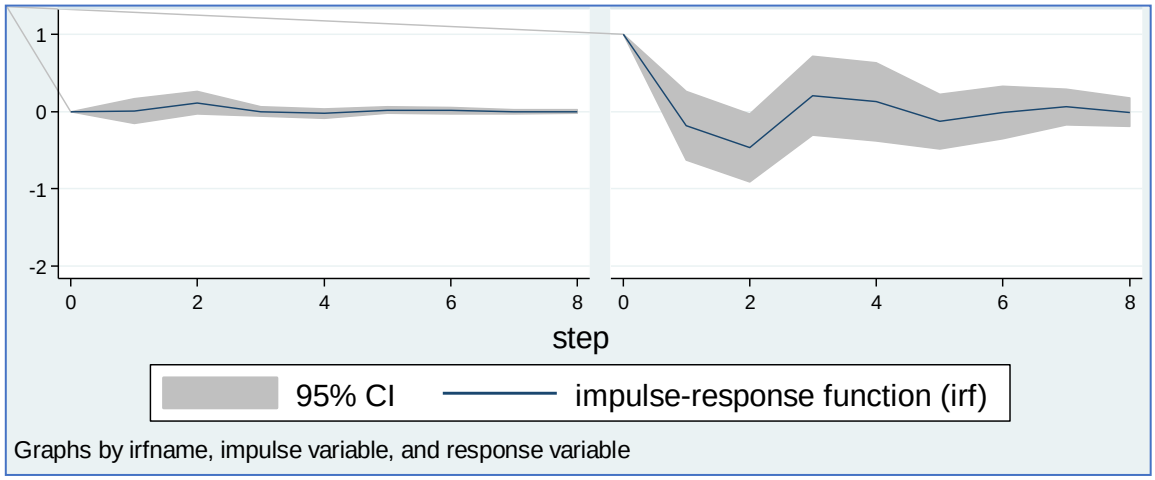

Figure 1. Impulse function of the macroeconomic stability to the shocks of the Digital Transformation Index

Source: Authors' calculations

The simulation results showed the sensitivity of the macroeconomic stability of the analyzed countries to the shocks of the Digital Transformation Index. Thus, the obtained results confirm the importance of implementing measures aimed at increasing the level of digitalization of the economy as a prerequisite for increasing its macroeconomic stability.

5. CONCLUSION

The study shows that there is a statistically significant link between the level of macroeconomic stability and the Digital Transformation Index for the majority of EU countries. Considering the important role of digital transformation in doing business, the correlation between them indicates, on the one hand, the relationship between the economic and technical development of the country, and on the other hand, can serve as a tool of prediction of the level of the macroeconomic stability. Based on the put forward hypothesis, an approach was proposed to estimate the Digital Transformation Index, based on the set of international indexes.

Thus, the results of the analysis indicate the necessity to consider the level of digitalization of the economy in the process of developing a methodological toolkit for increasing the level of the macroeconomic stability of the country.

Despite the current limitation of the sample size for some countries it is impossible to make general and fundamental conclusions. However, the reasons for the significant differences in the obtained results and the results of research conducted by scientists using other methods of assessing the level of macroeconomic stability are not analyzed in more detail.

Secondly, we do not consider the fact that for some factors an average correlation can be increasingly caused by the similarity of tendencies regarding the changes in these indicators, but not by the close relationship between them.

The aim of further research may be to define the tightness and nature of the relationship between the level of business competitive advantages and the Digital Transformation Index.

ACKNOWLEDGEMENT

This research was funded by the grant "Quadrocentric recursive model of de-shadowing of Ukraine's economy for growth of its macroeconomic stability" (0120U104798, funding – National Research Foundation, 2020-2021). This research was supported by the Ministry of education, science, research and sport of the Slovak Republic [grant VEGA 1/0689/20 Digital economy and changes in the education system to reflect labour market demands].

REFERENCES

Afonasova, M. A., Panfilova, E. E., Galichkina, M. A., & Ślusarczyk, B. (2019). Digitalization in Economy and Innovation: The Effect on Social and Economic Processes. *Polish Journal of Management Studies*, *19*(2), 22-32. http://doi. org/10.17512/pjms.2019.19.2.02

Bacik, R., Gavurova, B., Fedorko, R., & Olearova, M. (2020). Using Digital Devices in the Online Shopping: a Study of Demographic Differences. *Marketing and Management of Innovations*, *4*, 154-167. http://doi.org/10.21272/mmi.2020.4-12

Basri, S. (2018). Determinants of Adoption of Mobile Banking: Evidence from Rural Karnataka in India. *International Journal Trade and Global Markets*, *11*(1/2), 77-86. http://doi. org/10.1504/IJTGM.2018.092490

Bhatt, V. V. (1989). Financial Innovation and Credit Market Development. WPS52. Washington, DC: World Bank.

Biegun, K., & Karwowski, J. (2020). Macroeconomic imbalance procedure (MIP) scoreboard indicators and their predictive strength of multidimensional crises. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *15*(1), 11-28. https://doi.org/10.24136/eq.2020.001

Bilan, Y., Tiutiunyk, I., Lyeonov, S., & Vasylieva, T. (2020). Shadow economy and economic development: A panel cointegration and causality analysis. *International Journal of Economic Policy in Emerging Economies*, *13*(2), 173-193. doi:10.1504/IJEPEE.2020.107929

Bilan, Y., Vasilyeva, T., Kryklii, O., & Shilimbetova, G. (2019). The creative industry as a factor in the development of the economy: Dissemination of european experience in the countries with economies in transition. [Kūrybinė

industrija kaip ekonomikos plėtros veiksnys: Europietiškosios patirties sklaida pereinamojo laikotarpio ekonomikos šalyse] *Creativity Studies, 12*(1), 75-101. doi:10.3846/cs.2019.7453

Bondarenko, A. F., Zakharkina, L. S., Syhyda, L. O., & Saher, L. Y. (2020). The economic and marketing attractiveness of countries: Measurement and positioning in terms of economic security. *International Journal of Sustainable Development and Planning*, *15*(4), 439-449. doi:10.18280/ijsdp.150404

Brychko, M., Bilan, Y., Lyeonov, S., & Mentel, G. (2021). Trust crisis in the financial sector and macroeconomic stability: A structural equation modelling approach. *Economic Research-Ekonomska Istrazivanja*, *34*(1), 828-855. doi:10.1080/1331677X.2020.1804970

Brychko, M., Polách, J., Kuzmenko, O., & Olejarz, T. (2019). Trust cycle of the finance sector and its determinants: The case of Ukraine. *Journal of International Studies*, *12*(4), 300-324. doi:10.14254/2071-8330.2019/12-4/20

Chigrin, O., & Pimonenko, T. (2014). The ways of corporate sector firms financing for sustainability of performance. *International Journal of Ecology and Development, 29*(3), 1-13.

Chou, Y., & Chin, M. (2011). Financial innovations and endogenous growth. *Journal of Economics and Management*, *25*(2), 25-40.

Cwiklicki, M., & Wojnarowska, M. (2020). Circular economy and industry 4.0: One-way or two-way relationships? *Engineering Economics*, *31*, 387 https://doi.org/10.5755/j01.ee.31.4.24565

Didenko, I., Volik, K., Vasylieva, T., Lyeonov, S., & Antoniuk, N. (2021). Environmental migration and country security: Theoretical analysis and empirical research. Paper presented at the E3S Web of Conferences, , 234 doi:10.1051/e3sconf/202123400010

Didenko, I., Volik, K., Vasylieva, T., Lyeonov, S., & Antoniuk, N. (2020b). Migration, environment, and country safety: Analysis of touchpoints. Paper presented at the E3S Web of Conferences, 202 p. doi:10.1051/e3sconf/202020203028

European Commission (2020). European Innovation Scoreboard 2020. Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_1150

Frolov, D., & Lavrentyeva, A. (2019). Regulatory Policy for Digital Economy: Holistic Institutional Framework. *Montenegrin Journal of Economics*, *14*(4), 33-44. doi: 10.14254/1800-5845/2019.15-4.3

Karaoulanis, A., & Karaoulanis, A. C. (2020). Information and Communication Technology in Organizational Operations. Ethical and Operational Implications. *Business Ethics and Leadership*, 4**(**4), 6-13. doi: https://doi.org/10.21272/bel.4(4).6-13.2020

Kaya, H. D. (2021). How Does The Use Of Technology In Entrepreneurial Process Affect Firms' Growth? *SocioEconomic Challenges*, 5(1), 5-12. doi: https://doi.org/10.21272/sec.5(1).5-12.2021

Kliestik, T., Valaskova, K., Lazaroiu, G., Kovacova, M., & Vrbka, J. (2020). Remaining Financially Healthy and Competitive: The Role of Financial Predictors. *Journal of Competitiveness*, *12*(1), 74-92.

Kobushko, I., Tiutiunyk, I., Kobushko, I., Starinskyi, M., & Zavalna, Z. (2021). The triadic approach to cash management: Communication, advocacy, and legal aspects. *Estudios De Economia Aplicada*, *39*(7) doi:10.25115/eea.v39i7.5071

Koibichuk, V., Ostrovska, N., Kashiyeva, F., & Kwilinski, A. (2021). Innovation Technology and Cyber Frauds Risks of Neobanks: Gravity Model Analysis. *Marketing and Management of Innovations*, *1,* 253-265. doi: http://doi.org/10.21272/mmi.2021.1-19

Kolodko, G. W. (1993). Stabilization, recession and growth in a postsocialist economy. MOST: Most: Economic *Journal on Eastern Europe and the Soviet Union*, *3*(1), 3-38.

Kolosok, S., Dementov, V., Korol, S., & Panchenko, O. (2018). Public policy and international investment position in european integration of ukraine. *Journal of Applied Economic Sciences*, 13(8), 2375-2384.

Kotenko, N., & Bohnhardt, V. (2021). Digital health projects financing: challenges and opportunities. *Health Economics and Management Review, 2*(1), 100-107. https://doi.org/10.21272/hem.2021.1-10

Kozubikova, L, & Kotaskova, A. (2019). The Impact of Technological Factors on the Quality of the Business Environment. *Transformations in Business and Economics*, *1*(46), 95-108.

Kuek, T. H., Puah, C. H., Arip, M. A., & Habibullah, M. S. (2021). Macroeconomic perspective on constructing financial vulnerability indicator in China. *Journal of Business Economics and Management*, *22*(1), 181-196. https://doi.org/10.3846/jbem.2020.13220

Kuzmenko, O., Šuleř, P., Lyeonov, S., Judrupa, I., & Boiko, A. (2020). Data mining and bifurcation analysis of the risk of money laundering with the involvement of financial institutions. *Journal of International Studies, 13*(3), 332-339. doi:10.14254/2071-8330.2020/13-3/22

Leonov, S., Yarovenko, H., Boiko, A., & Dotsenko, T. (2019). Information system for monitoring banking transactions related to money laundering. Paper presented at the CEUR Workshop Proceedings, *2422*, 297-307. Retrieved from https://www.scopus.com/record/display.uri?eid=2-s2.0-85071081226&origin=resultslist

Limba, L., Driaunys, K., Kiskis, M., & Sidlauskas, A. (2020). Development of Digital Contents: Privacy Policy Model under the General Data Protection Regulation and User-Friendly Interface. *Transformations in Business and Economics*, 19(1), 133-154

Lopez, B. S., & Alcaide, A. V. (2020). Blockchain, AI and IoT to Improve Governance, Financial Management and Control of Crisis: Case Study COVID-19. *SocioEconomic Challenges, 4*(2), 78-89.

Lydeka, Z., & Karaliute, A. (2021). Assessment of the Effect of Technological Innovations on Unemployment in the European Union Countries. *Engineering Economics*, *32*(2), 130-139. doi:https://doi.org/10.5755/j01.ee.32.2.24400

Lyeonov, S., Pimonenko, T., Bilan, Y., Štreimikiene, D., & Mentel, G. (2019). Assessment of green investments' impact on sustainable development: Linking gross domestic product per capita, greenhouse gas emissions and renewable energy. *Energies, 12*(20) doi:10.3390/en12203891

Lyeonov, S., Vasilyeva, T., Bilan, Y., & Bagmet, K. (2021). Convergence of the institutional quality of the social sector: The path to inclusive growth. *International Journal of Trade and Global Markets, 14*(3), 272-291. doi:10.1504/IJTGM.2021.115712

Lyon, D. (1996). Information society: problems and illusions. *Modern foreign social philosophy*, 362–380.

Lyulyov, O., Lyeonov, S., Tiutiunyk, I., & Podgórska, J. (2021). The impact of tax gap on macroeconomic stability: Assessment using panel VEC approach. *Journal of International Studies*, *14*(1), 139-152. doi:10.14254/2071-8330.2021/14-1/10

Lyulyov, O., Paliienko, M., Prasol, L., Vasylieva, T., Kubatko, O., & Kubatko, V. (2021). Determinants of shadow economy in transition countries: Economic and environmental aspects. *International Journal of Global Energy Issues, 43*(2-3), 166-182. Retrieved from https://www.scopus.com/record/display.uri?eid=2-s2.0-85106862529&origin=resultslist

Melnyk, L., Sineviciene, L., Lyulyov, O., Pimonenko, T., & Dehtyarova, I. (2018). Fiscal decentralization and macroeconomic stability: The experience of ukraine's economy. *Problems and Perspectives in Management, 16*(1), 105-114. doi:10.21511/ppm.16(1).2018.10

Miller, M. H. (1986). Financial Innovation: The Last Twenty Years and the Next. *Journal of Financial Quantitive Analysis*, *21*(4), 459-471. https://doi.org/10.2307/2330693

Mokhtar, S. S. S., Mahomed, A. S. B., Aziz, Y. A., & Rahman, S. Ab. (2020). Industry 4.0: the importance of innovation in adopting cloud computing among SMES in Malaysia. *Polish Journal of Management Studies*, *22*(1), 310-322.

Njegovanović, A. (2018). Digital Financial Decision with a View of Neuroplasticity / Neurofinancy / *Neural Networks. Financial Markets, Institutions and Risks*, 2(4), 82-91. doi: https://doi.org/10.21272/fmir.2(4).82-91.2018

Novikov, V.V. (2021). Digitalization of Economy and Education: Path to Business Leadership and National Security. *Business Ethics and Leadership*, 5(2), 147-155. https://doi.org/10.21272/bel.5(2).147-155.2021

Obeid, H., Hillani, F, Fakih, R., & Mozannar, K. (2020). Artificial Intelligence: Serving American Security and Chinese Ambitions. *Financial Markets, Institutions and Risks*, 4(3), 42-52. https://doi.org/10.21272/fmir.4(3).42-52.2020

Papík, M., & Papíková, L. (2021). Application of selected data mining techniques in unintentional accounting error detection. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *16*(1), 185–201. doi: https://doi.org/10.24136/eq.2021.007

Petroye, O., Lyulyov, O., Lytvynchuk, I., Paida, Y., & Pakhomov, V. (2020). Effects of information security and innovations on Country's image: Governance aspect. *International Journal of Safety and Security Engineering, 10*(4), 459-466. doi:10.18280/ijsse.100404

Petrushenko, Y., Vadym, A., Vorontsova, A., & Ponomarenko, O. (2020). Sustainable development goals as a tool for strategic planning in communities: A bibliometric analysis of research. Paper presented at the E3S Web of Conferences, 202. doi:10.1051/e3sconf/202020203005

Pimonenko, T., Us, Y., Lyulyova, L., & Kotenko, N. (2021). The impact of the macroeconomic stability on the energy-efficiency of the european countries: A bibliometric analysis. Paper presented at the E3S Web of Conferences, 234 doi:10.1051/e3sconf/202123400013

Redda, E. H, Surujlal, J., & Leendertz, V. (2017). Internet Banking Service Quality in South Africa: a Qualitative Analysis of Consumer Perceptions. *International Journal of Trade and Global Markets*, *10*(1), 67-74. doi: http://doi.org/10.1504/IJTGM.2017.082373

Roszko-Wójtowicz, E., & Grzelak, M. M. (2020). Macroeconomic stability and the level of competitiveness in EU member states: A comparative dynamic approach. *Oeconomia Copernicana*, *11*(4), 657-688. doi:10.24136/OC.2020.027

Samoilikova, A., Lieonov, S., & Huseynova, A. (2021). Tax Incentives for Innovation in the Context of Macroeconomic Stability: an Analysis of Causality. *Marketing and Management of Innovations*, 1, 135-157. http://doi.org/10.21272/mmi.2021.1-11

Samusevych, Y., Vysochyna, A., Vasylieva, T., Lyeonov, S., & Pokhylko, S. (2021). Environmental, energy and economic security: Assessment and interaction. Paper presented at the E3S Web of Conferences, 234. doi:10.1051/e3sconf/202123400012

Sekhar, S. (2013). Theorems and Theories of Financial Innovation: Models and Mechanism Perspective. *Financial and Quantitative Analysis*, *1*(2), 26-30. doi:10.12966/fqa.05.02.2013

Shkarlet, S., Oliychenko, I., Dubyna, M., Ditkovska, M., & Zhovtok, V. (2020). Comparative analysis of best practices in e-Government implementation and use of this experience by developing countries. *Administratie si Management Public*, *34*, 118-136. doi:10.24818/amp/2020.34-07

Skrynnyk, O. (2020). Surrogate Leadership Model for Digital Organizational Systems. *Business Ethics and Leadership, 4*(4), 140-146. https://doi.org/10.21272/bel.4(4).140-146.2020

Skvarciany, V., Lapinskaite, I., & Volskyte, G. (2021). Circular economy as assistance for sustainable development in OECD countries. *Oeconomia Copernicana*, *12*(1), 11–34. doi: https://doi.org/10.24136/oc.2021.001

Smiianov, V. A., Vasilyeva, T. A., Chygryn, O. Y., Rubanov, P. M., & Mayboroda, T. M. (2020). Socio-economic patterns of labor market functioning in the public health: challenges connected with COVID-19. *Wiadomosci Lekarskie (Warsaw, Poland: 1960)*, *73*(10), 2181-2187. Retrieved from https://www.scopus.com/record/display.uri?eid=2-s2.0-85098244490&origin=resultslist

Tiutiunyk, I., Humenna, Yu., & Flaumer, A. (2021). Covid-19 impact on business sector activity in the EU countries: digital issues. *Health Economics and Management Review, 2*(1), 54-66. https://doi.org/10.21272/hem.2021.1-06

Vasilyeva, T., Bilan, S., Bagmet, K., & Seliga, R. (2020). Institutional development gap in the social sector: cross country analysis. *Economics and Sociology*, *13*(1), 271-294. doi:10.14254/2071-789X.2020/13-1/17

Vasilyeva, T., Kuzmenko, O., Kurylowicz, M., & Letunovska, N. (2021). Neural network modeling of the economic and social development trajectory transformation due to quarantine restrictions during covid-19. *Economics and Sociology, 14*(2), 313-330. doi:10.14254/2071-789X.2021/14-2/17

Vasylieva, T., Jurgilewicz, O., Poliakh, S., Tvaronavičienė, M., & Hydzik, P. (2020). Problems of measuring country's financial security. *Journal of International Studies*, *13*(2), 329-346. doi:10.14254/2071-8330.2020/13-2/22

Vasylieva, T., Lyulyov, O., Bilan, Y., & Streimikiene, D. (2019). Sustainable economic development and greenhouse gas emissions: The dynamic impact of renewable energy consumption, GDP, and corruption. *Energies, 12*(17) doi:10.3390/en12173289

Vorontsova, A., Vasylieva, T., Bilan, Y., Ostasz, G., & Mayboroda, T. (2020). The influence of state regulation of education for achieving the sustainable development goals: Case study of central and eastern European countries. *Administratie Si Management Public, 2020*(34), 6-26. doi:10.24818/amp/2020.34-01

Wolnicki, M., & Piasecki, R. (2019). The New Luddite Scare: The Impact of Artificial Intelligence on Labor, Capital and Business Competition between US and China. *Journal of Intercultural Management*, *11*(2), 5-20. doi: https://doi.org/10.2478/joim-2019-0007

World Bank (2020). *World development indicators*, World Bank. Retrieved from: https://data.worldbank.org/indicator.

Yarovenko, H., Bilan, Y., Lyeonov, S. & Mentel, G. (2021). Methodology for assessing the risk associated with information and knowledge loss management. *Journal of Business Economics and Management*, *22*(2), 369-387. doi:10.3846/jbem.2021.13925

Zolkover, A. & Renkas, J. (2020). Assessing the level of macroeconomic stability of EU Countries. *SocioEconomic Challenges*, *4*(4), 175-182. doi: https://doi.org/10.21272/sec.4(4).175-182.2020

Zolkover, A., & Georgiev, M. (2020). Shadow investment activity as a factor of macroeconomic instability. *Financial Markets, Institutions and Risks, 4*(4), 83-90. doi: https://doi.org/10.21272/fmir.4(4).83-90.2020