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SECTORAL ANALYSIS OF THE EFFECTIVENESS OF BANK RISK CAPITAL IN THE VISEGRAD GROUP COUNTRIES

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Abstract. Bank risk capital (*capital at risk*) is identified with the value of banks' own funds maintaining to absorb potential losses and protect against insolvency. It is calculated for the capital adequacy ratios, recommended by the Basel Committee on Banking Supervision. On other words, it is a kind of banks' capital that financing securing the negative effects of risk occurring. A comparative analysis of effectiveness of bank risk capital in the Visegrad Group countries, constituting the main objective of the study, results from the needs indicated in the already conducted preliminary research. In the article, statistical and econometric methods were used, based on linear regression models. The conducted research were aimed to verify the research hypothesis stating that in the analyzed banking sectors of the Visegrad Group countries there is a positive correlation between banks' profitability and a level of their bank risk capital. The study indicated that net profit of the analyzed banking sectors increases with a growth of total own funds, while profitability is diversified in individual countries. Declining operational efficiency results from the growing cost of obtaining and maintaining risk capital.

Keywords: risk capital, bank's own funds, effectiveness of risk capital, regression model, Visegrad Group countries, effectiveness of banking sectors.

JEL Classification: G21, G28, G32.

Introduction

The main research problem, undertaken in the study, is effectiveness of bank risk capital, which is recently the subject of particular interest, but also the controversies of scientific communities, as well as policymakers and banking practitioners. The main reason for reviving discussions in this area is undoubtedly the document, commonly referred as Basel III, prepared by the international environment of financial safety net institutions as a response to the global financial crisis. The direct effect of implementation of post-crisis Basel regulations is significant tightening of capital requirements for banks, regarding both new capital

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buffers, as well as an increase of quality and transparency of equity, their greater adequacy to bank risk, or finally how banks measure and identify the value of risk capital. This issue has often been the subject of wide interest in scientific research and numerous publications due to the consequences that has caused for the financial system and the real economy (Boyd & De Nicoló, 2005; Apostolik, Donohue, & Went, 2009; Bessis, 2015; Altunbas, Manganelli, & Marques-Ibanez, 2011; Županović, 2014; Iwanicz-Drozdowska, 2017; Jajuga, Karaś, Kuziak, & Szczepaniak, 2017; Marcinkowska, 2010; Moreno, 2006; Altunbas, Binici, & Gambacorta, 2017; Szustak, 2017; Czerwińska & Jajuga, 2016). However, regulations – resulting from Basel III – change the attitude of banking supervision to the method of bank risk control, which is reflected directly in the demand for bank capital. This situation means that its active management forces growth of risk capital in banks, changes their business model or accelerates retention of bank risk through its transfer, justifying the purposefulness of the undertaken research on consequences of regulations implemented in the banking sectors.

The main aim of the study is the assessment of bank risk capital effectiveness in the banking sectors of the Visegrad Group countries. The article tries to confirm or negate the existing view of only a negative impact of the need to increase the value of bank risk capital on its effectiveness. It will be the main contribution of the paper to the economic sciences. So far, the Authors have conducted preliminary research in the Polish banking sector, pointing out in the research conclusions the need for a comparative analysis of the Polish banking sector with results for other European Union Member States, where the "CRD IV/CRR package" (including Capital Requirements Directive IV (Directive, 2013) and Capital Requirements Regulation (Regulation, 2013)) was also implemented.

The study verifies the research hypothesis stating that in the analyzed banking sectors of the Visegrad Group countries there is a positive correlation between banks' profitability and a level of their bank risk capital. This hypothesis was confirmed for the Polish banking sector in the preliminary research. Justification for expanding the scope of empirical research to other banking sectors of the Visegrad Group countries are the results, obtained from three different groups of Polish banking institutions, which have shown that an increase of risk capital in those banks did not impact on an increase of their profitability, tested both by *Return on Assets* and *Return on Equity*. This means that formulated sectoral conclusions should be treated very carefully and confirmed by extending scope of the subject and time of the research. This paper is a consequence of all this assumptions.

Structure of the study was subordinated to the stated research hypothesis and defined objective. First part includes critical literature studies, which concentrate on bank risk capital, its essence and ways of definition. There was presented leading concepts, referring to the idea of risk management in financial institutions and enterprises. Second part of the paper covers description of the methodology, used during the research. The main variables of the linear regression model, as well as data, used at specific stages, were presented. Third part (main part) presents results of the research on risk capital effectiveness in the Visegrad group countries' banking sectors. The results are provided in four stages, respectively to the four stages of the research. Final part of the study includes conclusions and recommendations resulting from the research. There was also presented main limitation of the research as well as starting point to the Authors' further research.

1. Literature studies

Bank risk is a subject of broad interest of academics and policymakers due to its significance and possible consequences for the financial system and the real economy. Its active management favors the creation of bank risk capital, which in banks is of particular relevance and has different sources of its origin, application and also serves various purposes.

Risk capital, also referred as *capital at risk* (Duliniec, 2011), is identified with financing securing the negative effects of risk occurring (Wieczorek-Kosmala, 2017). The concept of risk capital is not new (Merton & Perold, 1993a, 1993b; Matten, 2000; Culp, 2002a, 2002b, 2002c; Shimpi, 2001; Doherty, 2000, 2005; Ishikawa, Yamai, & Ieda, 2003), although it is still up-to-date, due to the dynamically developing theory of risk management (Banks, 2004; Graham, 2008; Jajuga, 2007; Rejda, 2001; Williams Jr. & Heins, 1989; The Conference Board of Canada, 2003; Klimczak, 2007; Spikin, 2013; Nocco & Stulz, 2006; Purdy, 2010; Dionne, 2013; International Organization of Standarization [ISO], 2009; Kaplan & Mikes, 2016; Ennouri, 2013; Schieg, 2006; OECD, 2014), including methods of its measurement and reduction (Ratliff & Hanks, 1992; E. J. Vaughan & T. Vaughan, 2003; Scott & Vessey, 2002; ISO, 2009; The National Archives, 2017; Jajuga et al., 2017; Protivity, 2006; Iacob, 2014; McCuaig, 2008). Conception of risk capital derives from considerations regarding functioning of financial institutions, especially banks and insurance companies. Risk capital occupies an important place in banking enterprises, which activity was always burdened with high risk, due to the mechanism of credit money creation and methods of financing their operating activity. Currently, banks are characterized by a highly developed risk management system, mainly focused on maintaining risk within the accepted tolerance level (Van Greuning & Brajovic Bratanovic, 2009; Pyle, 1997; Iwanicz-Drozdowska, 2012; Żółtkowski, 2017; Aaron, Armstrong, & Zelmer, 2012; Santomero, 1997). This means that bank risk capital mainly secures its negative but only recognizable and therefore expected financial consequences.

The risk capital category has been identified and defined in three leading concepts, referring to the idea of risk management in financial institutions and enterprises (Wieczorek-Kosmala, 2017). For the first time, the concept of risk capital was presented by R. C. Merton and A. F. Perold in 1993 (1993a). They proposed a definition of risk capital based on the concept of hedging the net asset value. For a given t-period, net assets (AN) are gross assets (A) less liabilities to customers of a given financial institution (L):

$$AN_{(t)} = A_{(t)} - L_{(t)}. \tag{1}$$

Therefore, Merton and Perold referred risk capital to capital hedging the value of bank net assets[1]. Determining the level of this capital, they assumed that it should be the lowest amount to invest in order to hedge a possible loss of net asset value, taking into account the rate of return that can be achieved by engaging these assets in risk-free investment (Merton & Perold, 1993a; Basel Committee on Banking Supervision, 2010; Elizalde & Pepullo, 2007). At the same time, they pointed out that risk capital should be distinguished from regulatory capital, which tries to measure capital intended to cover losses resulting from risk, but within

[1] Net asset value is estimated as gross assets less liabilities to bank's clients.

certain accounting standards and also separated from cash capital – which is a component of working capital, necessary to finance operational activities.

The concept of Merton and Perold indicated a clear direction of bank risk capital perception, identifying it with the capital intended for the losses absorption. The second concept, developed by P. Shimpi in 1999, referred to a somewhat broader perspective on this category of capital, concerning not only financial institutions but also enterprises (Shimpi, 1999; Wieczorek-Kosmala, 2017). He believed that the total capital of a business entity consists of: *operational capital*, *signalling capital* and *risk capital*, defined as an additional capital resource, intended to finance the negative effects of risk. In his opinion, the value of risk capital should be determined by a level of risk tolerance of a given institution[2]. Therefore, it should be the capital necessary to maintain the probability of company's bankruptcy below a certain level, which is the indicated limit of this tolerance level. In Shimpi's concept, insurance and derivatives are a source of risk capital. So, the risk of financial institution may be a subject to risk retention or may be transferred, using insurances or derivatives.

The third concept – defined by C. Culp in 2002 (2002a, 2002b), which largely involve Shimpi's findings, refers to the classic theory of capital structure. Culp pointed out that a company, apart from maintaining operational capital, to finance its activity, also maintains certain additional capital, which consists of: *regulatory capital*, *signaling capital* and *risk capital* (Wieczorek-Kosmala, 2017). He defined risk capital as a capital, which is maintained as a buffer (reserve) of security. The importance of risk capital in institutions is therefore due to their desire to avoid bankruptcy costs. Culp also indicated that regulatory capital is related to risk capital, which results from the premises for formulating capital requirements for banks.

Since 1988, the Basel Committee on Banking Supervision has been the institution setting capital exposure for bank risk[3]. It constantly monitors a level of banks' own funds (*risk capital*) – core and supplementary – depending their value on a scale and nature of bank risk, as well as changing an internal structure of risk capital. The first document, defined as the Basel Capital Accord (Basel I), was based on the measurement of credit risk, assuming that the capital requirement for this risk should amount to at least eight percent. Further Basel Accords implemented significant modifications, additionally taking into account the exposure of bank capital to market risk and operational risk, or by improving methods of bank risk measurement (Basel Committee on Banking Supervision, 2004). After the global financial crisis, bank risk capital is a subject of much more specific control of national and international supervision authorities. In prudential regulations, there was a significant increase of the quality of bank capital, growth of the minimum capital requirements, as well as additional capital buffers appeared (Szpunar, 2016). Thus, the prudential norms have been strongly tightened in the area of bank risk capital creation.

Bank risk capital is a subject of regulations and recommendations not only of the Basel Committee on Banking Supervision but also many others institutions and authorities (like: ESRB, EBA, national supervisors), which pay particular attention to a level and structure of banks' capital protection. European Central Bank developed guide to the internal capital

[2] P. Shimpi equated a level of risk tolerance with the possible level of risk retention.

[3] It operates under the auspices of the Bank for International Settlements in Basel.

adequacy assessment process (ICAAP) – economic capital, aimed at raising the resilience of individual credit institutions in periods of stress by seeking improvements in their forward-looking internal capital adequacy assessment processes. The ICAAP plays a key role in the banks' risk management. The ECB expects the ICAAP in accordance with the provisions in Article 73 of the Capital Requirement Directive (CRD IV) to be prudent and conservative. ECB emphasized that sound, effective as well as comprehensive ICAAPs comprise a clear assessment of the risk capital and have well-structured risk governance and risk escalation processes based well-thought out strategy, which is translated into an effective risk limit system (ECB, 2018).

Based on the Culp approach, bank risk capital used in the study does not mean the same as regulatory capital. The concepts of own funds and regulatory capital are similar but not identical. Regulatory capital, according to the Basel Committee on Banking Supervision, is the amount of capital necessary to secure bank risk. The higher level of bank risk, included in the denominator in calculation the capital adequacy ratio, the higher regulatory capital. Thus, regulatory capital is bank capital used to secure Basel's types of bank risk. While, own funds secure not only Basel's risks. Banks are also exposed to other types of bank risk, that they hedge in the risk management process. Therefore, regulatory capital may be lower or higher than own funds, necessary to secure bank risk – depending on its generated level. They can transfer e.g. credit risk through the securitization of their assets, or maintain a higher level of own funds, e.g. due to recognized reputation risk. They can also use own funds to secure losses of unexpected bank risk. Hence, the Basel Committee requires compliance of a level of own funds, not only with regulatory capital, but also with economic capital (for unexpected risk). However, banks have a problem with rising costs of risk protection by own funds, the more that a quality of this capital (core and supplementary) increases in the following Basel Accords. Therefore, they increasingly maintain own funds on regulatory capital level.

The level and structure of risk capital undoubtedly determines effectiveness of banking institutions. On the one hand, a higher level of capital collateral may foster an increase of scale of economic activity and thus improvement of its profitability. On the other hand, the high cost of obtaining and maintaining risk capital can reduce this efficiency. Therefore, it seems reasonable to seek the so-called "*golden mean*" – an appropriate relation between the value of risk capital and profitability of a banking sector, or an individual bank, in order to meet prudential requirements, and – at the same time – maximize operations' effectiveness. The scientific research on the effectiveness of risk capital was undertaken by I. Pyka and A. Nocoń (Authors of this paper) in 2017. The effect of preliminary research was an analysis of bank risk capital in the Polish banking sector, from the point of view of profitability of the whole sector – macroeconomic analysis, as well as the largest banks (by total assets) – analysis at the microeconomic level (Nocoń & Pyka, 2018). The obtained results indicate a positive linear relation between the amount of own funds and basic indicators of banks' effectiveness assessment. In the next stage, the researchers extended the analyzes to other EU countries, which results for the Visegrad Group countries are presented in this study. These research include the assessment of risk capital effectiveness from the perspective of selected profitability ratios.

2. Methodology

Profit is the main objective of banks' operational activity. Profit is also the most important category of assessing effectiveness and efficiency of banking institutions (Capiga, 2010; Niewiadoma, 2008; Barron Putnam, 1983; Bobkiewicz, 2002). The preliminary stage of an analysis of risk capital effectiveness is therefore related to determine a relation between a level of profit and a value of own funds (Nocoń & Pyka, 2018). To assess banking sector's profitability in relation to the value of bank risk capital, commonly used profitability ratios were adopted. They belong to one of the most important groups of financial ratios, which are used to assess the condition of banking institutions (Kopiński, 2008). They allow for analysis of effectiveness of resources, involved in banking activities. The most commonly used profitability ratios are:

- *Return on Assets* (ROA) – which is the ratio of net profit to the average value of total assets (Iwanicz-Drozdowska, 2012; Niewiadoma, 2008; Kopiński, 2008),
- *Return on Equity* (ROE) – which illustrates the ratio of net profit to equity (Iwanicz-Drozdowska, 2012; Niewiadoma, 2008; Kopiński, 2008),
- *Return on Sales* (ROS) – which reflects the ratio of net profit to total revenues from sales (Iwanicz-Drozdowska, 2012; Kopiński, 2008),
- *Cost Income Ratio* (CIR) – which is calculated as a relation of operational costs to income on banking activities[4].

The ROA indicator illustrates how a company effectively manages its assets. It informs how much of the financial result is generated by one unit of national currency of involved assets. Thus, it expresses the bank's income potential, i.e. assets efficiency. The ROE indicator informs about the amount of net profit attributable to the unit of invested equity. The higher return on equity, the higher opportunities for bank development and, as a result, an increase in its value. A characteristic feature of banking entities is a small share of equity in their total liabilities. The ROS indicator, in turn, is the ratio of net financial result to the total bank's income. Denominator of the indicator includes all bank's income presented in the profit and loss account, including revenues from the release of provisions and from value updates, as well as a positive result of financial operations from the exchange position and extraordinary profits (Kopiński, 2008). For all the above indicators, it is desirable to have the highest value. While, the Cost Income Ratio, as a one of main profitability ratios, is a measure of cost-effectiveness evaluation and has different interpretation. If value of the indicator is closer to 1 (or 100%), the value of costs is close to the value of banking sector revenues. Relatively low CIR value of a given banking sector may mean more effective cost management, or an increase of an income at a relatively constant level of costs. Although, Cost Income Ratio is not strictly valuable measure, representing in the analysis of banks' effectiveness of risk capital and its distribution, it defines how the institutions are effective from different point of view. Because the CIR ratio is commonly included among the profitability ratios, it was incorporated to the study. Thus, it complements conducted analysis.

In the research, the assessment of effectiveness of bank risk capital was made by estimating the linear regression function successively of: net profit, return on assets, return on equity,

[4] Net income on banking activities is the sum of interest income as well as fee and commission income.

return on sales and the cost income ratio of the analyzed banking sectors relative to a given feature – value of risk capital, identified with an amount of own funds estimated to calculate solvency ratio of the whole banking sector. At the same time, own funds have not been identified with regulatory capital. For this purpose, values of regression coefficients as well as linear regression equation were determined. A linear regression equation (*linear model*) takes the general form of (Rachev, Mittnik, Fabozzi, Focardi, & Jasic, 2008):

$$y = ax + b\,, \tag{2}$$

where: a – regression coefficient (*slope*), b – constant of regression (*intercept*).

During the research the following statistical measures were estimated:

The standard error (SE) of a parameter is the standard deviation of its sampling distribution or an estimate of the standard deviation. The smaller the standard error, the more accurately a parameter, a measure, and a statistics are predicted. The standard error is determined by the amount of variation (variance) of a given feature. If the given feature is characterized by greater variability (variance), estimation of the real value will be lower. The standard error of a model takes the form of (Babbie, 2007):

$$S_e = \sqrt{S^2} = \sqrt{\frac{1}{n-k}\sum(y_t - \hat{y}_t)} = \sqrt{\frac{1}{n-k}\sum e_t^2}\,,$$

where: n – number of observations, k – number of estimated parameters.

The Pearson product-moment correlation coefficient is used to study the rectilinear relations between variables. This coefficient, marked by the symbol r_{XY}, has a value in the range between [–1, 1] (Pyka & Nocoń, 2016). Interpretation of the correlation coefficient:

- $r > 0$, positive correlation;
- $r = 0$, no correlation;
- $r < 0$, negative correlation.

In the literature there are different scales defining strength of the correlation. In the study, it was assumed that for |r| (Strahl, Sobczak, Markowska, & Bal-Domańska, 2002):

- $r_{xy} = 0$, no linear relation, variables are not correlated
- $r_{xy} < 0.2$, no correlation;
- $r_{xy} = 0.2$–0.4, weak correlation;
- $r_{xy} = 0.4$–0.7, moderate correlation;
- $r_{xy} = 0.7$–0.9, quite strong correlation;
- $r_{xy} > 0.9$, very strong correlation.

Coefficient of determination (R-Squared, r^2) is a useful statistics to check the value of regression fit. It measures the proportion of total variation about the mean Y^- explained by the regression. It is a measure used in statistical analysis that assesses how well a model explains and predicts future outcomes. It is relied on heavily in trend analysis and is represented as a value between zero and one. The closer the value is to one, the better the fit, or relationship, between the two factors. The coefficient of determination is the square of the correlation coefficient, also known as "r", which allows it to display the degree of linear correlation between two variables. Thus, coefficient of determination can take values as high as 1 or 100% when all the values are different i.e. $0 \leq r^2 \leq 1$. The coefficient of determination is estimated by the following formula:

$$R^2 = \frac{\sum_{t=1}^{n}(\hat{y}_t - \overline{y})^2}{\sum_{t=1}^{n}(y_t - \overline{y})^2} = 1 - \frac{\sum(y_t - \hat{y}_t)^2}{\sum(y_t - \overline{y}_t)^2} = 1 - \frac{(n-k)S_e{}^2}{\sum(y_t - \overline{y}_t)^2}.$$

Since r^2 is a proportion, it is always a number between 0 and 1.

If $r^2 = 1$, all of the data points fall perfectly on the regression line. The predictor x accounts for *all* of the variation in y.

If $r^2 = 0$, the estimated regression line is perfectly horizontal. The predictor x accounts for *none* of the variation in y.

If r^2 takes a value between 0 and 1 it can be interpreted as:

- 0.0–0.5 – unsatisfactory match
- 0.5–0.6 – weak match
- 0.6–0.8 – satisfactory match
- 0.8–0.9 – good match
- 0.9–1.0 – very good match

The above methodology applied in the research on effectiveness of risk capital in the Polish banking sector, so far has enabled verification of the research hypothesis regarding to occurrence a positive correlation between profitability and banks' own funds in Poland. The obtained results became a basis for expanding the research and conducting a comparative analysis for individual Visegrad Group countries. The research sample was not accidental. The Visegrad Group countries were picked because their banking sectors have similar structure. So the obtained results might be compare between themselves.

The analysis period covered the years of 2007–2016, divided into three research subperiods:

- 2007–2008 – during escalation of the global financial crisis – i.e. a period which was characterized by reduced banks' profitability, when the emphasis on the issues of capital collateral in banking sectors was marginal,
- 2009–2010 – a period of economic slowdown, caused by the spread of negative consequences of the financial crisis,
- 2011–2016 – a later period when, in accordance with EU regulations ("CRD IV/CRR package"), banking institutions, as a consequence of tightened regulation and newly defined capital buffers, were obliged to systematically increase a level of own funds that they maintained.

The three-stage nature of the research period resulted from the adopted research method, and in particular from the research properties of the linear regression model, enabling better recognition of the studied phenomenon.

The analysis of effectiveness of bank risk capital was focused on the assessment of an impact of own funds on profitability of banking sectors in Slovakia, the Czech Republic and Hungary. The conducted research in the Polish banking sector constituted, in the presented study, a basis for the comparison with the obtained results of banking sectors of the Visegrad Group countries (Nocoń & Pyka, 2018). Selection of the research sample was based on a comparable level of economic development as well as the scale and structure of banking sectors of the analyzed countries.

The research on risk capital effectiveness have been divided into four stages. The first stage included the assessment of relation between a value of own funds of the whole banking sectors and one of the basic position illustrating efficiency of banks' operations – i.e. a value of their net profit. In the second stage, effectiveness of bank risk capital was assessed using the Return on Assets ratio. The aim of this part of the analysis was to identify and assess the relation between the amount of own funds of the analyzed banking sectors and a level of their assets profitability. A decreasing rate of return on assets may indicate that the high cost of obtaining and then maintaining additional risk capital, resulting from the newly implemented prudential regulations, reduces banks' profitability. The third stage included correlation analysis between the value of own funds of analyzed banking sectors and the Return on Equity. This part of the research was focused on the assessment to what extent value of bank risk capital affects banking sectors' ability to increase their equity (Kochaniak, 2010). Finally, the fourth stage involved an analysis of relations between the value of bank risk capital and the Cost Income Ratio (CIR). A negative correlation between the amount of own funds of analyzed banking sectors and the costs income ratio may indicate an increase of bank risk capital effectiveness.

The research materials, used at specific stages, included consolidated data of the European Central Bank, regarding banking sectors of Poland, Slovakia, the Czech Republic and Hungary.

3. Results

The obtained results of the conducted estimation of linear regression models of particular parameters in relation to the analyzed feature – i.e. value of own funds of banking sectors of the Visegrad Group countries are presented in Appendix 1.

Before estimation of linear regression models, two-dimensional scatterplots were made. They reflect relations between the variables adopted in specific models. A two-dimensional scatterplot provides a graphical interpretation of potential correlation between analyzed variables. It illustrates a relation between the independent variable (explanatory variable, variable *X*) – i.e. the value of own funds of the analyzed banking sectors and the dependent variable (explained variable, variable *Y*) – a specific profitability ratio. In the first stage of the research the dependent variable represents a level of net profit, generated by the banking sectors. Points on the graphs correspond to individual observations – subsequent years of the analysis of the adopted time series (see Figure 1).

The scatterplots indicate positive, linear dependence between tested variables, however with different strength for specific banking sectors. Therefore, it can be concluded that in the analyzed period, an increase of risk capital in banking sectors of the Visegrad Group countries is accompanied by an increase of their profitability. Determination of strength of these dependences was estimated by conducting further statistical-econometric studies, determining the parameters of regression model and selected statistics. Estimated regression models take the following form – see Table 1.

Therefore, the models show that an increase of total own funds by 1,000 EUR, *ceteris paribus*, was associated with an increase of net profit respectively by 36.6 EUR of a banking

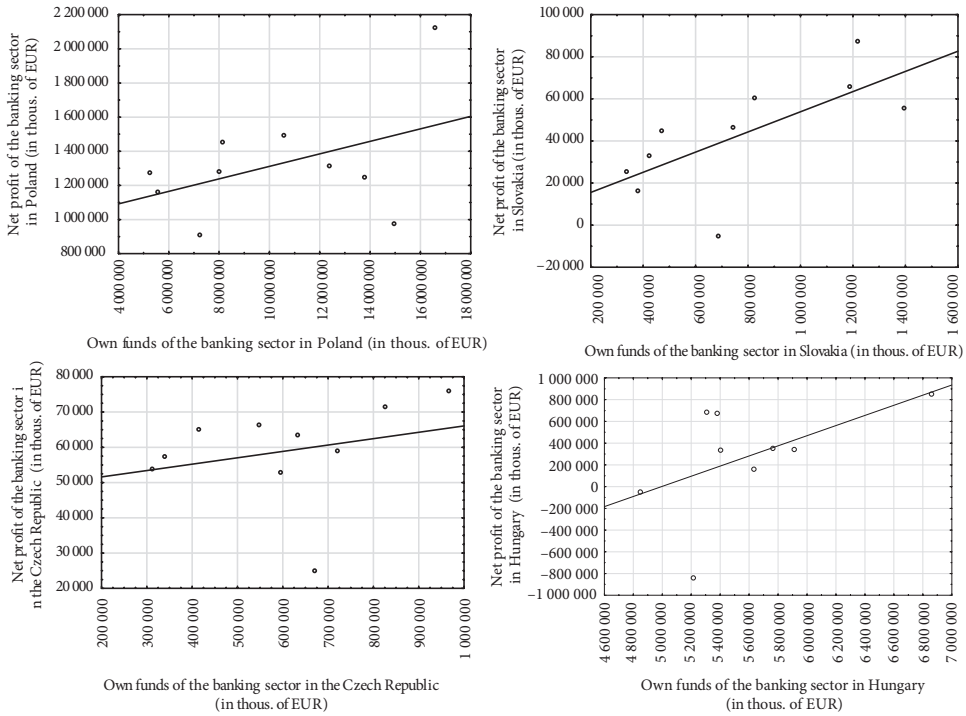

Figure 1. Two-dimensional scatterplots illustrating relations between own funds and net profit of the banking sector in Poland, Slovakia, the Czech Republic and Hungary in the years of 2007–2016

Table 1. Linear regression models of own funds and net profit of the analyzed banking sectors (source: own work)

Poland	Slovakia	Czech Republic	Hungary
$y = 0.0366x + 945861.7$	$y = 0.0479x + 6002.91$	$y = 0.0181x + 48012.43$	$y = 0.4659x - 2327138$

sector in Poland, 47.9 EUR of a banking sector in Slovakia, 18.1 EUR of a banking sector in the Czech Republic and 465.9 EUR of a banking sector in Hungary. Thus, the largest increase of profitability in the face of an increase of bank risk capital was recorded in Hungary. On the other hand, it is noted that in the given bank risk capital model for Hungary, empirical values deviate from theoretical values to the greatest extent, by an average of 458 234.6 thousand EUR, which is reflected by the value of the estimated standard error. Its high value indicates a large dispersion of results around the average, which is confirmed by the two-dimensional scatterplot (see Figure 1).

The analysis of obtained regression models results indicates an existing correlation dependences between net profit and a level of own funds of the banking sectors. Thus, it confirms that an increase of risk capital is accompanied by an increase of banking sectors' net profit. The Pearson correlation coefficient in Poland was at a level of r_{xy} = 0.4369. Much stronger dependencies were identified in Slovakia and Hungary respectively at a level of: r_{xy} = 0.6879 and r_{xy} = 0.5268, which means that there are moderate positive correlations between the ana-

lyzed variables. In turn, in the Czech Republic the value of the Pearson correlation coefficient is only at a level of r_{xy} = 0.2689, which indicates a weak correlation between the amount of own funds and the net profit. In general, with an increase of the value of own funds of banking sectors of the Visegrad Group countries, the amount of generated net profit increases. The strongest relation between the value of bank risk capital and the amount of net profit in the analyzed period is observed in Slovakia.

In the estimated linear regression models, based on the obtained coefficients of determination (r^2), can be stated that with the remaining factors unchanged, a level of own funds only slightly explained the volatility of net profit. This indicates that the regression equation very poorly explains the variability of the dependent variable. The highest value of r^2 was recorded in Slovakia equal to 47.32%. In other words, the model described the analyzed phenomenon in 47.32%.

The second stage of the research involved estimation of linear regression models of assets profitability (ROA) in relation to the own funds of banking sectors of the Visegrad Group countries. Before estimation of regression model parameters, two-dimensional scatterplots were also made (see Figure 2).

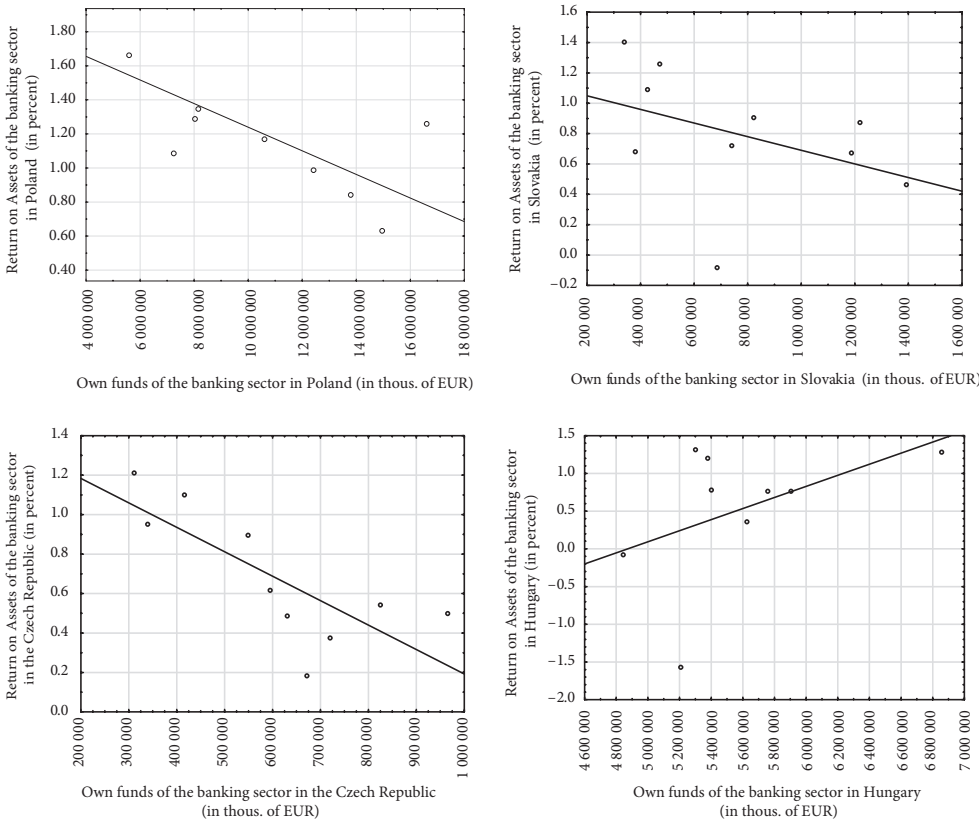

Figure 2. Two-dimensional scatterplots illustrating relations between own funds and Return on Assets of the banking sector in Poland, Slovakia, the Czech Republic and Hungary in the years of 2007–2016

The scatterplots of bank risk capital in relation to the ROA ratio point to a negative, linear dependence between the analyzed variables of the Polish, but also the Slovak and Czech banking sectors. Similarly as in the case of net profit – with different strength. The value of estimated Pearson correlation coefficients confirm the above conclusion. In Poland, there was quite strong negative dependence (r_{xy} = –0.7319). Similar results were obtained for the banking sector in the Czech Republic (r_{xy} = –0.7737) – quite strong negative dependence, as well as for the banking sector of Slovakia (r_{xy} = –0.4089) – moderate negative correlation. In turn, the two-dimensional scatterplot of bank risk capital in Hungary illustrates the positive relation between the analyzed variables. The value of the estimated correlation coefficient was r_{xy} = 0.4583, which indicates a moderate dependence.

Estimated regression models take the following form – see Table 2.

Table 2. Linear regression models of own funds and Return on Assets of the analyzed banking sectors (source: own work)

Poland	Slovakia	Czech Republic	Hungary
$y = -0.000000069x +$ 1.9328	$y = -0.00000045x +$ 1.1395	$y = -0.0000012x +$ 1.4312	$y = 0.00000073x -$ 3.5769

The models show that an increase of total own funds by 1,000 EUR, *ceteris paribus*, was related to a drop of return on assets by 0.000069% of the banking sector in Poland, by 0.00045% in Slovakia, by 0.0012% in the Czech Republic. The exception was the result of Hungarian banking sector, where an increase of own funds by 1,000 EUR, *ceteris paribus*, was associated with a slight increase of assets profitability by 0.00073%. Thus, costs of raising a level of banks' capital collateral, considering obligations imposed on them by regulatory discipline institutions, affect a decline in the profitability of banking sector assets in Poland, Slovakia and the Czech Republic. In the developed regression models of bank risk capital and assets profitability, empirical values deviate from theoretical values to the greatest extent also for the Hungarian banking sector, by an average of 0.8679%. Its high value indicates a large dispersion of results around the average. In the estimated linear regression models, the values of coefficients of determination (r^2) indicate – with the remaining factors unchanged, that a level of own funds only to a small extent explained the volatility of return on assets ratio. This means that the regression equation poorly explains the variability of the dependent variable. The highest value of r^2 was recorded in the Czech Republic equal to 59.86%. In other words, the model described the analyzed phenomenon in 59.86%.

In the third stage, linear regression models of Return on Equity were estimated in relation to own funds of the analyzed banking sectors. Two-dimensional scatterplots indicate the existence of similar dependencies as in the case of an analysis for the assets profitability (see Figure 3).

The above scatterplots of bank risk capital and ROE indicator identify a negative linear dependence between the analyzed variables for the banking sector in the Czech Republic, similar to the banking sector in Poland. The conducted estimation shows quite strong dependence, reflected by the value of Pearson correlation coefficient for the Czech Republic at a

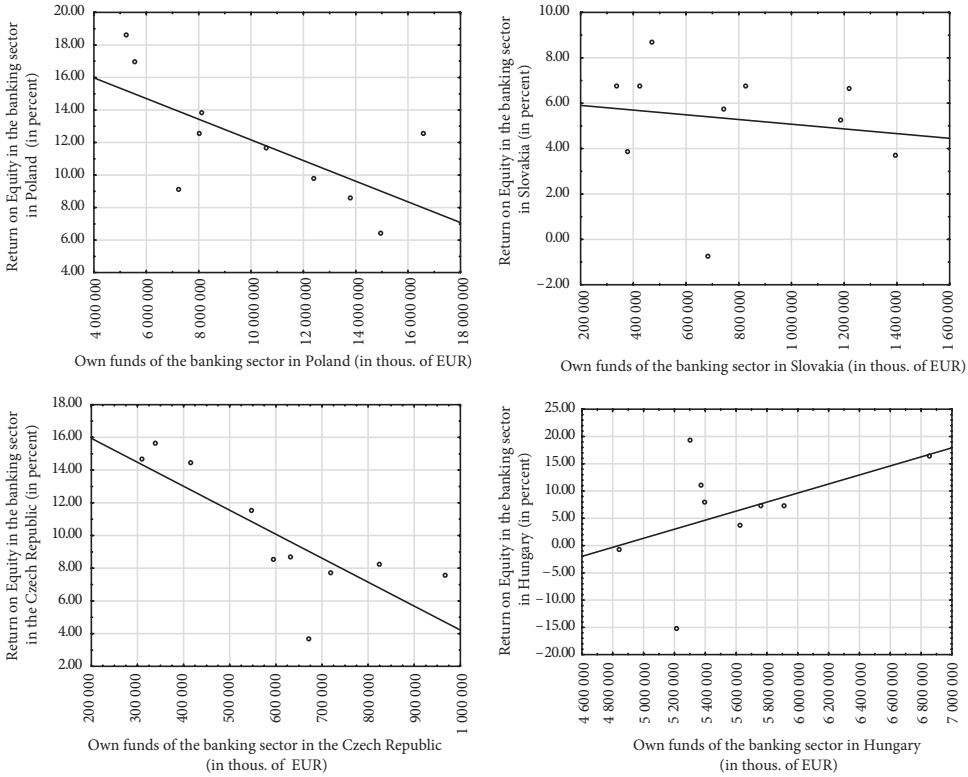

Figure 3. Two-dimensional scatterplots illustrating relations between own funds and Return on Equity of the banking sector in Poland, Slovakia, the Czech Republic and Hungary in the years of 2007–2016

level of r_{xy} = –0.7944, while in Poland this dependence was moderate (r_{xy} = –0.6754). In the case of Slovakia, the value of the correlation coefficient indicates a lack of linear dependence (r_{xy} = –0.1532). Furthermore, the scatterplot as well as estimated correlation coefficient of bank risk capital in Hungary show a moderate positive correlation between the analyzed variables (r_{xy} = 0.4664). Estimated regression models take the following form – see Table 3.

Table 3. Linear regression models of own funds and Return on Equity of the analyzed banking sectors (source: own work)

Poland	Slovakia	Czech Republic	Hungary
$y = -0.00000064x +$ 18.5246	$y = -0.0000010x +$ 6.1145	$y = -0.000015x +$ 18.8805	$y = 0.0000083x -$ 40.0835

Based on the obtained parameters of regression models, it is indicated that an increase of total own funds by 1,000 EUR, *ceteris paribus*, was related to a drop of return on equity by 0.000064% of the banking sector in Poland and by 0.0015% in the Czech Republic. Again, the banking sector in Hungary was an exception, where an increase of own funds by 1,000

EUR, *ceteris paribus*, resulted in a slight increase of equity profitability by 0.00083%. Therefore, additional costs resulting from the need to increase the value of bank risk capital imply a decline in profitability of the Polish and Czech banking sector. Also in this case, the value of the estimated standard error indicates that empirical values deviate from theoretical values to the greatest extent for the Hungarian banking sector, i.e. by an average of 9.5792%.

Analyzing the obtained values of coefficients of determination (r^2), it should be stated that – with the remaining factors unchanged, a level of own funds to a satisfactory degree explained the volatility of the dependent variable – return on equity. The highest value of r^2 was recorded for the Czech banking sector at a level of 63.11%. In other words, the model described the analyzed phenomenon in 63.11%.

Finally, the fourth stage of the research included estimation of linear regression models of the Cost Income Ratio (CIR) in relation to the own funds of Polish banking sector compared to the remaining V4 countries. The following figures show that in the particular analyzed banking sectors this dependence has a diverse form (see Figure 4).

Before interpretation of the obtained results, it should be mentioned that the forth measure complements the whole analysis. This is because Cost Income Ratio does not have a direct connection to own funds against previous analyzed ratios. Positive but weak correla-

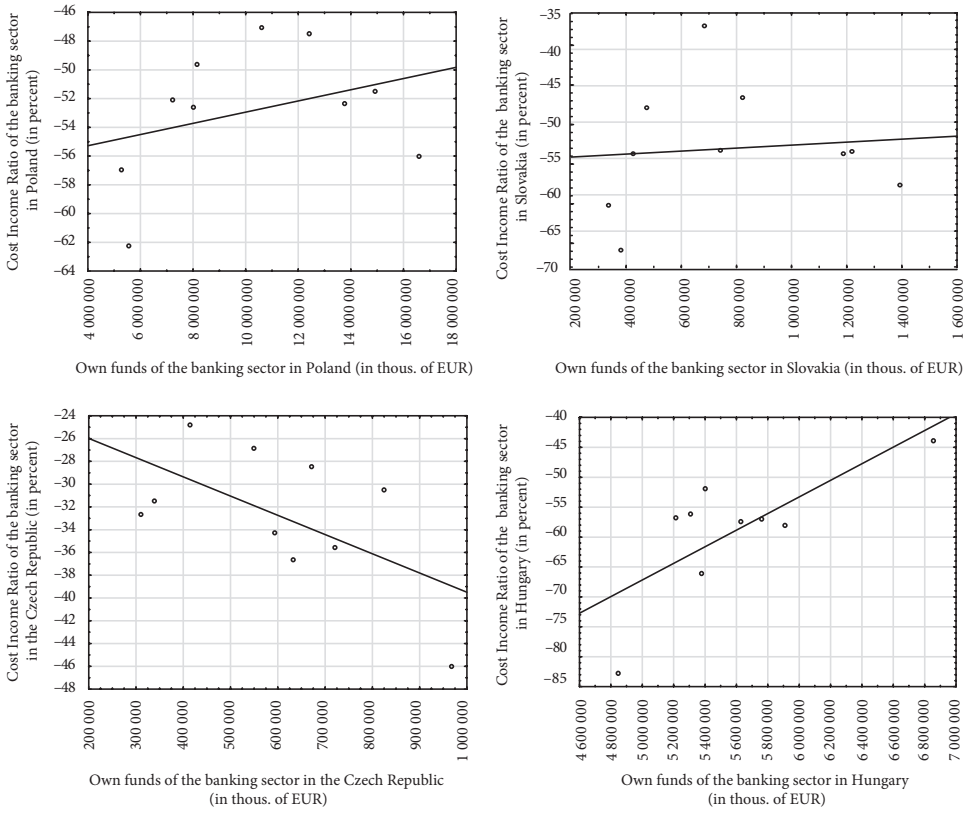

Figure 4. Two-dimensional scatterplots illustrating relations between own funds and Cost Income Ratio of the banking sector in Poland, Slovakia, the Czech Republic and Hungary in the years of 2007–2016

tion occurs in the Polish banking sector (r_{xy} = 0.3400). While in Hungary, there was observed a quite strong positive correlation (r_{xy} = 0.7409). Thus, along with an increase of bank risk capital, cost to income ratio increased, which indicates a deterioration of these banking sectors profitability. In the case of an analysis of the Pearson correlation coefficient for the Slovak banking sector, there is a lack of linear dependence (r_{xy} = 0.0925) – similar to the analysis for return on equity. Only in the Czech Republic, there is a moderate but negative correlation, therefore an increase of total own funds was accompanied by a drop in the CIR ratio (r_{xy} = –0.5881), which illustrates the improvement of the banks' cost-effectiveness.

Estimated regression models take the following form – see Table 4.

Table 4. Linear regression models of own funds and Cost Income Ratio of the analyzed banking sectors (source: own work)

Poland	Slovakia	Czech Republic	Hungary
$y = 0.00000039x -$ 56.8317	$y = 0.0000021x -$ 55.2146	$y = -0.000017x -$ 22.6023	$y = 0.000014x -$ 136.5770

The models show that an increase of total own funds by 1,000 EUR, *ceteris paribus*, was related to an increase of the Cost Income Ratio by 0.000039% of the banking sector in Poland and by 0.0014% in Hungary. In turn, in the Czech banking sector an increase of own funds by 1,000 EUR, *ceteris paribus*, was associated with a slight decrease of Cost Income Ratio by 0.0017%. Thus, in the regression models of the Cost Income Ratio in relation to own funds, unequivocal relation between the analyzed variables can not be indicated. Moreover, the value of the estimated standard error indicates that empirical values deviate from theoretical values to the largest extent for the banking sector in Slovakia, i.e. by an average of 8.9867.

In the adopted linear regression models, the estimated values of coefficients of determination (r^2) indicate – with the remaining factors unchanged, that a level of own funds to a small extent explained volatility of Cost Income Ratio. This means that the regression equations weak explain variability of the dependent variable. The highest value of r^2 was recorded for the Hungarian banking sector at a level of 54.90%. In other words, the model described the analyzed phenomenon in 54.90%.

Conclusions

The bank risk capital analysis, aimed at identification of the main sources of its origin, indicated that it is a complex category. Risk capital is created by banks through its transfer or retention (however it needs systemic approach). These methods secure expected losses, resulting from various types of risk. Regulatory capital in banks is only liable for identified losses of materializing bank risk. Bank secure high exposure to specific types of risk by creating economic (internal) capital.

The global financial crisis has confirmed a fairly common opinion that the most difficult to secure are "exceptional" losses, arising from unidentified bank risk. Therefore, Basel III increases the area of identified bank risk and methods of its protection. The research have

indicated that by this way banks limit risk transfer for its retention. Thus, banks' own funds increase, constituting a main subject of the empirical research.

The conducted research constituted an in-depth analysis, carried out and published in Authors' previous article (Nocoń & Pyka, 2018). They confirm existence of the positive linear dependence between banks' own funds and efficiency of their operations in the Polish banking sector.

The presented in the paper outcomes referred to the assessment of a level of bank risk capital and its impact on Visegrad group countries banking sectors' effectiveness, which was the main objective of the study. The analysis period covered the years of 2007–2016. The research sample included banking sectors of Poland, Czech Republic, Slovakia and Hungary. The conducted empirical research and analysis of the relations between profitability of banking sectors of the Visegrad Group countries and a value of own funds indicate the following dependencies:

- an increase of bank risk capital was accompanied by an increase of generated net profit in all analyzed banking sectors; in the case of Poland, Slovakia and the Czech Republic the strength of this dependence took a form of moderate correlation, while in Hungary – weak correlation;
- an increase of own funds resulted in a decrease of banks' assets profitability in Poland, Slovakia and the Czech Republic; while the Hungarian banking sector recorded an increase of ROA indicator, despite the fact that an increase of bank risk capital generated additional costs that might lower the efficiency of banks' operations;
- an increase of bank risk capital in Poland and in the Czech Republic favored lowering profitability of their banking sectors, measured by the return on equity ratio; in turn in Hungary, an increase of total own funds in the analyzed period caused a slight increase of ROE indicator; furthermore, lack of linear dependence was identified in Slovakia;
- an increase of a level of own funds had various consequences for the Cost Income Ratio in the analyzed banking sectors; in the case of Poland and Hungary, correlation was positive and therefore an increase of risk capital weakened the cost-effectiveness of banks; while in the Czech Republic an increase of bank risk capital was conducive to a decline in the CIR ratio, thus positively affecting the cost-effectiveness of Czech banks.

The conducted research do not allow for unambiguous confirmation or rejection of the adopted research hypothesis. This is due to the fact that bank risk capital to a different extent influences on profitability of banking sectors of the Visegrad Group countries. In nominal terms, it seems that raising own funds of banks is conducive to achieving higher and higher level of net profit. In turn, assessing relations between the amount of own funds and return on assets and return on equity, negative correlations were mostly identified (with the exception of the Hungarian banking sector). This informs about deterioration of banking institutions' profitability, due to the need to increase a level of their capital collateral.

The obtained results constitute a significant contribution to the economic sciences. Indeed, they point out that despite costs associated with the process of increasing own funds, banks that own a larger level of capital – to a large extent – generate higher profitability. Therefore, the results are innovative, refuting the existing view of only a negative impact –

increasing costs – resulting from the need to increase the value of risk capital in a banking sector.

The conducted research can be a reference point for further in-depth research in other EU countries, in particular other Central and Eastern European countries and Baltic countries, which represent similarity of the structure of their banking sectors to the Visegrad group countries.

Finally, there are arising additional questions to the issue, which could be a background for Authors' next research:

- Where is the border of regulatory capital effectiveness?
- Is the amount of own funds able to secure unidentified bank risk?
- Which risk protection profile should banks choose? With a higher level of own funds or more secure but with lower profitability?
- What kinds of problems does securing risk capital in banks involve? Whether in the long term, it does not cause a drop of banks' profitability?

Nevertheless, it should be noted that the main limitation of the current research is that the bank risk capital is a complex category and may be studied not only from the point of view of its impact on banking sectors' effectiveness.

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Appendix 1. Results of the estimation of linear regression models for the analyzed banking sectors of the Visegrad Group countries (source: own work)

	Poland	Slovakia	Czech Republic	Hungary
Stage 1: Linear regression models of net profit in relation to the value of own funds:				
Constant of regression (b)	945 861.7	6 002.91	48 012.43	–2 327 138
Regression coefficient (a)	0.0366	0.0479	0.0181	0.4659
Correlation coefficient (r)	0.4369	0.6879	0.2689	0.5268
Coefficient of determination (r^2)	0.1909	0.4732	0.0723	0.2775
Standard error of estimation	320 399.3	20 579,29	14 363,07	458 234.6
The value of t-student statistics	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 3.2440	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 0.3948	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 3.3022	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –1.4578
	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 1.3739	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 2.6804	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 0.7896	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 1.63965
The value of the F statistics	1.8876	7.1847	0.6234	2.6885
p-value	0.2067 > 0.05	0.0279 < 0.05	0.4525 > 0.05	0.1451 > 0.05
Stage 2: Linear regression models of Return on Assets (ROA) in relation to the value of own funds:				
Constant of regression (b)	1.9328	1.1395	1.4312	–3.5769
Regression coefficient (a)	–0.000000069	–0.00000045	–0.0000012	0.00000073
Correlation coefficient (r)	–0.7319	–0.4089	–0.7737	0.4583
Coefficient of determination (r^2)	0.5357	0.1672	0.5986	0.2100
Standard error of estimation	0.2746	0.4085	0.2251	0.8679
The value of t-student statistics	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 7.7352	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 3.7760	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 6.2820	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –1.1831
	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –3.0379	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –1.2672	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –3.4542	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 1.3641
The value of the F statistics	9.2291	1.6057	11.9313	1.8608
p-value	0.0161 < 0.05	0.2407 > 0.05	0.0086 < 0.05	0.2148 > 0.05

	Poland	Slovakia	Czech Republic	Hungary
Stage 3: Linear regression models of Return on Equity (ROE) in relation to the value of own funds:				
Constant of regression (b)	18.5246	6.1145	18.8805	–40.0835
Regression coefficient (a)	–0.00000064	–0.0000010	–0.000015	0.0000083
Correlation coefficient (r)	–0.6754	–0.1532	–0.7944	0.4664
Coefficient of determination (r^2)	0.4562	0.0235	0.6311	0.2176
Standard error of estimation	2.9539	2.7294	2.4865	9.5792
The value of t-student statistics	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 6.891321	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 3.0325	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ 7.5010	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –1.2012
	$t_{\alpha 1}=\frac{\alpha_1}{S(\hat{\alpha}_1)}=$ –2.5908	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –0.4386	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –3.6996	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 1.3952
The value of the F statistics	6.7121	0.1924	13.6870	1.9465
p-value	0.0321 < 0.05	0.6726 > 0.05	0.0060 < 0.05	0.2056 > 0.05
Stage 4: Linear regression models of Cost Income Ratio (CIR) in relation to the value of own funds:				
Constant of regression (b)	–56.8317	–55.2146	–22.6023	–136.5770
Regression coefficient (a)	–0.00000039	0.0000021	–0.000017	0.000014
Correlation coefficient (r)	0.3400	0.0925	–0.5881	0.7409
Coefficient of determination (r^2)	0.1156	0.0086	0.3459	0.5490
Standard error of estimation	4.5804	8.9867	5.1520	7.6673
The value of t-student statistics	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –13.6344	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –8.3167	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –4.3338	$t_{\alpha 0}=\frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)}=$ –5.1133
	$t_{\alpha 1}=\frac{\alpha_1}{S(\hat{\alpha}_1)}=$ 1.0225	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 0.2628	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ –2.0568	$t_{\alpha 1}=\frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)}=$ 2.9189
The value of the F statistics	1.0455	0.0691	4.2302	8.5199
p-value	0.3365 > 0.05	0.7993 > 0.05	0.0737 > 0.05	0.0224 < 0.05