

“Modeling the dynamic patterns of banking and non-banking financial intermediaries’ performance”

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MODELING THE DYNAMIC PATTERNS OF BANKING AND NON-BANKING FINANCIAL INTERMEDIARIES' PERFORMANCE

Abstract

Nowadays, there are many preconditions and circumstances for conducting shadow schemes in the financial market. Therefore, the level of risk of participation of bank and non-bank financial intermediaries in such schemes is assessed as high. The lack of a practical methodology for assessing the development trajectory of financial intermediaries raises the question of the need for preventive control and quality modeling of their growth dynamics. The study aims to identify and formalize the patterns of development paths of banking and non-banking financial intermediaries based on the Harrington desirability function, which will be used to identify risk patterns as indicative patterns of financial intermediaries' participation in shadow schemes. The sample includes 13 banking institutions, 3 credit unions, 3 pawnshops, 3 insurance companies, and 3 financial companies. The obtained results showed the relationship between the financial intermediary risk level in terms of its participation in shadow schemes and the phases of the economic cycle as a catalyst for the economic dynamics of the formal and informal economy. Thus, in 2012–2015, most financial intermediaries were in the zone of most significant risk, especially banks, characterized by economic, social, and political instability. Today, banks are in the group with a controlled level of risk of participation in scheme operations. Over the years analyzed, a stable neutral level of risk of participation in shadow schemes was inherent in most non-bank financial institutions. They were less sensitive than banks to the phases of the economic cycle.

Keywords financial intermediaries, banks, cluster analysis,
Harrington's desirability function, shadow economy

JEL Classification G17, G21, G23, O17

INTRODUCTION

Long-term economic growth depends on the level of investment, which is due to the efficiency of the structure of financial intermediaries in the economic system. The development and improvement of intermediary activities in the financial system increase the efficiency of savings and investment processes, positively affecting economic growth.

The shadow economy and corruption are the main threats to sustainable economic development. Shadow schemes are implemented through the movement of illegal financial flows. Most illegal financial schemes are carried out with financial intermediaries, whose arsenal of technologies and financial capabilities is changing rapidly under the pressure of the development of fintech and digital financial services. Based on globalization, the development of digitalization, automation, high mobility of consumers of financial services, the emergence of a generation of digital people who are always on the Internet or social networks, new financial intermediaries have entered the financial services market (fintech companies, P2P aggregators, crowdfunding

platforms, digital wallets, robot advisors, ecosystems of digital e-commerce platforms). Without being bound by the classical norms of banking regulation and supervision, as well as an active focus on modern digital technologies, including cloud computing, APIs, cryptography, machine learning, biometrics, big data analytics, blockchain, artificial intelligence, and Internet things, allows banking and non-banking financial intermediaries actively increase the volume of financial activities. At the same time, they are significantly increasing the risks of their participation in shadow schemes and tax evasion.

There are many schemes of illegal financial flows in which banking and non-banking financial intermediaries participate. These schemes are carried out to legalize illegally obtained income, withdraw capital from the country, evade taxes, withdraw cash illegally through fictitious enterprises or pay for non-existent goods and services. Detecting “scheme” transactions are not easy, but it is possible because several factors indicate the ability of financial intermediaries to participate in shadow schemes.

Thus, modeling the activities of banking and non-banking financial intermediaries will identify existing trends and develop strategies for further development.

1. LITERATURE REVIEW

Financial intermediation has recently been perceived as an essential supporting mechanism for economic growth. Much attention in the scientific literature is paid to studying the role of banks, credit unions, insurance companies, and other financial institutions.

In general, scientists focus on studying the impact of local and global crumbs on the activities of individual financial intermediaries and the financial market. Therefore, Kozmenko et al. (2016) offer bank patterns evaluation based on Kohonen’s self-organizing maps to determine further directions of financial institution strategies advanced under the influence of a disaster within the economy. The study used some guidelines for modeling the activities of banking intermediaries developed by the authors. At the same time, Plastun et al. (2018) inspect competitiveness within the stock market at some point of the local crisis of 2013–2015. The consequences advocate that the contemporary degradation of the Ukrainian inventory market is closely associated with good-sized changes within the marketplace attention resulting from the local crisis.

Many scientists study the role of financial intermediaries in the shadow sector of the economy. For instance, Tiutiunyk and Humenna (2021) examine and establish the scientists’ work to evaluate the chance of economic intermediaries’ participation in shadow transactions. The consequences of evaluating clinical guides on these problems show diverse tactics for analyzing those issues. Significant variations within

the functioning of different international locations’ monetary, banking, coverage, and funding markets have caused the need to develop and put into effect their methodologies for assessing the threat of participation of economic intermediaries in shadow transactions on the national stage. Moreover, Ozgur (2021) focuses on how shadow banking, known until recently as fringe and parallel banking, has emerged as a principal detail for the USA monetary system. Using current and new shadow banking indices, the author uses distinctive Markov switching models to discover the position of shadow banking on financial institution lending cycle dynamics in the USA.

It should be noted that some researchers focus on non-bank financial intermediaries, and others only on the banking sector. Thus, they share these markets without considering the shared banking and non-banking intermediation market. On the one hand, Aramonte et al. (2021) look at structural shifts in intermediation and how non-bank financial intermediaries have shaped the requirement and financial markets’ liquidity inventory. On the other hand, Santandrea et al. (2018) present the most effective enterprise version configuration for public intermediaries. Also, Martinez-Miera and Repullo (2019) analyze the effects of bank capital requirements on the structure and risk of a financial system where markets, regulated banks, and shadow banks coexist. Banks face moral hazard when screening entrepreneurs’ projects, and they could choose whether they need regulation. Oliynyk et al. (2017) profoundly investigated the activity of mixed life insurance intermediaries.

The following works are devoted to modeling the activities of financial intermediaries based on various quantitative and qualitative assessments of their activities. Thus, Boda and Zimkova (2018) offer a measure of monetary intermediation attainment that solves conditions, while the ability of economic intermediaries, from a macroeconomic perspective, can usually be decreased to taking deposits and imparting loans. Ghasemi et al. (2020) developed a quantitative monetary dynamic stochastic general equilibrium version with economical intermediaries and proposed endogenously determined stability sheet constraints. Also, Yang and Chang (2020) use the quantile regression approach to observe the uneven impact of middleman economic improvement on the monetary increase in low- and high-income countries. A three-zone neoclassical growth version contains a consultant circle of relatives, manufacturing, and middleman economic areas. The equilibrium answers decide the variables hired within the empirical version. This usually indicates that international locations should no longer expand economic intermediaries indiscriminately in pursuit of financial growth, especially for low-income countries. At the same time, Islam and Shah (2012) use cointegration and error correction mechanisms to test for causal relationship between the improvement in non-bank economic intermediaries and in line with per capita financial growth in Malaysia over the period 1974–2004.

The authors endorse that non-bank monetary intermediaries and financial growth are cointegrated. Financial growth is used as a structured variable, but no more, while the opposite variables are handled as fixed variables. The result also suggests a unique lengthy-run causal strolling from non-bank monetary intermediaries to per capita financial growth, rather than the other way around.

2. AIM, DATA, AND METHODOLOGY

The study aims to identify and formalize the patterns of development paths of banking and non-banking financial intermediaries based on the Harrington desirability function, which will be used to identify risk patterns as indicative patterns of financial intermediaries' participation in shadow schemes, and to explore the possibilities

of transition of financial intermediaries between patterns (risk, neutral, under control) and changes in the characteristics of the patterns themselves at different phases of the economic cycle and stages of the life cycle of a financial intermediary.

It is proposed to apply five stages of building a model to estimate the trajectories of financial intermediaries.

Stage 1. Defining the system of indicators based on which the cluster map is built. To build the model, 25 Ukrainian financial intermediaries were selected, which functioned during 2012–2020. To test the model, a sample of banks, credit unions, pawnshops, insurance companies, and financial companies was formed.

Table 1 presents the list of financial intermediaries included in the model.

Table 1. List of financial intermediaries included in the model as of January 1, 2021

No.	Banks
1.	Pivdennyi Bank
2.	JSB Ukrgasbank
3.	JSC A-Bank
4.	JSC Alfa-Bank
5.	OTP Bank JSC
6.	JSC Oschadbank
7.	JSC FUIB
8.	Raiffeisen Bank JSC
9.	Tascombank JSC
10.	JSC Ukreximbank
11.	JSC Uksribbank
12.	JSC Universal Bank
13.	JSC CB PrivatBank
Credit unions	
14.	Vygoda Credit Union
15.	Kreditsous Credit Union
16.	Financial Support Credit Union
Insurance companies	
17.	PJSC Grawe Ukraine Life insurance
18.	PJSC Metlife
19.	ICUIG PJSC
Pawnshops	
20.	FC Donkredit
21.	GP Loan Community Skarbnitsya-Lombard
22.	GP Lombard Svizha Kopyyka
Financial companies	
23.	Enterprise Development Fund FC NUF 2004
24.	FSC FCFSC 2009 FC, LLC
25.	FSC Center of Financial Decisions FC, LLC

To ensure the formation of the input variables of the model, it is proposed to use:

- 8 indicators for banks;
- 7 indicators for credit unions;
- 7 indicators for pawnshops;
- 7 indicators for insurance companies; and
- 8 indicators for financial companies.

Among the selected indicators, there are both absolute and relative indicators that can characterize the effectiveness of financial intermediaries (Table 2).

Table 2. Description of input model variables

Variable	Indicator
Banks	
<i>b1</i>	Return on assets (ROA), %
<i>b2</i>	Return on equity (ROE), %
<i>b3</i>	Total assets, UAH thousand
<i>b4</i>	Equity, UAH thousand
<i>b5</i>	Liabilities, UAH thousand
<i>b6</i>	Loans and receivables, UAH thousand
<i>b7</i>	Net financial result, UAH thousand
<i>b8</i>	Net commission income, UAH thousand
Credit unions	
<i>ks1</i>	Total assets, UAH thousand
<i>ks2</i>	Equity, UAH thousand
<i>ks3</i>	Liabilities, UAH thousand
<i>ks4</i>	Loans granted, UAH thousand
<i>ks5</i>	Retained earnings (uncovered loss), UAH thousand
<i>ks6</i>	Financial result, UAH thousand
<i>ks7</i>	Net financial result, UAH thousand
Insurance companies	
<i>sk1</i>	Total assets, UAH thousand
<i>sk2</i>	Equity, UAH thousand
<i>sk3</i>	Liabilities, UAH thousand
<i>sk4</i>	Insurance reserves, UAH thousand
<i>sk5</i>	Net earned insurance premiums, UAH thousand
<i>sk6</i>	Insurance payments and insurance indemnities, UAH thousand
<i>sk7</i>	Net financial result (profit), UAH thousand
Pawnshops	
<i>l1</i>	Total assets, UAH thousand
<i>l2</i>	Equity, UAH thousand
<i>l3</i>	Liabilities, UAH thousand
<i>l4</i>	Other operating income, UAH thousand
<i>l5</i>	Labor costs, UAH thousand
<i>l6</i>	Financial result before tax (profit), UAH thousand
<i>l7</i>	Net financial result (profit), UAH thousand
Financial companies	
<i>fk1</i>	Total assets, UAH thousand
<i>fk2</i>	Equity, UAH thousand
<i>fk3</i>	Liabilities, UAH thousand
<i>fk4</i>	Net income from sales of products, UAH thousand
<i>fk5</i>	Other operating income, UAH thousand
<i>fk6</i>	Other financial income, UAH thousand
<i>fk7</i>	Financial result before tax (profit) UAH thousand
<i>fk8</i>	Net financial result (profit), UAH thousand

Stage 2. Normalizing model input data.

The study proposes using the comparative approach to rationing indicators used in mathematical statistics.

It determines the maximum or minimum of the data using the MAX or MIN formulas in the MS Excel software and normalizes the next step. Accordingly, normalized values by formula were found out (6).

Stage 3. Optimizing input with the Harrington desirability feature. The convolution of the input based on the Harrington desirability function and the description of the intermediate variables are given in Table 3.

Thirty-seven model indicators form five groups:

- indicators describing the state of banks (Gb_{-1} , Gb_{-2} , Gb_{-3});
- indicators describing the state of credit unions (Gks_{-1} , Gks_{-2} , Gks_{-3});
- indicators describing the state of insurance companies (Gsk_{-1} , Gsk_{-2} , Gsk_{-3});
- indicators describing the state of pawnshops (Gl_{-1} , Gl_{-2} , Gl_{-3}); and
- indicators describing the state of financial companies (Gfk_{-1} , Gfk_{-2} , Gfk_{-3}).

The period 2012–2021 was chosen for the analysis. The calculation of indicators for Pivdennyi Bank as of January 1, 2020 is shown in Table 4.

Next, the weight of the indicators is considered and the convolution is performed.

The calculation of the synthesizing function G for each group of indicators as of January 1, 2003 is shown in Table 5.

Stage 4. Data processing using Viscovery SOMine software for the period 2012–2021.

Viscovery SOMine is based on the concept and algorithms of Kohonen's self-organizing maps pack-

Table 3. Description of intermediate model variables

Group of indicators	Indicator	Variable	Partial function <i>d</i>	Synthesis function <i>G</i>
Banks				
<i>Gb₋₁</i>	Return on assets (ROA), %	<i>b1</i>	$d_{b_{-1}} = \exp(-\exp(-b1))$	$Gb_{-1} = \sqrt[3]{d_{b_{-1}} \cdot d_{b_{-2}}}$
	Return on equity (ROE), %	<i>b2</i>	$d_{b_{-2}} = \exp(-\exp(-b2))$	
<i>Gb₋₂</i>	Total assets, UAH thousand	<i>b3</i>	$d_{b_{-3}} = \exp(-\exp(-b3))$	$Gb_{-2} = \sqrt[3]{d_{b_{-3}} \cdot d_{b_{-4}} \cdot d_{b_{-5}}}$
	Equity, UAH thousand	<i>b4</i>	$d_{b_{-4}} = \exp(-\exp(-b4))$	
	Liabilities, UAH thousand	<i>b5</i>	$d_{b_{-5}} = \exp(-\exp(-b5))$	
<i>Gb₋₃</i>	Loans and receivables, UAH thousand	<i>b6</i>	$d_{b_{-6}} = \exp(-\exp(-b6))$	$Gb_{-3} = \sqrt[3]{d_{b_{-6}} \cdot d_{b_{-7}} \cdot d_{b_{-8}}}$
	Net financial result, UAH thousand	<i>b7</i>	$d_{b_{-7}} = \exp(-\exp(-b7))$	
	Net commission income, UAH thousand	<i>b8</i>	$d_{b_{-8}} = \exp(-\exp(-b8))$	
Credit unions				
<i>Gks₋₁</i>	Total assets, UAH thousand	<i>ks1</i>	$d_{ks_{-1}} = \exp(-\exp(-ks1))$	$Gks_{-1} = \sqrt[3]{d_{ks_{-1}} \cdot d_{ks_{-2}}}$
	Equity, UAH thousand	<i>ks2</i>	$d_{ks_{-2}} = \exp(-\exp(-ks2))$	
<i>Gks₋₂</i>	Liabilities, UAH thousand	<i>ks3</i>	$d_{ks_{-3}} = \exp(-\exp(-ks3))$	$Gks_{-2} = \sqrt[3]{d_{ks_{-3}} \cdot d_{ks_{-4}}}$
	Loans granted, UAH thousand	<i>ks4</i>	$d_{ks_{-4}} = \exp(-\exp(-ks4))$	
<i>Gks₋₃</i>	Retained earnings (uncovered loss), UAH thousand	<i>ks5</i>	$d_{ks_{-6}} = \exp(-\exp(-ks6))$	$Gks_{-3} = \sqrt[3]{d_{ks_{-5}} \cdot d_{ks_{-6}} \cdot d_{ks_{-7}}}$
	Financial result, UAH thousand	<i>ks6</i>	$d_{ks_{-7}} = \exp(-\exp(-ks7))$	
	Net financial result, UAH thousand	<i>ks7</i>	$d_{ks_{-8}} = \exp(-\exp(-ks8))$	
Insurance companies				
<i>Gsk₋₁</i>	Total assets, UAH thousand	<i>sk1</i>	$d_{sk_{-1}} = \exp(-\exp(-sk1))$	$Gsk_{-1} = \sqrt[3]{d_{sk_{-1}} \cdot d_{sk_{-2}}}$
	Equity, UAH thousand	<i>sk2</i>	$d_{sk_{-2}} = \exp(-\exp(-sk2))$	
<i>Gsk₋₂</i>	Liabilities, UAH thousand	<i>sk3</i>	$d_{sk_{-3}} = \exp(-\exp(-sk3))$	$Gsk_{-2} = \sqrt[3]{d_{sk_{-3}} \cdot d_{sk_{-4}} \cdot d_{sk_{-5}}}$
	Insurance reserves, UAH thousand	<i>sk4</i>	$d_{sk_{-4}} = \exp(-\exp(-sk4))$	
	Net earned insurance premiums, UAH thousand	<i>sk5</i>	$d_{sk_{-5}} = \exp(-\exp(-sk5))$	
<i>Gsk₋₃</i>	Insurance payments and insurance indemnities, UAH thousand	<i>sk6</i>	$d_{sk_{-6}} = \exp(-\exp(-sk6))$	$Gsk_{-3} = \sqrt[3]{d_{sk_{-6}} \cdot d_{sk_{-7}}}$
	Net financial result (profit), UAH thousand	<i>sk7</i>	$d_{sk_{-7}} = \exp(-\exp(-sk7))$	
Pawnshops				
<i>Gl₋₁</i>	Total assets, UAH thousand	<i>l1</i>	$d_{l_{-1}} = \exp(-\exp(-l1))$	$Gl_{-1} = \sqrt[3]{d_{l_{-1}} \cdot d_{l_{-2}}}$
	Equity, UAH thousand	<i>l2</i>	$d_{l_{-2}} = \exp(-\exp(-l2))$	
<i>Gl₋₂</i>	Liabilities, UAH thousand	<i>l3</i>	$d_{l_{-3}} = \exp(-\exp(-l3))$	$Gl_{-2} = \sqrt[3]{d_{l_{-3}} \cdot d_{l_{-4}} \cdot d_{l_{-5}}}$
	Other operating income, UAH thousand	<i>l4</i>	$d_{l_{-4}} = \exp(-\exp(-l4))$	
	Labor costs, UAH thousand	<i>l5</i>	$d_{l_{-5}} = \exp(-\exp(-l5))$	
<i>Gl₋₃</i>	Financial result before tax (profit), UAH thousand	<i>l6</i>	$d_{l_{-6}} = \exp(-\exp(-l6))$	$Gl_{-3} = \sqrt[3]{d_{l_{-6}} \cdot d_{l_{-7}}}$
	Net financial result (profit), UAH thousand	<i>l7</i>	$d_{l_{-7}} = \exp(-\exp(-l7))$	
Financial companies				
<i>Gfk₋₁</i>	Total assets, UAH thousand	<i>fk1</i>	$d_{fk_{-1}} = \exp(-\exp(-fk1))$	$Gfk_{-1} = \sqrt[3]{d_{fk_{-1}} \cdot d_{fk_{-2}}}$
	Equity, UAH thousand	<i>fk2</i>	$d_{fk_{-2}} = \exp(-\exp(-fk2))$	
	Liabilities, UAH thousand	<i>fk3</i>	$d_{fk_{-3}} = \exp(-\exp(-fk3))$	
<i>Gfk₋₂</i>	Net income from sales of products, UAH thousand	<i>fk4</i>	$d_{fk_{-4}} = \exp(-\exp(-fk4))$	$Gfk_{-2} = \sqrt[3]{d_{fk_{-3}} \cdot d_{fk_{-4}} \cdot d_{fk_{-5}}}$
	Other operating income, UAH thousand	<i>fk5</i>	$d_{fk_{-5}} = \exp(-\exp(-fk5))$	
	Other financial income, UAH thousand	<i>fk6</i>	$d_{fk_{-6}} = \exp(-\exp(-fk6))$	
<i>Gfk₋₃</i>	Financial result before tax (profit) UAH thousand	<i>fk7</i>	$d_{fk_{-7}} = \exp(-\exp(-fk7))$	$Gfk_{-3} = \sqrt[3]{d_{fk_{-7}} \cdot d_{fk_{-8}}}$
	Net financial result (profit), UAH thousand	<i>fk8</i>	$d_{fk_{-8}} = \exp(-\exp(-fk8))$	

Table 4. Description of Pivdennyi Bank's indicators as of January 1, 2021

Group of indicators	Indicator	Variable	Partial function <i>d</i>	Synthesis function <i>G</i>
Pivdennyi Bank				
<i>Gb</i> ₁	Return on assets (ROA), %	<i>b</i> ₁	0.6509	0.6761
	Return on equity (ROE), %	<i>b</i> ₂	0.7022	
<i>Gb</i> ₂	Total assets, UAH thousand	<i>b</i> ₃	0.8489	0.8531
	Equity, UAH thousand	<i>b</i> ₄	0.8510	
	Liabilities, UAH thousand	<i>b</i> ₅	0.8595	
<i>Gb</i> ₃	Loans and receivables, UAH thousand	<i>b</i> ₆	0.7930	0.7943
	Net financial result, UAH thousand	<i>b</i> ₇	0.7732	
	Net commission income, UAH thousand	<i>b</i> ₈	0.8174	

Table 5. Synthesis function *G* for each group of indicators as of January 1, 2021

Financial intermediary	Group of indicators		
	<i>G</i> ₁	<i>G</i> ₂	<i>G</i> ₃
Banks			
Pivdennyi Bank 2020	0.6761	0.8531	0.7943
JSB Ukrgasbank 2020	0.4682	0.8449	0.6847
JSC A-Bank 2020	0.3979	0.8770	0.7532
JSC Alfa-Bank 2020	0.5592	0.8832	0.7892
OTP Bank JSC 2020	0.5106	0.8886	0.7345
JSC Oschadbank 2020	0.6031	0.6095	0.5889
JSC FUIB 2020	0.6515	0.8797	0.7910
Raiffeisen Bank JSC 2020	0.5253	0.8359	0.7001
Tascombank JSC 2020	0.4456	0.8380	0.7394
JSC Ukreximbank 2020	0.3264	0.5783	0.4609
JSC Ukrsibbank 2020	0.5474	0.8252	0.5722
JSC Universal Bank 2020	0.5776	0.8788	0.8252
JSC CB PrivatBank2020	0.5387	0.8221	0.3737
Credit unions			
Financial Support Credit Union 2020	0.7436	0.2185	0.0917
Vygoda Credit Union 2020	0.4720	0.3090	0.0836
Kreditsous Credit Union 2020	0.5194	0.2596	0.1155
Insurance companies			
ICUIG PJSC 2020	0.2719	0.4509	0.0795
PJSC Metlife 2020	0.2505	0.5116	0.0689
Pawnshops			
FC Donkredit 2020	0.5889	0.2821	0.0949
GP Lombard Svizha Kopyyka 2020	0.4842	0.2600	0.1352
GP Loan Community Skarbniitsya-Lombard 2020	0.7656	0.1878	0.1375
Financial companies			
Enterprise Development Fund FC NUF 2004	0.6413	0.2571	0.0930
FSC FCFSC 2009 FC, LLC	0.7935	0.1667	0.1649
FSC Center of Financial Decisions FC, LLC	0.3808	0.4187	0.0702

age, a modern and progressive version of self-learning neural networks. The software package allows solving several complex analytical problems, such as searching for data clusters, studying numerical information and statistical processing of clusters, tracking new data, assessing the relationship between variables, studying geometrical properties of data distribution, etc.

3. RESULTS

At the model's output, a set of Kohonen maps was obtained for selected groups of indicators and the boundaries of division into clusters. Based on the colors of the representation, the distance between the elements of the samples can be described.

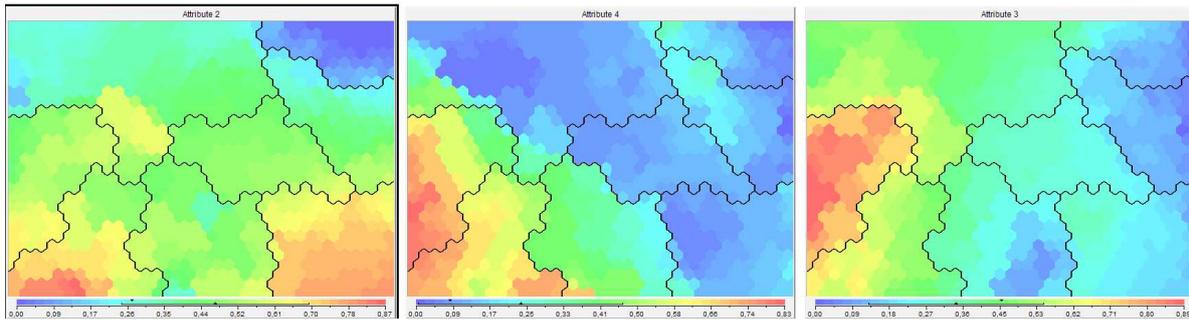


Figure 1. Kohonen maps obtained

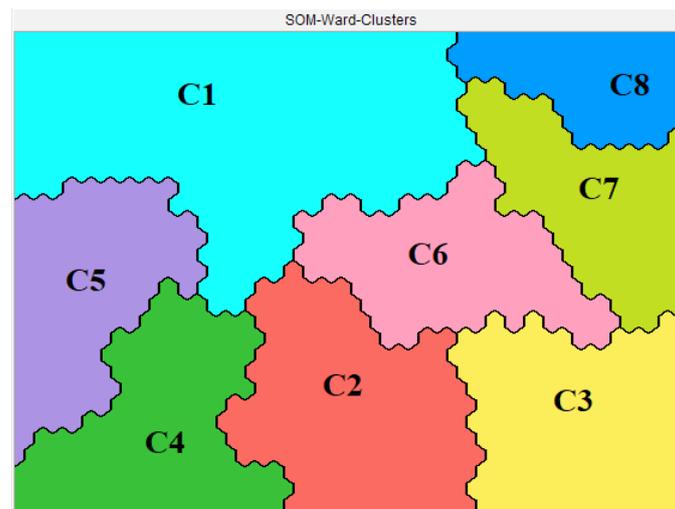


Figure 2. General Kohonen map

The model's input data will be synthesizing functions G for 9 reporting dates.

Map scales can also be used to determine cell values, compare and analyze them (Figure 1).

It should be noted that eight clusters were obtained as a result of data processing. The general Kohonen map is shown in Figure 2.

The belonging of the studied financial intermediaries to the created patterns is presented on the example of cluster C1 (Table 6).

Thus, the trajectories of financial intermediaries during 2012–2020 were formed to elucidate the results.

The Harrington desirability function scale was used to analyze each cluster's estimates (Table 7).

The formation of cluster ranks is presented in Table 8.

Based on the results obtained, the clusters were ranked (Table 9).

It is proposed to divide the clusters into groups (Table 10) conditionally to assess the effectiveness of each financial intermediary, which was assigned to a particular cluster.

Thus, among the 25 surveyed financial intermediaries that, as of January 1, 2020, operated in the financial market of Ukraine, the crisis in recent years could be observed in:

- Vygoda Credit Union (2014–2020);
- Kreditsous Credit Union (2013–2020);
- FC Donkredit (2013);
- GP Lombard Svizha Kopyyka (2015–2020);
- Pivdennyi Bank (2012–2013);
- JSC A-Bank (2015);
- OTP Bank JSC (2012–2013);
- JSC Oschadbank (2012–2013);
- JSC FUIB (2012–2014);
- Raiffeisen Bank JSC (2013);

Table 6. Financial intermediaries included in pattern C1

Attribute 1	Attribute 2	Attribute 3	Attribute 4
JSC Ukrsibbank 2016	0.2068	0.4318	0.3346
Pivdennyi Bank 2017	0.1427	0.5537	0.4504
JSC Ukreximbank 2017	0.5895	0.6200	0.0705
JSC Ukrsibbank 2017	0.6190	0.5371	0.1553
JSC CB PrivatBank 2017	0.2981	0.4523	0.1745
JSC CB PrivatBank 2018	0.5213	0.5649	0.3145
JSC Ukreximbank 2020	0.3264	0.5783	0.4609
Vygoda Credit Union 2012	0.3522	0.3506	0.1245
Kreditsous Credit Union 2012	0.3955	0.3590	0.1109
Vygoda Credit Union 2013	0.4253	0.3295	0.0849
FC Donkredit 2012	0.4363	0.3275	0.0975
FC Donkredit 2014	0.3999	0.2956	0.1375
FC Donkredit 2015	0.3668	0.3586	0.1058
ICUIG PJSC 2012	0.2807	0.5388	0.0427
PJSC Metlife 2012	0.3403	0.4421	0.0666
PJSC Grawe Ukraine Life insurance 2012	0.3333	0.4203	0.0746
ICUIG PJSC 2013	0.2948	0.5200	0.0459
PJSC Metlife 2013	0.3231	0.4443	0.0702
PJSC Grawe Ukraine Life insurance 2013	0.3225	0.4126	0.0801
PJSC Metlife 2014	0.3448	0.4283	0.0704
PJSC Grawe Ukraine Life insurance 2013	0.3073	0.3928	0.0914
ICUIG PJSC 2015	0.2908	0.4890	0.0527
PJSC Metlife 2015	0.2578	0.3808	0.1919
PJSC Grawe Ukraine Life insurance 2015	0.2969	0.3933	0.0944
ICUIG PJSC 2016	0.3364	0.4984	0.0414
PJSC Metlife 2016	0.2858	0.4871	0.0668
PJSC Grawe Ukraine Life insurance 2016	0.3008	0.3887	0.0949
ICUIG PJSC 2017	0.3403	0.4922	0.0377
PJSC Metlife 2017	0.2829	0.4892	0.0668
PJSC Grawe Ukraine Life insurance 2017	0.3038	0.3905	0.0933
ICUIG PJSC 2018	0.2922	0.5132	0.0398
PJSC Metlife 2018	0.2755	0.4916	0.0681
PJSC Grawe Ukraine Life insurance 2018	0.2997	0.3983	0.0915
ICUIG PJSC 2019	0.3312	0.5102	0.0408
PJSC Metlife 2019	0.2575	0.4974	0.0727
PJSC Grawe Ukraine Life insurance 2019	0.2995	0.4039	0.0895
ICUIG PJSC 2020	0.2719	0.4509	0.0795
PJSC Metlife 2020	0.2505	0.5116	0.0689
PJSC Grawe Ukraine Life insurance 2020	0.2970	0.4010	0.0915
FSC Center of Financial Decisions FC, LLC 2012	0.3582	0.4130	0.0760
FSC Center of Financial Decisions FC, LLC 2013	0.4267	0.3696	0.0742
FSC Center of Financial Decisions FC, LLC 2013	0.3059	0.5742	0.0387
FSC Center of Financial Decisions FC, LLC 2015	0.4272	0.3508	0.0921
FSC Center of Financial Decisions FC, LLC 2016	0.4329	0.3074	0.1098
FSC Center of Financial Decisions FC, LLC 2017	0.4019	0.3926	0.0720
FSC Center of Financial Decisions FC, LLC 2018	0.3754	0.4097	0.0728
FSC Center of Financial Decisions FC, LLC 2019	0.3958	0.4039	0.0712
FSC Center of Financial Decisions FC, LLC 2020	0.3808	0.4187	0.0702

Table 7. Distribution of points for cluster evaluation

Desirability	Score	Point
Very good	[0.80-1.00]	5
Good	[0.63-0.80]	4
Satisfactory	[0.37-0.63]	3
Bad	[0.20-0.37]	2
Very bad	[0.00-0.20]	1

Table 8. Cluster rank formation

Cluster	Frequency	Synthesis function attribute			Point distribution			Rank
		G1	G2	G3	G1	G2	G3	
C1	21.33%	0.3417	0.1088	0.4414	2	1	3	5
C2	8.89%	0.4889	0.3615	0.2414	3	2	2	3
C3	20.89%	0.7338	0.1261	0.2083	4	1	2	4
C4	9.78%	0.6490	0.6337	0.5573	4	4	3	2
C5	8.89%	0.5492	0.6820	0.8056	3	4	5	1
C6	9.78%	0.4936	0.1063	0.2830	3	1	2	6
C7	9.33%	0.3670	0.1287	0.1215	2	1	1	7
C8	11.11%	0.0428	0.0979	0.1508	1	1	1	8

Table 9. Cluster rating

Ranking place	Cluster
1	C5
2	C4
3	C2
4	C3
5	C1
6	C6
7	C7
8	C8

Table 10. Assessment of financial intermediaries by groups within clusters

Cluster	Financial intermediary evaluation	Group	Probability of participating in shadow operations
C5	5	Powerful	Controlled
C4	4	Stable	
C2	3	Problematic	Neutral
C3			
C1			
C6	2	Crisis	Risk
C7			
C8	1	Bankruptcy	

- Tascombank JSC (2012–2013);
- JSC Ukrsibbank (2012–2013);
- JSC Universal Bank (2012, 2014);
- ICUIG PJSC (2014).
- The following institutions were in the process of bankruptcy:
- Pivdennyi Bank (2014, 2015–2016);
- JSB Ukrigasbank (2014);
- JSC A-Bank (2012–2014);
- JSC Alfa-Bank (2015–2016);
- OTP Bank JSC (2014–2015);
- JSC Oschadbank (2014–2015);
- JSC FUIB (2015);
- Raiffeisen Bank JSC (2012, 2014–2015);
- Tascombank JSC (2014–2016);
- JSC Ukreximbank (2014–2015);
- JSC Ukrsibbank (2014);
- JSC Universal Bank (2015);
- JSC CB PrivatBank (2016).

Stage 5. Assessing the model adequacy. Two conditional financial intermediaries are introduced to the study population, with “good” and “bad” values of indicators to verify the adequacy of the model. The model’s reaction will conclude the correctness of the model’s reaction to diametrically different values of indicators.

Finally, a new Kohonen map was obtained (Figure 3).

As a result of the introduction of conditional financial intermediaries, eight clusters were obtained. The structure of indicator groups is shown in Figure 4.

The formation of cluster ranks of the studied financial intermediaries is presented in Table 11.

Thus, the cluster rating was made (Table 12).

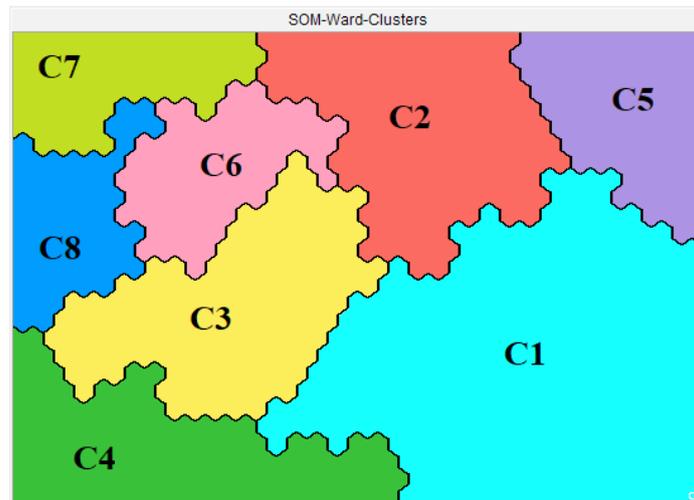


Figure 3. New Kohonen map with conditional financial intermediaries

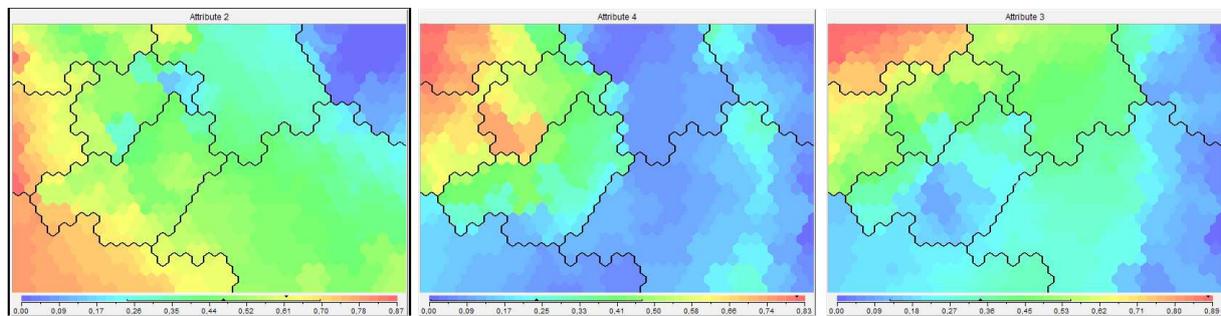


Figure 4. Obtained Kohonen maps by groups of indicators, considering conditional financial intermediaries

Table 11. Cluster rank formation

Cluster	Frequency	Synthesis function attribute			Point distribution			Rank
		G1	G2	G3	G1	G1	G2	
C1	24.23%	0.4332	0.1191	0.2243	3	1	2	6
C2	15.86%	0.3351	0.0844	0.4604	2	1	3	7
C3	9.25%	0.5287	0.3240	0.2387	3	2	2	4
C4	18.50%	0.7445	0.1213	0.2100	4	1	2	5
C5	11.45%	0.0412	0.0942	0.1452	1	1	1	8
C6	4.85%	0.4156	0.5586	0.4818	3	3	3	3
C7	9.25%	0.5645	0.6889	0.8095	3	4	5	1
C8	6.61%	0.7119	0.6483	0.5867	4	4	3	2

Table 12. Cluster ranking

Ranking place	Cluster
1	C7
2	C8
3	C6
4	C3
5	C4
6	C1
7	C2
8	C5

To assess the effectiveness of an individual financial intermediary assigned to a particular cluster, the clusters were conditionally divided into groups (Table 13).

Table 13. Assessment of conditional financial intermediaries by new groups within clusters

Cluster	Financial intermediary evaluation	Group	Probability of participating in shadow operations
C7	5	Powerful	Controlled
C8	4	Stable	
C6	3	Problematic	Neutral
C3			
C4	2	Crisis	Risk
C1			
C2			
C5	1	Bankruptcy	

In the upper left corner there is cluster C7, the indicators of which show the best financial reporting data, and in the upper right corner there is cluster C5, on the contrary, the worst. The membership of a financial intermediary in these clusters is presented in Tables 14 and 15.

Table 14. Financial intermediaries of the newly formed pattern C7

Attribute 1	Attribute 2	Attribute 3	Attribute 4
JSC Universal Bank 2013	0.4968	0.7551	0.5677
JSC Oschadbank 2017	0.5097	0.7335	0.5738
JSB Ukrgasbank 2019	0.5241	0.7795	0.6979
JSC A-Bank 2019	0.4272	0.7133	0.6244
JSC Alfa-Bank 2019	0.6505	0.7447	0.7153
OTP Bank JSC 2019	0.6160	0.7435	0.7734
Raiffeisen Bank JSC 2019	0.6252	0.7434	0.7278
Tascombank JSC 2019	0.6597	0.7419	0.7985
JSC CB PrivatBank 2019	0.5763	0.7299	0.4043
Pivdennyi Bank 2020	0.6761	0.8531	0.7943
JSB Ukrgasbank 2020	0.4682	0.8449	0.6847
JSC A-Bank 2020	0.3979	0.8770	0.7532
JSC Alfa-Bank 2020	0.5592	0.8832	0.7892
OTP Bank JSC 2020	0.5106	0.8886	0.7345
JSC FUIB 2020	0.6515	0.8797	0.7910
Raiffeisen Bank JSC 2020	0.5253	0.8359	0.7001
Tascombank JSC 2020	0.4456	0.8380	0.7394
JSC Ukrsibbank 2020	0.5474	0.8252	0.5722
JSC Universal Bank 2020	0.5776	0.8788	0.8252
JSC CB PrivatBank 2020	0.5387	0.8221	0.3737
The best financial intermediary	0.8718	0.8886	0.8252

Table 15. Financial intermediaries of the newly formed pattern C5

Attribute 1	Attribute 2	Attribute 3	Attribute 4
JSC A-Bank 2012	0.0768	0.0959	0.0643
Raiffeisen Bank JSC 2012	0.1551	0.1018	0.0763
JSC A-Bank 2013	0.1084	0.1193	0.0899
Pivdennyi Bank 2014	0.1013	0.1596	0.1600
JSB Ukrgasbank 2014	0.0283	0.0415	0.0416
JSC A-Bank 2014	0.1038	0.1238	0.0928
OTP Bank JSC 2014	0.0221	0.1128	0.0584
JSC Oschadbank 2014	0.0144	0.2203	0.0997
Raiffeisen Bank JSC 2014	0.0167	0.0913	0.0801
Tascombank JSC 2014	0.0658	0.1121	0.1106
JSC Ukreximbank 2014	0.0415	0.2930	0.1785
JSC Ukrsibbank 2014	0.0378	0.1120	0.1856
Pivdennyi Bank 2015	0.0925	0.3160	0.2139
JSC Alfa-Bank 2015	0.0227	0.1710	0.1350
OTP Bank JSC 2015	0.0001	0.1182	0.0246
JSC Oschadbank 2015	0.0001	0.0430	0.0206
JSC FUIB 2015	0.0000	0.1540	0.0600
Raiffeisen Bank JSC 2015	0.0142	0.1229	0.0665
Tascombank JSC 2015	0.0170	0.1318	0.1204
JSC Ukreximbank 2015	0.0000	0.0318	0.0515
JSC Universal Bank 2015	0.0000	0.1488	0.0053
Pivdennyi Bank 2016	0.1287	0.3607	0.2934
JSC Alfa-Bank 2016	0.0001	0.1864	0.0271
Tascombank JSC 2016	0.0235	0.2712	0.1892
JSC CB PrivatBank 2016	0.0000	0.1316	0.0023
The worst financial intermediary	0.0000	0.0042	0.0023

The added simulated financial intermediaries show an adequate model response to different input data values based on the obtained results.

The financial intermediary with underestimated indicators added to the study ends up in the worst pattern. The financial intermediary with inflated indicators gets into the best pattern, indicating the high quality of the proposed model for evaluating the pattern dynamics of financial intermediaries.

There is a clear relationship between the risk level of financial intermediaries and the probability of their participation in shadow schemes and the phase of the economic cycle of the economy. Thus, during the crisis period of 2012–2015, most bank financial intermediaries were in the zone of most significant risk. During the period of relative stabilization of the economy (2016–2017), bank financial intermediaries have stabilized their operations and since 2018 have been steadily in the controlled zone.

Thus, trajectories of financial intermediaries within individual patterns were formed (Table 16):

- Pivdennyi Bank C7→C7→C8→C8→C8→C1→C4→C4→C5;
- JSB Ukrgasbank C3→C3→C8→C2→C2→C4→C4→C5→C5;
- JSC A-Bank C8→C8→C8→C7→C2→C4→C4→C5→C5;
- JSC Alfa-Bank C7→C7→C7→C8→C8→C2→C4→C5→C5;
- OTP Bank JSC C7→C7→C8→C8→C2→C2→C4→C5→C5;
- JSC Oschadbank C7→C7→C8→C8→C2→C5→C4→C4→C4;
- JSC FUIB C7→C7→C7→C8→C2→C2→C4→C4→C5;
- Raiffeisen Bank JSC C8→C7→C8→C8→C3→C4→C4→C5→C5;
- Tascombank JSC C7→C7→C8→C8→C8→C4→C4→C5→C5;
- JSC Ukreximbank C2→C2→C8→C8→C2→C1→C4→C4→C1;
- JSC Ukrsibbank C7→C7→C8→C2→C1→C1→C4→C4→C5;
- JSC Universal Bank C7→C5→C7→C8→C2→C2→C2→C4→C5;
- JSC CB PrivatBank C2→C2→C2→C2→C8→C1→C1→C5→C5;
- Vygoda Credit Union C1→C1→C6→C6→C6→C6→C6→C6→C6;
- Kreditsous Credit Union C1→C6→C6→C6→C6→C6→C6→C6→C6;
- Financial Support Credit Union C3→C3→C3→C3→C3→C3→C3→C3→C3;
- Enterprise Development Fund FC NUF 2004 C3→C3→C3→C3→C3→C3→C3→C3→C3;
- PJSC Grawe Ukraine Life insurance C1→C1→C1→C1→C1→C1→C1→C1→C1;
- PJSC Metlife C1→C1→C1→C1→C1→C1→C1→C1→C1;
- ICUIG PJSC C1→C1→C7→C1→C1→C1→C1→C1→C1;
- FC Donkredit C1→C6→C1→C1→C3→C3→C3→C3→C3;
- GP Loan Community Skarbnytsya-Pawnshop C3→C3→C3→C3→C3→C3→C3→C3→C3;
- GP Pawnshop Svizha Kopyyka C3→C3→C3→C6→C6→C6→C6→C6→C6;
- FSC FCFSC 2009 FC, LLC C3→C3→C3→C3→C3→C3→C3→C3→C3;
- FSC Center of Financial Decisions FC, LLC C1→C1→C1→C1→C1→C1→C1→C1→C1.

Table 16. A set of development patterns of financial intermediaries’ trajectories according to the probability of participation in shadow operations

Financial intermediary	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pivdennyi Bank	R	R	R	R	R	N	C	C	C
JSB Ukrgasbank	N	N	R	N	N	C	C	C	C
JSC A-Bank	R	R	R	R	N	C	C	C	C
JSC Alfa-Bank	R	R	R	R	R	N	C	C	C
OTP Bank JSC	R	R	R	R	N	N	C	C	C
JSC Oschadbank	R	R	R	R	N	C	C	C	C
JSC FUIB	R	R	R	R	N	N	C	C	C
Raiffeisen Bank JSC	R	R	R	R	N	C	C	C	C
Tascombank JSC	R	R	R	R	R	C	C	C	C
JSC Ukreximbank	N	N	R	R	N	N	C	C	N
JSC Ukrsibbank	R	R	R	N	N	N	C	C	C
JSC Universal Bank	R	C	R	R	N	N	N	C	C
JSC CB PrivatBank	N	N	N	N	R	N	N	C	C
Vygoda Credit Union	N	N	R	R	R	R	R	R	R
Kreditsous Credit Union	N	R	R	R	R	R	R	R	R
Financial Support Credit Union	N	N	N	N	N	N	N	N	N
Enterprise Development Fund FC NUF 2004	N	N	N	N	N	N	N	N	N
PJSC Grawe Ukraine Life insurance	N	N	N	N	N	N	N	N	N
PJSC Metlife	N	N	N	N	N	N	N	N	N
ICUIG PJSC	N	N	R	N	N	N	N	N	N
FC Donkredit	N	R	N	N	N	N	N	N	N
GP Loan Community Skarbnytsya- Pawnshop	N	N	N	N	N	N	N	N	N
GP Pawnshop Svizha Kopyyka	N	N	N	R	R	R	R	R	R
FSC FCFSC 2009 FC, LLC	N	N	N	N	N	N	N	N	N
FSC Center of Financial Decisions FC, LLC	N	N	N	N	N	N	N	N	N

Note: R – risk, N – neutral, C – controlled.

CONCLUSION

This paper proposes a methodological approach to build a model for estimating the development trajectories of banking and non-banking financial intermediaries based on a set of patterns. Constructed patterns determine the level of probability of financial intermediaries' participation in illegal schemes based on Harrington's desirability function and Kohonen's self-organizing maps. The model uses 37 indicators that characterize the state of a particular group of 25 financial intermediaries. According to the model, the interaction trajectories of financial intermediaries were built into 8 patterns formed based on Kohonen's self-organizing maps and cluster analysis. This approach allows tracking the transition of financial intermediaries between patterns (risk, neutral, controlled) and changes in the patterns' characteristics at different stages of the economic cycle. During the analyzed period, the neutral level of participation risk in shadow schemes was inherent in most non-bank financial intermediaries (except for two credit unions and one pawnshop). It should be noted that non-bank financial intermediaries are less sensitive than banks to the phases of the economic cycle. According to the model, the riskiest patterns include pawnshops and credit unions.

The results obtained can further become the basis for de-shadowing tools that will take into account the microeconomic nature of business models of interaction between financial intermediaries and provide a significant positive macroeconomic and social effect.

AUTHOR CONTRIBUTIONS

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APPENDIX A

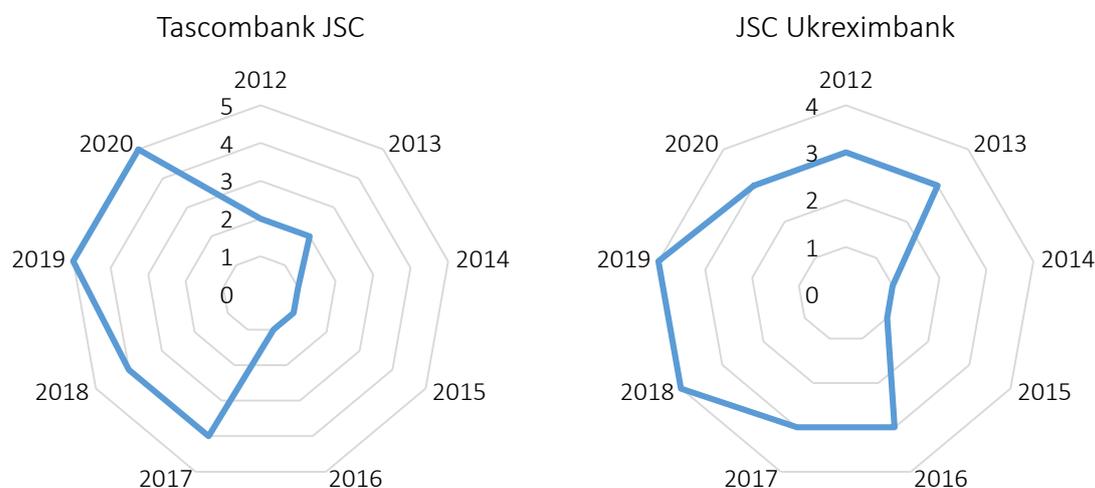


Figure A1. Development patterns of financial intermediaries' trajectories

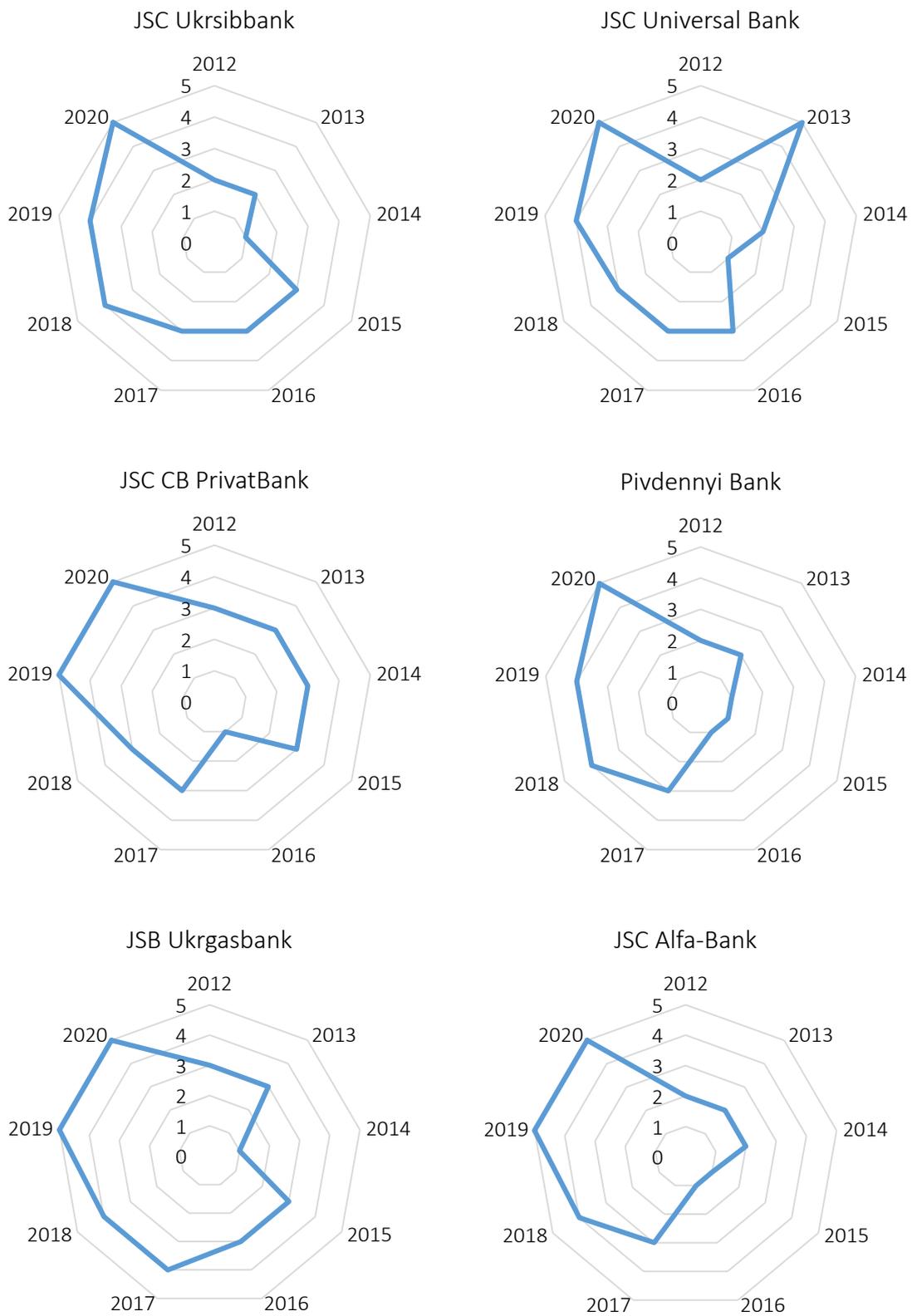


Figure A1 (cont.). Development patterns of financial intermediaries' trajectories

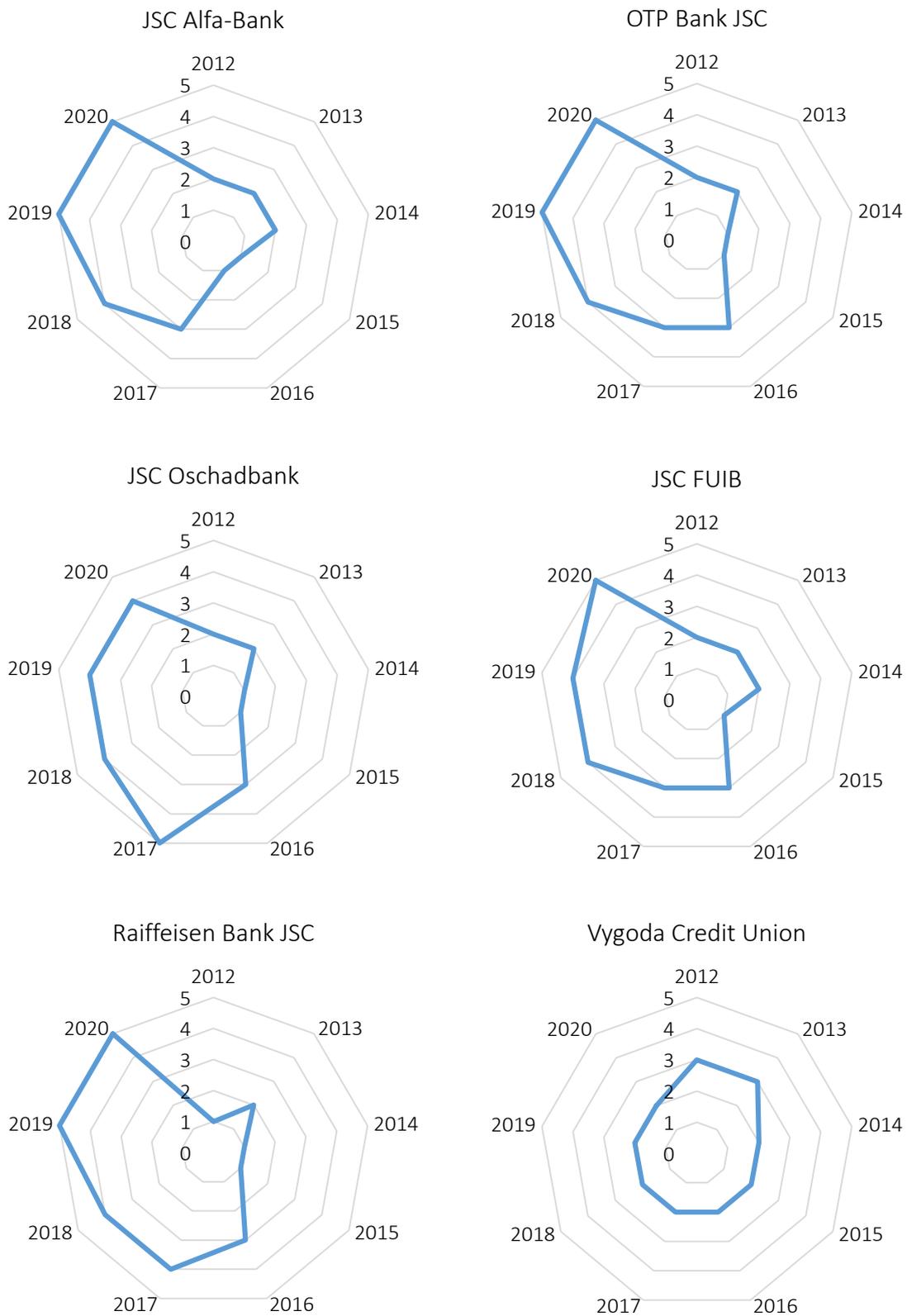


Figure A1 (cont.). Development patterns of financial intermediaries' trajectories

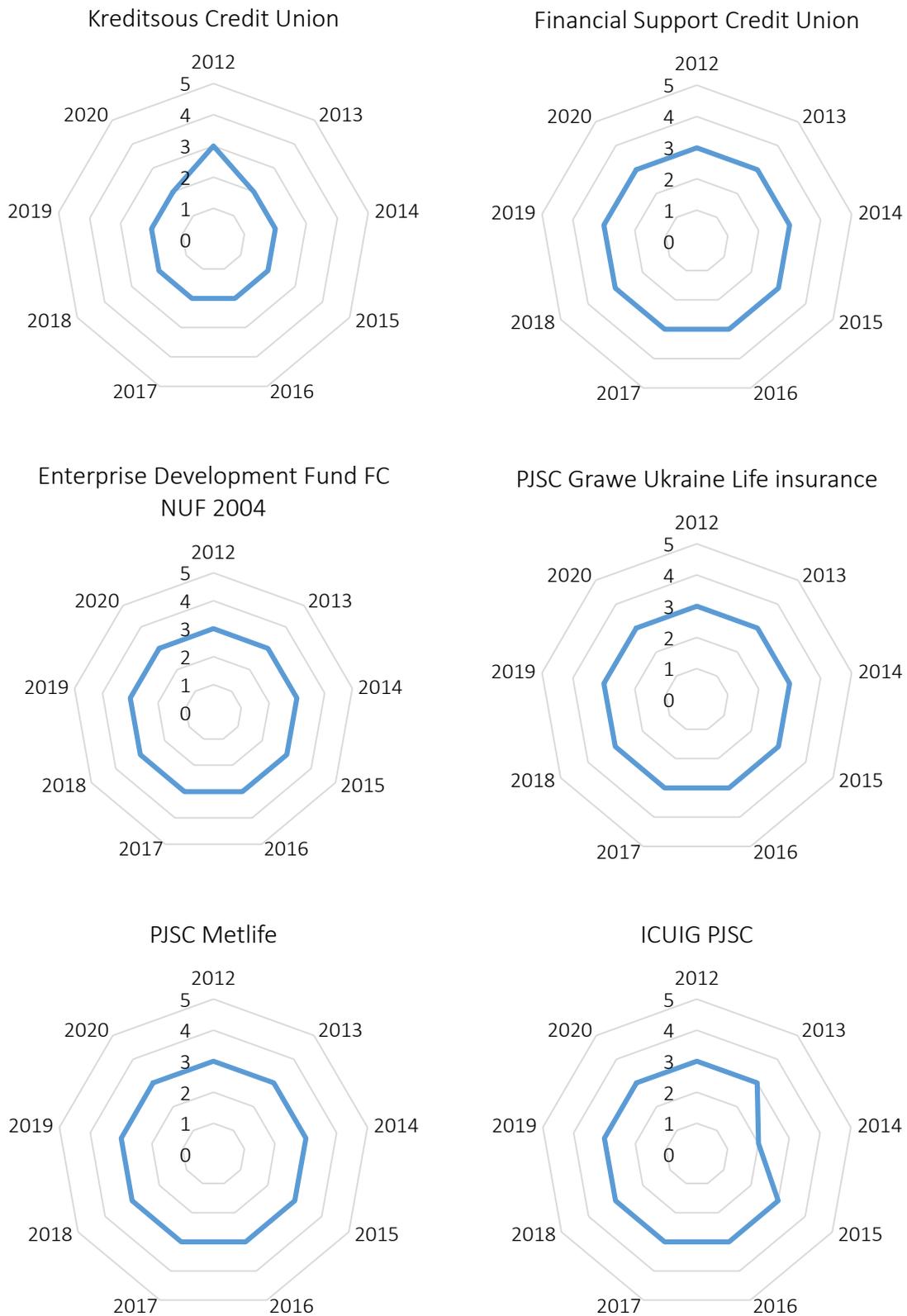


Figure A1 (cont.). Development patterns of financial intermediaries' trajectories

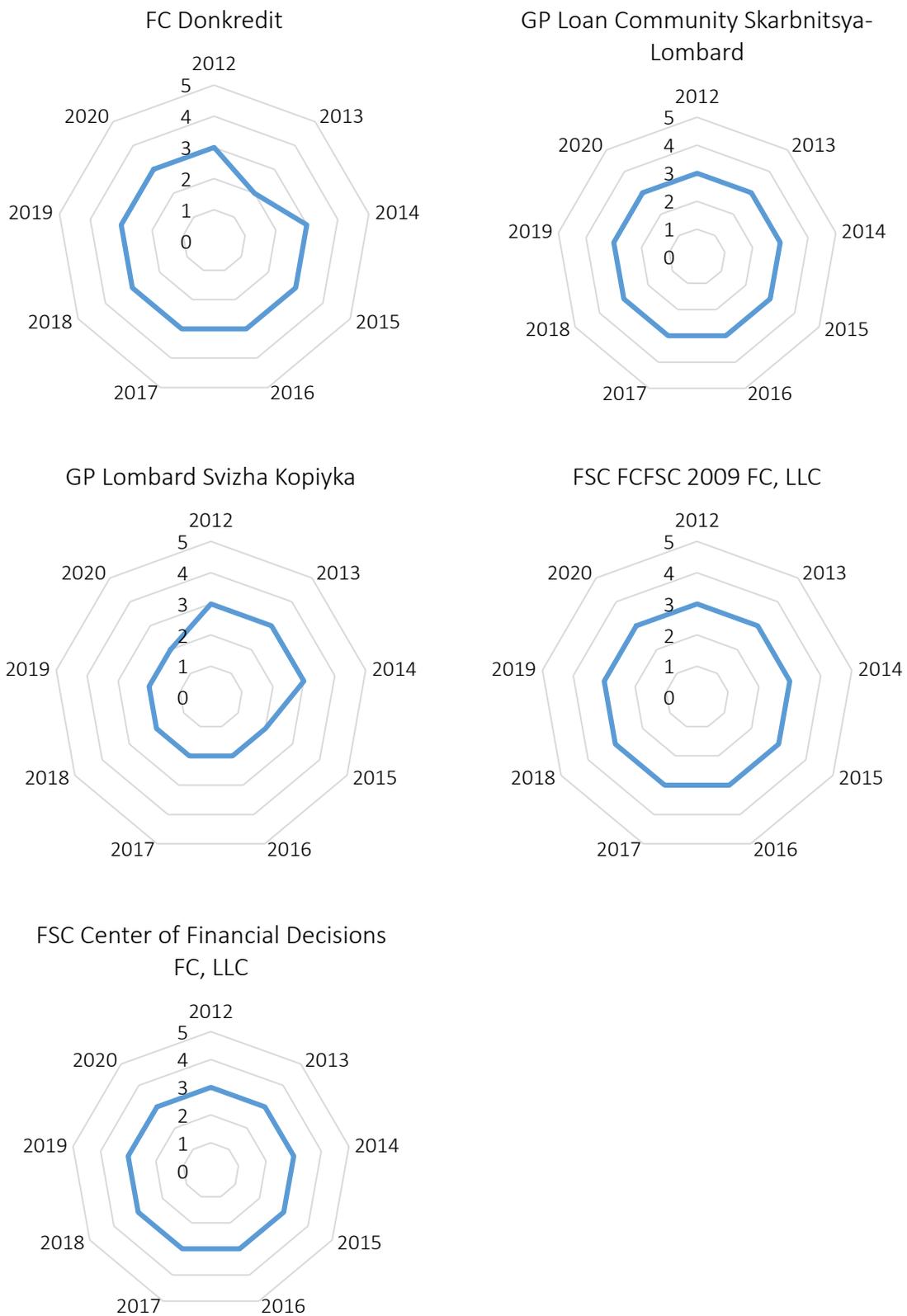


Figure A1 (cont.). Development patterns of financial intermediaries' trajectories