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## The Interrelationship Among Efficiency and Concentration of Banking System and its Stability: Evidence from Poland

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Małgorzata Mikita<sup>1</sup>

**Abstract:**

**Purpose:** This article aims to assess the impact of the efficiency of the banking sector and its concentration level on the stability of the banking system in Poland.

**Design/Methodology/Approach:** The impact assessment relies on correlation and regression analysis. The stability of the banking sector is expressed in Z-Score indicator. The assessment of banking efficiency is based on the Return on Equity (ROE) after tax and on the bank cost-to-income ratio. The concentration level is shown as the share of the assets of Poland's three largest commercial banks in the total assets of the banking sector. The calculations are based on panel data for the banking sector in Poland, for the period 1996–2017.

**Findings:** The results obtained suggest a positive influence of the return on equity after tax of the banking sector on the stability of Poland's banking sector and no relationship between the stability of the banking sector and the level of its concentration or the bank cost-to-income ratio.

**Practical Implications:** Identification of the factors determining the stability of the banking system may contribute to its increase, and thus reduce the likelihood of banking crises. Ultimately, this will translate into an increase in the stability of the entire financial system as well as an increase in the stability of the entire economy.

**Originality/Value:** The paper contains the author's original research into stability of banking system in Poland. The study will contribute to the development of theories concerning factors of the stability of the banking system.

**Keywords:** Banking system, stability, Poland, Z-Score, ROE, concentration level, cost-to-income ratio.

**JEL codes:** G14, G21.

**Paper type:** Research article.

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<sup>1</sup>Warsaw School of Economics, Department of Capital Market, Collegium of World Economy, Poland, ORCID: 0000-0002-3831-6698. E-mail: [mmikit@sgh.waw.pl](mailto:mmikit@sgh.waw.pl);

## **1. Introduction**

A fundamental condition for the stability of a country's financial system is to ensure the stability of the banking system. In particular, it applies to countries with banking-oriented financial systems, including Poland. A stable banking system favours saving and investing, which is of crucial importance to the economic development and boosting the economic growth of the country concerned (King and Ross, 1993).

Ensuring the stability of the banking system requires comprehending its determinants. Such factors may vary between countries. The group of potential determinants includes both those regarding the security of operations of individual banks and those shaping the functioning of the banking system as a whole.

This article aims to assess the impact of the efficiency of the banking sector and its concentration level on the stability of the banking system in Poland. The stability of Poland's banking sector is expressed in z-score terms. The assessment of banking efficiency is based on the return on equity after tax and on the bank cost-to-income ratio. The concentration level is shown as the share of the assets of Poland's three largest commercial banks in the total assets of the banking sector. The study is composed of three parts: a review of the literature, a description of the data and of the research method and conclusions.

## **2. Literature Review**

The stability of the banking system is of crucial importance to the stability of the financial system and of the economy as a whole (Kahou and Lehar, 2017; Gross, Henry, and Semmler, 2018; Afanasyev and Shash, 2018). Therefore, research into the subject has been conducted for years. Relevant studies particularly intensified after the global financial crisis of 2008 (Laeven and Valencia, 2013). Researchers have attempted to find the best methods for assessing the stability of the banking system and its determinants. Investigations have been contributing to better management of the stability of banking systems (e.g., through national and international regulations (Chant, 2003)) and of the stability of individual banks by indicating factors with the greatest influence on the stability of a bank's operations and by developing new risk management methods).

Analysing the stability of any banking system is a major challenge (Fell and Schinasi, 2005). The difficulty results from the fact that it is impossible to identify a closed catalogue of factors shaping the stability of the banking system in question. Such factors include those both relating to the security of individual banks' operations (such as capital resources, operating efficiency, credit policy, financial leverage, liquidity) and determinants of the functioning of the whole banking system, e.g., banking regulations (Atellu, Muriu, and Sule, 2021), the economic development level of the country concerned, the development level of the financial

market (Shkolnyk, Kozmenko, Polach, and Wolanin, 2020), the monetary policy pursued (Nelson, 2018).

Furthermore, one can note that the catalogue of factors shaping the stability of the banking system continues to expand, which results from the rapid growth of the technological world (as it contributes to developing new banking services, new forms of contact with customers) and from the globalisation of the world economy (all trends observed in one country's market spread fast worldwide) (Gospodarchuk and Amosova, 2020). New threats and risks emerge, previously unknown. Therefore, it is necessary to keep searching for new forms of evaluating the stability of the banking system, taking into account new economic trends.

Thus far, no single indicator has been developed to show whether or not a country's banking system is stable. Researchers have used a variety of indicators. Some of them focus on analysing the financial ratios achieved by banks and comparing those with specified criteria (e.g., the thresholds of the prudential standards set for supervisory purposes, criteria arising from econometric studies). Most frequently, those examine the amount of regulatory capital, the level of financial leverage, the level of non-performing loans. Some scholars attempt to define new quantitative indicators of the stability of the banking system.

Ruza, de la Cuesta-Gonzalez and Paredes-Gazquez (2019) have developed a Composite Indicator (CI) for analysing the stability of banking systems in advanced economies. The CI takes into account not only the situation of banks, but also their operating environment. Liu, Van Heerden, and Wang (2005) measure banking stability with the Banking Stability Indicator (BSI), calculated using the Minimax normalisation method. The BSI is based on the weighted average of particular ratings of banks whose assets account for at least two-thirds of the total assets in any country. The BSI tends to be used for comparative analyses of the banking sectors of various countries (Gulaliyev, Ashurbayli-Huseynova, Gubadova, Mammadova, and Jafarova, 2019). Many researchers rely on the z-score in their assessments regarding the stability of the banking system (Andrieş and Căpraru, 2011; Mohsin, Haroon, Rizvi, and Syed Azmi, 2021; Uhde and Heimeshoff, 2009).

For evaluating the stability of their banking systems, central banks use stress tests, i.e., tests of extreme but plausible market conditions (Blaschke, Jones, Majnoni, and Peria, 2001). Stress testing aims to examine the resilience of individual banks and of the whole banking sector to unfavourable conditions which may arise in the environment of banks in the future. Two scenarios are built, a baseline scenario, based on the most likely parameters for future trends in the economic situation, and an adverse one, assuming developments such as a recession.

Since 2014, this method for assessing the stability of the banking system has been used by the European Banking Authority (EBA). Stress tests are conducted by the EBA every 2 years. If the result of a stress test for a bank is negative, it means that

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the materialisation of the relevant adverse scenario for the future would put the bank in question in jeopardy (although it might not collapse). In such a situation, it would be necessary for the bank to change its policies (e.g., to sell some of its assets of low profitability, to tighten the lending terms, to cancel dividend payments), with a view to strengthening its financial standing.

Scholars studying banking stability attempt to identify determinants increasing or decreasing the stability of the banking system. They examine factors at the micro level, i.e., those regarding the efficiency and security of operations of particular banks, and on a macro scale, i.e., the impact of the environment on the stability of the banking system.

Researchers focussing on studies of individual banks assume that the stability of particular banks is of major relevance to the stability of the banking system (Younsi and Nafla, 2019). It does not mean, however, that they fail to see the important role of external factors. Their objective is to indicate microeconomic factors with the greatest influence on the stability of individual banks, thus, on the stability of the banking system as a whole. Le-Tu (2020) studied the relationship between the stability of the banking system and banks' profitability and lending growth.

Gulaliyev, Ashurbayli-Huseynova, Gubadova, Mammadova, Jafarova, and Rumella (2019) concentrated on analysing the relationship of the stability of the banking sector with bank asset quality, bank profitability, liquidity and solvency. According to the research conducted by Gomez (2015), the instability of banks is related to factors such as the undercapitalisation of banks, the poor quality of their credit portfolios and aggressive lending policies. Diaconu and Oanea (2014) and Nguyen, Hai, Duy, Anh, and Nguyen (2021) studied whether the determinants of the stability of a bank varied according to the type of bank.

Investigators of the influence of the environment on the stability of the relevant banking system have pointed to a number of external factors likely to destabilise the banking system (Dedu, Dan-Costin, and Cristea, 2021). It allows them to assess the systemic risk, i.e., the risk of disruption in the whole financial system (including the banking system) of a country due to an external shock (Danielsson, James, Valenzuela, and Zer, 2016). Such external shocks may stem from a wide range of factors. Those indicated most frequently include the collapse of an institution of major relevance to the financial market (systemically relevant) or the over-regulation of the financial system.

Ter-Mkrtychyan and Franklin (2019) studied how the levels of countries' economic development, political stability, regulation quality and rule of law influenced the stability of their financial systems. Effects of banking regulations on financial stability have also been investigated by Atellu, Muriu, and Sule (2021), Chen, Li, Liu, and Zhou (2021), Kočišova (2020) and Crockett (1996). Naceur, Candelon, and

Lajaunie (2019) attempted to estimate the impact of countries' financial development levels on their financial stability.

According to Ozili (2018), the main determinants of the stability of the banking system include – in addition to banking efficiency – the level of concentration in the banking sector and its size, government effectiveness, political stability, regulatory quality, investor protection, corruption control and unemployment. As pointed out by De Nicolo and Kwast (2002), the level of concentration in the banking system is of relevance to its stability. According to the authors, the consolidation of the financial system increases systemic risk, thus the instability of the banking system.

The influence of financial integration on the stability of the banking system has been addressed by scholars such as Gamze and Tarazi (2020), Sun and Ni (2021). A number of researchers (Kočišova, 2020; Ijaz, Hassan, Tarazi, and Ahmad, 2020; Berger, Klapper, and Turk-Ariss, 2017; Andrieş and Căpraru, 2011; Firano, Zakaria, Filali, and Fatine 2019; Bashir, Khan, Jones, and Hussain, 2021; Kiemo and Samuel, 2021; Soldatos, 2021; Mateev, Tariq, and Sahyouni, 2021; Beck, Demirgüç-Kunt, and Levine, 2003) have analysed the effects of the levels of concentration and competition in the banking sector on its stability.

As concluded by Liyanagamage (2018), more fierce competition in the banking sector increases the risk exposures of banks, thus rendering the banking sector less stable. But according to Boyd and De Nicolo (2005), the opposite is the case. In their opinion, increased competition in the banking sector enhances its stability. As inferred by Beck, Demirgüç-Kunt, and Levine (2003), crises are less likely to occur in economies with more concentrated banking systems. Salter and Tarko (2019) claim that the problem of ensuring financial stability goes far beyond the economy, frequently being political and institutional in nature.

New trends in investigations into the stability of the banking system include global risk assessment (Gospodarchuk and Amosova, 2020). Some researchers see that the stability of a country's banking system is determined not only by micro- and macroeconomic conditions, but also by global factors, including global economic crises. Scholars have analysed the effects of the global financial crisis having begun in the US mortgage market in 2008 on the banking systems of various countries or the impact of the COVID-19 pandemic on banking sectors (Salter and Tarko, 2019; Kozak, 2021; Korzeb, Niedziółka, and Silva, 2021; Miklaszewska, Kil, and Idzik, 2021).

The author's research intention is to analyse the sensitivity of the stability of the banking system in Poland to banking efficiency and the concentration level. The study belongs in the group of investigations focussing on the examination of the stability of the banking system depending on the selected micro- and macroeconomic factors.

### 3. Data and the Research Method

The study aims to show the influence of the efficiency of the banking sector in Poland and of its concentration level on its stability. The impact assessment relies on correlation and regression analysis. The stability of the banking sector in Poland is expressed in z-score terms (the explained variable – Y). The assessment of banking efficiency is based on the return on equity after tax (the explanatory variable – V1) and on the bank cost-to-income ratio (the explanatory variable – V2). The concentration level is shown as the share of the assets of Poland’s three largest commercial banks in the total assets of the banking sector (the explanatory variable – V3) – Table 1.

**Table 1.** *The set of variables used in the study*

Indicator name	Indicator symbol	Indicator description
Z-Score	Y	explained variable
Bank return on equity – ROE (% after tax)	V1	explanatory variable
Bank cost-to-income ratio (%)	V2	explanatory variable
Bank concentration (%)	V3	explanatory variable

*Source:* Prepared by the author.

The examination is based on panel data for Poland, for the period 1996-2017. The source of all data is the Global Financial Development Database of the World Bank<sup>2</sup>.

#### 3.1 Description of the Explanatory Data

The Z-Score is one of the indicators used for assessing the stability of the functioning of the banking sector. It shows whether the banking system of the country concerned is at risk of a crisis situation. The higher the z-score, the better. An increase in the indicator in question means growth in the stability of the banking system. A dramatic fall in the indicator reflects an abrupt deterioration in the stability of the banking system. The Z-Score for a country’s banking sector is based on statistical data for banks aggregated at the national level. The Z-Score calculation takes account of the bank return on assets (ROA), the bank capital adequacy ratio (CAR) and the ROA variation measured by the standard deviation ( $\sigma_{ROA}$ ):

$$Zscore = \frac{(ROA + CAR)}{\sigma_{ROA}} \quad \text{(Equation 1)}$$

The ROA is an indicator showing a bank’s return on its assets. The higher the ROA, the better. It means that the bank concerned can make more profit with specific

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<sup>2</sup>The Global Financial Development Database – <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (access: 10.1.2022).

assets, which implies more efficient asset management. The CAR, also referred to as the solvency ratio or the Cooke ratio, is calculated as the ratio of a bank's net equity to risk-weighted assets and off-balance-sheet items. Risk levels are expressed in per cent. The CAR indicates the possibility of protecting a bank in crisis situations (unexpected losses suffered by the bank) using its equity. Pursuant to Poland's Banking Law, banks in Poland must keep their solvency ratios of at least 8% (the Banking Law of 29 August 1997). For banks starting operations, the ratio is set out as a minimum of 15% for the first 12 months of operation and 12% for the following 12 months.

The analysis of the z-score for the banking sectors of individual EU Member States in 1996-2017 indicates that it varied widely, from 0.02 (in Greece in 2011) to 47.57 (in Luxembourg in 2016). It reflects significantly varying levels of the security of banking systems in the EU Member States. In some of them, the average values of the ratio for 1996-2017 remained below 10 (e.g., in Lithuania, Latvia, Romania, Hungary, Poland, Bulgaria, Croatia, Cyprus, Estonia, Greece, Ireland, Portugal, Slovenia), in other Member States, the average Z-Scores for 1996-2017 exceeded 20 (e.g., in Austria, Luxembourg and Malta). Poland ranked among the countries with average z-scores below 10 between 1996 and 2017 (at 8.03). The comparison of Poland's Z-Scores between the 5<sup>th</sup> and the 95<sup>th</sup> percentiles shows that 90% of the values of the variable under analysis ranged from 6.13 to 9.33 – Table 2.

**Table 2.** *Descriptive statistics of the Z-Score Indicator in UE countries (1996 - 2017)*

	Arithmetic average	5.percentile	95. percentile	Number of observations
Austria	20.17	12.81	26.37	22
Bulgaria	9.05	7.02	13.23	22
Croatia	4.49	3.42	5.29	22
Czech Republic	11.49	7.48	14.82	22
Denmark	17.35	12.21	21.57	22
Estonia	6.41	4.17	8.36	20
Finland	12.29	7.36	20.22	19
France	17.95	13.64	22.32	22
Germany	18.43	13.34	24.52	22
Greece	4.56	1.97	7.32	17
Hungary	5.56	4.49	6.94	22
Ireland	5.40	1.03	12.47	21
Italy	13.19	9.74	15.87	22
Latvia	5.95	3.53	8.22	22
Lithuania	6.18	4.51	8.07	22
Luxembourg	28.51	18.29	44.45	22
Malta	24.45	16.53	34.61	22
Netherlands	12.42	6.08	23.55	22
Poland	8.03	6.13	9.33	22
Portugal	9.86	6.81	13.46	22

Republic of Cyprus	7.50	3.38	10.42	22
Romania	7.26	4.45	11.11	21
SBelgium	11.00	7.31	17.38	22
Slovakia	15.38	8.46	18.58	22
Slovenia	2.99	2.06	4.12	21
Spain	18.54	13.67	22.79	22
Sweden	10.74	8.27	14.68	22

**Source:** The author's own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 10.02.2022).

For Poland, the Z-Score dropped abruptly in 2003 (to 1.6 from 6.07 in 2002), which reflected a decreased level of the stability of Poland's banking sector, and then it soared in 2004 (to 9.68) – Table 3.

**Tabel 3.** Z-Score in Poland (1996-2017)

Year	Z-score in Poland
1996	9.35
1997	7.59
1998	8.38
1999	8.13
2000	7.78
2001	7.22
2002	6.07
2003	1.60
2004	9.68
2005	9.08
2006	9.08
2007	8.83
2008	7.48
2009	7.51
2010	8.06
2011	8.01
2012	8.97
2013	8.75
2014	8.84
2015	8.72
2016	8.63
2017	8.98

**Source:** The Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).

The bank return on equity (ROE) shows the profitability of the equity of the entity concerned. It can be calculated for individual banks or for the banking sector as a



whole. In the case of particular banks, the ROE is calculated by dividing a bank's net income by its equity. The ROE is expressed as a percentage. It shows the profit generated by the bank concerned per unit of equity. The ROE calculation takes into account the profit for a period in relation to equity as at the beginning of the period. The higher the ROE, the greater the efficiency of the bank in question. The ROE of the banking sector is calculated on the basis of aggregated data for all banks operating in the country concerned. The after-tax net income of commercial banks is divided by yearly averaged equity. The ROE largely depends on banking efficiency.

Nevertheless, its development can be significantly affected by taxation in the country concerned or by dividend policies. Increased fiscal burdens drive down after-tax net income, which directly translates into a reduced ROE. The non-payment of dividends pushes up equity, which lowers the ROE as well. As suggested by the analysis of the ROE for the Polish banking sector in 1996–2017, the ratio varied greatly (the coefficient of variation was 1.64 in the period in question – Table 5). The maximum ROE noted for Poland's banking sector between 1996 and 2017 was 22.23 in 2004, whereas the minimum value (-50.23) was observed in 2003 – Table 4.

**Table 4.** Bank return on equity - ROE (% , after tax) of Polish banking sector (1996 – 2017)

Year	Bank return on equity - ROE (% , after tax)
1996	21.78
1997	17.7
1998	15.92
1999	12.21
2000	13.5
2001	1.69
2002	(-9.42)
2003	(-50.23)
2004	22.23
2005	16.07
2006	19.37
2007	21.8
2008	14.6
2009	7.13
2010	10.37
2011	11.11
2012	11.68
2013	9.78
2014	9.59
2015	7.56

2016	8.6
2017	8.85

*Source: The Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 12.01.2022).*

**Table 5. Coefficient of variation of ROE**

Standard deviation of ROE	15.06
Arithmetic average of ROE	9.18
Coefficient of variation of ROE	1.64

*Source: The author's own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).*

The bank cost-to-income ratio is another indicator used to reflect banking efficiency. Income is expressed as the sum of net-interest revenue and other operating income. The highest value of the ratio was 88.7% in the period in question (in 2003), whereas the lowest ratio was 51.46% (in 1996) – Table 6. A lower ratio indicates greater efficiency of the banking sector. The coefficient of variation was 0.16 – Table 7.

**Table 6. Bank Cost to Income Ratio % in Poland (1996-2017)**

Year	Bank cost to income ratio (%)
1996	51.46
1997	54.63
1998	57.84
1999	66.42
2000	63.86
2001	70.74
2002	80.85
2003	88.70
2004	66.45
2005	61.58
2006	60.91
2007	58.71
2008	56.83
2009	56.03
2010	53.12
2011	53.71
2012	54.21
2013	55.14
2014	53.12
2015	58.67
2016	53.04

2017	54.74
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**Source:** *The Global Financial Development Database*, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 11.01.2022).

**Table 7.** *Coefficient of variation of Bank Cost Income Ratio*

Standard deviation of Bank Cost Income Ratio	9.44
Arithmetic average of Bank Cost Income Ratio	60.49
Coefficient of variation of Bank Cost Income Ratio	0.16

**Source:** *The author's own research on the basis of the Global Financial Development Database*, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 13.01.2022).

Another indicator used in the analysis, a proxy for the concentration of the banking sector (bank concentration), shows the assets of the three largest commercial banks in Poland as a share of total commercial banking assets. The indicator varied widely between 1996 and 2017. For example, the bank concentration ratio was 34.32% in 2012, whereas it exceeded 78% in 2003 – Table 8. The coefficient of variation was 0.31 – Table 9.

**Table 8.** *Bank concentration (%) in Poland (1996-2017)*

Year	Bank concentration (%)
1996	48.95
1997	49.74
1998	60.04
1999	67.07
2000	76.59
2001	69.93
2002	76.52
2003	78.32
2004	43.04
2005	41.60
2006	40.65
2007	41.55
2008	37.12
2009	36.63
2010	34.33
2011	35.50
2012	34.32
2013	37.96
2014	39.46
2015	41.98
2016	40.28
2017	42.18

**Source:** *The Global Financial Development Database*, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).

**Tabel 9. Coefficient of Variation of Bank Concentration**

Standard deviation	15.07
Arithmetic average	48.81
Coefficient of variation of Bank Concentration	0.31

*Source: The author’s own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).*

### 3.2 The Research Steps Taken

The study conducted was of a quantitative nature. For the purpose of identifying the determinants of the stability of the banking system in Poland, an attempt was made at estimating the parameters of an econometric model with three explanatory variables (V1, V2, V3). It was assumed that the model estimated was a linear one. The classical least squares method was employed. The study included the following steps:

- calculating the coefficients of variation for the explanatory variables with a view to eliminating quasi-constant variables,
- calculating and assessing the coefficients of correlation between the explanatory variables as well as between the explained variable and the explanatory variables (using the Pearson correlation coefficient),
- reducing potential explanatory variables using the Hellwig method,
- building an econometric model,
- estimating the structural parameters of the model using the classical least squares (regression) method,
- interpreting the estimations of the model parameters and checking them for sensibleness (analysing the coincidence properties, or whether the signs made sense),
- testing the goodness of fit of the model,
- checking whether the explanatory variables of the model showed the catalysis effect,
- analysing the standard errors of the model parameter estimates,
- testing the statistical significance of the explanatory variables using Student’s *t*-test,
- drawing conclusions based on the model developed.

### 3.3 The Results Obtained

According to the analysis of the coefficients of variation of the explanatory variables, the explanatory variables (V1, V2, V3) are characterised by sufficiently high levels of variation (above 16%) to be considered the explanatory variables of the model – Table 10.

**Table 10.** *Coefficient of variation of explained variables*

<b>Explained variables</b>	<b>Coefficient of variation</b>
V1 - Coefficient of variation of ROE	1.64
V2 - Coefficient of variation of Bank Cost Income Ratio	0.16
V3 - Coefficient of variation of Bank Concentration	0.31

**Source:** *The author's own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).*

The selection of the model variables (V1, V2, V3) is also correct in statistical terms. The explanatory variables are statistically significantly correlated with the indicator of the stability of the banking system, i.e., the z-score (Y). The correlation coefficients indicate a very strong positive relationship between Y and variable V1, a strong negative relationship between Y and variable V2 and a moderate negative relationship between Y and variable V3. Unfortunately, there is also a strong negative relationship between explanatory variables V1 and V2 as well as a strong positive relationship between variables V2 and V3. The relationship between variables V1 and V3 is moderate and negative – Table 11.

**Table 11.** *Pearson's linear correlation coefficient (r) between the variables Y, V1, V2, V3*

	Pearson's linear correlation coefficient
r(Y,V1)	0.93
r(Y,V2)	(- 0.77)
r(Y,V3)	(- 0.62)
r(V1,V2)	(- 0.76)
r(V1,V3)	(- 0.54)
r(V2,V3)	0.79

**Source:** *The author's own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 12.01.2022).*

Based on the correlation analysis, none of the explanatory variables (V1, V2, V3) was excluded from further calculations.

The next step in the selection of the explanatory variables for the model was the application of the Hellwig method. The method in question allows to choose the combination of variables having the greatest effect on the explained variable. The Hellwig method is used to identify a number of possible combinations of explanatory variables for a model and then to calculate the information capacity of each variable in particular combinations (h) and the integral indicators of the information capacities for particular combinations (H). The combination of indicators with the highest H is the best combination, i.e. it best describes the explained variable.

The initial number of the explanatory variables considered was 3; therefore, it was possible to build 7 different combinations including different explanatory variables (C1, C2, C3, C4, C5, C6, C7). The presence of specific explanatory variables in particular combinations is shown in Table 12 (zero means that the variable in question is excluded from the combination concerned, whereas 1 denotes its inclusion).

**Table 12.** The share of individual explanatory variables (V1, V2, V3) in various combinations (C1, C2, C3, C4, C5, C6, C7).

	V1	V2	V3
C1	1	0	0
C2	0	1	0
C3	0	0	1
C4	1	1	0
C5	1	0	1
C6	0	1	1
C7	1	1	1

**Source:** The author’s own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 27.01.2022).

According to the calculations performed, the highest level of the integral indicator of the information capacity (H) was found in combination C4, composed of two variables: V1 and V2 – Table 13.

**Table 13.** Individual (h) and integral (H) indicators of information capacity

	h(V1)	h(V2)	h(V3)	H
C1	0.86	0.00	0.00	0.86
C2	0.00	0.59	0.00	0.59
C3	0.00	0.00	0.39	0.39
<b>C4</b>	<b>3.54</b>	<b>2.42</b>	<b>0.00</b>	<b>5.95</b>
C5	1.88	0.00	0.84	2.72
C6	0.00	0.33	0.22	0.54
C7	-2.91	0.57	0.31	-2.04

**Source:** The author’s own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).

As the optimal set of explanatory variables included two variables, i.e., V1 and V2, out of the three adopted for analysis, those were the ones used in the model. Explanatory variable V3 was eliminated. Therefore, the model under examination was developed as follows:

*Model I:*  $Y = \alpha_0 + \alpha_1 V1 + \alpha_2 V2$  (Equation 2)

The structural parameters of the model estimated using the classical least squares method allowed to build the following model:

$$\text{Model I: } Y = 8.83 + 0.09V1 - 0.03V2 \quad (\text{Equation 3})$$

The substantive verification of the model proved positive. It follows from the model that an increase in variable V1 (ROE after tax) improves the stability of the banking sector (a one-unit increase in V1 causes a rise in the z-score by approx. 0.09, other variables remaining constant). At the same time, an increase in variable V2 (the bank cost-to-income ratio) pushes down the z-score by approx. 0.03, other variables remaining constant. The positive substantive verification of the model is also confirmed by the fact that it is a coincident model. It means that the signs of the correlation coefficient  $r(Y, V1)$  and of the parameter for variable V1 are consistent (the signs are positive). The consistency of signs is also maintained between  $r(Y, V2)$  and the parameter for variable V2 (the signs are negative) – Table 14.

**Table 14.** Substantive verification of the model

Sgn	
sgn $r(Y, V1)$	(+)
sgn $\alpha1$	(+)
sgn $r(Y, V2)$	(-)
sgn $\alpha2$	(-)

**Note:**  $r(Y, V1)$  – Pearson correlation coefficient for Y and V1,  $r(Y, V2)$  – Pearson correlation coefficient for Y and V2,  $\alpha1$  – parameter for variable V1,  $\alpha2$  – parameter for variable V2

**Source:** Own calculations.

According to the goodness-of-fit test of the model, it fits empirical data well. The coefficient of determination ( $R^2$ , R squared) exceeds 87%. It indicates that the model explains the variation of the explained variable to a high degree. The coefficient of multiple correlation (R) is statistically significant. The significance level of the F statistic is much lower than 0.05 (the adopted significance level).

An examination of the catalysis effect showed no such effect between variables V1 and V2, which meant that neither of the explanatory variables (V1 and V2) was a catalytic variable. Therefore, it was not necessary to eliminate them from the model.

Analysing the standard errors of parameter estimates allowed to conclude that the estimate of parameter V1 was sufficiently accurate, with the relative average error of the parameter estimate at 15%. Unfortunately, the estimate of parameter V2 was insufficiently accurate. The relative average error of the parameter estimate exceeded 50% (at 82%), which negated the cognitive value of the numerical estimation of the parameter. Therefore, the evaluation of the model needed to be negative. At the same time, it meant that variable V2 should not be taken into account in the construction of the model. The analysis of the standard errors of parameter estimates eliminated variable V2 from further examination, which implied

that the econometric model under development should only be based on a single explanatory variable, i.e. V1. Therefore, a new econometric model was developed:

$$\text{Model II: } Y = \alpha_0 + \alpha_1 V1 \quad (\text{Equation 4})$$

The new model involved repeating all the econometric modelling stages. The structural parameters of the model, estimated using the classical least squares method, allowed to build the following model (model II) with a single variable (V1):

$$\text{Model II: } Y = 7.09 + 0.1V1 \quad (\text{Equation 5})$$

The substantive analysis of model II, based on the comparison of the sign of the Pearson correlation coefficient for variables Y and V1 and of the sign of the estimated coefficient for variable V1 in the model, allowed to recognise model II as a coincident one, thus to verify it positively.

According to the goodness-of-fit test of model II, the model fits empirical data well. The coefficient of determination ( $R^2$ , R squared) exceeds 86%. It indicates that the model explains the variation of the explained variable to a high degree. The coefficient of multiple correlation (R) is statistically significant – Table 15. The significance level of the F statistic is much lower than 0.05 – Table 16.

**Table 15. Regression Statistics**

Multiple R	0.92886257
R Square	0.862785673
Adjusted R Square	0.855924957
Standard Error	0.63032992
Observations	22

**Source:** The author’s own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).

**Table 16. Analysis of variance**

	df	SS	MS	F	F crit
Regression	1	49.96539293	49.96539	125.7574	4.46E-10
Residual	20	7.946316162	0.397316		
Total	21	57.91170909			

**Source:** The author’s own research on the basis of the Global Financial Development Database, <https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (Access: 17.01.2022).

Analysing the standard error of the estimate of parameter V1 (in model II) allows to conclude that the estimate of parameter V1 is sufficiently accurate. The relative average error of the parameter estimate does not exceed 50% (at 9%). Testing the



statistical significance of the explanatory variable V1 using Student's *t*-test allows to conclude that variable V1 (accompanied by parameter  $\alpha_1$ ) is statistically significant to the explained variable Y. The model must be evaluated positively. The probability of making an error consisting in a wrong verification decision is 0.05.

#### **4. Conclusions**

The article attempts to answer the question whether banking efficiency (expressed as the return on equity after tax of the banking sector and as the bank cost-to-income ratio) and the level of concentration in the banking sector have significant effects on the stability of the banking sector in Poland.

The study conducted suggests the following conclusions:

- the return on equity after tax (ROE) of the banking sector is a determinant of the stability of the banking sector (expressed in z-score terms). The factor in question has a positive influence on the stability of Poland's banking sector.
- No relationships have been observed between the stability of the banking sector in Poland (expressed in z-score terms) and the bank cost-to-income ratio or the level of concentration, showing the combined share of the three largest commercial banks in Poland in the total assets of the banking sector as a whole.

The results obtained allow to conclude that in the observation of the stability of the Polish banking system it is important to analyse developments in the ROE after tax, calculated based on aggregated data covering all banks operating in Poland. A decline in the ratio concerned translates into deteriorated stability of the banking system. It is clearly reflected in the relevant statistical data. The lowest ROE after tax of the banking sector in Poland was recorded in 2003 and 2004 (Table 4). In the years in question, the Z-Score stability indicator showed marked decreases as well (Table 3). In addition, the investigation also entitles to conclude that all measures driving down the ROE (e.g. increased taxation of banks) reduce the stability of the banking sector.

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