








“Risk management through a Kohonen map bank business model survey: The case of Ukraine”

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ARTICLE INFO	Olena Zarutska, Olena Dobrovolska, Iuliia Masiuk, Ralph Sonntag and Wolfgang Ortmanns (2024). Risk management through a Kohonen map bank business model survey: The case of Ukraine. <i>Banks and Bank Systems</i> , 19(2), 221-233. doi: 10.21511/bbs.19(2).2024.18
DOI	http://dx.doi.org/10.21511/bbs.19(2).2024.18
RELEASED ON	Thursday, 27 June 2024
RECEIVED ON	Saturday, 20 January 2024
ACCEPTED ON	Thursday, 20 June 2024
LICENSE	 This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Banks and Bank Systems"
ISSN PRINT	1816-7403
ISSN ONLINE	1991-7074
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”



NUMBER OF REFERENCES

37



NUMBER OF FIGURES

9



NUMBER OF TABLES

5

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BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

Received on: 20th of January, 2024

Accepted on: 20th of June, 2024

Published on: 27th of June, 2024

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Conflict of interest statement:

Author(s) reported no conflict of interest

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RISK MANAGEMENT THROUGH A KOHONEN MAP BANK BUSINESS MODEL SURVEY: THE CASE OF UKRAINE

Abstract

The purpose of this paper is to identify the peculiarities of banks' business models and assess their risks, which is especially relevant in the context of the war in Ukraine since 2014. The information base is the published statements for each month of 63 Ukrainian banks for the period from 1 January 2018 to 1 January 2024. The number of indicators is chosen in an empirical manner. Business models are investigated using the method of structural-functional groups of banks, which allows estimating large arrays of financial indicators, grouping banks with similar characteristics and drawing conclusions about the main risks. It is convenient to use neural networks, namely Kohonen's self-organizing maps, to estimate large data sets. The largest group of banks places a significant part of assets in government securities and has an unstable resource base. The share of these banks in the system as of January 1, 2024 is 38% and total assets are 10%. The second group by number of banks is focused on corporate lending with a high share of current resources in liabilities, and includes 21% of banks, whose assets account for 31% of total assets. State-owned banks, PrivatBank and OschadBank, account for 35% of total assets. The business models of these banks are characterized by dependence on retail funds, a high share of investment operations, and high credit and currency risks. Ukraine's banking system has significantly developed a risk-oriented approach to management, which allowed it to maintain stability in the face of a full-scale war.

Keywords

banking system, credit risk, currency risk, assets,
liabilities, management models, cluster analysis

JEL Classification

C45, G21, G17

INTRODUCTION

In Ukraine, the banking system was formed for decades, starting in 1991. Only after the collapse of more than a hundred banks in the last 15 years, they began to create, coordinate, and manage the organization of the risk management system both within a single bank and on the part of the regulator, the National Bank of Ukraine. Many scientific and practical studies have been devoted to classifying risks, modeling, and improving the organization's risk management system management.

The National Bank of Ukraine develops regulatory requirements to improve the efficiency of risk management. The fulfillment of these requirements depends on a bank's specific business model, products, structure, and quality of assets and liabilities.

In recent years, the financial condition of banks in Ukraine has been assessed only using a risk-based approach due to the emergence of a new risk – Russia's full-scale invasion of Ukraine. Ukrainian banks build their own business models relying on the range of banking products, structure and quality of assets and liabilities, and assessment of

their place in the banking services market. At the same time, the role of risk management in a bank increases in direct proportion to the increase in the range of banking products and client base.

Ukraine implements the norms and standards of the international Basel Committee on Banking Supervision. It uses the best European ideology of introducing unified standards in banking regulation, including risk management. Today, Ukraine's banking system ensures the effective implementation of Basel III recommendations.

Therefore, identification, measurement, monitoring, control, reporting, and minimization of all types of risks, as well as determining the direction of causality, remain urgent scientific and practical tasks for Ukraine's banking system.

1. LITERATURE REVIEW

The study of risks is characterized by a strong academic heritage in their classification. The classification ordering of banking risks developed by Rose (2000) covers six main types of risks that occur in commercial banks (credit risk, liquidity imbalance risk, market risk, interest rate risk, risk of not making a profit, insolvency risk), and four risks are highlighted as additional risks (inflation risk, currency risk, political risk, fraud risk).

The classification of risks from Greuning and Bratanovic (2009) is considered more appropriate because it really shows the current practical situation in Ukrainian banks. These risks include financial, operational, business, and extraordinary risks, which are determinants in Ukraine's banking system.

The classification proposed by Ukrainian scientists Kozmenko et al. (2003) can also be used by commercial banks in Ukraine. The distinctive feature of this classification is the creation of such a system of risks that divides all risks of commercial banks into external and internal.

Pagliari et al. (2012), Merk et al. (2012), and Köhler (2014) investigate different approaches to the classification of business models of commercial banks. Pagliari et al. (2012) categorize business models by line of business and divide them into commercial and investment. Merk et al. (2012), based on the study of business models of large international banks, take historical experience and trends of international banking business development as the basis of classification criteria. They distinguish the following business models of banks: commercial,

investment, specialized, and universal. Köhler (2014) based his classification on two criteria – a type of client and range of products offered, and, consequently, distinguished retail, investment, specialized, and diversified business models of commercial banks. According to Onyshchenko and Zaiats (2020), the approach of Köhler (2014) to the classification of banks' business models requires improvement, as there are different financial market models in different countries of the world.

To improve the risk assessment system of financial institutions, it is necessary to strive to strengthen preventive measures to manage them by using methods of descriptive statistics to assess and identify risks at all levels of banking activities (Shorokh, 2021; Tarasevych, 2021). Changes in legislation in Ukraine under martial law provided almost 100% coverage of household deposits in banking institutions. (Kravchuk, 2023). The introduction of a risk-based approach in banks will contribute to combating money laundering, financing of terrorism, and financing of proliferation of weapons of mass destruction.

Acharya and Pedersen (2005) provide evidence that risks inherent in the banking business need to be managed to prevent financial losses to stakeholders in the sector and negative externalities to the global economy when dealing with securities.

Hsieh and Lee (2020), Davydenko et al. (2023b), Samorodov et al. (2019), Jing (2019), and Kaminsky et al. (2022) used the GMM model, descriptive statistics methods, and retrospective analysis to improve the efficiency of bank financial stability management based on strategic maps and bor-

rower segmentation based on the whale curve approach. The results of the studies by Mishchenko and Naumenkova (2022), Tarasevych (2021), and Azarenkova et al. (2022) made it possible to form clusters of countries according to the level of stability of their banking systems and map financial stability risks at the global level. The use of mathematical models based on statistical data is important for making effective management decisions (Zomchak, & Nehrey, 2022).

During 2017–2019, Ukraine experienced a decrease in three economic norms of banking regulation: regulatory capital adequacy, high credit risk and high regulatory capital adequacy, high credit risk, and medium investment (Kuznetsova et al., 2020). The quality of banking regulation is determined by the degree of independence of a country's central bank regardless of the political regime in the country (Vasylieva et al., 2022). Davydenko et al. (2023a) and Peykani et al. (2023) believe that information and analytical support of bank financial security provides an objective assessment of the situation and balanced management decision-making.

The practice of using self-organizing neural networks and Kohonen maps in international practice and in the Ukrainian banking system also exists (Gelhausen, 2010; Kohonen, 2013; Da Silva et al., 2017; Hryckiewicz & Kozłowski, 2017; Kozmenko et al., 2016; Kasianenko et al., 2019; Shkolnyk et al., 2020; Zarutskaya et al., 2018, 2020, 2022). In Ukraine, the reliability of commercial banks was analyzed from 2014 to 2018, broken down into three periods (Mints, 2018). The current risk management mechanism requires improvement, taking into account the achievements of economic science, the real state and prospects of the development of banking, world experience (Tarasevych, 2021; Druhov & Druhova, 2022; Arzhevitin et al., 2023).

Numerous studies (Zarutskaya et al., 2018; 2020; 2022) confirm that modern innovative methods of banking supervision are related to the study of business models and risk profile of banks. It is this method that is simple and informative for practical use by commercial banks.

In this regard, the scientific interest of this study is to identify the features of business models of

Ukrainian banks during the period of martial law and to assess the risks of each of the defined business models.

The purpose of the paper is to form clusters of banks' business models for the period from January 1, 2018 to January 1, 2024, by grouping indicators of the structure of assets, liabilities, and other indicators and assessing the risks of each of the identified business models. Risk management systems at the bank level should consider the peculiarities of business models, taking into account the list of identified indicators that characterize them.

2. METHODS

The construction of the SFGB is based on the procedure of forming a self-organizing map using the Viscovery SOMine software product. The study uses 31 indicators for each of the banks for all reporting dates for the period from January 1, 2018 to January 1, 2024. The number of indicators was chosen empirically based on the publicity of banks' reporting and the need to assess the structure and quality of banks' assets and liabilities, other indicators reflecting banks' risks. The array of bank indicators for a certain period consists of 5,000 rows and 31 columns.

The method of self-organizing maps is a kind of neural network methods of learning without a teacher. This method uses a heuristic algorithm to "pull" points in 31-dimensional space to the centers of certain clusters. The objects closest to each node show close index values and hence close Euclidean distance in 31-dimensional space. The property of visualizing the distance difference between indices is preserved and displayed in a two-dimensional map of clusters. Any point in this map is the location of one or more banks. Locations that are close to each other are close in terms of values of all 31 indices. Large clusters combine close values of most indicators and are closer to the center of the map. SFGBs located in the corners and on the map's borders are significantly different and have specific business model characteristics. The groups with specific characteristics include a more stable mix of banks than the center groups with less variation.

The list of indicators used to construct the map is presented in Table 1, along with the values of the 6 largest banks out of 63 banks in operation as of January 1, 2024 and the system average.

Table 1. SFGB indicators as of January 1, 2024, %

No.	Indicator	Privatbank	Oschadbank	Ukrexim-bank	UkrGas-Bank	Sense Bank	Raiffeisen Bank
1	L1	17.4	18.2	16.5	12.3	16.5	22.8
2	SAV	11.6	10.4	6.5	7.7	8.1	14.9
3	SAMI	11.0	7.6	21.9	12.9	12.3	4.7
4	SAMN	0.0	0.3	0.0	0.1	0.1	1.0
5	SAUI	0.7	7.4	17.0	14.1	16.3	10.3
6	SAUN	4.5	14.2	11.6	18.9	6.6	15.3
7	SAFI	0.0	0.0	0.0	0.1	0.7	0.0
8	SAFN	8.8	4.4	0.0	2.9	7.5	2.3
9	SACI	6.4	4.8	3.2	0.1	0.4	14.8
10	SACN	38.2	31.5	28.4	40.1	42.2	28.4
11	RA	28.2	7.6	8.2	8.2	20.5	7.6
12	A-s	23.3	11.7	9.0	6.0	3.7	6.4
13	VCA	19.3	20.9	42.7	28.7	31.1	35.0
14	VL	-4.4	0.3	-8.1	0.0	-0.2	3.2
15	SPMI	0.0	0.5	1.0	1.7	0.0	0.1
16	SPMN	0.0	0.0	1.5	0.0	0.0	0.1
17	SPUI	8.6	7.5	19.9	18.6	8.7	19.1
18	SPUN	17.6	26.9	38.9	53.9	39.9	39.5
19	SPUP	24.0	29.1	36.6	55.6	40.3	46.7
20	SPUS	2.1	5.3	22.2	17.0	8.3	11.9
21	SPFI	16.9	13.0	9.2	7.5	26.1	15.6
22	SPFN	48.2	46.5	5.6	12.9	23.0	20.2
23	SPFP	52.2	33.0	4.2	11.0	14.8	27.4
24	SPFS	12.9	26.5	10.7	9.4	34.3	8.4
25	CA	12.2	7.8	3.5	6.2	10.5	11.5
26	PM	8.7	5.5	1.8	3.8	5.1	8.8
27	KD	3.6	2.0	0.4	0.7	2.2	1.6
28	TD	2.0	-0.8	0.2	0.6	1.4	1.3
29	VA	3.6	4.5	1.3	2.5	6.3	4.8
30	VR	0.7	-0.4	-0.3	0.0	1.2	2.0
31	ROA	5.5	1.4	2.0	1.1	4.6	2.5

L1 – ratio of cash and cash equivalents to demand liabilities, SAV – ratio of cash and cash equivalents to net assets, SAMI – ratio of funds with oth-

er banks in foreign currency to net assets, SAMN – ratio of funds with other banks in national currency to net assets, SAUI – ratio of credits of legal persons in foreign currency to net assets, SAUN – ratio of legal persons' credits in national currency to net assets, SAFI – ratio of credits of natural persons in foreign currency to net assets, SAFN – ratio of credits of individuals in national currency to net assets, SACI – foreign currency securities portfolio to net assets ratio, SACN – the ratio of securities portfolio in national currency to net assets, RA – ratio of aggregate provisions for credit risks to net assets, A-s – share of net assets of the given bank in total net assets of the system, VCA – ratio of net assets in foreign currency to net assets, VL – open foreign exchange position, which is calculated as the difference between assets and liabilities in foreign currency in relation to net assets, SPMI – the ratio of other banks' funds in foreign currency to liabilities, SPMN – the ratio of other banks' funds in national currency to liabilities, SPUI – ratio of economic entities' funds in foreign currency to liabilities, SPUN – ratio of economic entities' funds in national currency to liabilities, SPUP – ratio of economic entities' demand funds to liabilities, SPUS – ratio of economic entities' term funds to liabilities, SPFI – ratio of natural persons' funds in foreign currency to liabilities, SPFN – ratio of natural persons' funds in national currency to liabilities, SPFP – demand deposits of natural persons to liabilities ratio, SPFS – the ratio of natural persons' term funds to liabilities, CA – ratio of balance sheet capital to net assets, PM – interest margin, ratio of net interest income to net assets, KD – ratio of net fee and commission income to net assets, TD – ratio of trading result to net assets, VA – ratio of administrative and other operating expenses to net assets, VR – ratio of credit risk provisioning expenses to net assets, ROA – return on assets

A detailed breakdown of the indicators is provided later in the study.

3. RESULTS

Figure 1 shows the general view of Kohonen maps as of January 1, 2024. 12 SFGBs were formed, the size of which depends on the number of banks that had relevant characteristics during the whole research period.

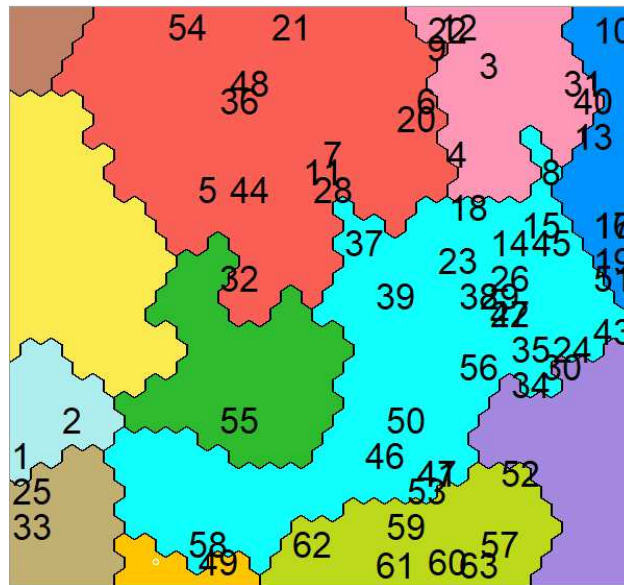


Figure 1. Kohonen map as of January 1, 2024

The numbers indicate the location of specific banks as of the reporting date. The number reflects the number of a bank in the list by asset size.

As the arrangement of numbers on the map shows, the largest number of banks as of January 1, 2024 is concentrated in its north-east. Some of them are in the largest group with the first number, occupying the center and north of the map. Also, many banks are in the group with number 2, which is close to the eastern border. The northeast corner of the map is occupied by foreign-owned banks. The two largest banks in Ukraine, Privatbank and Oschadbank, are ranked in a small group in the southwest part of the map at the beginning of January 2024. Let us consider the characteristics of each SFGB and the risk characteristics of the respective groups of banks in Table 2.

The following structural indicators of the asset side were used to describe the structure of the banks' loan portfolio: SAUN – loans of legal entities in national currency, SAUI – loans of legal entities in foreign currencies, SAFN – loans of individuals in national currency and SAFI – loans of individuals in foreign currencies. The distribution of values of these indicators on the map is shown in Figure 2. Loans to individuals in foreign currencies are almost non-existent. Business models focused on corporate lending declined significantly during the war years and the Corona crisis. The largest share of corporate loans in local currency is in small banks in the center group 4. Consumer loans are concentrated in group 9 of so-called “retail banks” in the south-west of the map.

The total loan portfolio is gradually shrinking. At the beginning of 2024, loans accounted for 23.4%

Table 2. Indicators of the asset structure as of January 1, 2024

No.	Indicator	Average values of indicators for business model groups (%)									
		1	2	4	5	6	7	8	9	10	12
1	SAV	8.5	10.4	7.3	6.0	8.9	4.5	5.8	7.4	11.0	8.4
2	SAMI	7.7	13.6	5.5	10.7	25.6	3.4	18.0	6.7	9.3	3.5
3	SAMN	0.4	0.6	0.0	0.2	0.5	3.5	0.0	1.2	0.2	0.5
4	SAUI	5.7	9.4	11.1	8.8	10.5	0.0	0.7	2.3	4.0	0.6
5	SAUN	12.9	14.8	37.7	20.0	17.6	10.3	5.8	1.8	9.4	2.7
6	SAFI	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
7	SAFN	2.2	4.1	0.3	1.2	0.6	0.7	0.0	46.2	6.6	0.1
8	SACI	2.8	9.9	0.0	0.0	1.3	0.5	1.1	0.9	5.6	0.3
9	SACN	48.4	32.1	26.5	36.2	25.0	59.5	66.3	26.1	34.8	75.3

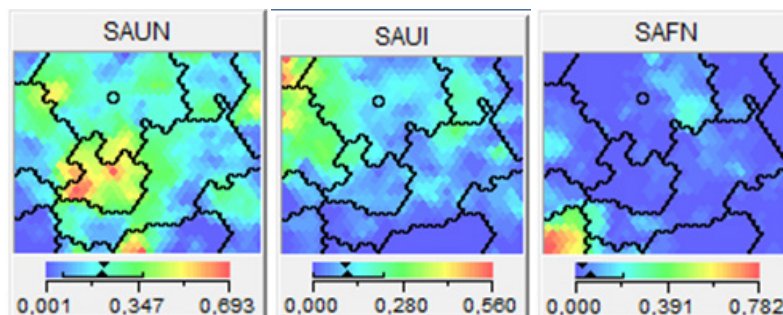


Figure 2. Distribution of values of the loan portfolio structure indicators

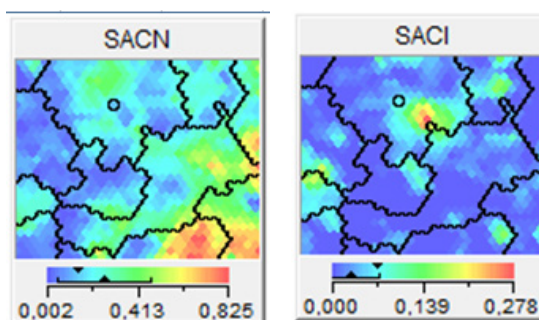


Figure 3. Distribution of investment portfolio structure indicators

of Ukrainian banks' assets. Instead, banks' securities portfolios are gradually growing.

As of January 1, 2024, banks' funds placed on the stock market account for 42.5% of total assets. The lion's share of assets is invested in government securities, internal government loan bonds, and certificates of deposit. The following indicators are used to assess the structure of assets placed in the stock market: SACN – securities in the national currency, SACI – securities in foreign currencies. The distribution of these indicators on the map is presented in Figure 3.

Securities hold a particularly large share in banks' assets in the southeast corner of the map. The share of securities in foreign currencies in SACI assets is much smaller than in domestic currencies.

Placement of funds in the interbank market is measured by indicators SAMN - share of funds in interbank credits in national currency and SAMI – share of funds in interbank credits in foreign currency in assets. Interbank loans in national currency average 0.7 % and have no clear extremes on the map. The SAMI indicator reaches its maximum level in the northeast cor-

ner of the map, where foreign-owned banks are located. The interbank market is actively used by this group of banks as an alternative direction of funds placement.

Structural indicators of banks' assets assessment also include SAV – the share of funds on a correspondent account with the NBU and in cash in assets. Indicators of instantaneous liquidity assessment do not have an increased value in individual clusters. The liquidity position of the majority of Ukrainian banks is controllable (Table 3).

The following indicators are used in the system of indicators characterizing the attracted funds of the corporate market: SPUN – liabilities of legal entities in national currency, SPUI – funds of legal entities in foreign currencies, SPUP – current funds of legal entities, SPUS – term funds of legal entities. The distribution of values of these indicators is shown in Figure 4. All types of resources of corporate clients are concentrated in banks with foreign capital in the north-east of the map. Current resources prevail over term resources, funds in national currency – over resources in foreign currencies.

Table 3. Indicators of the structure of liabilities as of January 1, 2024

No.	Indicator	Average values of indicators for business model groups (%)									
		1	2	4	5	6	7	8	9	10	12
1	SPMI	1.1	0.5	0.0	0.0	1.3	0.0	1.1	0.1	0.3	0.0
2	SPMN	0.5	0.4	0.0	6.2	1.5	4.3	0.0	0.1	0.0	30.1
3	SPUI	9.2	13.4	8.3	10.1	27.4	4.6	20.6	1.0	8.0	1.1
4	SPUN	56.4	36.8	29.5	51.4	37.7	40.7	71.2	20.6	22.3	44.6
5	SPUP	44.0	41.3	24.1	49.3	43.8	36.6	53.9	15.1	26.6	17.3
6	SPUS	21.6	8.8	13.7	12.2	21.3	8.7	37.9	6.5	3.7	28.5
7	SPFI	9.5	22.4	19.2	4.2	10.2	4.3	1.4	13.7	14.9	8.5
8	SPFN	17.1	19.4	40.4	17.2	12.5	16.7	1.0	53.9	47.4	6.8
9	SPFP	8.9	25.4	13.9	4.1	8.7	11.1	1.8	18.2	42.6	11.0
10	SPFS	17.7	16.4	45.7	17.2	13.9	9.9	0.5	49.4	19.7	4.3

Funds of natural persons occupy the second place in Ukrainian banks' liabilities. The majority of attracted funds are resources in the national currency. The ratio of term and current resources is gradually improving in favor of a more stable base. The distribution of indicators on the map is shown in Figure 5.

of retail banks and the largest state-owned banks are located. Current resources of individuals SPFP prevail in the largest first group of banks. Individuals' funds in foreign currency SPFI are distributed so that no banks, as of January 1, 2024, fell into the zones of maximum values.

The indicators of the share of households' term funds SPFS and the share of households' funds in the national currency SPUN are highly correlated. They are maximally significant in the southwestern part of the map, where the group

Since banks' business models depend, first, on the structure of banks' assets and liabilities, it is possible to formulate their characteristics according to the above-mentioned patterns of each group (Table 4).

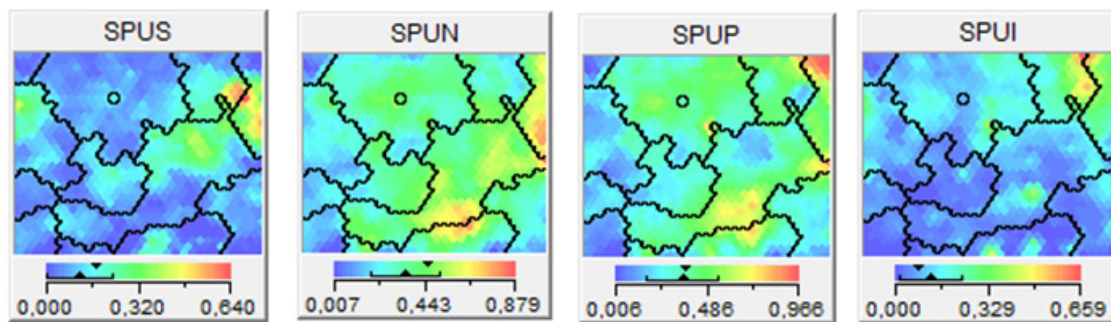


Figure 4. Distribution of values of the legal persons' liability structure indicators

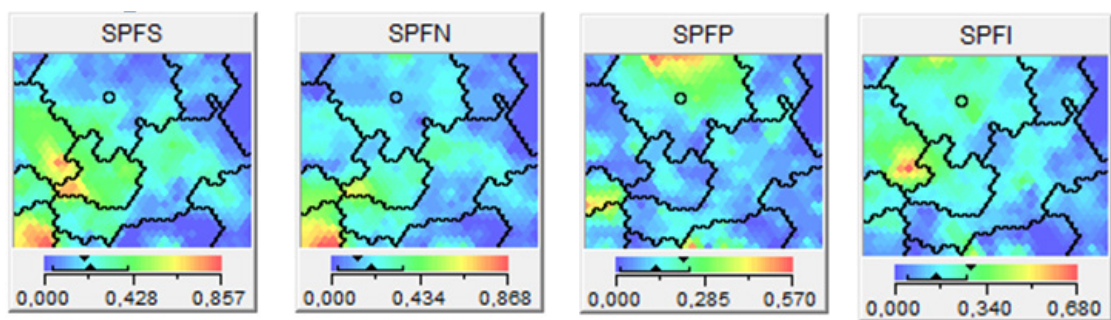


Figure 5. Distribution of indicator values of the natural persons' liability structure

Table 4. Characteristics of SFGBs as of January 1, 2024

No.	Business model	Indicators	Number of banks	Assets, UAH mln.
1	Securities with corporate financing	SACN, SAUN, SPUP	24	295,651
2	Corporate with current financing	SAUI, SAUN, SPFI, SPFP, VCA	13	910,941
4	Corporate with retail financing	SAUI, SAUN, SPFN, SPFS, VR	1	828
5	Corporate with current financing	SAUN, SPUP, SPMN, SPUN	1	12,408
6	Interbank loans with corporate financing	SAMI, SAUI, SAUN, SPUI, VCA	6	546,325
7	Securities with interbank financing	L1, SACN, SPMN, CA, VA	7	3,279
8	Corporate finance securities, foreign capital	SAMI, SACN, SPUI, SPUS, SPUN, SPUP	6	112,465
9	Retail banks	SAFN, RA, VL, SAMN, SPFN, SPFS, SPFP, PM, VR, ROA	2	30,892
10	The largest	A-s, SAV, SPFN, SPFP, SACI, VL, RA, ROA	2	1,028,521
12	Securities with interbank financing	L1, SACN, SPMN, SPUS, CA, TD, VA	1	1,496
Total			63	2,942,805

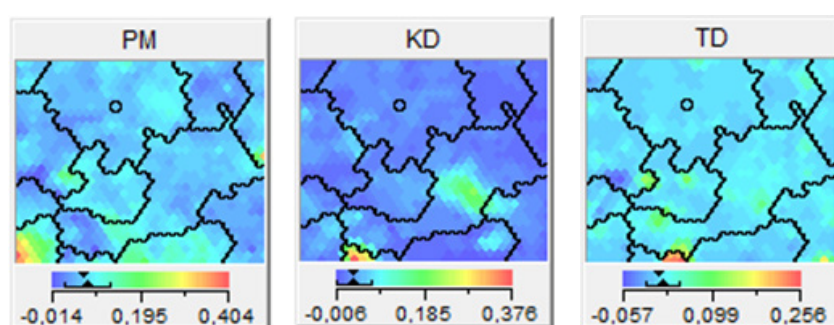
Table 5. Other indicators of bank clustering as of January 1, 2024

No.	Indicator	Average values of indicators for business model groups (%)									
		1	2	4	5	6	7	8	9	10	12
1	L1	21.4	17.9	29.3	12.3	18.7	49.2	15.7	26.4	17.8	48.1
2	RA	5.2	7.2	11.3	10.5	7.3	6.9	2.2	43.9	17.9	4.4
3	A-s	0.4	2.4	0.0	0.4	3.1	0.0	0.6	0.5	17.5	0.1
4	VCA	18.0	34.6	18.0	22.3	41.9	5.4	20.3	11.5	20.1	6.9
5	VL	-0.4	1.7	-0.1	3.9	-0.8	1.6	1.5	-1.6	-2.0	0.9
6	CA	15.0	13.4	34.2	8.7	6.5	62.9	19.8	16.7	10.0	38.1
7	PM	5.3	7.0	8.1	3.1	3.9	10.7	10.6	20.6	7.1	3.4
8	KD	2.0	1.5	3.1	2.7	0.8	1.4	0.2	1.7	2.8	1.5
9	TD	0.9	1.2	0.8	2.9	0.5	0.3	0.5	1.4	0.6	21.8
10	VA	8.1	5.8	7.3	5.3	3.0	12.8	4.6	10.8	4.0	24.5
11	VR	-0.5	1.5	4.6	2.7	0.6	0.5	-1.3	4.9	0.1	2.7
12	ROA	0.5	1.7	0.1	0.8	1.1	0.4	4.7	5.2	3.4	0.2

The 31 indicators used for clustering were used to classify the business models presented in Table 4. To characterize the business model, it is also important to consider the structure of banks' revenues and expenses, i.e., the effectiveness of their chosen development strategies (Table 5).

To assess the efficiency of interest operations, the net interest margin indicator RM is used – the ratio of net interest income to assets. The highest level of the indicator is observed in retail banks. The

results of operations that provide banks with fee and commission income, net of commission expenses, are assessed using the net fee and commission income indicator KD – the ratio of net fee and commission income to assets. The third important component of modern banks' profit is trading income, measured with the TD indicator's help – the ratio of trading income to assets. Banks with a high investment portfolio level have the highest level of this indicator. The distribution of these indicators is shown in Figure 6.

**Figure 6.** Distribution of indicator values of banks' profitability sources

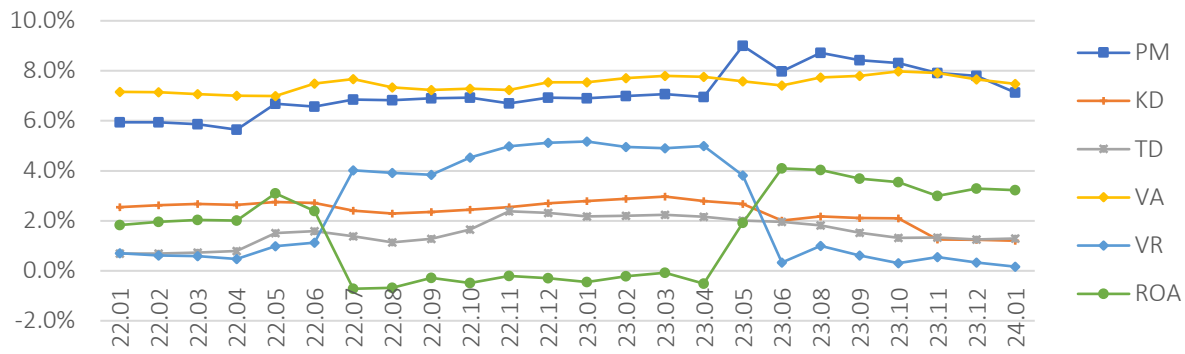


Figure 7. Dynamics of Ukrainian banks' average profitability indicators

Return on assets (ROA) allows us to assess the overall level of bank efficiency. The average level of ROA as of 1 January 2024 is 3.2%. The most profitable groups are the largest banks (3.4%), retail banks (5.2%), and banks with foreign capital (ROA is 4.7% for group 8) (Figure 7).

The high level of interest margin PM is traditionally observed at retail banks of group 9, which is equal to 20.6 % as of January 1, 2024. The banks of this group demonstrate a high indicator of expenses on the formation of provisions for credit risks. If the average value of the VR indicator is 0.1 %, then for retail banks of group 9, this indicator is 4.9 %. Small banks of group 4 also have a high level of VR indicator. The quality of bank assets can be assessed by the ratio of reserves to assets RA. The indicator reaches the maximum value of 43.9 % in the group of retail banks. An increased RA value of 17.9 % is observed in the largest banks of group 10.

Large state-owned banks are burdened with non-performing assets, which appear on the balance sheets of these banks under the influence of vari-

ous negative factors. Banks with foreign capital have the lowest level of reserves.

The following two indicators are used to assess banks' currency risks: VCA – the ratio of assets in foreign currencies to net assets and VL – the ratio of the difference between assets and liabilities in foreign currencies to assets. The first indicator allows us to estimate the total share of funds in foreign currencies in the banks' balance sheet, and the second one - the banks' open foreign exchange position.

Any bank's business model depends on the scale of its operations. The scale indicator A-s, calculated as the ratio of a particular bank's assets to the system's total assets, is proposed to be used for medium-sized banks. The A-s indicator does not affect the distribution for medium-sized banks by asset size.

An example of such groups is shown in Figure 8. In the southwest of the map, there are retail banks with a higher share of attracted funds from natural persons in national currency and granted consumer loans in national currency.

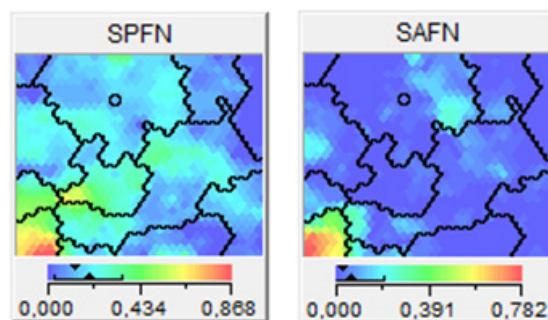


Figure 8. Example of concentration of the highest level of SAFN and SPFN indicators of individuals' attracted and placed funds in the group of retail banks

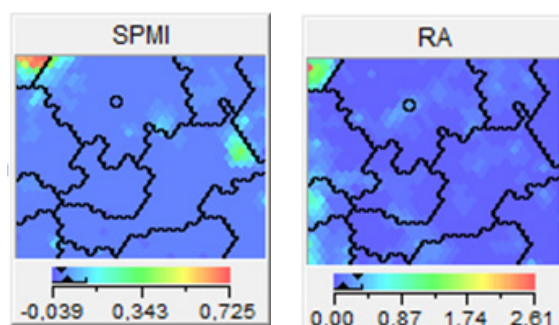


Figure 9. Example of concentration of the highest level of indicators of interbank funds attracted by SPMI and reserves RA in a group of problem banks

An example of the coincidence of the maximum number of indicators with the configuration of the SFGB can be seen in the northwest of the map, where there are problem banks with an increased share of attracted funds in the interbank market in foreign currencies. It was in this group that the banks of the aggressor country were before the outbreak of the full-scale war. As of January 1, 2024, there are no banks in this group under number 12. The poor quality of the loan portfolio of banks in this group is determined by the increased level of RA. The position of the maximum values of these indicators is shown in Figure 9.

Some indicators do not have clear extreme values or reach them within several SFGBs. The position of the extremum points and the boundaries of SFGBs depend on the topology of the 31-dimensional space of indicators' values.

Using the SFGB method, the banks were distributed into homogeneous groups, and each group's efficiency and business model risks were analyzed. It was found that the largest group of banks with the business model "Corporate with current financing" has an unstable resource base and an increased share of assets in foreign currency. Under conditions of limited development of credit operations, liquidity risk does not significantly affect the development of banks, but the advantage of current resources in liabilities sets a task for banks to develop and strengthen the resource base. The share of banks with this business model is 21%, and total assets are 31% of the total assets of Ukrainian banks.

The second largest group consists of banks with a business model that has been dubbed "Corporate Financed Securities." Two subgroups of this business

model are distinguished. The share of assets and liabilities in foreign currencies is larger for banks with foreign capital than for Ukrainian banks with the corresponding business model. Subsidiary banks of foreign banking corporations have high SAMI – placement of temporarily free resources in the interbank market. At the same time, banks with the corresponding business model are not oriented to fulfill the important task of credit support to the businesses. It is the development of credit operations that should be a priority for banks in these groups. In general, the group of banks with a higher level of investment portfolio accounts for 38% of the total number of banks, while total assets occupy only 10% of the total assets of the system.

A separate group consists of Ukraine's 2 largest state-owned banks, with assets equal to 35% of total assets. The business models of these banks are characterized by their dependence on the funds of individuals. Such a resource base has certain advantages and is based on many years of experience in promoting banking products and developing a network of branches. At the same time, the retail market is quite sensitive to operational, reputational, and information risks and requires enhanced control measures. The share of transactions with government securities in the largest banks' assets has also increased. This requires additional management measures and balanced development. The indicators of the group of the largest banks show increased credit and currency risks.

The traditional business model of the retail market has shrunk significantly in Ukraine in recent years. As of January 1, 2024, two banks with assets slightly more than 1% of the system's total assets belong to the group of banks in which attracted funds of in-

dividuals and consumer loans prevail. Retail banks traditionally have a high level of profitability. At the same time, the loan portfolio quality is the worst in the system.

Banks in other SFGBs have insignificant amounts of assets and do not significantly affect the characterization of the banking market, the development of business models, and inherent risks. For example, the group with the “Securities with Interbank Financing” business model of 7 banks occupies only 0.1% of total assets. Until June 2022, the relevant group included many banks that used refinancing loans to place funds in government securities. After the NBU increased the discount rate from 10 to 25%, the relevant operations became unprofitable, and the group of banks with this business model shrank.

4. DISCUSSION

In previous publications, a sample of a maximum of 32 banks was formed, where four groups of banks were represented in accordance with the classification determined by the National Bank of Ukraine. When building the model, only 15 indicators characterizing the efficiency of bank functioning were used (Kozmenko et al., 2016; Kasianenko et al., 2019; Shkolnyk et al., 2020).

This study developed practical recommendations for controlling risk management and interpreting the characteristics of structural and functional groups of banks at different reporting dates based on the results of SFGB methodology and cluster analysis.

As evidenced by the results of the study, the comparison of banks’ distribution indicators at each subsequent reporting date provides important information on the current state of the banking system, changes in the number of banks in each SFGB, reasons for banks’ migration to other groups, and peculiarities of risk indicators of each group. At the same time, the development trajectory of small banks may be influenced by current changes in the structure of assets and liabilities. The development trajectories of these banks are most often unstable, as they depend on the movement of clients’ funds. The relevant circumstances complicate the interpretation of the characteristics and structure of SFGBs.

The prospects for further research lie in expanding indicator systems and building maps with a gradual transition to reporting dates. Interpreting the characteristics of the groups and analyzing the relationship between the values of indicators and map topology allows us to confirm the objectivity and efficiency of the obtained models of banks’ distribution.

CONCLUSIONS

The study of identifying banks’ business models and their time characteristics reflecting the structure of assets, liabilities, income, expenses, and other qualitative indicators based on monthly statistical reporting is a tool for assessing the bank’s risk profile and the possibility of risk management for its future development. The assessment of Ukrainian banks’ business models is based on the use of self-organized Kohonen maps, which perform visualization and clustering tasks.

The proposed method allowed the grouping of banks with homogeneous features into the so-called structural-functional groups and showed the change in the features of the groups of banks over time to compare their behavior during periods of active system development and during the crisis.

The calculations confirmed the conclusion that bank size affects its business model. The largest banks in group 10 have an A-s value of 17.5%. The medium-sized banks are in the large center groups numbered 1 and 2, and in group 8 of foreign capital banks and retail banks in group 9.

Thus, the proposed system of indicators used to form structural-functional groups of banks makes it possible to promptly respond to changes in the banking system, identify high-risk areas, and examine the adequacy and efficiency of banks’ business models.

AUTHOR CONTRIBUTIONS

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