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EVALUATION OF UKRAINIAN BANKS' BUSINESS MODELS BY THE STRUCTURAL AND FUNCTIONAL GROUPS ANALYSIS METHOD

ABSTRACT

A method of identifying banks' business models and studying the features of their risk profile, considering the system of indicators featuring the structure of assets, liabilities, income, expenses, and other qualitative indicators based on monthly statistical report-ing. Kohonen's self-organizing maps (SOM) are used to process large data sets, reveal-ing objects' hidden features by forming homogeneous groups according to similar values of a large system of indicators. The choice of the system of indicators that play the most significant role in describing the business models of modern banks is substantiated. The proposed method makes it possible to group banks with homogeneous characteristics into so-called structural-functional groups and studies the change in the characteristics of groups of banks over time to compare their behavior during periods of active devel-opment of the system and during a crisis. That approach is useful for studying the banking system at the macro level, as it provides a quantitative measure of its financial stability. The more banks are in groups with negative values of parameters, increased risks, and unprofitable performance, the worse the general state of the system. The method also allows studying the features of each structural and functional group and the business models' features at the meso-level. The number and composition of banks inherent in any group change dynamically, which characterizes the features of the rel-evant business model in a particular period. The averages of each group reflect the objective changes in the banking system structure. In addition, the SOM trajectory can be built for each individual bank determining the development of its strategy, features of a particular business model, and risk profile. At the micro-level, it allows comparing the features of individual banks within the SFGB and models' ways to improve efficiency and financial stability by forecast values for SOM. An extensive system of indicators used to form structural and functional groups of banks allows to quickly respond to changes in the banking system, identify areas of increased risk and explore the ade-quacy and effectiveness of banks' business models.

Keywords: banking risks, bank risk profile, business models of banks, banking system, cluster analysis, Kohonen maps, structure of bank assets, structure of bank resources, sources of bank profit

JEL Classification: C45, G21, D21

INTRODUCTION

In an unstable environment, the stability and efficiency of the bank depend on the choice of an adequate business model. Research on features of business models of modern banks is devoted by numerous publications by Ukrainian [5; 14; 10] and foreign scientists [1; 3; 4]. Many authors often emphasize the crucial impact of choosing a business model on the banks' financial stability. Meanwhile, a common understanding of the essence of the business model and methods of their classification in the context of dynamic development has not been determined yet.

In our opinion, a very important task in defining business models is to justify an ac-ceptable procedure for separating banks with the same business models in the market considering behavioral factors [18; 12; 13]. The terms "retail," "investment," or "corpo-rate" type of business model are commonly used. At the same time, the attribution of the bank to a particular type behaves intuitively, according to the structure of assets

and liabilities, without modern mathematical approaches. To avoid ambiguous subjective determination of belonging to a particular business model type, it is necessary to include as many structural features as possible of the study object in the analysis and consider forming homogeneous groups including all those indicators simultaneously. Further, the business models' description can capture changes in current operating conditions and adapt to modern rapid changes in banks' risk profiles.

We substantiated the method of structural-functional groups (SFGB) by SOM for implementing differentiated banking supervision in Ukraine [17; 16]. Over 30 indicators were used to form homogeneous groups. The practice of the SFGB method over the past decades has shown that an extensive system of indicators allows responding promptly to changes in the bank's risk profile to identify current threats to financial stability. There are times when threats and certain aspects of risks increase, and problem banks are formed near the relevant indicators of a certain system. The SFGB method is useful for studying the development of banks' business models and risk management at the banking system level and at individual banks. It reflects the features of financial stability and efficiency of the bank and provides a clear quantitative tool for assessing qualitative changes in the banking system over time.

LITERATURE REVIEW

The importance of assessing the efficiency and financial stability of market participants, given their business models, is well described in the scientific literature. Osterwalder and Euchner (2019) [11] note that the business model is a "conceptual tool" whose components allow reflection of the business logic of a particular company via a system of their relationships. The business model is an essential feature that distinguishes companies, unique parameters, expressed in the relationship among the success most critical factors, and describes the basic principles of creation, development, and successful operation.

Ayadi (2019) [2] identified the main business models of 26 European banks at different stages of the economic cycle: before the financial crisis, during and after the crisis, analyzed productivity, stability, risk, efficiency, and corporate governance, identified strengths, and weaknesses, inherent in dominant business models in the context of regulatory changes related to the Basel III requirements implementation. The following business models are described: diversified retail, retail target, investment, and corporate banks. The study lacks a clear mathematical model for distinguishing business models by financial indicators values. Besides, the number of indicators in the authors' studies is about 5-8.

Mergaerts and Vander Vennet (2015) [9] studied over 500 banks from 30 European countries from 1998 to 2013 to describe the long-term impact of banks' business models on their efficiency and risks. An approach is proposed that focuses on the short-term effects of banks' choice of business model and their long-term impact. The study also concentrates on the nature and role of business models rather than methods of classifying banks.

The building business models methodology was studied by Goncharenko (2020) [6], which defines the bank's business model as a formalized result of strategic management determining the basic patterns of key strategic management decisions and should maximize shareholder value under risk control. The bank's business model comprehensively coordinates its chosen business strategy with the management system components, is formed under the influence of exogenous and endogenous determinants, ensures compliance of the chosen business strategy with the requirements of banking regulation and supervision, and allows achieving certain quantitative and qualitative strategic goals. At the same time, the methods of cluster analysis proposed by the author do not allow considering the numerous factors influencing business models' features.

Vagizova, Lurie, and Ivasiv [15] used the SOM method to determine business models of interaction between the banking sector and the real sector of the banking economy. The number of indicators used is limited to 8 and concentrates on the resource base, not allowing assessment of the banks' business models.

AIMS AND OBJECTIVES

The proposed approach provides a clear quantitative assessment of the financial stability and efficiency of banks and banking system peculiarities at each development stage. The paper substantiates the choice of indicators for separating Ukrainian banks' business models, which allows exploring each business model's features and risk profile by the SFGB method.

METHODS

SOM runs the separation of Ukrainian banks' homogeneous groups. That approach allows considering the value of a large number of indicators that describe the features of business models. According to the values of indicators, structural and functional groups of banks with the same business models are formed. By a structural-functional group of banks, we mean a homogeneous cluster of banks on SOM, including elements with similar features and models of response to external shocks.

The method of Kohonen's self-organizing maps refers to the class of methods of neural networks of learning without a teacher [7; 8]. It is constructed as a heuristic algorithm of step-by-step "pulling" of points in 31-dimensional space to the nodes of some abstract mesh of future centers of clusters or groups of objects. The objects closest to each node have relative values, i.e., a close Euclidean distance in 31-dimensional space.

The Viscovery SOMine software product implements Kohonen's mapping. Clusters are mapped to a two-dimensional map so that the property of visualizing the difference in distance is preserved. Nearby objects have many features in common, and distant objects differ significantly. That provides a convenient data interpretation. Homogeneous objects are grouped into clusters and colored on the map in appropriate colors, reminiscent of a regular map. Each point of this map is the location of one or more banks [7; 8]. Objects that approximate the values of all 31 indicators have a similar position.

The map construction algorithm ensures that all indicators' values are considered simultaneously, and therefore the position of each object is not obvious and predictable. Thus, the algorithm reveals the hidden properties of the system's structural elements. Even a slight change in performance can affect the transition of an object to another cluster. At the same time, the aggregate analysis of indicators' values of each cluster allows us to understand the reasons for their combination and to describe the characteristic properties of this cluster.

Indicator values visualization provides very useful information about their internal relationship and the impact on the position of individual objects on the map. For each indicator that participates in the map construction, one can generate a distinct values visualization that it takes on the SOM. The range of indicator values varies from maximum, red, to a minimum, blue, according to the "physical maps." At the same time, the main map with multicolored clusters resembles a "political map." Depending on the internal features and connections, the indicators may have a clear maximum and minimum on the map, a clear zone of extremes. The zone of extreme indicator values can be unique and local or more or less evenly distributed in different parts of the map.

In the study, we use 31 indicators for each bank for 49 reporting dates, from the 1st of January 2018 to the 1st of January 2022. The consolidated database consists of 31 columns corresponding to the number of indicators and 3632 terms. The indicators values for each bank at the beginning of each month of the study are consistently accumulated. During the period, the number of banks decreased from 75 to 71.

RESULTS

Grouping banks on SOM provides the user with a convenient and useful visualization of homogeneous groups of banks. After the next addition to the new reporting database, one can get the current distribution of banks on SFGB, compare it with the previous one, and assess changes in group features, system risks, and the trajectory of banks.

Fig.1 represents a typical Kohonen's map for the two reporting dates in 2021 and 2022. The location of each bank according to the reporting date is marked with a label. The label corresponds to the bank number in the list by reducing the number of net assets. The map of each subsequent period is slightly different from the previous one, although it has many common features. For instance, the largest banks are close to each other in the map's northeast and are numbered 1 and 2. Those banks are in a group of large banks, which is different from others. There are 12 groups with the corresponding color and borders on the map.

As a rule, the map topology is maintained for a long period, and the clusters' boundaries are slightly different for each reporting date. Sometimes there is an inversion - the map reversal with the connections' preservation among internal elements. As a rule, key changes in the map topology are affected by significant changes in the banking system's structure of assets, liabilities, income, and expenses.

Long-term relationships among indicators and their grouping as homogeneous clusters determine the essence of the method of structural and functional groups of banks and characterize the features of those banks' business models.

Figure 1. SOM's general view for Ukrainian banks as of the beginning of 2021 and 2022.

The most balanced indicators' values are observed in the map's central part banks. Central clusters are larger, and their performance is not very different from the average in the system. Banks in the map's corners have some significant differences. The clusters at the borders and corners of the map are usually small. The difference between the banks at a diagonal distance is especially large. For instance, on the diagonal of the largest banks, in the southwest corner are small banks, in the structure of assets of which the securities level is increased, and in liabilities - the interbank market resources. The corresponding structural indicators are higher than the system's average values, although their share in the assets and liabilities of banks is not the maximum. To describe each structural and functional group, it is necessary to study all 31 indicators with a corresponding impact on the business model's features.

In the southeast of the map, there is a group of retail banks with an increased share of attracted term funds of individuals in the national currency and placed loans to individuals. Banks in this group also have several features that affect their risk profile. As a rule, the reserves level to cover credit risks and the net interest margin ratio to net assets are increased for those banks.

At a diagonal distance from retail banks, in the map's northwest corner, there are banks, which liabilities increased the level of current resources, and whose assets include loans on the interbank market. That group of banks is featured by an increased share of net assets in foreign currency.

On the map's western part, there are banks with a high share of securities in assets. In recent years, the number of such banks has been increasing. During 15 years of monitoring the banks located on the map, the migration of many banks to certain parts was observed. During the crisis, high-risk groups grew significantly.

In order to broadly cover the features of banks' business models, we use the main structural indicators of assets, liabilities and some qualitative indicators that manifest the banks' results: return on assets, the reserves' ratio for credit risks to assets, the foreign currency assets share, interest margin and others.

The system of indicators is based on the main structural elements of banks' assets and liabilities. The sheet balances reflect specific forms of attracting and allocating resources. The banks' published reporting structure also determines the indicators' system construction. In national and foreign currency, the distribution of assets and liabilities by currency type is essential. That form of reporting began in 2018, after the manifestation of currency risks during the crisis of 2014-2016.

Table 1 lists the indicators that reflect the structure of banks' assets and their average values during the study period.

№	The content of the indicator	Abbr.	Average value
Table 1. Indicators of asset structure and their average values.			
	Highly liquid assets		**7.3%**
1	Share of funds on correspondent account and in cash in assets	SAV	7.3%
	Interbank assets		**10.2%**
2	Share of funds in interbank loans in national currency in assets	SAMN	0.7%
3	Share of funds in interbank loans in foreign currency in assets	SAMI	9.5%

Table 1. (continued).

№	The content of the indicator	Abbr.	Average value
	Credits		**42.8%**
4	Share of loans of legal entities in national currency in assets	SAUN	23.2%
5	Share of loans of legal entities in foreign currency in assets	SAUI	12.1%
6	Share of loans to individuals in the national currency in assets	SAFN	7.2%
7	Share of loans to individuals in foreign currency in assets	SAFI	0.3%
	Securities		**24.7%**
8	Share of securities in the national currency in assets	SACN	21.5%
9	Share of securities in foreign currency in assets	SACI	3.2%
	Other assets		15.0%

Most indicators changed insignificantly during the study period. The share of loans to legal entities in national and foreign currency gradually decreased, and the portfolio share of securities in national currency increased. Banks prefer less risky funds allocation in local government bonds (IGLBs). As of 01.01.18, the SACN indicator was 20.7%; on 01.01.22, it increased to 37%, i.e., by 79.2%.

Table 2 lists the indicators that reflect the structure of banks' liabilities and their average values during the study period.

№	**Table 2. Indicators of the structure of liabilities and their average values.**		
№	The content of the indicator	Abbr.	Average value
	Interbank liabilities		**8.0%**
1	Share of funds in interbank liabilities in national currency in liabilities	SPMN	5.4%
2	Share of funds in interbank liabilities in foreign currency in liabilities	SPMI	2.6%
	Liabilities of legal entities		**45.2%**
3	Share of funds of legal entities in the national currency in liabilities	SPUN	33.0%
4	Share of legal entities' funds in foreign currency in liabilities	SPUI	12.1%
5	Share of term funds of legal entities in liabilities	SPUS	10.9%
6	Share of current assets of legal entities in liabilities	SPUP	34.3%
	Liabilities of individuals		**36.2%**
7	Share of funds of individuals in the national currency in liabilities	SPFN	19.4%
8	Share of funds of individuals in foreign currency in liabilities	SPFI	16.8%
9	Share of term funds of individuals in liabilities	SPFS	24.3%
10	Share of current assets of individuals in liabilities	SPFP	11.9%
	Other obligations		**10.6%**
	Capital adequacy		
11	The ratio of capital to assets	CA	25.1%

Funds of legal entities and individuals account for almost 81.4% of banks' total liabilities. We classify those resources by types of currencies (national and foreign currencies) and by terms of attraction (demand and term funds). That analysis allows a clear understanding of the different banks' resource base features and describes the differences among business models and risk profiles of banks in groups where resources of each type predominate.

Using two criteria for allocating the same resource base can lead to a high correlation among some indicators. At the same time, studying the relationships between indicators provides additional information on the nature of their relationships and dynamics. For instance, one of the indicators with a high correlation with others is the share of attracted funds of SPFS term individuals. The correlation coefficient between this indicator and the share of individuals' funds in the national currency (SPFN and SPFS) is 83.5%. The correlation coefficient between the share of borrowed funds of individuals in foreign currency and term funds of individuals (SPFI and SPFS) is 97.4%. The share of time deposits varies synchronously in different currencies. At the same time, for current resources attracted from individuals (SPFP), there is no dependence, which indicates differences in the factors that affect the dynamics of liabilities to demand, usually balances on card accounts.

Attracted funds of legal entities by 76% include current resources, while the funds of individuals are dominated by term funds, which amount to 67%. 73% of legal entities and 54% of funds of individuals were formed in the national currency. There have not been any significant structural changes for four years.

Recently, the National Bank of Ukraine has been actively providing bank refinancing loans. This tool was used to maintain liquidity in crisis conditions; now, the market is growing offers to attract and allocate funds from the National Bank of Ukraine. As of 01.01.2018, the SRMN indicator was 5%; on 01.01.2022, it increased to 13%. On the one hand, the active presence of the central bank in the credit market corresponds to the international rules of active influence of the refinancing rate on the banks' interest rate policy. At the same time, concentrations of refinancing loans in individual banks create additional problems for the bank and the system. For instance, as of 01.01.2022, 34% of all loans of the National Bank of Ukraine were provided to one JSC Ukreximbank. Refinancing loans account for 15% of this bank's liabilities structure. The study of banks' groups with certain structural differences by the SFGB analysis method allows for determining the risks of those banks in more detail.

The proposed estimate of the capital share in liabilities is based on the structure of published balance sheets. Unlike the previous indicators, which describe the liabilities structure, the ratio of balance sheet capital to net assets features the ratio of own and borrowed funds. The CA indicator does not coincide with the regulatory capital adequacy ratio used in the banking supervision system, yet a similar formula calculates it. The study showed a pattern of the CA increased value in small banks. Small banks must meet the minimum capital requirements but cannot attract enough customers to raise assets and liabilities to the capital adequacy ratio. Thus, in the structural indicators system, the CA level features the bank size more than the coverage of risks with equity. At the same time, there is a certain connection between capital adequacy and CA. Practice shows that a significant reduction in CA to 10% or less is a consequence of unprofitable activities and a sign of troubled banks.

An essential feature of the bank's business model is the structure of its income and expenses. Sources of profit and the main expenditure items feature the essence of the bank's development strategy. Revenues and expenses reveal obvious and hidden features of financial management and its efficiency and risks. Table 3 demonstrates the indicators calculated according to the published reporting of banks and their average values during the study period.

Table 3. Structure's indicators of income and expenses.

№	The content of the indicator	Abbr.	Average value
1	Net interest margin: the ratio of net interest income to assets	PM	7.3%
2	Net commission income: the ratio of net commission income to assets	KD	3.3%
3	The ratio of trading income to assets	TD	1.3%
4	The ratio of administrative costs to assets	VA	8.9%
5	The ratio of the cost of forming reserves for credit risk to assets	VR	1.6%
6	Return on assets: the ratio of profit to assets	ROA	1.7%

The structure indicators of income and expenses tend to decrease. Some reduction in net interest margin and net commission income is a consequence of changes in the market conditions of banks. If at the beginning of 2018, the interest margin fluctuated at 8%, in 2021, its level decreased to 6%. KD's net commission income decreased by 1.5% during this period. The trade income indicator has no definite trends. With the profit base reduction, banks reduce their administrative costs, and as a result, the VA rate decreased from 8.5 to 7%. The expenses reduction for the formation of VR credit risk reserves from 2.7 to 0.5% is a consequence of qualitative changes in the loan portfolio. The final ROA has no clear trend. Since 2017, the banking system has been operating with a profitable result, although in the previous three years, the result had been negative due to the formation of reserves for credit risk. All the above income and expense items are useful for combining groups of banks with homogeneous business models.

The last five indicators are designed to assess the main risks parameters: credit, currency, liquidity risk, and systemic risk held by the size of each bank. The choice of indicators was conducted empirically according to the published reporting of banks. Table 4 presents obtained list of risk indicators and their average values during the study period.

Table 4. Risk indicators of banks.

№	The content of the indicator	Abbr.	Average value
1	The ratio of highly liquid assets to current liabilities	L1	28.5%
2	The ratio of credit risk reserves to assets	RA	12.8%
3	The ratio of foreign currency assets to assets	VCA	27.8%
4	The ratio of the difference between assets and liabilities denominated in foreign currencies to assets	VL	0.3%
5	The ratio of bank assets to total system assets	A-s	1.3%

Indicator L1 is used to assess the instant liquidity of banks. Its value is variable during the study period and decreased to less than 15% only for banks with a high share of borrowed current resources. For most banks, liquidity is assessed as sufficient. The largest surplus of highly liquid assets is observed in problem banks with limited capacity to place resources for profit.

The RA indicator allows assessing the quality of assets via the size of the created reserves for credit risks. The RA level increases during periods of crisis and is the highest in groups of problem banks. As a rule, increased credit risks are accompanied by a loss-making financial result. The indicator decreased on average from 14% to 11% during the study period.

VCA and VL indicators are used to assess currency risks. The share of assets in foreign currency VCA for four years has decreased from 29 to 25%. The discrepancy between the values of the indicator in different banks is large. For instance, on 01.01.2022, the values ranged from 1 to 61%. The share of foreign currency assets features the business models of specific banks. The VL indicator, which models the currency position, is more suitable for assessing currency risks. The indicator's numerator calculates the difference between assets and liabilities in foreign currency, normalized by the value of assets. The indicator can be positive or negative. Its average volatility is insignificant and is limited by the limits of the currency position set by the National Bank of Ukraine. At the same time, for some banks, the VL indicator deviates significantly from the zero mark. That deviation determines the business model features of such banks.

Indicator A-s features the share of a particular bank in the system and allows identifying the largest banks, which account for 15-20% of total assets. In Ukraine, the largest banks are state-owned and have many signs of increased risk but are not completely homogeneous. The formation of groups is carried out according to the values of all 31 indicators and not only the indicator of the scale of activity A-s. The largest banks also need a different approach to the banking supervision system. The problem of being too big to fail is very relevant for four large state-owned banks, which occupy 47% of the system's total assets as of 01.01.2022.

Figure 2 depicts the amplitudes of the values of the individual indicators on the SOM, which show the differences in the impact of specific indicators on the formation of the clusters.
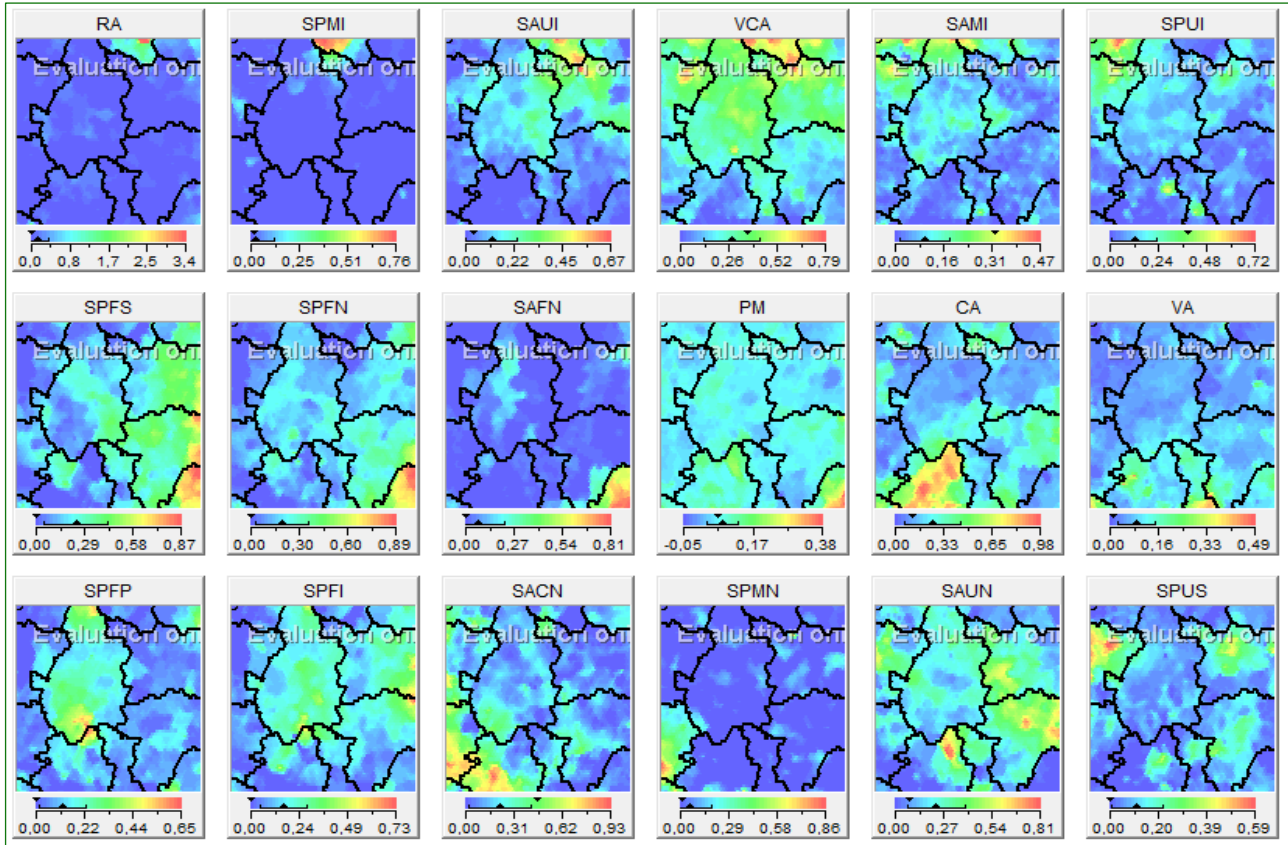

Figure 2. Distribution of individual indicators values on SOM at the beginning of 2022.

Some indicators, such as A-s, RA, SRMI, and SAFN, have a single clearly defined extremum. Appropriate clusters are formed near those indicators. Thus, the largest banks are grouped near A-s, retail - near SAFN, and problem - near RA. It should be emphasized once again that clusters are formed according to the values of all 31 indicators, not just the extreme one, which has the greatest impact on the grouping of objects.

Some indicators do not have clear extremes or have several maximum values. Correlation coefficients can be calculated to study the effect of such indicators. Analysis of the pairwise correlation between the 31 selected indicators indicates the presence of high direct or feedback, with a coefficient of over 75%. Table 5 shows the list of highly related indicators.

Table 5. Groups of indicators with a high correlation.		
Indicator	**Number of connections**	**Highly related indicators**
SAUI	12	SAUN, SAFI, SACN, A-s, VCA, SPMN, SPUP, SPUS, SPFI, SPFS, CA, KD
SAUN	12	SAUI, SAFI, SACN, RA, A-s, SPMN, SPUP, SPUS, SPFI, SPFP, SPFS, CA
SPFS	12	SAUI, SAUN, SAFI, SACN, A-s, SPMN, SPUP, SPUS, SPFI, SPFN, CA, KD
SPFI	11	SAUI, SAUN, SAFI, SACN, A-s, VCA, SPMN, SPUP, SPFN, SPFS, CA
A-s	10	SAUI, SAUN, SAFI, SACN, SPMN, SPUP, SPUS, SPFI, SPFS, CA
SACN	9	SAUI, SAUN, A-s, SPMN, SPUP, SPFI, SPFN, SPFS, CA
SPMN	9	SAUI, SAUN, SACN, A-s, SPUS, SPFI, SPFN, SPFS, CA
SAFI	8	SAUI, SAUN, RA, A-s, SPUS, SPFI, SPFP, SPFS
CA	8	SAUI, SAUN, SACN, A-s, SPMN, SPFI, SPFS, KD
SPUS	7	SAUI, SAUN, SAFI, A-s, SPMN, SPFP, SPFS
SPUP	6	SAUI, SAUN, SACN, A-s, SPFI, SPFS
KD	5	SAUI, SPFS, CA, PM, VA
SPFN	4	SACN, SPMN, SPFI, SPFS
SPFP	3	SAUN, SAFI, SPUS
RA	2	SAUN, SAFI
VCA	2	SAUI, SPFI
SAMI	1	SPUI
PM	1	KD
VA	1	KD
SPUI	1	SAMI

There is a high correlation between many structural indicators that feature the assets and liabilities components. The structural indicators of assets SAUI, SAUN, SAFI, SACN, liabilities SPFS, SPFI, SPMN, SPUS, and SPUP have the greatest connections with other indicators.

The significant relationship between the A-s scale and other indicators is not important to interpret, as it focuses on individual assessment rather than average value. The indicator is gradually increasing along with reducing the number of banks.

The average ratio of balance sheet capital to CA assets tends to decrease, although the entire capitalization of banks, according to the regulatory capital level, is growing. The CA indicator is also focused on the assessment of not the average, but the individual value, which features the ratio of the main aggregates of assets, liabilities, and balance sheet capital. Other indicators are analyzed below.

Table 6 represents the structural correlations with the highest correlation in more detail. The highest positive correlation values are shown in the upper part of the table, and the negative values of the negative correlation are in the lower part.

Table 6. Groups of indicators with a high correlation.

	SAUI	SAUN	SAFI	SACN	SPFS	SPFI	SPFN	SPFP	SPUS	SPUP	SPMN
SAUI		90.0%	84.5%		96.5%	96.5%			82.4%		
SAUN			82.5%		90.5%	86.1%			82.7%		
SAFI					77.7%	78.6%			81.3%		
SACN	-89.9%	-87.5%								78.4%	87.6%
SPFS				-91.8%		97.4%	83.5%		79.5%		
SPFI				-90.6%			76.7%				
SPFN				-76.9%							
SPFP		-77.0%	-81.3%								
SPUS							-79.2%				
SPUP					-80.1%	-78.1%					
SPMN	-91.1%	-83.2%			-96.3%	-93.0%	-85.8%		-76.4%		

The indicators system that characterizes banks' liabilities is quite complex, as it includes ten structural indicators: 4 for liabilities of individuals, 4 - for legal entities, and 2 - for interbank liabilities. The distribution is considered by types of currencies and by terms of attracting resources. For research, it is interesting to consider all the correlation coefficients between different indicators about one that has many relationships with others, such as SPFS.

The indicator of the term funds share of individuals' SPFS tends to decrease, from 26.9%, as of 01.01.2018, to 15%, as of 01.01.2022, i.e., by 44.4%. Table 7 presents the correlations of SPFS with several other indicators.

Table 7. Correlation among SPFS and individual indicators.

High direct communication rates		Disconnection indicators		High feedback rates		High connectivity metrics	
SAUI	96.5%	SAMI	-44.8%	SACN	-91.8%	CA	85.9%
SAUN	90.5%	SAMN	26.2%	SPMN	-96.3%	KD	74.9%
SAFI	77.7%	SAFN	30.4%	SPUP	-80.1%		
SPUS	79.5%	SACI	14.6%				
SPFI	97.4%	SPMI	52.5%			A-s	-92.2%
SPFN	83.5%	SPUI	-51.2%				
		SPUN	-7.1%				
		SPFP	-65.0%				

The first three columns of Table 7 present the structural indicators of assets and liabilities, divided into three groups: direct, feedback, and no relationship. The fourth column shows other indicators that are highly correlated with SPFS but do not belong to the group of structural indicators.

The identified relationship among the indicators is shown in the placement of structural and functional groups of banks on the map. Fig.1 represents the positions of the clusters, and their colors correspond to the second part of the map. Figure 3 depicts a schematic position of the groups on the SOM.

For each of the 12 groups, a list of profile indicators is given, the values of which are the largest for the corresponding group. For instance, for central group number 1, the values of the share of loans granted to legal entities in national and foreign currency and attracted current funds of individuals and legal entities are quite high. There is also an increased share of borrowed funds from individuals in foreign currency. It should be noted that the increased share of term funds of individuals is in the neighboring map's eastern part. At the same time, the map's western part is occupied by banks with a smaller share of corporate loans and an increased share of securities in assets. It is in the map's western part where

most banks in 2021-2022 are located. The migration of banks reflects the increased attention to the funds' allocation in IGLBs.

As can be seen in Figure 1, a large number of banks are located in group number 6. The assets of these banks have an increased share of securities portfolios and in liabilities - borrowed interbank market funds, primarily refinancing loans of the National Bank of Ukraine.

The neighbouring group 5 is close in terms of indicators, but the share of securities in the assets of banks in this group is smaller, and the share of loans to legal entities is higher. The individual trajectories of individual banks sometimes shift between such neighboring groups. It should be noted that each group's detailed structural and functional features can be obtained only by comparing all 31 indicators.

SAMI, VSA, SPUP SPUI, SPUS, SPUN **9**	SAUI, SAUN, SPFI, SPFP, SPUP **1**	SAUI, VSA RA, L1, SPMI **11**	A-s, SACI VL, RA **10**
SPUI, SPUN, SPMN SACN, SAUI, SAUN **5**		SAUI, SPFS, VSA **3**	
SACN, SPMN **6**		SPFN, SPFS, SAUN **2**	
SACN, SPMN VA, TD **12**	SACN, SPUN, L1 SPUP, CA **4**	SACN, SPUN SPUP **7**	SPFS, SPFN, SAFN, PM **8**

Figure 3. Schematic distribution of indicator values on SOM in early 2022.

There are many commonalities between the groups occupying the adjacent position on the SOM. Group number 4 also has an increased share of securities in assets. In these banks, the liabilities of legal entities in the national currency have an increased share. Banks in the neighboring group number 7 have the same features.

In the banks of the map's southern part, the share of funds in foreign currency is usually smaller than in its northern part. In the southeast, in the angular position, are retail banks, which refers to group 8. In addition to the increased share of consumer loans in national currency and attracted deposits of individuals in national currency, those banks have a higher interest margin.

The two large SFGBs with numbers 2 and 3 are in the centre of the map and have a balanced system of indicators close to the average values. In contrast to the indicators of the first group, the resource base of these banks is dominated by term indicators. Group 2, closer to the south, has a larger share of assets and liabilities in the national currency.

Banks have increased currency and credit risks. The angular position in the map's northeast is occupied by the largest banks, which belong to group 10. In the assets of banks, the increased share of securities in foreign currency and liabilities are the term funds of individuals. Given the fact that the largest banks are state-owned, their risk profile should be examined in more detail.

In the past crisis years, it was possible to observe how banks have migrated an masse to problem groups with increased risks. Group 11 combines the most problem banks with increased reserves to cover losses on credit operations and a high share of an open currency position. As of the beginning of 2022, no bank was included in this group.

The bank business model features from any group are determined by the values of indicators and comparison with banks that are next to SOM. The obtained conclusions were processed based on specific banking examples, which confirm their logic and objectivity. For instance, in the event of a change in the strategy or the bank's owner, its trajectory on the map changes accordingly.

An overview of the bank's system of indicators over a period clearly explains the reasons for the transition to any cluster. Modeling the division of banks into homogeneous structural and functional groups provides additional useful information about banks' business models.

DISCUSSION AND CONCLUSIONS

An analysis of the relationship between asset structure indicators leads to the following conclusions:

- There is a close relationship among each indicator of the group (SAUI, SAUN, SAFI), the share of loans to legal entities in national and foreign currency, and the share of loans to individuals in foreign currency. Over a period, those types of assets declined synchronously, while the share of retail loans in national currency (SAFN) increased. The latter indicator is not strongly related to other indicators.

- There is feedback between the share of corporate loans in national and foreign currency (SAUI, SAUN) and the share of assets in the securities portfolio in national currency (SACN). That confirms the alternative nature of investing resources in loans or securities. With the loan portfolio shrinking, the total portfolio of banks' securities in the national currency is growing. At the same time, the indicator of the share of assets in the portfolio of securities in foreign currency (SACI) has no clear trend of change and correlation with any indicators.

- There is a close relationship between the credit block (SAUI, SAUN, SAFI) and the share of borrowed funds of individuals in foreign currency (SPFI) and term funds of individuals (SPFS), and the share of term funds of legal entities (SPUS). Relevant resources have a similar tendency to decrease. Thus, time deposits of legal entities and individuals and deposits of individuals in foreign currency can be considered a resource base for the main types of credit operations.

- Relevant borrowings increased along with the reduction of other liabilities. The high direct relationship between the share of assets in the national currency securities portfolio (SACN) and the share of current assets of legal entities (SPUP), and the share of attracted interbank loans in the national currency (SPMN) is not obvious. That explains the feedback between the dynamics of indicators (SPUP and SPMN) and (SPFS and SPFI). Interbank and current corporate liabilities can be considered an alternative resource that contributes to developing the securities portfolio.

- The share of placed interbank loans in the national currency (SAMN) has no clear trend of change and correlation with any indicators. At the same time, for interbank loans in foreign currency (SAMI), there is a high correlation (86.1%) with a single indicator of the share of current resources of legal entities in foreign currency (SPUI). The corresponding connection indicates the development of operations to place customer resources on correspondent accounts with non-resident banks.

- Time deposits for a certain period decreased synchronously in different currencies. The close connection between all indicators of the block, which has the share of term liabilities of individuals (SPFS), and liabilities of individuals in national and foreign currency (SPFN, SPFI), is confirmed. The three defined indicators can be considered a block with a high relationship between each other and the block of fixed assets (SAUI, SAUN, SAFI).

- The corresponding resource base demonstrates the reduction dynamics. The relationship between the share of term liabilities of individuals (SPFS) and legal entities (SPUS) has been established. There is no connection between the share of term liabilities of individuals (SPFS) and liabilities of legal entities in foreign and national currency (SPUI and SPUN). There is also no connection with the SPMI indicator of the share of borrowed interbank resources in foreign currency.

- There is no connection between the share of term liabilities of individuals (SPFS) and current liabilities of individuals (SPFP). Demand funds, as a rule, balances on card accounts have different natures and dynamics of slow growth. At the same time, Table 6 shows the feedback between the SPFP indicator and the block of indicators of declining assets (SAUN and SAFI). There is also feedback between the SPFP and legal entities' share of term funds (SPUS). Current funds of the population compensate for the reduction of term persons of enterprises.

- Feedback is observed between the share of term liabilities of individuals (SPFS) and the share of current liabilities of legal entities (SPUP) and borrowed interbank resources in national currency (SPMN). SPUP and SPMN are growing, which contributes to the resource base components replacement.

A certain indicators system determines the structural and functional groups of banks, which characterize the state of the modern banking market. The business model features and risk profile are determined for each group. The method provides useful information for studying banking risks at the macro and macro levels.

Describing each group and comparing it with others is a very time-consuming process. At the same time, it is notable that the map is too sensitive to changes in the system of indicators. Even a small addition or reduction in the number or composition of indicators leads to a significant change in the map topology and the need for additional adjustments in the relationships' interpretation.

The map sensitivity ensures timely reflection of negative changes in the banking system. For instance, in the first quarter of 2022, during Russia's military invasion of Ukraine, the map's topology changed. Massive outflows of term funds, growth of refinancing loans, reduction of credit programs, and deterioration of asset quality have led to a change in the business models features of most banks. The model immediately responded to changes in the values of the indicators' system. The proposed method is an essential tool for assessing the financial stability of the banking system and individual banks.

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ОЦІНКА БІЗНЕС-МОДЕЛЕЙ УКРАЇНСЬКИХ БАНКІВ ЗА ДОПОМОГОЮ МЕТОДУ АНАЛІЗУ СТРУКТУРНО-ФУНКЦІОНАЛЬНИХ ГРУП

У статті розроблено методику ідентифікації бізнес-моделей банків та вивчення особливостей їхнього профілю ризику з урахуванням системи показників, що відображають структуру активів, пасивів, доходів, витрат та інших якісних показників на основі місячної статистичної звітності. Із метою обробки великих масивів даних запропоновано використовувати карти Кохонена (SOM), які виявляють приховані особливості об'єктів шляхом формування однорідних груп за схожими значеннями великої системи показників. Обґрунтовано вибір системи показників, які відіграють найбільшу роль в описі бізнес-моделей сучасних банків. Запропонований метод дозволяє згрупувати банки з однорідними ознаками в так звані структурно-функціональні групи та вивчає зміну ознак груп банків у часі для порівняння їхньої поведінки в періоди активного розвитку системи та під час кризи. Такий підхід корисний для вивчення банківської системи на макрорівні, оскільки забезпечує кількісне вимірювання її фінансової стабільності. Що більше банків у групах із від'ємними значеннями параметрів, підвищеними ризиками та збитковістю, то гірший загальний стан системи. Метод також дозволяє вивчати особливості кожної структурно-функціональної групи та особливості бізнес-моделей на мезорівні. Кількість і склад банків, притаманних будь-якій групі, динамічно змінюються, що характеризує особливості відповідної бізнес-моделі в конкретний період. Середні показники кожної групи відображають об'єктивні зміни в структурі банківської системи. Крім того, траєкторію SOM можна побудувати для кожного окремого банку, визначаючи розвиток його стратегії, особливості конкретної бізнес-моделі та профіль ризику. На мікрорівні це дозволяє порівнювати особливості окремих банків у межах SFGB та моделювати шляхи підвищення ефективності та фінансової стабільності за прогнозними значеннями SOM. Розгалужена система показників, що використовуються для формування структурно-функціональних груп банків, дозволяє оперативно реагувати на зміни в банківській системі, виявляти зони підвищеного ризику й досліджувати адекватність та ефективність бізнес-моделей банків.

Ключові слова: банківські ризики, профіль банківського ризику, бізнес-моделі банків, банківська система, кластерний аналіз, карти Кохонена, структура активів банку, структура ресурсів банку, джерела прибутку банку

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