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Analysis of banking sector stability using the taxonomic measure of development

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Abstract

Motivation: The stability of the financial system means that the entire system performs its key functions properly. It is a prerequisite for sustained economic growth. Maintaining stability of the banking sector is of particular importance for the firmness of the financial system, as it plays a key role in financing the economy, transmission of monetary policy impulses, and monetary settlements. Therefore, in the context of financial security, it is extremely important to analyse the banking stability.

Aim: Assessment of the stability of banking sectors of the Central and Eastern European EU Member States and a comparative analysis and classification of the CEE countries in terms of selected indicators characterising the stability of their banking sectors using the model method of linear ordering, i.e. the Hellwig's method. The analysis will verify the thesis whether banks in countries of lower national income (according to the World Bank's classification) perform worse in terms of stability than banks in countries of higher national income. To illustrate the situation in the field of banking sector stability more clearly, the authors presented the dynamics of all variables considered from the point

of view of the analysis (dynamics were presented for 2015 and 2019 in relation to the base year, which was assumed to be 2011).

Results: A multivariate analysis was used in the comparative analysis of banking sectors development in Central and Eastern Europe. For this purpose, the development pattern method was used so that a synthetic indicator of the development of the banking sector with regard to its stability was calculated. Based on the proposed measure of development, a ranking of the Central and Eastern European EU Member States was prepared for 2019. It should be emphasized that the thesis outlined in the article was not empirically confirmed, namely, banks from countries of lower national income (according to the World Bank classification) did not have much worse results than banks from countries of higher national income.

Keywords: banking sector; Central and Eastern Europe EU member states; statistical methods; area of stability; Hellwig's method
JEL: G21; N14; C38

1. Introduction

Contemporary banks perform many differentiated and unique economic functions and more and more often social ones as well. The emergence of a two-tier system and the formation of various institutional structures in commercial banking are other reasons for the current shape of modern banking systems. The first tier is the central bank, while the second tier is consists of all operational (commercial) banks (Baka, 2001, pp. 30–55). Each of these institutions has its own goals and performs specific functions in the system. Central banks in most developed countries are institutionally independent of political interference (Fielding, 2008, pp. 1–8). The bank's original activity was considered from the point of view of its role as a financial intermediary, since the bankers were historically the first intermediaries (Andreau, 1999, pp. 30–50). As financial intermediaries, banks fulfil functions in the transactional area (they perform operations of accepting and making funds available) and transformational (related to various requirements of borrowers and depositors) (Niczyporuk & Talecka, 2004, pp. 77–89). Banks also function as a payer, guarantor, or agent.

The role of a financial intermediary carries a risk, usually understood as the danger of not achieving the intended goals. From the point of view of a bank, it is mainly about events which have a negative impact on the condition of a financial institution (Gruszka, 2001, pp. 359–368). Therefore, risk, as an inherent feature of bank operations, should be both assessed and limited at the level of a single institution, but also at the level of the entire banking system (Baszyński, 2014 p. 14). Hence, one should also perceive the huge role of supervision institutions on the part of public authorities. It should be remembered that the bank, as an institution of public trust, is to ensure security of funds entrusted by its clients, since the systemic risk for banks, in a sense, translates into risk for the entire society (Dziawgo,1999, pp. 300–355).

Apart from banks, the banking system also includes other entities established to fulfil the tasks provided for by law in order to ensure the security of the clients of these institutions (Pisani-Ferry et al., 2012, p. 4).

The main objective of this article is to assess the stability of banking sectors of the Central and Eastern European countries belonging to the EU and a comparative analysis and classification of the CEE countries in terms of selected indicators characterizing the stability of their banking sectors using the model method of linear ordering, i.e. the Hellwig's method. The analysis will verify the thesis whether banks from countries of lower national income (according to the World Bank's classification) perform worse in terms of stability than banks from countries with higher national income. The presentation of this thesis is dictated by the transformations that took place in the 21st century in the financial systems of EU Member States of the Central and Eastern Europe. The banking sectors of these economies were relatively smaller and the prudential regulations were not fully developed. Hence, it seems justified to assess the stability of the banking sectors of these economies. For this purpose, the development pattern method was used so that a synthetic indicator of the development of the banking sector with regards to its stability was calculated. Based on the proposed measure of development, a ranking of the Central and Eastern European EU Member States was prepared for 2019.

2. Literature review

A sound and efficient banking sector in a country contributes to an improvement in the collection of situation savings, which makes it possible to allocate them to the most productive investments, thus supporting innovation, leading to economic growth (Marcinkowska et al., 2016, pp. 22–25). Banks are the most important financial intermediaries in all countries of Europe (Ostraszewska, 2017, pp. 59–61). First, it should be emphasized that a very important issue in this regard is the answer to the question of what capital a bank should have at its disposal to protect itself against the risk of insolvency. Regulation of the level of equity capital in the form of minimum capital requirements is a common instrument used by bank regulators. The issue of the minimum capital requirement is closely related to the issue of banks' capital adequacy. Capital adequacy is a broader concept related to the above-mentioned supervisory regulations (Moles & Terry, 1997). After the 2008 financial markets, the banking sector was subjected to a wave of regulation (Stawska, 2017, p. 244). The implementation of Basel III framework in the field of capital and liquidity standards was to reduce the risk of instability in the banking sector and thus the likelihood of financial crises (Elsinger et al., 2006, pp. 75–88). The aim was to ensure a better quality of bank capital, reduce systemic risk, and increase bank capital requirements (Czechowska et al., 2021, pp. 38–43). Actions of the regulators led to increasingly restrictive standards in banks' capital adequacy. In the context of these requirements, a problem has arisen, namely the impact of imposing

of new guidelines on capital adequacy on the balance sheet structure of the banking institutions themselves, the costs resulting from these regulations (Dziawgo & Dziawgo 2018, pp. 12–14) and their impact on the very stability of sectors and their profitability (Karkowska & Niedziółka, 2019, pp. 149–170; Miklaszewska & Kil, 2019, pp. 173–190).

Due to the above, one of the measures used in this area was the ratio of banks' total capital to total assets, which is an important factor of this stability, as well as the ratio of regulatory capital to risk-weighted assets (capital adequacy ratio). The definition of regulatory capital is included in the Basel Committee guidelines (BCBS, 2010).

The pressure on the hardest capital from the regulator is to reduce the use of debt-based transactions to increase lending without worsening the solvency ratio. The proposed solutions were aimed at strengthening banks' capital by introducing capital buffers as countercyclical mechanisms (Admati et al., 2014, pp. 33–45). Banks around the world and in Europe significantly strengthened their capitals, shortened the leverage, and a significant part of them have already met liquidity standards. The last, twelfth consecutive monitoring of the implementation of Basel III recommendations (Howarth & Quaglia, 2013, pp. 333–346). The review of the situation by the Bank for International Settlements showed that since mid-2011 the hardest CET 1 capital of the 105 largest banks in the world has increased from 7.2 to 12.3%, and in absolute numbers from EUR 2,125 billion to EUR 3,738 billion. In Europe, the hardest capitals of the largest banks have increased by 56.8% to 13.4% (Ramotowski, 2018). According to the most recent changes, on the 7th of December 2017, the Basel Committee on Banking Supervision (BCBS) published new rules to calculate risk weighted assets (RWA), including increasing the sensitivity of the standardized approach, and to calculate risk and regulatory capital (Feridun & Özün, 2020, p. 8). New regulations, due to the large scale of changes referred to by the sector as Basel IV, will be introduced gradually to banks in the years 2022–2027. They are to contribute to the stability of banking systems around the world.

Financial stability is an indispensable feature of a well-functioning economy (Czechowska et al. 2020, pp. 15–18; Jokipii et al., 2013, p. 1–16; Shkolnyk et al. 2021, p. 380). A stable financial system easily fulfills its assigned functions of monetary, capital, and redistributive settlement, risk reduction, information, and control nature (Thakor, 2014, pp. 200–223). Instability causes shocks to the financial system, which disrupts the correct flow of information, where the financial system cannot properly carry out its tasks in the field of capital flow (Mishkin, 1999, pp. 3–20). The great importance of financial stability (including the stability of banks as the main link in this system) for the efficient functioning of the state makes many researchers attempt to analyze this phenomenon. For example, in countries where the banking sector has a dominant position in the financial system (e.g., in Poland and in the rest of the European countries analyzed here), the stability of the financial system is equated with the stability of the banking sector. Analysis of the safety of banking sectors

in countries of Central and Eastern Europe was the subject of considerations, inter alia, in the context of the recent financial crisis (Dietrich et al., 2011, pp. 415–430). Research shows that the financial crisis caused structural changes in banking systems, with positive changes in the shock resilience of these systems (as evidenced by the results in terms of capital adequacy and the ratio of deposits to loans). In the CEE countries, the focus was on building a financial safety net (Iwanicz-Drozdowska & Smaga, 2016, pp. 29–33).

Among the measures used to test the stability of the banking sector that one can find, including indicators proposed by the World Bank (2021), therefore, were analyzed for the purposes of this study:

– Z-score;
– bank non-performing loans to gross loans;
– bank capital to total assets;
– bank credit to bank deposit;
– bank regulatory capital to risk-weighted assets;
– liquid assets to deposits and short-term funding;
– provisions to non-performing loans.

The publication of financial stability indicators is also the responsibility of the International Monetary Fund (IMF, 2021). Data on banking sectors in countries of the European Union can also be found in the database of the European Central Bank (ECB, 2022). Since 2011, stress tests have been used to assess the stability of the banking system in the EU (Mikita, 2021, p. 95). Their aim is to test the resilience of individual banks and the entire banking sector to unfavourable conditions that may arise in the environment of these institutions in the future (e.g. recession).

3. Methods

The linear ordering method allows one to establish a hierarchy of objects, that is, arrange them from the highest object in the hierarchy to the lowest (Paliszkiewicz, 2010, p. 346). Thus, the use of the linear ordering method yields a result which is the basis for determining which of any two objects in the set is the first (i.e. better) and which is the second (i.e. worse), or whether they are identical. The first proposal for linear ordering was presented by Hellwig (1968, pp. 307–327; 1981, pp. 46–68). This publication initiated intensive research, which resulted in further proposals of linear ordering methods (Kozar, 2016, pp. 31–34; 2021, pp. 40–53; Pluta, 1976, pp. 511–517; Strahl, 2003, pp. 76–83).

Due to the nature of the research, the empirical part of the article uses the linear ordering (Hellwig's method). This method consists of dividing a data set into groups in order to obtain clusters in which the elements are similar to each other and at the same time differ from elements from other groups (Walesiak, 2004, pp. 351–355). The linear ordering method used enabled presenting the situation of banks from the Central and Eastern European EU Member States on the basis of the results achieved with regard to stability. Eleven countries from the Cen-

tral and Eastern Europe region were qualified for the study[1]. The list is presented in Table 2.

To achieve a uniform method of calculation, the resources of the World Bank (2021) were used and the *Global financial development database* was made available. The scope of the input variables that illustrate the situation in the field of banking sector stability and their definition are presented in Table 1.

To better illustrate the situation in the field of stability of the banking sector, the authors presented the dynamics of all variables considered from the point of view of the analyzed phenomenon (dynamics were presented for 2015 and 2019 in relation to the base year, which was assumed to be 2011) (Table 7). The results are obtained by the linear ordering method and more precisely by the Hellwig's development pattern method, refer to 2019 (i.e. the latest available data from the World Bank (2021) database).

The selected set of diagnostic variables in the area of stability of the banking sector (presented in Table 1) was then subjected to a statistical analysis procedure in terms of determining the discriminant ability of the selected variables, i.e. their variability in relation to the examined objects (Panek, 2009, pp. 69–75). For this purpose, the variability criterion proposed by Hellwig (1990) was used:

$$v_i = \frac{s_i}{\overline{x}_i}, \tag{1}$$

where:

s_i — standard deviation of the variable x_i;

$\overline{x}_i$ — average value of the variable x_i.

In the case of finding that the differentiation of a variable is too small in the conducted analysis, such a variable should be eliminated from the set of diagnostic variables (value where the coefficient of variation (V_i) for a given variable is less than 10%).

As a result of the data presented in Table 3, the value of the coefficients of variation for the selected variables is in each case above the minimum threshold, that is, 10%. Thus, it can be concluded that their informational value allows for a proper comparative analysis using the linear ordering method.

The variables were subjected to determining their information potential. For this purpose, the threshold value of the correlation coefficient r^* was established

[1] The geographical scope of the area known as the Central-Eastern Europe being the subject of disputes and controversies, is not clearly and precisely defined. Based on the literature review, taking into account the criterion of belonging to the indicated geographical area and belonging to the EU, the countries of the Visegrad Group (Poland, Slovakia, Hungary and the Czech Republic), the Baltic states, i.e. Lithuania, Latvia and Estonia, the countries established after Yugoslavia, i.e. Slovenia, Croatia, and other Balkan countries, i.e. Romania and Bulgaria.

(above this value, it is assumed that the variables are significantly correlated with each other). The minimax method was used:

$$r^* = min_j\, max_{j'} \left| r_{jj'} \right|, \tag{2}$$

where:

$r_{jj'}$ — correlation coefficient between the *j*-th and *i*-th admissible diagnostic variables and *j*, *j'*=1, 2, 3,..., *m*.

The values of the correlation coefficients calculated by the above method (2). The critical value of the correlation coefficient calculated using the minimax method was 0.365. Based on these results, two representative variables (x_2, x_5) were selected from the initial set of variables (x_1, x_2, x_3, x_4, x_5). The results are presented in Table 4. Due to the above, the set of diagnostic variables constituting the basis for the construction of the synthetic measure consisted of two indicators determining the development in terms of the stability of banking sectors of the CEE countries of the EU. Among the variables, there were two stimulants, which are, bank capital-to-total-assets (%) (x_2) and provisions to non-performing loans (%) (x_5).

The next step to apply the adopted research method is to carry out a transformation in the set of indicators in order to bring them for mutual comparability or unification of the nature of the variables (Hellwig, 1968, pp. 307–326). Due to the fact that both variables are of the same nature (they are stimulants), this step could be omitted.

Generally, the higher the level of a given indicator, the more its value contributed to a more favorable synthetic assessment of banks in each country in the overall ranking from the point of view of banking sector stability.

Next, in accordance with the procedure adopted in the linear ordering, the classical procedure of variable normalization procedure (their standardization) was performed.

$$z_{ij} = \frac{x_{i_j} - \overline{x}_j}{S\left(x_j\right)}, \tag{3}$$

i=1, 2,..., *n*; *j*=1, 2,..., *m*.

After carrying out the above procedure, normalized variables were subjected to the procedure of eliminating negative values. A constant ε was used (5) for this purpose, which allowed for obtaining positive values without changing the relationship between the variables (Panek, 2009, p. 41).

$$z_{ij} = \begin{cases} z_{ij} & when\ \ max\left\{z_{ij}\, j\right\} > 0 \\ z_{ij} + \varepsilon & when\ \ min\left\{z_{ij}\, j\right\} \le 0 \end{cases}, \tag{4}$$

i=1, 2,..., *n*; *j*=1, 2,..., *m*, where:

$$\varepsilon = \min_{i,j}\{z_{ij}j\} + \frac{1}{5}s(z), \tag{5}$$

where:

$s(z)$ — standard deviation calculated from all elements of the matrix of normalized inputs;

a, b, p — normalization parameters: $a=M(x_j)$; $b = \max_i\left\{\left|x_{ij} - M\left(x_j\right)\right|\right\}$; $p=1$;

The synthetic measure on the basis of which the ranking of countries will be prepared is determined according to the formulas below. In this study, the coordinates of the reference object were determined using the following formula:

$$z_{oj} = max\{z_{ij}\}, \tag{6}$$

$i=1, 2,..., n$; $j=1, 2,..., m$.

Therefore, the pattern for a given indicator was the EU country with the highest observed value of the analyzed variable, i.e., the most favorable situation. In order to determine the distance of objects from the pattern, the Euclidean distance measure between the considered entities qualified for the analysis was used. It is the most direct way to calculate the distance between objects in a multidimensional space[2], expressed by the following formula:

$$d_i = 1 - \frac{d_{i_0}}{d_0}, \tag{7}$$

where:

d_i — value of a synthetic (aggregated) variable: the higher the d_i values, the higher the complexity level. The development measure for the pattern is 1, and for the antipattern it is 0, so d_i [0, 1],

where:

$$d_{i0} = \sqrt{\sum_{j=1}^{m}\left(z_{ij} - z_{oj}\right)^2}. \tag{8}$$

The more similar an object (z_{ij}) is to the pattern (z_{i0}), the higher the level of complex phenomena for that object.

The final stage of the measured value study is to determine the presented measure of the development pattern:

$$d_0 = \bar{d}_0 + 2s_0, \tag{9}$$

[2] Breaking up the observations into groups requires some methods to compute the distance or dissimilarity between each pair of observations. The result of this computation is called the dissimilarity matrix. There are many methods for calculating distance information; the choice of distance measures is a critical step in creating clusters — it defines how the similarity of two elements (x, y) is computed and affects the shape of the clusters.

where:

d_0 — distance between the pattern, calculated on the basis of the Euclidean metric,

$$\overline{d}_0 = \frac{1}{n}\sum_{i=1}^{n} d_{io}, \tag{10}$$

is the average distance the arithmetic mean of a feature (synthetic index) d_0;

$$s_0 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(d_{io} - \overline{d}_0\right)^2}, \tag{11}$$

is the standard deviation of a feature d_0.

The next stage of the study was classification of the objects analyzed. The "best" facilities are the countries classified in group 4, the class of objects achieving the "lowest" results is the group of countries classified to the group 1.

By analysing the obtained results, we can divide the objects into classes depending on the size of the measure. Then the values were ordered linearly according to non-increasing values, and on the basis of which, typological classes of units were distinguished, separating four disjoint subsets of similar objects as follows:

group I:

$$d_i < \overline{d}_{\bar{i}} - s_{d_i}, \tag{12}$$

group II:

$$d_i - s_{d_i} \le d_i < \overline{d}_i, \tag{13}$$

group III:

$$\overline{d}_i \le d_i < d_i + s_{d_j}, \tag{14}$$

group IV:

$$d_i \ge \overline{d}_i + s_{d_i}, \tag{15}$$

where:

$\overline{d}_i$ — arithmetic mean of the calculated taxonomic measure of development,

s_{d_i} — standard deviation of the calculated taxonomic measure of development.

4. Results

To illustrate the situation in the field of banking sector stability in a much clearer way, the authors presented the dynamics of all variables considered from the phenomenon point of view of the analyzed (dynamics was presented for 2015 and 2019 in relation to the base year, which was assumed to be 2011) (Table 7). The authors also illustrated the shaping of the variables representing the ordering method on the graphs (data are presented for three years, i.e. 2011, 2015 and 2019 — which means every four years). The results obtained by the linear ordering method which is the Hellwig's development pattern method, refer to 2019 (i.e. the latest available data from the World Bank (2021) database).

4.1. Analysis of levels and dynamics in terms of variables selected for the study

In 2011, the capital share ratio in total assets (x_2) in the analyzed period fluctuated on average at the level of approximately 6–14%. The best results were achieved by countries such as Croatia, Lithuania, the Slovak Republic, and Bulgaria (Chart 2). High values of this ratio should be interpreted as an improvement in financial independence and an improvement in securing debt repayment with assets held. At the same time, a low share of equity in total assets may indicate that the collateral for the repayment of liabilities is insufficient. The banking sectors in the Czech Republic and Poland are characterized by a relatively low level of this indicator compared to other countries in 2011 (Chart 2), where this ratio was below 8%. On the other hand, in terms of NPL provisions for NPLs (x_5), Poland, Latvia and Bulgaria were the best performers, indicating effective measures to minimize credit risk.

In 2015, the value of the ratio of equity to total assets was found to range from 7.5% to 20% (Chart 3). It should be noted that improving the results in this area of almost every country (except for Croatia, where this indicator decreased but only by approximately 6%). Regarding non-performing loans and provisions for NPLs (x_5), it should be noted that Slovenia, Hungary and Croatia recorded a significant improvement in their results. This should be assessed positively, as maintaining the minimum coverage ratio, which is adequate bank provisions, is extremely important for the safety and stability of the entire financial sector. On the other hand, the deteriorating results obtained in this case by Estonia, Romania and Bulgaria may be disturbing. This may indicate problems in effective recognition, classification, and minimization of the potential risk related to possible losses resulting from credit activity.

In 2019, in terms of the value of the capital-to-total-assets ratio, the worst result was noted in Lithuania. The share of capital in total assets in the analyzed period in this country amounted to 6.88% and was below the average of this indicator for the analyzed countries (Chart 4). In 2015, this ratio improved compared to 2011, however, taking into account the situation in 2019 — it de-

creased by 36% compared to 2011 (Table 7). Regarding non-performing loans and provisions for NPLs (x_5), it should be noted that Slovenia, Hungary, Croatia and also Lithuania saw a significant improvement in their performance.

4.2. Grouping results obtained by the linear ordering

The results obtained by using the linear ordering method, i.e. the method of development pattern by Hellwig, are presented in Table 5. This is a ranking of Central and Eastern European EU Member States in terms of the development of banking sectors considered from the point of view of the stability of these sectors. Countries have been ranked from most to least stable. In the ranking, the leading position belongs to Croatia. The synthetic measure for this country was calculated at the level 1.000 (which means that this country, from the point of view of the variables analyzed, was considered a model for other countries). On the other hand, the last place in the presented was taken by Lithuania and Czech Republic (Chart 1).

The results obtained in terms of the classification of countries were then subjected to the grouping procedure in order to define the situation of a given country in comparison to other banking sectors in terms of stability. Four groups were distinguished when the standard deviation method was used for this purpose. The results of this grouping are presented in Table 6. The objects with the highest scores are the countries classified to group 4, the class of objects achieving the lowest results is the group of countries classified to group 1.

Croatia was classified into group 4, that is, the group characterized by the best situation in terms of the stability of banking sectors with a synthetic measure at the level of 1.000. In group 3, which is a group of a relatively good level in terms of the stability of the banking sector comprised of five countries included Slovenia, Hungary, Slovak Republic, Poland and Romania, where the synthetic measure for these countries was above the average characteristic, that is, 0.467 and below 0.711. Group 2 characterized by the average situation of the classified countries in terms of the stability of banking sectors included Bulgaria, Estonia, and Latvia (the synthetic measure for these countries was below the average, that is, 0.467 and above the level of 0.225). In terms of the phenomenon analyzed, the banking sectors in Lithuania and the Czech Republic should be assessed the worst (group 1, where the value of the synthetic measure was below 0.225). The prepared classification of countries reflects the stability of their banking sectors through the variables selected for the study. Croatia took the lead position in the group of countries analyzed. In Croatia, as in the countries occupying the next top three positions in the ranking, i.e. Slovenia, Hungary, and Slovakia, the level of variable representatives (x_2, x_5) was above the average calculated for all analyzed countries. With regard to the countries classified into groups 4 and 3, it can be stated that, relatively compared to the analyzed countries, they are in a favourable position in terms of the stability of their banking sectors, where we include the aforementioned Croatia, the countries of the Visegrad

Group outside the Czech Republic, and also Slovenia and Romania. Bulgaria, Estonia, and Latvia show an average situation in terms of banking sector stability. It should be emphasized that the thesis outlined in the article was not empirically confirmed, namely, banks from countries of lower national income, according to the World Bank classification, i.e., Bulgaria and Romania, did not perform worse than banks from countries of higher national income. It should be noted that the situation of the banking sectors of these countries, from the point of view of stability, can be considered average compared to the countries analyzed. Romania came sixth in the ranking and therefore was classified in group 3, where the development measure reached the level above the average, that is, 0.486. On the other hand, Bulgaria came seventh and was classified into group 2 (with a measure of development slightly above average, that is, 0.392).

5. Conclusions

A multivariate analysis was used in the comparative analysis of the development of banking sectors of Central and Eastern European EU Member States. For this purpose, the development pattern method was used so that a synthetic indicator of the development of the banking sector with regard to its stability was calculated. Based on the proposed measure of development, a ranking of the countries of EU Member States of the Central and Eastern Europe was prepared for 2019. This way, it was possible to achieve the adopted goal of this study, i.e. the assessment and comparative analysis of the stability of banking sectors in the CEE countries.

It should be emphasized that the thesis outlined in the article was not empirically confirmed, that is, banks from countries of lower national income (according to the World Bank classification) did not perform much worse in terms of stability than banks from countries of higher national income. It should be noted that the situation of the banking sectors of these countries, from the point of view of stability, can be considered average compared to the countries analyzed. Romania came sixth in the ranking, and therefore classified in group 3, where the development measure reached a level above the average, that is, 0.486. On the other hand, Bulgaria came seventh and was classified into group 2 (with a measure of development slightly above average, that is, 0.392).

Furthermore, it should be noted that the variables relating to the stability of banking systems which differentiate them most with regard to development level of banking sectors are those related to capital requirements in line with the European guidelines. The results in this regard showed (which was consistent with the conclusions obtained through the literature review) that the stability of the banking sectors of the CEE countries in terms of stability has improved over the last decade. When analyzing the dynamics in 2019 in relation to the base year adopted in this article, i.e. 2011, it should be noted that significant improvement in the capital-to-total-assets ratios, with the exception of Lithuania, Latvia and Slovak Republic. Regarding the share of regulatory cap-

ital in risk-weighted assets, there was an improvement in all countries analyzed in this paper. However, in terms of provisions for NPL impaired loans, for instance, Bulgaria and Latvia presented definitely higher results, ultimately taking second and third place respectively in the ranking of linear ordering in the area of stability in the banking sector in 2019, behind Estonia. On the other hand, in terms of provisions for NPL impaired loans, Croatia, Slovenia and Hungary presented higher results, ultimately taking second and third place respectively in the ranking of linear ordering in the area of stability in the banking sector in 2019 behind Croatia.

In general, the improvement in the stability of the banking sectors of Central and Eastern European EU Member States should be combined with the fact that European banks are obliged to comply with European Commission's directives implementing the Basel Committee's recommendations on capital requirements which are to lead to more stable banking sectors, and thus the stability of the entire financial system. Taking into account this research, future considerations may be devoted to transformations in banking sectors in the context of increasing capital requirements for banks that will implement the final Basel III approach, or to the changes in prudential requirements regarding the introduction of new ESG regulations (European Financial Congress, 2022). Moreover, the analysis could be extended to new countries and research periods, which may constitute a certain limitation of this research.

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Appendix

Table 1.
Diagnostic variables determining the area of banking stability and their definition

No	The name of the variable	Definition	Character	Source*
1.	bank non-performing loans to gross loans (%) (x_1)	Ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio). The loan amount recorded as non-performing includes the gross value of the loan as recorded on the balance sheet, not just the amount that is overdue.	destimulant	IMF
2.	bank capital to total assets (%) (x_2)	Ratio of bank capital and reserves to total assets. Capital and reserves include funds contributed by owners, retained earnings, general and special reserves, provisions, and valuation adjustments. Total assets include all nonfinancial and financial assets.	stimulant	IMF
3.	bank regulatory capital to risk weighted assets (%) (x_3)	The capital adequacy of deposit takers. It is a ratio of total regulatory capital to its assets held, weighted according to risk of those assets.	stimulant	IMF
4.	liquid assets to deposits and short term funding (%) (x_4)	The ratio of the value of liquid assets (easily converted to cash) to short-term funding plus total deposits. Liquid assets include cash and due from banks, trading securities, and at fair value through income, loans and advances to banks, reverse repos and cash collaterals. Deposits and short term funding includes total customer deposits (current, savings and term) and short term borrowing (money market instruments, CDs and other deposits).	stimulant	IMF
5.	provisions to non-performing loans (%) (x_5)	Provisions to non-performing loans. Non-performing loans are loans for which the contractual payments are delinquent, usually defined as and NPL ratio being overdue for more than a certain number of days (e.g., usually more than 90 days).	stimulant	Orbis Bureau van Dijk (BvD)

Note:

* Source indicated in the World Bank (2021) database.

The Z-score variable and the bank credit-to-bank deposit variable were excluded from the output base due to single missing data.

Source: Own preparation based on the World Bank (2021).

Table 2.
Selected countries to be analyzed together with the classification of the countries according to the World Bank

Countries	National income level (2011, 2015, 2019)	Variables
Croatia (HR)	high income	x_1, x_2, x_3, x_4, x_5
Czech Republic (CZ)		
Estonia (EST)		
Hungary (HU)		
Latvia (LV)		
Lithuania (LT)		
Poland (PL)		

Countries	National income level (2011, 2015, 2019)	Variables
Slovak Republic (SK) Slovenia (SLO)	high income	x_1, x_2, x_3, x_4, x_5
Romania (RO) Bulgaria (BG)	upper middle income	

Source: Own preparation based on the World Bank (2021).

Table 3.
Value of the coefficient of variation for selected diagnostic variables

Variable	Coefficient of variation for variables in 2019
x_1	0.61
x_2	0.20
x_3	0.11
x_4	0.57
x_5	0.22

Source: Own preparation using STATA software based on the World Bank (2021).

Table 4.
List of representative (central) and satellite (isolated) variables

Variable representants	The type of the representative variable	Satellite variables for the central variable
x_5	central variable	x_3, x_4
x_2	central variable	x_1

Source: Own preparation using STATA software based on the World Bank (2021).

Table 5.
Linear ordering results in the area of stability in the banking sector in year 2019

Ranking position	Country	Value of the synthetic variable (di)
1	Croatia	1.000
2	Slovenia	0.654
3	Hungary	0.626
4	Slovak Republic	0.554
5	Poland	0.509
6	Romania	0.486
7	Bulgaria	0.392
8	Estonia	0.296
9	Latvia	0.249
10	Lithuania	0.219
11	Czech Republic	0.149

Source: Own preparation based on the World Bank (2021).

Table 6.
Segmentation of the studied group of banks from the analysed subregion according to their situation in the area of stability in the analysed time horizon in 2019 (using the standard deviation method)

Group 1	Group 2	Group 3	Group 4
di<0.225	0.225<=di<0.467	0.467>=di<0.711	di>=0.711
Lithuania	Bulgaria	Slovenia	Croatia
Czech Republic	Estonia	Hungary	
	Latvia	Slovak Republic	
		Poland	
		Romania	

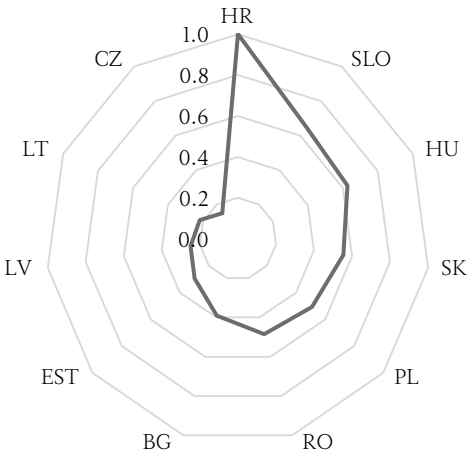
Source: Own preparation based on the World Bank (2021).

Table 7.
Dynamics of diagnostic variables in 2015 and 2019 (2011=100)

Country	2015	2019	2015	2019	2015	2019	2015	2019	2015	2019
	Variable x_1		Variable x_2		Variable x_3		Variable x_4		Variable x_5	
BG	97.59	44.21	111.62	107.67	126.35	115.13	123.42	135.56	82.12	79.98
HR	133.06	56.95	93.52	102.15	102.49	113.48	91.63	178.57	149.81	197.82
CZ	105.11	51.81	115.91	105.29	117.36	131.47	141.80	161.41	94.87	113.46
EST	24.27	8.92	120.50	135.29	150.53	136.63	163.59	112.95	66.82	92.26
HU	85.27	11.03	164.84	123.30	122.69	130.36	158.69	239.56	151.31	144.71
LV	33.05	35.59	101.38	97.77	131.99	131.17	114.70	231.93	117.73	67.12
LT	26.27	5.54	102.62	63.89	174.44	139.66	114.74	79.47	110.83	178.20
POL	93.11	81.51	119.85	122.32	121.78	141.51	116.72	256.60	97.61	96.82
RO	94.26	28.51	101.31	126.35	128.89	147.97	172.67	273.97	68.37	71.96
SK	86.78	51.15	103.46	97.08	132.54	135.82	102.84	102.80	97.28	117.79
SLO	84.32	28.48	224.72	119.23	158.30	156.38	155.49	272.83	164.52	190.77

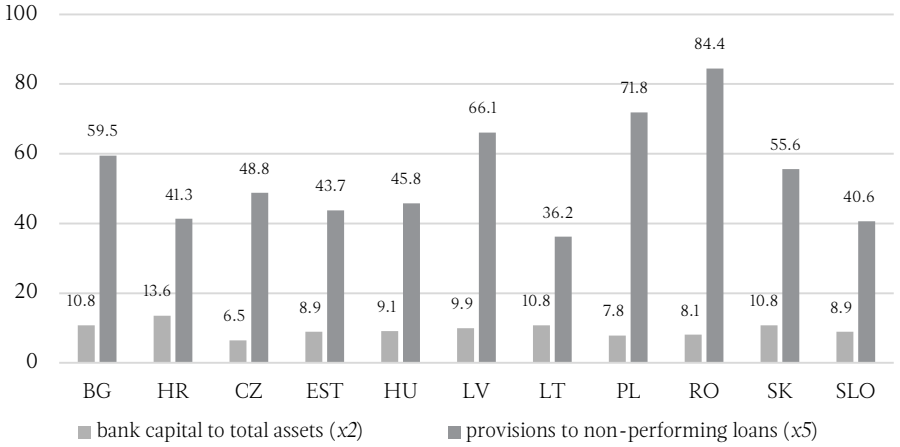
Source: Own preparation based on the World Bank (2021).

Chart 1.
Ranking of countries according to the level of development of the banking sector stability area in 2019



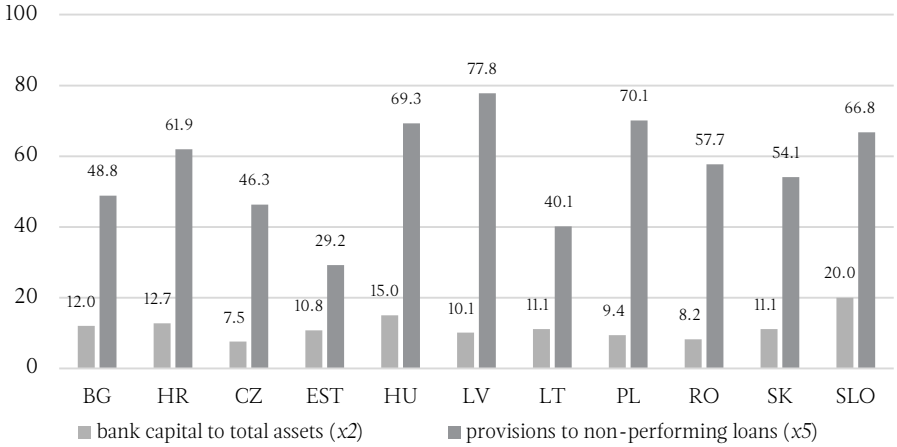
Source: Own preparation.

Chart 2.
Shaping of variable representatives in 2011 in the analyzed countries (%)



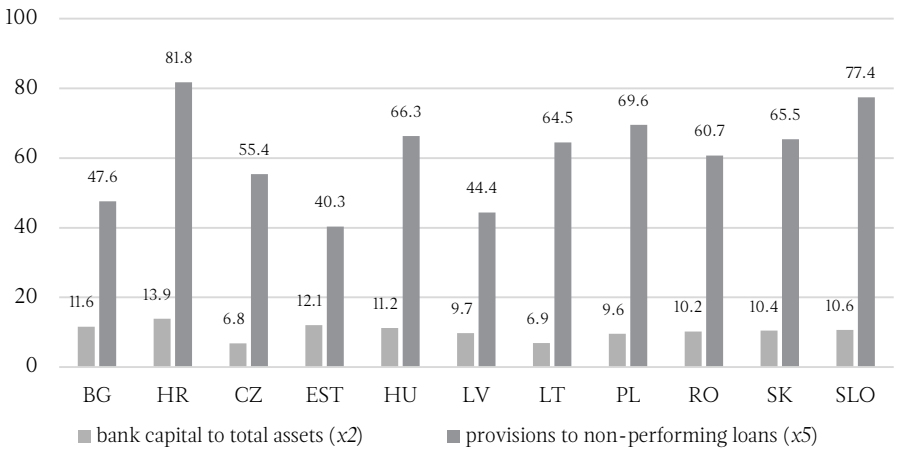
Source: Own preparation based on the World Bank (2021).

Chart 3.
Shaping of variable representatives in 2015 in the analyzed countries (%)



Source: Own preparation based on the World Bank (2021).

Chart 4.
Shaping of variable representatives in 2019 in the analyzed countries (%)



Source: Own preparation based on the World Bank (2021).