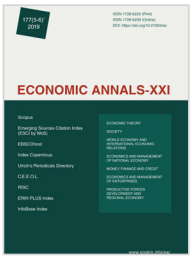

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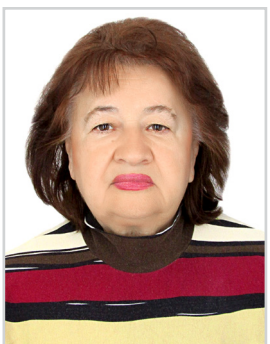

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Cluster approach to banking supervision with reference to bank risk profile

Abstract
Introduction. The result of the global financial crisis is the process of transformation of banking supervision aimed at increasing the efficiency of banking risk management and improving mechanisms for dealing with various risk factors. The transformation of the banking surveillance system in the global aspect has defined a set of measures which are constantly monitored by international regulators. The improvement the supervisory methodology is mainly governed by the recommendations of the Basel Committee on Banking Supervision and currently involves introduction of new standards and approaches to regulating and supervising banks based on risk diversification, development of regulations and prompt application of measures to influence banks activities in case of excessive risk build up and increasing threats to the realization of systemic risk, implementation of internal control recommendations at banks aimed at identifying and minimizing the aggregate level of their risk, improvement of analytical rules and procedures and agreeing on intra-bank risk assessment techniques.
Purpose. This paper presents the results of the possibility of using the cluster approach in the process of investigating the relationship between the ownership structure and risk profile of Ukrainian banks and, on this basis, improving their supervision.

Methods. While assessing the financial condition of Ukrainian banks, the authors used statistical monitoring and cluster analysis.
Results. The results of the study show that cluster analysis in banking supervision, depending on the ownership of banks, allows to determine the scale of the impact of crisis factors, identify the ways and methods of crisis management, as well as measures to overcome the future crisis with the least losses. It is proved that by means of cluster analysis, the regulator is able to group banks according to the similar business models and risk profiles. The criterion for including banks with different as to their size assets within a definite supervisory cluster is the same ownership structure. The analysis of 77 Ukrainian banks operating on the 1 January 2019 shows that, by the form of ownership, the banks of the 1st and 2nd groups can be distinguished as state-owned banks, large private banks and banks with foreign capital. By the character of operations they fall into risky (7 banks), schematic (4 banks), inactive (7 banks), captive (6 banks) and market banks (20 banks). The authors identify the groups of indicators that characterize bank risk profile, namely by counterparties, by instruments and by currencies. The study proposes an algorithm of bank clustering according to risk profile, which includes five stages: formation of data array, elimination of statistical units that generate extremes, normalization of the data array, analytical operations based on neural networks, formation of clusters and development of diversified modes of supervision. A strong correlation between the ownership structure and the risk profile in the Ukrainian banking system is proved.
Conclusions. The analysis shows that ownership is not the only factor affecting a bank business model. Further stages of qualitative transformation of the banking supervision system in Ukraine should be aimed at specifying the regimes of control over the activities of financial intermediaries based on their risk profile according to the proposed methodology.
Keywords: Banking Supervision; Cluster Approach; Bank Risk Profile; Ownership Structure
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Кластерний підхід до нагляду за діяльністю банків з урахуванням їх профілю ризику

Анотація. У статті представлено результати дослідження можливості використання кластерного підходу до аналізу взаємозв'язку між структурою власності та профілем ризику банків України та на цій основі удосконалення нагляду за ними. Розроблено класифікацію банків за формою власності та характером проведених операцій. Визначено групи показників, що характеризують профіль ризику банків. Запропоновано алгоритм кластеризації банків за профілем ризику, який складається з п'яти етапів. В якості середовища кластеризації використано надбудову Neural Network Toolbox до пакету MatLab. Результатом проведених розрахунків є формування чотирьох кластерів банків.
За умови нез'ясованості ролі вітчизняних державних банків в економічних процесах та втручання державних органів в їх політику зростає загроза виникнення конфлікту інтересів. З точки зору залучення коштів фізичних осіб переважна більшість банків продемонструвала високі показники концентрації, окрім банків із російським капіталом та банків із іноземним капіталом, стратегія яких передбачає вихід з роздрібного ринку або продаж значної частки активів, розміщених у кредитах фізичним особам. Банки з українським капіталом характеризуються значною диверсифікацією щодо розподілу за кластерами, оскільки для них характерний різний ступінь підтримки з боку власників, що проявляється в їх здатності здійснювати докапіталізацію порівняно з банками з державною або іноземною власністю.
Доведено стійку залежність між структурою власності та профілем ризику в банківській системі України. Встановлено, що структура власності не є єдиним фактором, що впливає на бізнес-модель банку.
Ключові слова: банківський нагляд; кластерний підхід; профіль ризику банку; структура власності.

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Кластерный подход к надзору за деятельностью банков с учетом их профиля риска

Аннотация. В статье представлены результаты исследования возможности использования кластерного подхода к анализу взаимосвязи между структурой собственности и профилем риска банков Украины и на этой основе усовершенствования к надзору над ними. Разработана классификация банков относительно их формы собственности и характера проведенных операций. Определены группы показателей, характеризующие профиль риска банков. Предложен алгоритм кластеризации банков относительно профиля риска, состоящий из пяти этапов. Доказана стойкая зависимость между структурой собственности и профилем риска в банковской системе Украины. Определено, что структура собственности не является единственным фактором, влияющим на бизнес-модель банка.

Ключевые слова: банковский надзор; кластерный подход; профиль риска банка; структура собственности.

1. Introduction

The result of the global financial crisis is the process of transformation of the banking supervision aimed at increasing the efficiency of the banking risks management and improving mechanisms for dealing with various risk factors. The current banking surveillance procedures and algorithms focus on assessing structural imbalances in banking, which being implemented, create a bank risk profile and threaten to lose revenue, capital or liquidity. Such assessments serve as a basis for selecting supervisory regimes, each of which requires some preventive measures against the loss of financial soundness. Considering the above, the issue of taking into account the banking risk profile while creating and functioning of supervisory mechanisms is urgent.

2. Brief Literature Review

The problem of determining the relationship between the risk profile and the ownership structure of banks has received considerable attention in the works of such researchers as T. Berry, L. Lepetit & A. Tarazi (2011) [1], G. Iannotta, G. Nocera & A. Sironi (2013) [2], B. Aymen (2014) [3], Y. Dong (Dong et al., 2014) [4], N. Rahman & A. Rejab (2013) [5], M. Hanafi, F. Santi & M. Muazaroh (2013) [6], H. Al-Tamimi & N. Jellali (2013) [7], M. ElBannan (2015) [8], T. García-Marco & M. D. Robles-Fernández (2008) [9] and S. E. Chun, M. Nagano & M. H. Lee (2011) [10].

As Table 1 presents, these scientists typically analyze markets that are developed under the influence of national business traditions, therefore the extrapolating the research findings to the markets of other countries may not correspond to current realities. Thus, in the works by T. Berry (Barry et al., 2011) [1] and G. Iannotta (Iannotta et al., 2013) [2], the object of study is the banking system of European countries, with Ukrainian banks being included to the list.

However, a complex approach to the analysis of the ownership structure of banks, which includes financial intermediaries with private, state and foreign capital, is characteristic of the works by B. Aymen (Aymen, 2014) [3], Y. Dong (Dong et al., 2014) [4] and N. Rahman (Rahman et al., 2013) [5]. In the papers by M. Hanafi (Hanafi et al., 2013) [6] and H. Al-Tamimi (Al-Tamimi et al., 2013) [7], banks with private capital are classified according to the geographical location of the final beneficiary (domestic and foreign), however state-owned banks are not taken into consideration, which may lead to a deterioration of the quality of the statistical array. Instead, the works by M. ElBannan (2015) [8], T. García-Marco (García-Marco et al., 2007) [9], S. E. Chun

Table 1:
Systematization of scientific and methodological approaches to determining the relationship between risk profile and ownership structure of banks

Author	Market	Period	Structure of capital under analysis		
			Private	State	Foreign
B. Aymen (Aymen, 2014)	Tunisia	2000-2010	+	+	+
M. ElBannan (2015)	Egypt	2000-2011	+	-	+
T. Barry (Barry et al., 2011)	Europe	1999-2005	+	+	-
Y. Dong (Dong et al., 2014)	China	2003-2011	+	+	+
M. Hanafi (Hanafi et al., 2013)	Indonesia	2005-2012	+	+	-
G. Iannotta (Iannotta et al., 2013)	Europe	2000-2009	-	+	-
T. García-Marco (García-Marco et al., 2007)	Spain	1993-2000	+	-	+
S. E. Chun (Chun et al., 2011)	Japan	1990-2000	+	-	+
N. Rahman (Rahman et al., 2013)	Malaysia	2000-2011	+	+	+
H. Al-Tamimi (Al-Tamimi et al., 2013)	UAE	1998-2010	+	+	-

Source: Compiled by the authors based on [1-10]

(Chun et al., 2011) [10] are not focused on the specification of private ownership in the part of the separation of banks with foreign capital.

At the same time, a significant time lag between filing and divulgation periods of financial records in aggregated databases complicates the analysis based on up-to-date data, so, despite covering a considerable amount of time, the presented papers investigate the correlation between a bank risk profile and its ownership structure, and using panel regressions as the basic mathematical tool allows only to establish the closeness of such a connection. That means that the scenarios and modes of supervision and regulation, which are determined on the basis of the results of the analysis, remain irrelevant. This fact actualizes the need for scientific research in this field for Ukrainian banks.

3. The purpose of the research is to investigate the relationship between the ownership structure and the risk profile of Ukrainian banks and to develop recommendations on the implementation of cluster surveillance of their activities. To achieve this goal, the following tasks have been set: to identify a range of issues that determine the benefits of using a cluster approach to banking supervision with regard to their risk profile, specify banks business models by risk profiles, systematize the data that characterize the bank risk profile and develop a clustering algorithm for banks by risk profile.

4. Results

The transformation of the banking surveillance system in the global aspect has defined a set of measures which are constantly monitored by international regulators. The process of improving the supervisory methodology is mainly governed by the recommendations of the Basel Committee on Banking Supervision and currently involves: the introduction of new standards and approaches to regulating and supervising banks based on risk diversification, development of regulations and prompt application of measures to influence banks activities in case of excessive risk build up and increasing threats to the realization of systemic risk, implementation of internal control recommendations at banks aimed at identifying and minimizing the aggregate level of their risk, improvement of analytical rules and procedures and agreeing on intra-bank risk assessment techniques.

In his book On Competition, M. Porter (2008) [11] indicates that the cluster is a new way of structuring and understanding the economy, organizing the theory and practice of economic development, which provides additional opportunities for the formation and establishment of the state policy.

According to Ch. Romesburg (2004), this technique is a mathematical microscope for reviewing the relationship of similarities between a given set of objects. It cannot be used to draw statistical conclusions about this relationship: any conclusions that a researcher makes studying the tree and analogy reasoning rather than formal statistical methods [12].

Cluster analysis in banking supervision, depending on the ownership of banks, makes it possible to recognize the scope of the impact of the crisis factors to identify ways, methods of crisis management and measures to overcome the future crisis with the least losses (Table 2).

The use of new standards of supervision is based on a proactive approach to management, so the identifying and permanent monitoring of the risk level must take into account the variability of business models of banks.

Table 2:
Levels of crisis management of the financial stability of the banking sector

Elements of the system of levels	Meta-level control system	Macrolevel control system and sub-systems	Microlevel control system and sub-systems
Management of the process of the implementation of directions	Stress testing; macroprudential regulation; forecasting, corrective measures	Monitoring, methodological approaches to assessment and preparation of financial stability reports; corrective measures	Choice of management strategy, development of management strategy, development and implementation of anti-crisis financial stability management programs
Subjects of management	International regulatory bodies	Internal system regulators	Banks
Subject of influence	Destabilizing factors of the external environment	Processes of formation and extension of systemic risk	Internal banking risks
Goals of influence	Defining the scope of impact of crisis factors; defining ways of crisis managing and risk mitigation measures	Timely identification and minimization of crisis factors	Timely identification and minimization of crisis factors
Instruments of influence	Standardization and unification of anti-crisis legislation in different countries of the world; improving financial firmness indicators; the general system of standards of financial reporting of banking activity and its transparency	Carrying out preventive measures to supervise the activities of banks; early diagnosis of financial problems of banks; improvement of banks, improvement of deposit insurance system; establishment of standards of banking taking into account the specifics of the state	Stress testing; determining internal limits and standards; reorganization of banks on their own initiative; special events; benchmarking; outsourcing

Source: Author's improved variant based on own research and [13]

R. Ayaudi (2016) claims that bank business model enables to determine the vector of its activity by active or passive operations. The business model provides a holistic view of how a bank behaves at the market (retail, corporate, mixed) and determines a bank ability to invest [14].

The activity of the National Bank of Ukraine (NBU) in this direction is aimed at the implementation of a cluster model, according to which the surveillance regimes and procedures may differ significantly depending on the group to which the bank falls under the analysis. To date, the main criterion to distinguish of surveillance regimes is the size of bank assets. However this criterion is not informative about the types of activities and their risk levels.

Using cluster analysis (Figure 1), the regulator will group banks by similar business models and risk profiles, and one of the criteria for uniting financial institutions with different assets within the same supervisory cluster is their ownership structure.

The differentiation of banks of the 3rd and 4th groups for the purpose of supervision will be carried out on the basis of an assessment of business models and the character of operations.

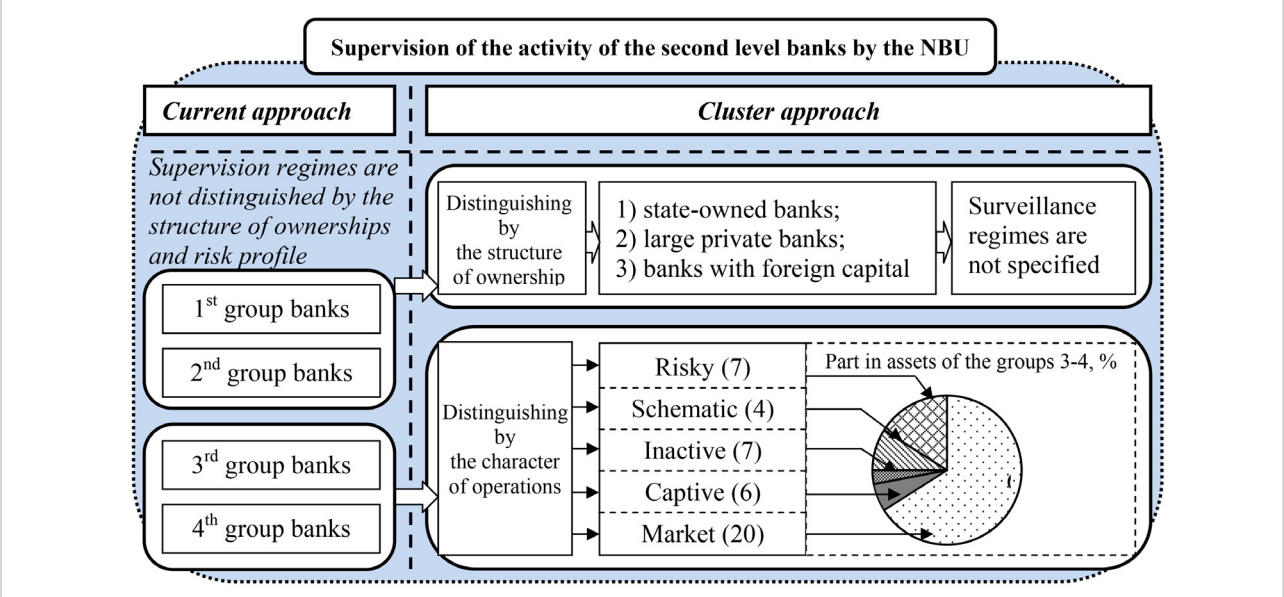

Figure 1:
Approaches to the supervision of banks in Ukraine by the NBU
Source: Compiled by the authors based on [15-16]

To assess the state of an individual bank, a three-dimensional scale is used, which takes into account:

- transparency of the ownership structure - the shareholder's resource potential determines the ability to capitalize and maintain the liquidity of the financial institution, as well as to identify its dependency on the related parties;
- presence of a business model - a way to generate the assessment of banking business by implementing certain strategies and tactics of behaviour at the market;
- business model risk level - concentrating in active operations on a particular industry or business leads to increased credit and investment risk and can serve as a tool for withdrawing funds through related party lending. Table 3 shows the characteristics of the clusters formed by the regulator method.

Table 3:
Characteristics and recommendations for the functioning of banks of the 3rd and 4th groups included in the respective clusters

Cluster	*Characteristics*	*Recommendations of the NBU for the functioning*
Market	Run a classic banking business, do not carry out suspicious transactions.	Implementation of market strategy.
Captive	They only serve their owners and are completely dependent on them.	Merger with market banks or debt repayment by related parties.
Inactive	They were created for resale and do not actually carry out banking activities.	Sale or liquidation.
Schematic	Designed exclusively for money laundering operations.	Liquidation with the involvement of law enforcement agencies.
Risky	Carry out risky activities.	Liquidation or reduction of concentration in assets.

Source: Compiled by the authors based on [15]

The market cluster includes banks that form a resource base and carry out active transactions with unrelated entities competitively. This group is the largest. Their assets make up 66% of bank assets of the 3rd and 4th groups.

Inactive banks do not have a well-defined business strategy, since most of them were created before the crisis and did not have sufficient capital to cover the unforeseen outflow of customers. This cluster also includes active banks that underwent large reductions in units and lines of business during periods of volatility at the financial markets, but no significant changes in the structure of their balance sheets are observed today. Hence, there is uncertainty about the future behaviour of such financial intermediaries.

According to the NBU's classification, the list of captive banks includes the banks whose assets and liabilities structure are formed by transactions with their shareholders. That is, they are not focused on performing the basic functions of financial intermediation and were created for the purpose of servicing the financial flows of a group of companies. In this case, there is an instrumental rather than a functional approach to the bank activities. Consequently, in the event of a non-settlement of the concentration of related party transactions within three years, it is probable that they will be sold or liquidated.

Features of functioning of risky banks are related to the fact that, on the one hand, their resource base is formed on market conditions, and, on the other hand, there are significant imbalances in the asset structure that generate concentration risks, the realization of which under an unfavourable scenario may cause rapid deterioration of economic activity standards.

The last cluster was formed by the banks that conducted money laundering transactions. The only scenario for such banks is liquidation with the involvement of law enforcement agencies in order to establish the degree of liability of owners and senior management for detected violations.

Applying a cluster approach for supervisory purposes helps optimize the workload for supervisors, identify the most relevant areas for analyzing bank operations, coordinate activities of supervisory units and enhance financial monitoring and currency control.

The clustering technique proposed by the NBU focuses mainly on the banks of the 3rd and 4th groups, since the IMF emphasizes the need for additional regulatory influence on their activities. This is to prevent existing breaches of management standards for strategy implementation, related party transactions and reporting manipulation.

It is worth noting that capital affiliation is considered as the exclusive criterion for the separation of banks of the 1st and 2nd groups in three clusters: state-owned banks, large private

banks and banks belonging to international banking groups. Based on a critical analysis of the literature, it can be argued that the ownership is the main, but not the only, determinant of the bank behaviour, therefore the mechanistic separation of the banks of the 1st and 2nd groups in three clusters is not justified. Thus, large banks are characterized by market behaviour. At the same time, it is formed within a competitive environment, so the way of generating business value and risk profiles can differ significantly at the banks with the same capital. To address this shortcoming, it is advisable to use clustering tools that take into account the bank risk profile.

The input of statistical data for the implementation of analytical procedures is formed by a sample of banks of the 1st and 2nd groups for the period of 2008-2019. This allows us to take into account the variability of the input characteristics values and their influence on the formation of a generalized risk profile of a particular bank, for the characteristics of which is formed a list of indicators of financing concentration (Table 4), proposed by the Basel Committee on Banking Supervision. The key feature of the cluster approach is that the monitoring is performed not on an individual basis but on an aggregated cluster.

Table 4:
Indicators characterizing the bank's risk profile

Concentration of financing	*Indicators included in the sample*
Significant counterparties	– assets in other banks / total assets (C_b/A); – individuals' debt / total assets (C_i/A); – legal entities' debt / total assets (C_c/A); – bank funds / total liabilities (L_b/L); – individuals' funds / total liabilities (L_i/L); – legal entities' funds / total liabilities (L_c/L).
Significant instruments	– securities / total assets (S/A).
Significant currencies	– foreign currency assets / total assets (A_{fx}/A); – foreign currency commitments / total liabilities (L_{fx}/L).

Source: Compiled by the authors based on [17]

The preliminary stage of the analysis eliminates the statistical units that can generate extremes and impair the adequacy of the results.

After that the normalization procedures are applied to integrate the inputs in different units of measure into the consolidated indicator which can be used to draw conclusions about the bank risk profile, the feasibility of the in-depth analysis and the corrective actions to ensure that the target parameters are met.

The simultaneous study of several statistical units begins with the determination of the sets of features that characterise the bank risk profile. Each observation matrix includes features that reflect the properties of each bank at the reporting date in dynamics. If we denote the individual observation matrix of the unit j by the symbol X_j, then the summary matrix covering all r of the banks under study can be represented as a block matrix ($X_0 = [X_1 X_2 \dots X_j \dots X_r]$).

The next step is to determine the coordinates of the combined reference vector, which should contain such a number of elements that corresponds to the summary matrix of observations. It can also be represented as a block matrix, the elements of which are the individual standards of the development of individual banks ($P_0 = [P_1 P_2 \dots P_j \dots P_r]$). The calculation of the consolidated indicator of the level of development is carried out according to Formula 1:

$$d_i^* = \frac{\sqrt{\sum_{j=1}^{r}\sum_{s=1}^{n_j}(z_{is} - z_{0s})^2}}{\frac{1}{t}\sum_{i=1}^{t} c_{i0} + \sqrt{\frac{1}{t}\sum_{i=1}^{t}(c_{i0} - \overline{c}_0)^2}}, \quad (1)$$

where:
r is the number of sampled banks;
n_j is the number of features that characterize the risk profile for bank j;
z_{0s} is the coordinates of the normalized vector;
z_{is} is the standardized value of features within the period i.

The consolidated indicator calculated this way displays a risk profile taking into account the characteristics of all the statistical units considered, and its magnitude reflects the aggregate

changes in the values of the input indicators in the dynamics. The disadvantage of the consolidated indicator is that it does not take into account the structural imbalances of banks assets and liabilities by either items or their scope. To counteract these shortcomings, it is necessary to modify the consolidated indicator by determining the dependence that characterizes the impact of changes in the individual indicators of the level of development of each unit according to Formula 2:

$$c_{i0,\,j} = \sqrt{\sum_{s=1}^{n_j} \left(z_{is} - z_{0s,\,j}\right)^2}\,, \tag{2}$$

where:
i equals 1, 2, …, t;
j equals 1, 2, …, r;
n_j is the number of features characterizing the risk profile for the bank j;
$z_{0s,j}$ are the coordinates of the standard of the development of the bank j.

The dependence between the square of the distance calculated for the consolidated indicator and the squares of distances for the individual indicators can be represented by the ratio Formula 3:

$$\sum_{j=1}^{r} \sum_{s=1}^{n_j} \left(z_{is} - z_{0s}\right)^2 = \sum_{s=1}^{n_1} \left(z_{is} - z_{0s,\,1}\right)^2 + \sum_{s=1}^{n_j} \left(z_{is} - z_{0s,\,j}\right)^2 + \ldots + \sum_{s=1}^{n_r} \left(z_{is} - z_{0s,\,r}\right)^2 . \tag{3}$$

Based on the above, it is possible to establish the dependence between the consolidated and individual indicators of the level of development (Formula 4):

$$d_i^* = \sqrt{\frac{\sum_{j=1}^{r} c_{0,\,j}^2 d_{i,\,j}^{*2}}{c_0^2}}\,. \tag{4}$$

This dependence makes it possible to determine the impact of individual risk profile indicators for each of the banks included in the input statistical array on the total value of the consolidated indicator of the risk profile achieved by the banks in the dynamics. The result of the calculations is a normalized matrix, the elements of which are input parameters for the further analysis.

The next stage is the formation of bank clusters based on the appropriate analytical procedures. The Neural Network Toolbox for MatLab was used as the clustering environment. The choice of neural network training method is conditioned by the lack of information about the number of clusters as a result of the variability of their business models. The result of the calculations is the formation of four bank clusters (Figure 2).

As figure 2 shows, there is a strong correlation between the ownership structure and the risk profile in the Ukrainian banking system. Thus, all state-owned banks are included in the 4th cluster, which is characterized by a significant share of securities in the structure of assets, which is caused by the redemption of government bonds. Due to the lack of clarity on the role of domestic state-owned banks in economic processes and the involvement of public authorities in their policy in order to solve current financial problems of the budget, the risk of a conflict of interests increases, which can have negative consequences for their solvency in the future.

The study of the degree of exposure to foreign exchange risk gives grounds to argue that banks with Russian and foreign capital are in the high risk zone. At the same time there is a transition of the latter to the category of banks with moderate risk level. Furthermore, the dependence of Russian banks on foreign currency in the domestic market is high, and their credit policy is focused on the priority of the corporate segment financing.

In terms of attracting funds from individuals, the vast majority of banks have demonstrated high activity, except for Russian and foreign banks whose strategy involves withdrawing funds from the retail market or selling a large portion of assets placed in loans to individuals (PJSC «ING Bank»).

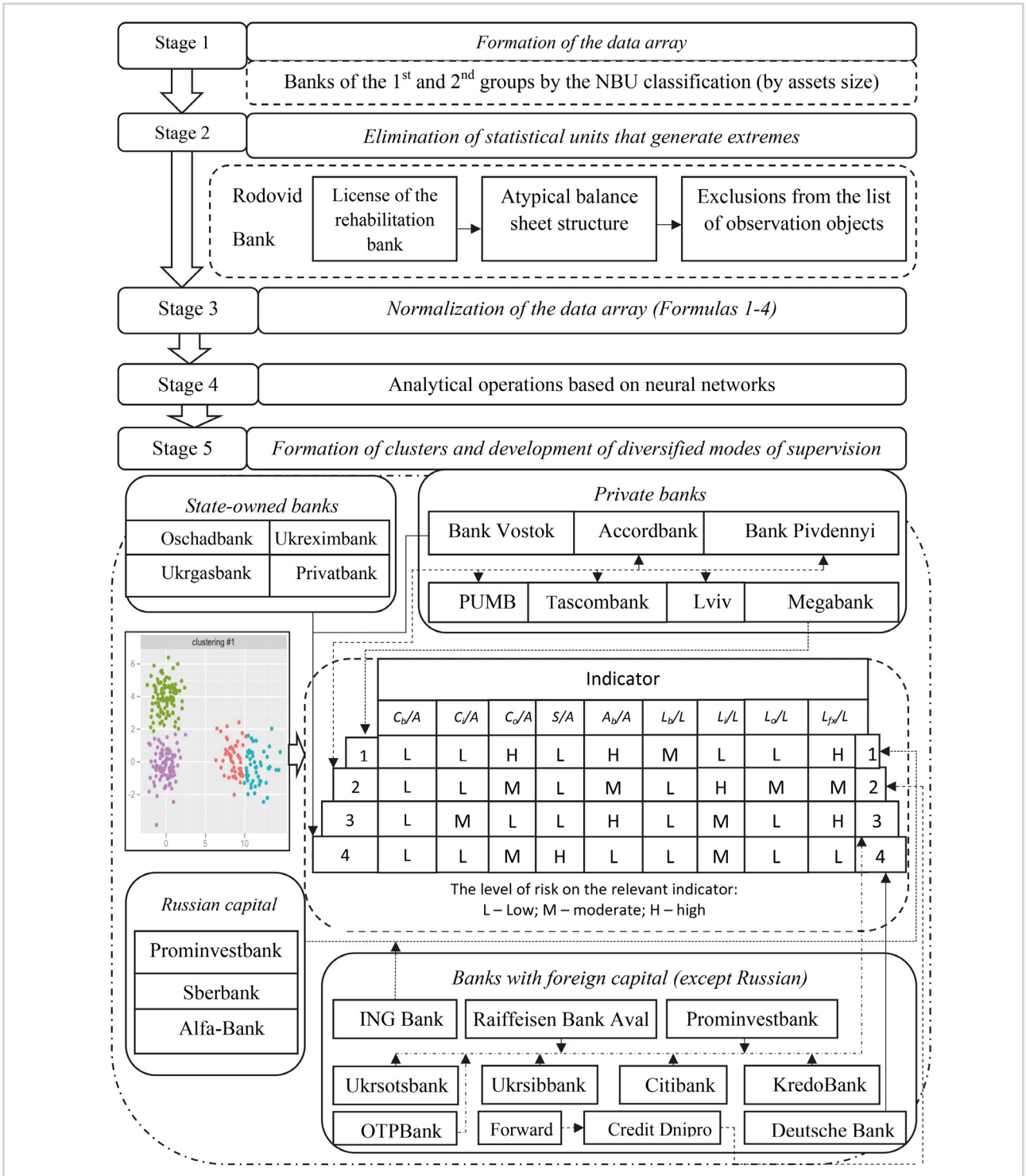

Figure 2:
Improved clustering algorithm for banks by risk profile
Source: Compiled by the authors

Private banks with Ukrainian capital show significant diversification in terms of distribution by cluster caused by the varying degrees of support from the owners, which is manifested in their ability to capitalize, as compared to the state-owned and foreign banks.

Thus, the type of the ownership significantly influences the risk profile, yet it is not the exclusive condition for its formation.

5. Conclusions

Based on the analysis of the public financial statements of the Ukrainian banks belonging to the 1st and 2nd groups, it is empirically proven that there is a strong relationship between the structure

of ownership (equity) and risk profile. Also, it is substantiated that the ownership structure is not the only factor influencing the business model of the bank. Therefore, the use of this criterion as the exclusive one for clustering is impractical. In view of this, the further stages of qualitative transformation of the banking supervision system in Ukraine should be aimed at specifying the regimes of control over the activities of these financial intermediaries based on their risk profile according to the proposed methodology.

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