

## Shadow economy and financial stability from the perspective of finance digitalization

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**Abstract.** Digital financial technologies create a basis for forming new concepts for studying the prerequisites for the emergence of the shadow economy, the search for mechanisms to counteract illicit financial flows, and ensuring financial stability in the country. The article aims to assess the degree of connections between the shadow economy, financial stability and finance digitalization using the principles of cognitive modelling. The empirical study proved that the current status of development of digital finance and financial strength in Ukraine is sufficient for

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a significant reduction of shadow operations in the economy, namely to the level of 14.43% of GDP, which is 55.8% less compared to the average annual value for the period 2005-2021 years. It is advisable to implement a set of measures aimed at increasing the volume of the cashless economy; reducing non-performing loans; optimization of banking infrastructure; encouraging citizens to use online banking; reduction in the level of fictitious direct investments.

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## 1. INTRODUCTION

About a quarter of the world's GDP is in the shadow today. The overall share of shadow activity in the world economy steadily decreased thanks to innovative digital solutions for monitoring the movement of funds at the transnational level and exchanging information about financial transactions within the framework of the cooperation of national regulators and international organizations in the pre-Covid period. However, Covid-19 caused a sharp drop in GDP and a significant increase in the unemployment rate, resulting in a record growth rate of the shadow economy in the EU countries in 2020, namely 9.8 times more than in 2019 (Schneider, 2022).

The issue of counteracting the shadowing of the national economy remains one of the key challenges for the stable development of the country today, as it provokes a decrease in tax revenues to state funds, distorts market competitive connections between economic agents, promotes the development of informal employment, and leads to the ineffective functioning of the budget system on at all levels, which causes the underfunding of socially necessary budget expenditures and the growth of social tension in society. Despite the declaration by many governments of measures of the unshadowing national economy, an increase in the volume of the shadow economy was recorded in 39 of the 144 analysed countries of the world during the decade (2008-2017), while during the five years (2017-2021) there were already 62 countries with a positive increase in the shadow economy. Thus, shadow processes are intensively rooted in the system of economic connections in countries, which implies the need to develop a complex of financial and economic measures, improve the work of law enforcement and judicial bodies, as well as a radical change in the collective consciousness in society regarding toleration of manifestations of illegal activity in the country. Reliable institutions provide the necessary protection against corruption and confiscation of private property (Berdiev et al., 2016; Vyas-Doorgapersad, 2022).

The excessive level of the shadow economy makes the country's financial system vulnerable. Albulescu et al. (2016) claim that a high level of financial stability means better access to various forms of financing, the attraction of private investment resources and funds of international organizations. On the other hand, a decrease in financial stability can provoke a reduction in the total volume of income and difficulty in accessing financial resources. As a result, economic agents will tend to develop informal activities, avoid paying taxes and operate in the shadow sector of the economy (Kuzmenko et al., 2023). In addition, the consequences of illegal economic activity can be seen in the growth of unexpected credit losses, exchange rate volatility, allocation of funds by the central bank to support certain financial institutions, etc. In addition, the financial sector can be considered as a mechanism for restraining the pace and reducing the volume of illegal financial transactions in the country by establishing limits on the use of cash and restrictions on its use for certain transactions, requirements for the borrower's creditworthiness for obtaining a new or

extending an existing loan, and limits for making non-cash payments by both citizens and business entities, etc. The government and the central bank can implement a financial policy to monitor tax evasion (Blackburn et al., 2012). In addition, the stable development of the financial system creates prerequisites for overcoming poverty in the country (Kozmenko et al., 2014) and reducing social tension (Bilan et al., 2019).

Digitalization is a driver of modern development, which helps increase the transparency of public administration (Mynenko et al., 2022; Rahmanov et al., 2023) and improve business processes at the company level (Kartanaitė et al., 2021). The development of digital financial technologies increases the speed of financial transactions and creates conditions for stable and secure transactions (Pazarbasioglu et al., 2020). The expansion of digital financial services also increases the share of the unbanked population in formal banking services, thereby diversifying market risks and contributing to the financial sector's stability. At the same time, accumulating a significant array of data on financial transactions and using artificial intelligence technologies for their analysis allows qualitative monitoring of the sources of funds' origin and directions of use. Thus, digital financial technologies create a basis for forming new concepts for studying the prerequisites for the emergence of the shadow economy, the search for mechanisms to counteract informal economic connections, and ensuring financial stability in the country.

## 2. LITERATURE REVIEW

A bibliographic analysis was conducted to define the landscape of scientific publications on this issue. The international scientometric database Scopus from Elsevier was chosen as the source of bibliographic data for this study. For the analysis of scientific publications devoted to the issues of the shadow economy and financial stability in the context of digital financial transformations, a twenty-year period was chosen, divided into smaller periods: I period – 2003-2007 (the impact of digitalization on the sphere of financial connections is minimal); II period – 2008-2012 (the beginning of fintech development, the appearance of the first cryptocurrencies and new technologies, such as P2P, electronic wallets); III period – 2013-2017 (exponential growth of the Fintech payment segment, development of venture capital investment); IV period – 2018-2022 (growth of new technologies BaaS, PaaS, IaaS, development of cloud technologies, development of altcoins). Various terms are used to characterize the shadow economy (illegal economy, underground economy, parallel economy, informal economy) in the English-language scientific literature, which we considered when searching for scientific publications on this topic.

Table 1

Search results for scientific publications in specific areas, indexed in the Scopus database

Search query	Number of publications (units)				
	2003-2007	2008-2012	2013-2017	2018-2022	In total
"Shadow economy" OR "Illegal economy" OR "Informal economy" OR "Underground economy" OR "Parallel economy"	402	862	1430	1985	4379
"Finan* stab*" AND Digit* OR Tech* OR Electron* OR Cyber*	51	96	202	618	967
"Shadow economy" OR "Illegal economy" OR "Informal economy" OR "Underground economy" OR "Parallel economy" AND Digit* OR Tech* OR Electron* OR Cyber*	19	74	160	369	626

*Source:* own elaboration

Table 1 indicates that 4,379 scientific publications related to issues of the shadow economy have been published over the past two decades. Despite many years of scientific work on this topic, studying the issues of the shadow economy constantly grows in each of the analyzed five-year periods. In particular, 1,985 publications indexed by the Scopus scientometric database were published during 2018-2022, which is 38.8% and 130.3% more compared to 2013-2017 and 2008-2012, respectively.

Researchers from the USA (897 publications or 20.5% of the total volume) and Great Britain (753 publications or 17.2%) study mostly the issues of the shadow economy in the world. At the same time, Sheffield University Management School (178 publications), the University of Sheffield (101 publications), Johannes Kepler University Linz (89 publications), University of Johannesburg (57 publications), London School of Economics and Political Science (45 publications) are the main scientific centers whose researchers examine issues of the shadow economy. The most prominent scholars who study the shadow economy are Williams C.C. (Sheffield University Management School, UK), who published 215 publications indexed by the Scopus database, and Schneider F. (Johannes Kepler University Linz, Austria) – 81 publications.

The shadow economy has a significant negative impact in the short term, which is reflected in an increase in the tax burden on economic entities operating in the legal field. However, the shadow economy also has a positive effect on economic growth in the long run; in fact, when it is a means of survival for the poor (Medina et al., 2021).

Bilan et al. (2020) proved the presence of causal connections between the shadow economy and social, political and economic consequences in the economy. In particular, the growth of the share of shadow economic connections leads to a decrease in the investment attractiveness of the country and the inflow of direct and capital foreign investments (Bilan, Vasylieva et al. 2019; Tiutiunyk, Cieśliński et al., 2022), growing income inequality and unemployment (Mishchuk et al., 2018; Remeikiene & Gaspareniene, 2021).

The development of shadow connections in the country results from low material or criminal responsibility for committing illegal acts and the lack of effective control by law enforcement and judicial bodies (Tiutiunyk & Kozhushko, 2022). The high level of the tax burden and inefficient tax administration contribute to the search for mechanisms to evade the payment of taxes and other mandatory charges (Lyulyov et al., 2021; Bello et al., 2022; Muharremi et al., 2022).

The second search query aims to identify publications devoted to financial stability issues in the context of digital change. 967 scientific works were published in the publications included in the scientometric database Scopus during 2003-2022, while 64% were printed during the last five years. It allows us to claim that the development of digital information technologies has sharpen the situation around the issue of ensuring the country's financial stability. The paper empirically proves that an increase in the share of Internet users has a positive and statistically significant effect on the country's economic growth (Melnyk et al., 2021).

The rapid growth of information technologies and the increase in the scale of venture capital investment have transformed the traditional models of commercial banks and forced financial institutions to optimize their costs, look for non-traditional sources of income and cooperate with fintech companies to develop innovative financial products or improve business processes. The growth of innovative fintech technologies is associated with the growth of the volume of transactions with derivatives on stock exchanges and other trading platforms (Novak et al., 2021; Baltgailis et al., 2022).

According to Khattak et al. (2023), digital transformation will cause changes in the internal and external environment of commercial banks. Changes in the external environment are associated with the appearance of new non-bank participants in the financial services market, which leads to increased competition and the involvement of fintech companies' technologies by banking institutions. Digital transformation also occurs inside the bank through the implementation of advanced modern technologies (artificial intelligence,

blockchain, big data, cloud computing technologies, etc.) by banks (Khattak et al., 2023). However, the technologization of the financial sector not only has a positive effect on the development of the financial sector and economic growth but also causes negative consequences. Easier access to credit resources leads to an increase in the volume of non-performing loans. In contrast, excessive use of fintech technologies increases digital risks such as data theft, failures in payment systems, etc. (Vives, 2019).

The growing number of cyberattacks on financial institutions is one of the main challenges of financial digitization (Kuzmenko et al., 2021). According to data from IBM Security X-Force, in 2021, about a quarter of all cyber victims fell in the financial sphere. Using the algorithm of associative rules based on the Eurobarometer survey, a phase portrait of a potential victim of a cyberattack was developed (Vasilyeva et al., 2022). The work recommends using a trend-cyclic additive model with a fading trend for forecasting cyber attacks on network infrastructure (Kuzior et al., 2022).

The improvement of financial transaction methods and the rapid development of the cryptocurrency market leads to an increase in the frequency of the use of the services by financial institutions in the legalization of criminal proceeds (Kuzmenko et al., 2020). Under these conditions, managers of financial institutions need to implement public initiatives and help clients to understand their role in the fight against money laundering (Patel et al., 2023).

Therefore, digital transformation will determine the future of companies and the direction of anti-crisis tools in their management strategies (Gurbanov et al., 2022; Straková et al., 2022).

The third search query is focused on the study of the impact of digitalization on the pace of development of the shadow economy. The number of publications in this direction grows exponentially with each period, 85% of scientific works on this topic were published during the last decade (2013-2017 and 2018-2022).

It has been empirically proven in several scientific works (Haruna et al., 2022; Silalahi, 2022; Boitan et al., 2023) that digitalization contributes to the shadow economy's spread rate, regardless of the country's economic development level. To avoid these outcomes, measures aimed at developing the state regulatory system are implemented (Vasilyeva et al., 2023), including those connected with increasing civil servants' digital skills (Bilan et al., 2023).

The practice of many parts of the world shows that the decrease in the volume of cash transactions and the increase in non-cash payments leads to a proportional reduction in the size of the shadow economy (Erns & Young, 2018). Specialists of the consulting company ATKearney&VISA (2017) have determined that if non-cash payments grow by 10% annually for five years, this will allow an additional accumulation of 1.2 trillion US dollars, which is commensurate with the size of the Canadian economy. And that is why national financial regulators are introducing measures to stimulate cashless payments (Oliinyk et al., 2020) and similar approaches to control the possible corruption schemes (Al-Naser & Hamdan (2021). In particular, the National Bank of Ukraine uses many new methods to expand the toolkit of non-cash money issuance (credit windows, short-term refinancing of banks secured by government securities in a pawnshop loan) (Dobrovolska et al., 2021).

The paper assesses the long-term connection between the development of digital finance, the shadow economy and financial stability in the example of South Asian countries using cointegration regression models. It has been established that financial digitization contributes to the reduction of the share of the shadow economy in GDP. However, excessive use of mobile and ATM cash transactions in developing countries contributes to the instability of the financial sector by increasing the percentage of non-performing loans and the ratio of bank loans to deposits (Syed et al., 2021).

### 3. METHODOLOGY

This study aims to assess the degree of connections between the shadow economy, financial system stability, and financial digitalization. It is proposed to use cognitive modeling to achieve this goal. The cognitive approach is a process of modeling the behavioral patterns of complex systems in response to environmental changes based on analysing factors that quantitatively and qualitatively characterize the state of this system. The specificity of cognitive modeling methods application is that the strength and direction of the influence of factors on the object of management are determined, considering the similarities and differences in the power of various factors on the object of management (Lebid, 2015). It is the volume of the shadow economy to GDP, while three groups of indicators are proposed as:

- 1st group – indicators characterizing the indirect participation of financial institutions in illegal activities;
- 2nd group – indicators reflecting the state of financial digitization;
- 3rd group – indicators for characterizing the country's financial stability.

The list of indicators and their notations is presented in Table 2. It contains several relative indicators that were previously determined based on primary data: the level of economy dollarization (the ratio of the volume of deposits of residents and non-residents in foreign currency to the money supply (monetary aggregate M3), the average annual volatility of the exchange rate (the ratio of the standard deviation of the value of the national currency in US dollars for a given period before the analyzed period); the level of fictitious direct investments (the ratio of the volume of incoming and outgoing flows of direct foreign investments, the initiator or recipient of which is a country from the offshore zone to the GDP of the country, %) (Lionov et al., 2019).

Table 2

Independent variables			Source
Shadow economy	SE	Shadow economy to GDP, %	Schneider et al. (2007)
Participation of financial institutions in servicing the shadow economy	CASH	The ratio of cash (M0) to GDP	National Bank of Ukraine (NBU)
	CLP	The ratio of non-cash card transactions to the total number of transactions	NBU
	DOL	The level of economy dollarization *	NBU
	F_FDI	Level of fictitious direct investment, % of GDP*	NBU
Financial digitalization	ATM	Number of ATMs per 100,000 adults	NBU
	TER	Number of payment terminals per 100,000 adults	NBU
	BRN_C	Number of commercial bank branches per 100,000 adults	NBU
	PMT	Volume of private money transfers through bank accounts and international payment systems, % of GDP	NBU
	DEP_A	Number of deposit accounts per 1,000 adults	NBU
	LOAN_A	Number of loan accounts with all microfinance institutions per 1,000 adults	IMF
	DBT_C	Number of debit cards per 1,000 adults	IMF
	CRD_C	Number of credit cards per 1,000 adults	IMF
	ONL_B	Share of citizens using online banking	IMF
NVT	Bitcoin Network value to transactions ratio	Blockchain	
Financial stability	ROA	Return on assets, % (risk of profitability)	NBU
	RCA	Norm of sufficiency (adequacy) of regulatory capital (liquidity risk)	NBU
	NPL	Share of non-performing loans, % (credit risk)	NBU
	GDP	Change in real GDP, % to the previous year (macroeconomic risk)	NBU
	LIQ	Short-term liquidity standard (capital risk)	NBU
	EXR	Average annual exchange rate volatility* (currency risk)	NBU

Source: own elaboration

\* calculation indicators

The proposed scientific and methodological approach to evaluating the system of connections in the chain “shadow economy – finance digitalization – financial stability” involves the implementation of the following stages:

- definition of a set of factors (indicators) that affect the object of management – the shadow economy;
- factors determination that have a statistically significant connection with the object of management;
- building a cognitive map to identify the nature of the influence between the factors and the object of management;
- quantitative determination of the degree of factors influence on the shadow economy based on linear and non-linear equations;
- building an optimization model to define the probable decrease in the volume of the shadow economy, given the current state of digital finance development and the level of financial stability in the country;
- analysis and interpretation of findings.

Approbation of the proposed scientific and systematic approach was carried out based on statistical data on Ukraine, while the period 2005-2021 was chosen for the research.

#### 4. EMPIRICAL RESULTS AND DISCUSSION

For this research 21 indicators were chosen to explain the dynamics of changes in the shadow economy at the initial stage. Correlation analysis was used to identify the most significant factors affecting the object under study, which is the shadow economy. The correlation coefficient was calculated to assess the closeness of the statistical connection between the studied variables and the volume of the shadow economy, which are presented in Table 3. For further calculations, indicators were selected for which the correlation coefficient is more significant than 0,5.

Table 3

Results of correlation analysis

Indicator	Correlation coefficient, units	Indicator	Correlation coefficient, units
CASH	0,319	DBT_C	-0,330
CLP	-0,501*	ONL_B	-0,665*
DOL	-0,154	NVT	-0,057
F_FDI	0,532*	ROA	-0,290
ATM	-0,697*	RCA	-0,600
TER	-0,527*	NPL	-0,568*
BRN_C	0,568*	GDP	0,596*
PMT	0,441	LIQ	-0,278
DEP_A	0,004	EXR	0,006
LOAN_A	0,447		

Source: own calculation

\* - statistically significant indicators

According to the results of the correlation analysis, 9 out of 21 indicators had an average and high degree of connection with the result indicator. Based on this, these indicators will serve as the basis for constructing a cognitive map.

A cognitive map is the primary tool for cognitive modeling. It is a convenient and effective technique for visualizing the cause-and-effect connections of factors with the object of management. The cognitive

map consists of vertices (systemically significant elements affecting the system) and arcs (cause-and-effect connections between factors).

According to the concept of cognitive consonance, the object of management is formed under the influence of many factors that meet the following criteria (Mokin et al., 2020): the factor has an impact on the vertex of the system (object of management); the factor is quantifiable; other factors influence the factor; each factor corresponds to a separate management tool.

The result of constructing a cognitive map for pre-selected 9 factors of influence on the object of management, which is the shadow economy, is presented in Figure 1.

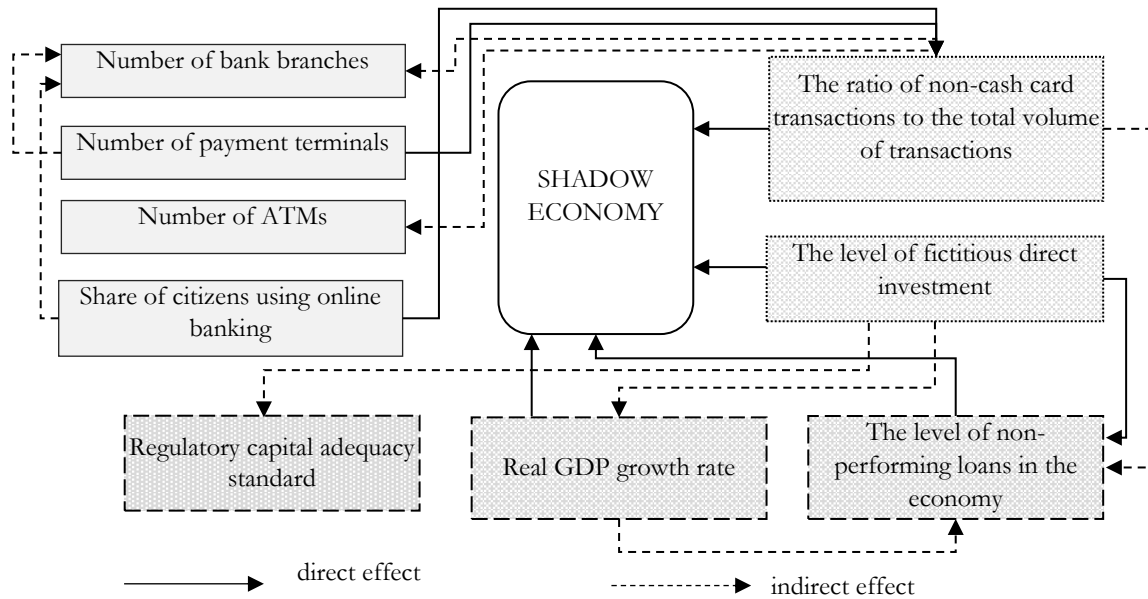


Figure 1. Cognitive map of modelling the influence of factors on the shadow economy

Source: own elaboration

The basis for constructing a cognitive map considers the principles of system dynamics. At the same time, the connections between objects were determined based on the results of correlation analysis and subjective assumptions. The informational and statistical base for calculations is presented in Table 4.



Table 4. Variables which describe chain “shadow economy – finance digitalization – financial stability” in Ukraine

	SE	CLP	ATM	TER	BRN_C	RCA	NPL	GDP	ONL_B	F_FDI
2005	37	3,2044	28,160	830,772	3,860	14,650	5,800	27,907	19,700	14,800
2006	34	3,308	36,720	1056,760	3,870	13,980	6,200	23,549	22,100	14,200
2007	35	3,606	52,420	1553,920	3,860	13,920	4,300	32,935	27,680	14,600
2008	36	4,559	70,370	2373,300	3,740	13,080	3,100	31,915	30,760	14,000
2009	30	5,203	73,140	2950,880	3,220	18,280	4,500	-4,418	33,710	13,454
2010	33	6,538	76,570	2616,410	2,330	20,340	14,100	13,970	37,110	12,895
2011	32	8,047	84,300	2762,700	1,600	18,510	17,000	20,443	39,180	12,779
2012	30	12,351	92,800	3171,300	1,070	18,090	17,600	8,052	40,880	14,287
2013	30	17,373	104,060	4196,430	0,920	17,550	19,300	4,309	42,910	15,165
2014	36	25,043	95,090	5748,310	0,770	14,030	16,300	8,307	45,330	16,391
2015	35	31,213	87,120	5326,730	0,560	8,920	22,000	25,309	47,080	22,807
2016	33	35,477	88,770	5110,000	0,500	13,340	31,700	19,956	49,030	21,561
2017	32	39,298	97,830	5796,270	0,450	15,350	49,400	24,980	51,900	17,305
2018	29	45,104	97,390	6699,590	0,430	15,520	52,100	19,424	54,370	14,028
2019	27	50,277	96,300	7967,210	0,420	18,720	48,900	11,710	57,500	13,864
2020	30	55,814	93,740	9446,040	0,410	21,630	45,700	6,156	60,780	12,507
2021	32	60,807	91,240	11793,300	0,390	21,440	37,800	29,105	60,620	12,225

Source: own calculation

The next stage of the developed scientific-methodological approach is the connection formalization between the studied indicators using linear or non-linear (polynomial, logarithmic, hyperbolic and power functions) econometric dependencies, which are visually presented on a cognitive map. Calculations were made using the statistical software package Statistica.

Table 5 shows the results of the interdependence formalization between the indicators with the highest adequacy indicators in constructed econometric models.

Table 5 reports that at different levels of significance (1%, 5%, 10%), most indicators are statistically significant. The statistically insignificant parameters will not be used in the calculations, particularly the optimisation model. For 6 out of 7 nonlinear regression models, the F-statistic is statistically significant. The p-value being less than the selected significance level ( $p = 1\%$ ), a decision is made to accept the alternative hypothesis, i.e. the adequacy of the models. However, for some models, adjusted R2 is 0,54, which indicates a low level of explanation of the actual data by the model, but according to the F- statistic, it can be recognised as quite significant.

Figure 2 shows the residuals plots which allow to check whether the residuals follow the normal distribution. Overall, the models are adequate, as demonstrated by the closeness of the coefficient values, the high coefficient of determination, and the almost absence of autocorrelation of the residuals.

Table 5. Formalization results between indicators in the system of connections “shadow economy – finance digitalization – financial stability”

	Dependent variable	Independent variables	Regression summary		Criteria of model adequacy			
			Coefficient	Std. Error	Adjusted R <sup>2</sup>	F-statistic	p-value	
Indicators of the shadow economy and financial stability	$SE_t$	Constant	33,508 ***	3,182	0,54	3,51	0,04	
		$CLP_{t-1}$	0,146 **	0,065				
		$NPL_{t-1}$	-0,247 **	0,100				
		$GDP_{t-1}$	-0,020	0,057				
		$F\_FDI_{t-1}$	0,093	0,123				
	$GDP_t$	Constant	5,539	14,699	0,05	0,73	0,41	
		$F\_FDI_{t-1}$	0,805	0,945				
	$NPL_t$	Constant	-119,347 *	67,005	0,95	35,89	0,00	
		$\sqrt{CLP_{t-1}}$	4,001	3,267				
		$1/GDP_{t-1}$	165,244 *	66,944				
		$\ln(CL P_{t-1})$	8,095	6,728				
		$GDP_{t-1}^2$	-0,037*	0,018				
		$\ln(GDP_{t-1})$	39,194	22,383				
	Indicators of the shadow economy and financial services digitalization	$RCA_t$	Constant	-198,672 **	82,683	0,54	8,17	0,00
			$1/F\_FDI_{t-1}$	1305,698 **	457,996			
$\sqrt{F\_FDI_{t-1}}$			32,677 **	13,372				
$CLP_t$		Constant	578,600 *	319,67	0,97	105,74	0,00	
		$1/TER_{t-1}$	-41379,300 *	2348,11				
		$\ln(TER_{t-1})$	-83,300 *	47,36				
BRN_C		Constant	-7,286	-4,249	0,97	140,09	0,00	
		$1/CLP_{t-1}$	9,499 ***	1,448				
		$1/ONL\_B_{t-1}$	83,487 ***	24,868				
		$\ln(TER_{t-1})$	0,671 *	0,374				
$ATM_t$		Constant	100,380 ***	5,287	0,62	24,51	0,00	
		$1/CLP_{t-1}$	-162,805 ***	32,882				

Source: own calculation

Note: \*\*\*  $p < 0,01$ ; \*\*  $p < 0,05$ ; \*  $p < 0,1$

An optimization problem was constructed considering the connections identified above in the chain “shadow economy – digital finance – financial stability” and the general direction of minimization of the objective function (shadow economy). To solve the constructed optimization problem of formalizing the cognitive model of assessing the impact of digital finance on the dynamics of the spread of shadow connections in the economy, we use the “Solution Search” toolkit of MS Excel (in particular, solving the problem of nonlinear programming using the generalized gradient method). We present findings in Table 6 (column 5) and compare them with actual (columns 3 and 4) and average (column 2) values.

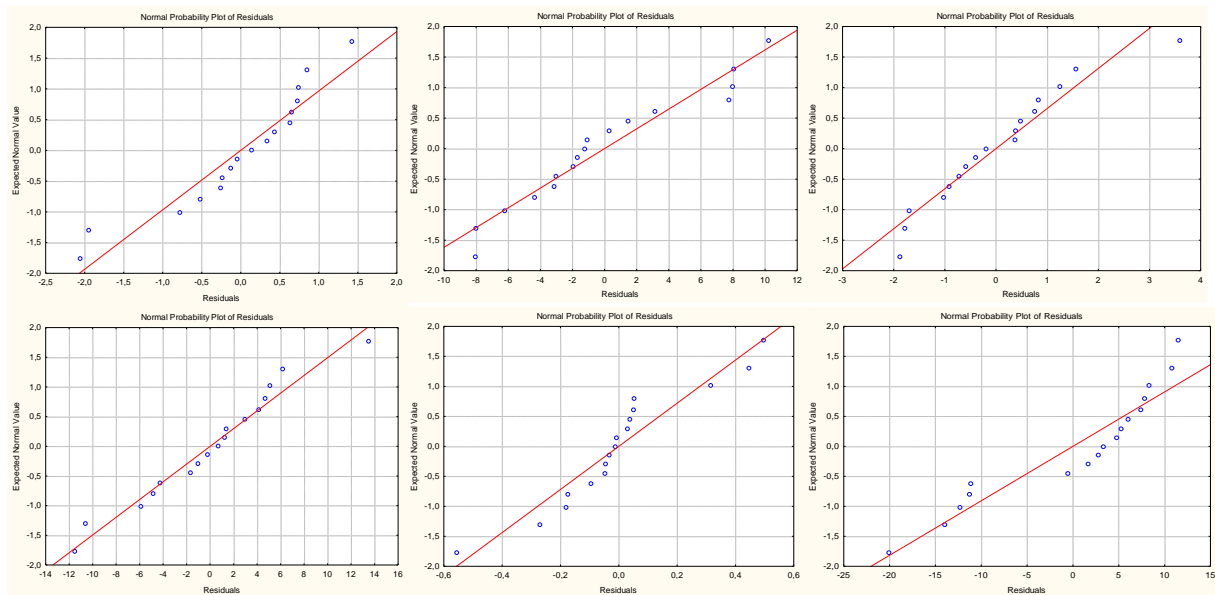


Figure 2. Residual plots for model adequacy checking

Source: own calculation

It was established that the level of the shadow economy in Ukraine, considering the current state of digital finance development and the financial stability level, can be reduced to the level of 14.43% of GDP, which is 55.8% less compared to the average annual value based on the results of solving the optimization problem. The calculations show that the current status of the development of digital finance and financial strength in Ukraine is sufficient for significantly reducing shadow operations in the economy. To achieve the optimal value of the shadow economy under the current conditions of the financial market, it is advisable to implement a set of measures aimed at: an increase in the volume of the cashless economy by a quarter compared to 2021; reduction of non-performing loans by 59.5%; banking infrastructure optimization (reduction in the number of ATMs by 10.1%, reduction in the number of commercial bank branches by 28.2%, increase in payment terminals by 4.2%); encouraging citizens to use online banking; reduction of the level of fictitious direct investments by 14.3%.

Table 6

## Results of cognitive modeling

Indicator		Average actual value	Minimum actual value	Maximum actual value	Optimal value
1		2	3	4	5
The level of the shadow economy		32,69	27,00	39,00	14,43
Participation of financial institutions in servicing the shadow economy	The ratio of non-cash card transactions to the total number of transactions	22,92	3,20	60,81	75,36
	Level of fictitious direct investment	15,13	12,23	22,81	10,48
Financial digitalization	Number of ATMs	77,01	20,09	104,06	82,00
	Number of payment terminals	4447,51	655,23	11793,31	12288,91
	Number of branches of commercial banks	1,78	0,39	3,87	0,28
	Share of citizens using online banking	41,02	17,73	60,78	65,00
Financial stability	Regulatory capital adequacy standard	16,16	8,92	21,63	22,46
	Share of non-performing loans	22,28	3,10	52,10	15,30
	Change in real GDP	18,47	-4,42	32,94	28,46

Source: own calculation

## 5. CONCLUSION

The proposed scientific and methodological approach to determining the potential reduction of the volume of the shadow economy is based on considering the cognitive consonance between controlled and observed factors. Practical testing of the developed approach proved that the constructed cognitive map was stable; that is, it can be used for cognitive modeling tasks. The analysis of obtained calculations made it possible to formulate recommendations for countering the shadow economy in Ukraine by optimizing the leading related indicators. We note that the fight against the shadow economy is a long-term, coordinated, comprehensive measure of many state institutions, for the implementation of which all line ministries should continue a constructive dialogue with enterprises and non-governmental organizations. At the same time, improving the work of controlling and judicial bodies plays an essential role in successfully implementing the road map for the unshadowing of the national economy, and it should reasonably guarantee the protection of human rights and freedoms and the rights and legitimate interests of business entities.

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