Journal of
Risk and Financial Management

MDPI

Article

Bank Risk Capital and Its Effectiveness in Selected Euro Area Banking Sectors

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Abstract: Risk capital or capital at risk (CaR) refers to the amount of capital set aside and maintained by banks to cover different types of risk. For banks, it is used as a buffer against claims or expenses in the event that ordinary capital is not enough to cover them. Thereby, risk capital can also be recognized as risk-bearing capital or surplus funds. Risk capital may generate very high costs, but on the other hand it protects against insolvency. That's why a bank needs to find the 'Gold mean'—the optimal value of risk capital that will not lower its efficiency, but still ensure financial security. The main objective of the study is identification of interdependencies between bank risk capital and effectiveness of the aggregated Eurozone banking sector and selected national banking sectors of the euro area. The paper tries to answer the research question whether the risk capital supports or lowers banks' operational effectiveness. The adopted research hypothesis stated that there is a positive correlation between profitability and size of bank risk capital. To verify the hypothesis regression models were used. The results indicate that the size and structure of bank capital impact on the credit institutions' effectiveness in the analyzed banking sectors, however with different intensity. Thereby, the article fulfils a research gap in the field of research studies that take into account how capital at risk and specific capital adequacy regulations may impact on a bank's efficiency.

Keywords: bank risk capital; capital at risk; regulatory capital; own funds; capital effectiveness; prudential regulations; euro area banking sector

Citation: Pyka, Irena, and Aleksandra Nocoń. 2021. Bank Risk Capital and Its Effectiveness in Selected Euro Area Banking Sectors. *Journal of Risk and Financial Management* 14: 555. https://doi.org/10.3390/jrfm14110555

Academic Editor: James R. Barth

Received: 15 October 2021
Accepted: 12 November 2021
Published: 17 November 2021

1. Introduction

Bank risk capital identified with risk capital or capital at risk (CaR) (Duliniec 2011) causes controversy among scientists, policymakers and representatives of the banking industry due to the Basel Accord—Basel III (Basel Committee on Banking Supervision 2010), implemented as a response to the global financial crisis. The new set of Basel recommendations concentrate on tightening capital requirements for banks, through new capital buffers, methods of their measurement, but also pay particular attention to higher capital quality, transparency and greater adequacy to bank risk. Banks tend to have a low level of capital, while they have to maintain an appropriate (minimum) level in accordance with the capital regulations. The level of risk capital should be large enough to protect banks—and as a result the whole world economy—against liable unpredictable risks. That's why maintaining appropriate value of risk capital is crucial in case of unexpected losses (Athanasoglou et al. 2008). But on the other hand, too high a level of capital at risk may significantly lower the operational efficiency of banking institutions, due to very high costs of gathering and then maintaining it among other liabilities. Deelchand and Padgett suggested that if capital is regarded as very expensive and banks want to increase its level to meet regulations, than they will have to bear more risk to generate a higher rate of return (Deelchand and Padgett 2009). Moreover, this relation implies banks' stability. If cost of capital is high and a level of undertaken risk is higher, the financial stability of an individual bank may also be at risk (Bitar et al. 2019).

The key is to find out the 'Gold mean'—the optimal value of risk capital that will not lower its efficiency, but ensure financial security. Hence, the paper tries to answer the research question whether the risk capital supports or lowers banks' operational effectiveness. The research that involve risk capital, efficiency and profitability of banking sectors, are the results of prior studies' concerns presented in the literature that any explorations of the relation between capital and risk should be extended to efficiency and profitability (Bitar et al. 2018). That's why the main aim of this study is identification of interdependencies between bank risk capital and effectiveness of the aggregated Eurozone banking sector and selected national banking sectors of the euro area. Thereby, the Authors tried to verify the potential impact of capital at risk on the efficiency of credit institutions' activity in the selected banking sectors of the Monetary Union. Previously, the Authors conducted a similar study, but the sample was concentrated on the Visegrad Group countries: Poland, Czech Republic, Slovakia and Hungary. However, this did not provide explicit confirmation of the assumption, which exists in theoretical considerations, that an increase of bank risk capital decreases the effectiveness of credit institutions and/or directly leads to a change in their business model. For this reason, extension the scope of the research on the effectiveness of bank risk capital allows one to reduce the likelihood of making mistakes in formulating research conclusions, objectifies results and significantly complements the state of knowledge in the field of bank capital, while contributing to the development of economic sciences.

These aspects—bank risk capital, capital adequacy requirements, capital efficiency—are the main research problems in the paper, due to the important role of credit institutions' activities in the financial systems and functioning of the real economy, are the subject of broad scientific interest (Wieczorek-Kosmala 2019; Basel Committee on Banking Supervision 2017; Feridun and Özün 2020; Perottia et al. 2011; Erel et al. 2021; Saita 1999; Beltrame et al. 2014; Dagher et al. 2020; Stolz 2002; Elizalde and Pepullo 2007; Ahnert et al. 2020; Chockalingam et al. 2018; Mendicino et al. 2021). However, a significant part of the study focuses on identifying new, post-crisis regulatory framework. Several publications have also presented dependencies between capital, risk and efficiency in banking. A triangle where all variables impact on the others, but the strength of this relations is determined by a level of specific variables. Fiordelisi et al. emphasized the phenomenon of "vicious circle"—low effectiveness causes higher bank risk, while higher value of capital may absorb risk consequences, but on the other hand may decrease bank's efficiency (Fiordelisi et al. 2011). These results are the more significant because they provide implications for supervision authorities and for long-term financial stability.

The research presented in the article tries to verify the research hypothesis stating that in the analyzed banking sectors of the euro area countries there is a positive correlation between profitability and size of bank risk capital. In this respect, the conducted research is new and innovative. Its novelty is based on the specific approach to risk capital and measuring its impact on banks' effectiveness. In the literature, studies mainly focus on dependencies between capital, risk and efficiency, but from the point of view of specific banks. Here we analyze the category of capital at risk in relation to banking sectors' profitability. Especially that due to the post-crisis capital regulations, the formulated theoretical views related to the effectiveness of bank risk capital need to be supplemented and undoubtedly objectively verified.

For a long time, the Authors have been conducting research focusing on the problems of optimizing the size of bank capital under the new post-crisis regulatory order in the European Union credit institutions, operating under the pressure of sustainable development of modern financial systems. However, compared to the previous studies, the article widens their subjective scope, assuming that the obtained results should create a greater field of objectification of the research conclusions. Furthermore, the article fulfils the research gap in the field of research studies that take into account how capital at risk and specific capital adequacy regulations may impact on bank's efficiency. An increasing number of publications examine the issue of potential effect of minimum capital requirements

on capital and bank's risk. However, none of them estimate how risk capital influences banking institutions' financial outcomes. That's why the Authors decided to try to fill the identified research gap.

The paper provides a significant theoretical as well as application contribution to the current state of knowledge. In theoretical aspects, it presents the concepts of risk capital due to the Basel Accords as well as the effectiveness of banking institutions, while in the application aspects, the research results show how the value of risk capital impacts on main profitability ratios of selected banking sectors.

The paper is structured in the following way: The first part includes an introduction to the manuscript. Then, the second section consists of a broad, international literature review, which mainly concentrates on new prudential regulations for credit institutions, as well as the concept of bank risk capital. It presents methods commonly used to analyze and assess an impact of risk capital value on banking efficiency. The third part shows the research methodology, which includes main research methods and the procedure of conducted studies. The main variables of the regression models and data, used at specific stages, were also presented. The fourth section concerns the empirical research results on risk capital effectiveness in the euro area banking sectors. The outcomes are presented in three stages that refer to the selected phases of the research—risk capital versus return on assets, return on equity and cost income ratio, respectively. The final part of the study provides a discussion and main conclusions from the research.

2. Literature Review

The global financial crisis has pressured banking institutions to collect and maintain an adequate capital level, necessary for their smooth running. A huge wave of bankruptcies and failures striking numbers of banks of the world economy, increased an interest of scientific community concerning the banks' excessive risk-taking and methods of its protection (Bhattacharyya and Purnanandam 2012; Augur and Demertzis 2012; Baldwin 2012; Schwarcz and Peihani 2018; Kibritcioglu 2002; Stulz 2015; Iqbal and Vähämaa 2019). The experience of the crisis revealed that credit risk and market risk, intensified by the systemic risk, can proliferate quickly along with the fear of appropriate assets valuation, scattering funding sources and capital adequacy realization. Thereby, it seems extremely important to identify what should be an appropriate relation between risk exposure and size of bank capital, on the one hand to absorb potential losses resulting from different types of risk and on the other hand not to limit banks' effectiveness.

Bank risk capital remains a very important category in banking systems, closely related to the Basel Prudential Requirements (Basel Committee on Banking Supervision 2010) and widely discussed among scientists and banking practitioners (Merton and Perold 1993a, 1993b; Matten 2000; Culp 2002a, 2002b, 2002c; Shimpi 2001; Doherty 2005; Ishikawa et al. 2003; Wieczorek-Kosmala 2017; Wieczorek-Kosmala 2019). Changes that result from the post-crisis prudential norms in creation of bank risk capital, concern the following (Jumreornvong et al. 2018):

- tightening of capital requirements—strengthening the size and quality of banks' equity,
- implementation of liquidity requirements—which did not occur in previous Basel Accords,
- determination of the maximum banks' leverage—the leverage ratio.

The post-crisis prudential regulations also implemented a new definition of own funds, tightened the criteria for recognizing components of bank's capital[1], identified capital conservation and countercyclical buffers as well as strengthened the role of high-quality capital. They cause that the search for causes of banks' low credit activity is quite categorically associated with changes in the size and quality of core and supplementary capital (Basel Committee on Banking Supervision 2010).

The capital requirements for banks covered by the European Banking Supervision consist of three main elements (ECB 2019):

- minimum capital requirement—the Pillar I,
- additional capital requirement—Pillar II,
- capital buffers.

First, all banks covered by the European Banking Supervision have to comply with the minimum capital requirement (Pillar 1), which was set on a level of 8% of their 'risk-weighted assets'. The value of risk-weighted assets is calculated by multiplying the total amount of bank's total assets by the relevant risk factors (weights). These ratios reflect the degree of riskiness of individual types of assets. The lower the risk associated with an asset, the lower its risk-weighted value will be—and the less capital a bank need to cover it.

Second, the European Banking Supervision is also responsible for fulfilment of the additional capital requirement (Pillar II). Supervisors from the ECB and the national supervision authorities of the euro area analyze the situation of individual banks and assess their risks exposure. This is done under the so-called the Supervisory Review and Evaluation Process (SREP). If supervisors find that the bank's compliance with the minimum capital requirement is not enough to cover the risk, they order it to set aside additional capital requirement (ECB 2019).

The third capital requirement for banks concerns additional capital buffers for various purposes, including general capital conservation and cyclical and non-cyclical systemic risk. In addition to these three types of requirements, supervisors expect that banks will reserve a certain amount of capital in the event of crisis (this is known as Pillar II). Furthermore, except capital required by regulators and supervisors, banks should themselves determine how much capital they need to stably implement the adopted business model.

Due to the new regulations presented in the Basel Accords, the concept of risk capital is also constantly evolving (Posacka and Szelągowska 2006; Jonek-Kowalska and Zieliński 2017; Charnes et al. 1978; Samuelson and Nordhaus 2012; Begg et al. 1995; Dudycz and Brycz 2006; Rutkowska 2013; Matwiejczuk 2005; Directive 2013; Regulation 2013). At the same time, it is a consequence of the development of the theory of risk management (Jumreornvong et al. 2018; Pyka et al. 2019; Angrick and Nemoto 2017; Arseneau 2017; Cœuré 2014; Dong and Wen 2017; International Monetary Fund 2017), paying particular attention to its assessment and reduction (Nocoń and Pyka 2018; Nocoń and Pyka 2019; Merton and Perold 1993a, 1993b; Matten 2000; Culp 2002a, 2002b, 2002c; Shimpi 2001; Doherty 2005; Ishikawa et al. 2003; Wieczorek-Kosmala 2017; Wieczorek-Kosmala 2019; Jobst and Lin 2016; Pyka and Nocoń 2017; Pyka and Nocoń 2019; Gómez-Fernández-Aguado et al. 2018; Erfani and Vasigh 2018).

The issue of bank risk capital in literature and scientific research has been undertaken for a long time and analyzed in various contexts (Peltzman 1970; Pringle 1974; Mingo 1975; Santomero and Watson 1977; Taggart and Greenbaum 1978). The research on banks' safety impact on their capital structure was initiated by Buser, Chen and Kane (Buser et al. 1981). An important aspect undertaken in research on risk capital has been and still remains its appropriate amount, depending on a number of factors (Orgler and Taggart 1983). They include regulatory requirements implemented for banks, a bank's strategy or risk exposure. However, the overriding goal in determining the bank's capital requirements is the necessity to cover risk and maximize a rate of return on invested capital (Marcinkowska 2009). The risk capital has been developed in three leading concepts (Nocoń and Pyka 2019), by Merton and Perold at the beginning of the 90s in the twentieth century (Merton and Perold 1993a), by Shimpi at the end of the previous century (Wieczorek-Kosmala 2017; Shimpi 1999) and by Culp at the beginning of the new century (Culp 2002a, 2002b). All these concepts emphasized that risk capital should be understood as an appropriate amount of capital maintained to absorb losses and it is very difficult to define its appropriate level.

The paper concentrates on bank risk capital effectiveness, which is justified by the extension of supervisory regulations and prudential standards for credit institutions (and more) after the global financial crisis (Altunbas et al. 2017a; Caprio 2013; Committee on the Global Financial System 2018; International Monetary Fund 2018; World Bank 2019; Sironi 2018; Danielsson 2015; Tropeano 2018; Maddaloni and Scopelliti 2019; Redo 2015; Bougatef and Mgadmi 2016; Agénor et al. 2018; Lui 2017; Kovner et al. 2018; Viñals 2016; Altunbas et al. 2017b; Cerutti et al. 2017). Their implementation to the banking system resulted in restrictions in banks' access to short-term sources of funding, a change in the cost of obtaining bank capital, and ultimately a modification of banks' operational and strategic activities, affecting changes in their performance indicators (Behn et al. 2016; Basel Committee on Banking Supervision 2019; Kovner and Van Tassel 2018; Baker and Wurgler 2015; Cohen and Scatigna 2014; Colyer and Sebag-Montefiore 2011; ECB 2016), determining the sustainable development of modern financial systems.

The research on capital effectiveness or profitability in relation to the bank risk exposure have been conducted for a long time. Altunbas et al. examined the relationships between capital, risk and efficiency in European banking and stated that higher capital negatively impact on bank's efficiency, however at the same time these institutions undertake lower level of risk (Altunbas et al. 2007). Goddard et al. indicated that the relation between capital, risk and efficiency is different for banks with different ownership structures (Goddard et al. 2001). Hughes and Mester provided that it is necessary to take into account effectiveness when analyzing relation between risk and capital (Mughes and Mester 1998), while Fiordelisi et al. added that a level of capital and risk exposure are always determined by bank's profitability (Fiordelisi et al. 2011). Isnurhadi et al. analyzed this relation for Islamic banks. They suggested that bank capital positively affects bank stability and negatively affects credit risk. Their findings also show that efficiency has the same effect. Efficiency encourages banks to reduce risk, including when bank capital is relatively lower (Isnurhadi et al. 2021). Deelchand and Padgett examined the relation between risk, capital and efficiency but for Japanese cooperative banks. They proved that inefficient Japanese cooperative banks appear to operate with larger capital and take on more risk (Deelchand and Padgett 2009). Abbas et al. analyzing an impact of different capital ratios on non-performing loans, loan loss reserves, and risk-weighted assets by studying large commercial banks of the United States, found out that the role of high-quality capital on these positions is substantial (Abbas et al. 2021).

Effectiveness in the economic sciences is a category which is being constantly and thoroughly analyzed. This means that there are various possibilities for its definition and interpretation (Posacka and Szelągowska 2006; Jonek-Kowalska and Zieliński 2017; Czyżewski and Smędzik 2010). Currently, it is a multidimensional concept, which—especially in the last few decades—has undergone a process of deep evolution from the praxeological approach, through a financial indicator approach to the multidimensional category, closely related to the concept of sustainable socio-economic development, including recently the balanced development of financial system (Samuelson and Nordhaus 2012; Begg et al. 1995; Dudycz and Brycz 2006; Rutkowska 2013; Matwiejczuk 2005; Charnes et al. 1978). The study analyzes and assesses the effectiveness of risk capital of credit institutions (banks) using its classical meaning, which traditionally refers to the concept of how to allocate resources, aimed at maximizing objective function. The need to conduct research identifying an impact of changes in banks' prudential requirements on bank risk capital effectiveness and their constant monitoring is justified by:

- the new supervisory regulations and prudential norms implemented in financial institutions' operations, spread over time (until 2019) and constantly modified (Basel Committee on Banking Supervision 2010; Jumreornvong et al. 2018; Directive 2013; Regulation 2013),

- a wide objective and subjective scope of regulations, not encountered in the financial system until the global financial crisis,
- low, close to zero and sometimes even negative interest rate policy of central banks (Pyka et al. 2019; Angrick and Nemoto 2017; Arseneau 2017; Cœuré 2014; Dong and Wen 2017; International Monetary Fund 2017; Jobst and Lin 2016; Pyka and Nocoń 2017, 2019),
- strong concentration of impact of various regulatory, economic and behavioral factors on banking activities effectiveness (Gómez-Fernández-Aguado et al. 2018; Erfani and Vasigh 2018),
- a permanent decline in efficiency of credit institutions, observed in their operating activities.

The Authors have been following these issues for a long time, observing changes in the size and quality of bank funds resulting from new prudential regulations. Research conducted in this area, resulting in the publication of a series of articles, prompted them to build an empirical database of the European Union banking sectors, enabling verification of the direction of changes and determinants of the risk capital effectiveness, assessed due to the need to secure the sustainable development of modern banking systems.

In the study it was assumed that higher level of capital collateral may—on the one hand—be conducive to increasing the scale of operations, and thus improving profitability, and on the other hand, the high cost of raising and maintaining capital at risk may reduce effectiveness (Gemar et al. 2019). That's why the Authors decided to conduct a study aimed at explaining the causality of these relations. However, the obtained results did not allow to draw clear conclusions. In the analyzed banking sectors, bank risk capital had a varying degree of impact on their profitability. In nominal terms, an increase of banks' own funds was conducive to achieve even higher level of net profit. While analyzing dependencies between the size of risk capital and return on assets and then return on equity, mostly negative correlations were identified. This suggests a deterioration of banking institutions' profitability in the face of a need to increase a level of their capital collateral (Nocoń and Pyka 2018, 2019). The research results concern the assessment of capital at risk effectiveness from the perspective of selected profitability ratios in the banking system of the euro area and selected national banking sectors are presented in this study. They create a broader ground for concluding about an impact of the new Basel prudential regulations on the effectiveness of bank risk capital.

3. Materials and Methods

The study of bank risk capital effectiveness in relation to the selected banking sectors was based on the estimation of a dozen of multiple regression functions. Estimation was used to identify dependencies—and if they were identified, to assess their direction and strength—between risk capital and banks' profitability. The linear regression models were used. The variables included in the models were: own funds and main profitability ratios, such as return on assets (ROA), return on equity (ROE) and cost income ratio (CIR). The research sample selection was not accidental. It included the national euro area banking sectors selected by the value of total assets of all banking sectors in the euro area (see Figure 1). The research covered the German, French and Italian banking sectors, which are characterized by the highest level of the adopted measure. After that, the research results for the selected sectors were compared to the results obtained for the whole aggregated euro area banking sector. This comparison was made to find out how national banking sectors affect the whole European banking sector.

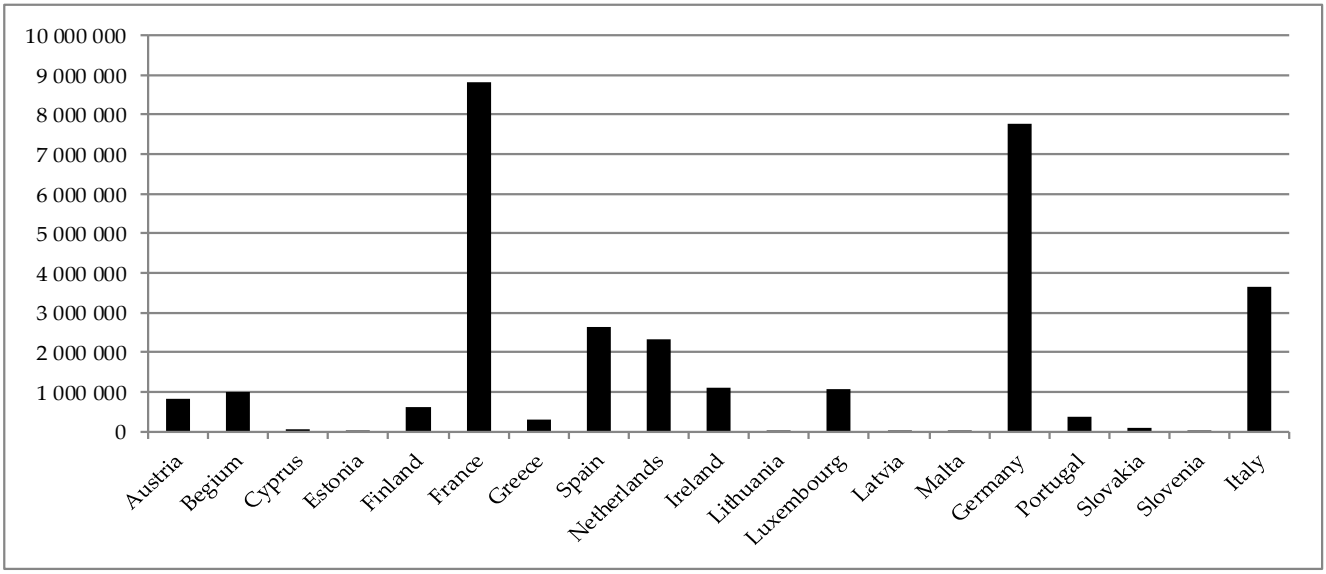

Figure 1. Total assets of the euro area banking sectors (at the end of 2018)—in mln EUR (source: own work based on the European Banking Federation data).

Following the selected observation criterion, Tier 1 capital ratio in the euro area and selected countries in 2008–2018 was also a subject of analysis. A level of tested coefficient remains well above the minimum capital requirement (see Figure 2).

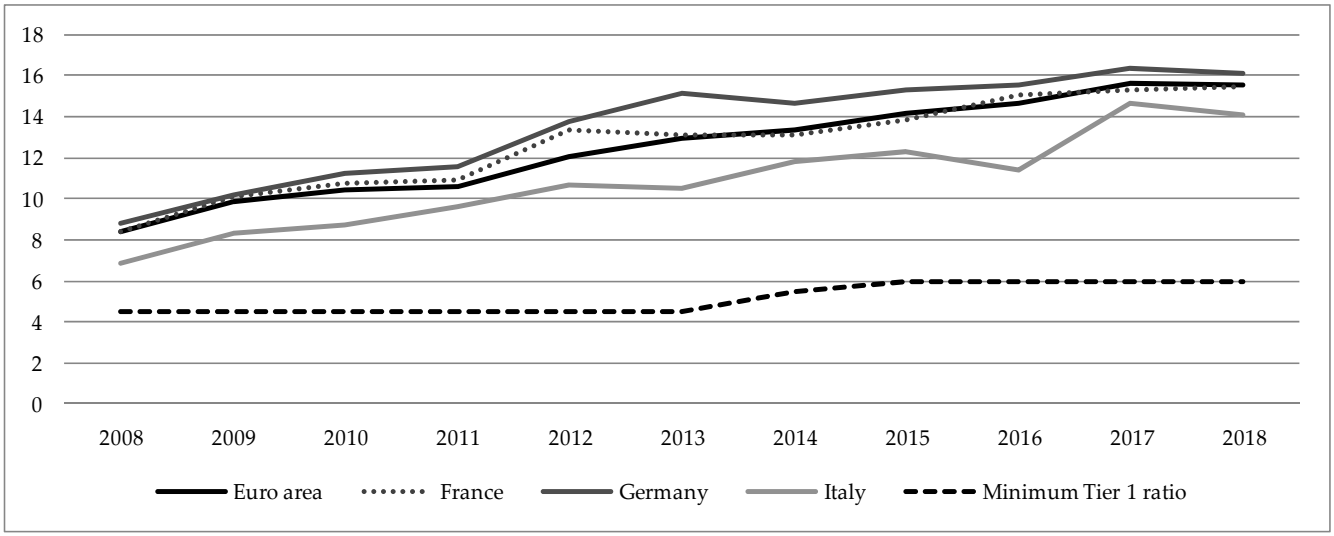

Figure 2. Tier 1 capital ratio in the analyzed countries on the background of the euro area in the years of 2008–2018—in percent (source: own work based on the ECB data).

The similar results are represented by the CET 1 ratio—estimated by banks since the implementation of the Capital Requirements Directive IV and the Capital Requirements Regulation. In the analyzed period, the ratio significantly exceeded the minimum level, indicated in the Basel recommendations (see Figure 3) (Directive 2013; Regulation 2013).

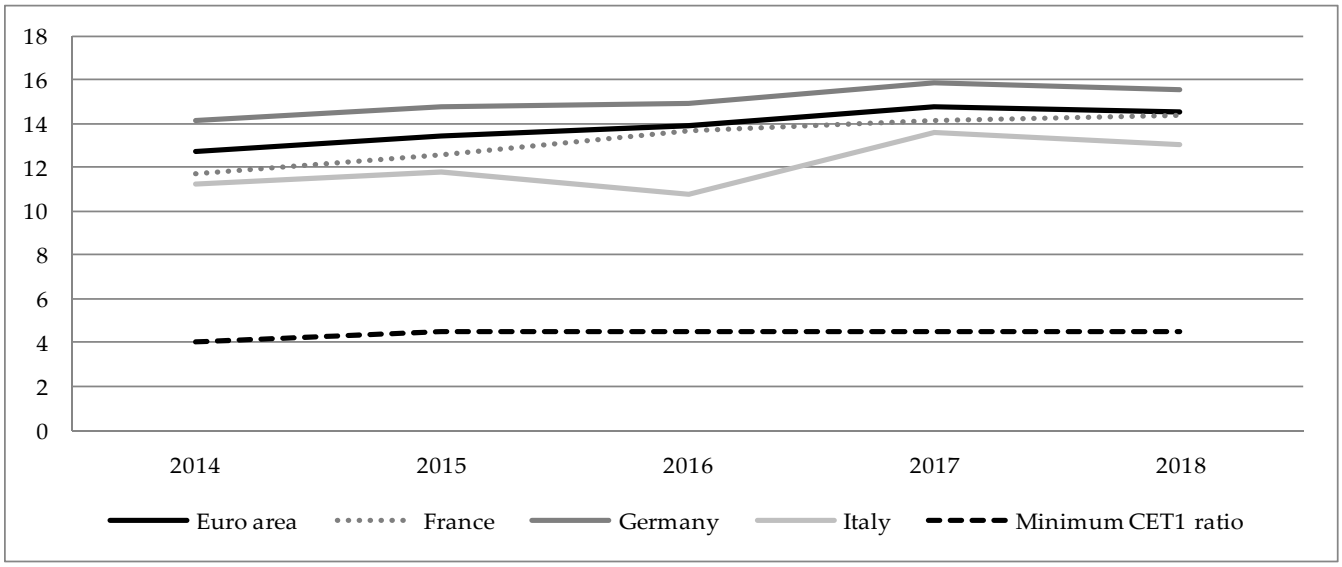

Figure 3. Common Equity Tier 1 in the analyzed countries on the background of the euro area in the years of 2014–2018—in percent (source: own work based on the ECB data).

After selection of the sample, the regression models were estimated. The adopted variables: return on assets (ROA), return on equity (ROE) and cost income ratio (CIR) of the analyzed banking sectors, were compared with the size of bank risk capital, identified with the regulatory capital (total own funds of the whole banks and credit institutions of a selected banking sector). As a result, values of regression coefficients as well as regression equations were developed. The adopted methodology was chosen to compare the findings with previously Authors' research results on the effectiveness of bank risk capital in the Polish and other Visegrad Group countries banking sectors.

The research period covered the years of 2008–2018, i.e., a period in which banking sectors of the global economy, including the euro area, have been strongly hit by the global financial crisis and a need to implement the new regulatory order (Pyka et al. 2019).

The research on the effectiveness of risk capital in the selected banking sectors has been divided into three stages, which created a basis of deeper analysis of the studied dependencies. The first stage covered the assessment of relations between size of bank risk capital and *return on assets* (ROA). The study tried to determine an impact of the cost of obtaining and then maintaining additional risk capital on the rate of return on bank assets. Then, the second stage, based on the analysis of correlation between the size of own funds of the analyzed banking sectors and return on equity (ROE), was carried out. The assessment concentrated on determining an impact of bank risk capital level on banking sectors' ability to increase their equity (Kochaniak 2010). The third stage included the analysis of dependencies between bank risk capital and cost income ratio (CIR). It was focused on determining correlation between regulatory capital and cost of running operations to a bank's operating income. The obtained results for national banking sectors were referred to dependencies identified for the aggregated euro area banking sector. At each stage, we identified existence or lack of dependencies, their direction and strength to answer the research question whether there is any correlation between bank's profitability and level of bank risk capital. In the event of its occurrence, we tried to prove its positive or negative impact and finally how strong the relation is.

Additionally, the following research methods were used: cause and effect analysis, observation method, document analysis method, as well as synthesis method. The research materials used the consolidated data of the European Central Bank database, regarding the following banking sectors: France, Germany, Italy and the aggregated data for the whole euro area.

4. Results

The conducted empirical research focused on the analysis of the relations between the amount of bank risk capital and the effectiveness of the analyzed banking sectors. Estimation with the linear regression models allowed for determination of the regression function and estimation of individual descriptive statistics (see Appendix A). Additionally, to illustrate the potential dependencies, two-dimensional scatterplots have been developed.

In the first stage, relations between the amount of risk capital and profitability of assets in the banking sectors of the euro area were analyzed (see Table 1). The obtained results showed that there is a positive, linear dependence between the analyzed variables in all banking sectors (see Figure 4). The differences relate to the strength of this relation. While this relation is moderate for the German banking sector and quite strong for the French as well as euro area aggregate banking sectors, for the Italian banking sector this relation is difficult to clearly identify. Therefore, based on the obtained descriptive statistics, it should be assessed as a lack of correlation. The estimated regression models also indicate, taking into account values of coefficients of determination (r^2) that, *ceteris paribus*, size of bank risk capital to a moderate extent explained the volatility of return on assets ratio. The first stage of the research allows us to formulate a conclusion that costs of raising bank capital collateral, considering new regulatory restrictions, do not affect negatively on the asset profitability of the analyzed banking sectors.

Table 1. Regression models of stage 1 (source: own work).

France	Germany	Italy	Euro Area
$y = 0.000000001382x - 0.1485$	$y = 0.000000002510x - 0.9950$	$y = 0.000000003740x - 0.7043$	$y = 0.000000001333x - 1.8718$

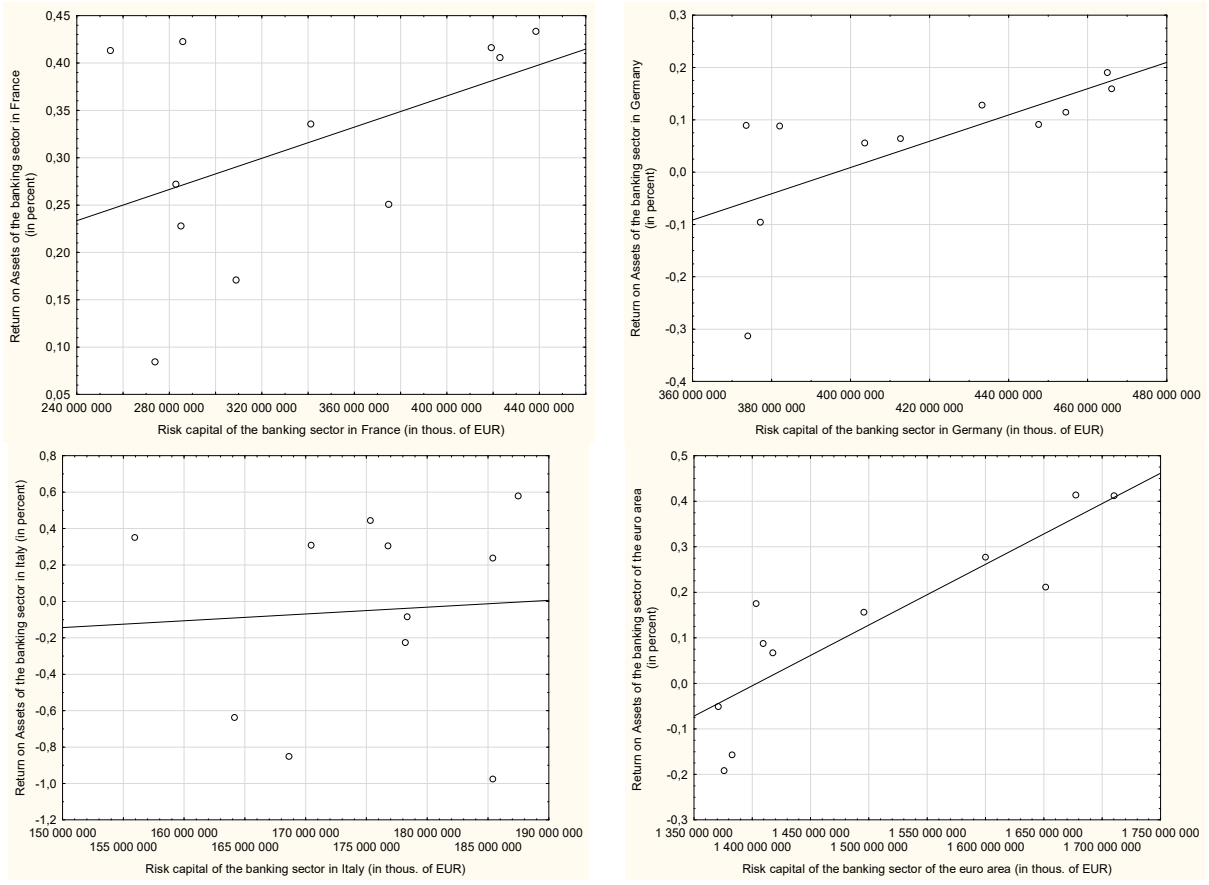

Figure 4. Two-dimensional scatterplots of stage 1 (source: own work).

Then, the relations between risk capital and profitability of equity of analyzed banking sectors were assessed. Based on the obtained description statistics (see Appendix A) and dependencies illustrated on two-dimensional scatterplots (see Figure 5), mostly positive dependences were observed. Namely, a quite strong dependence was identified for the euro area banking sector (see Table 2), while in France and Germany this dependence was moderate. As before, the estimation of the linear regression function showed no correlation for the Italian banking sector. Moreover, the conducted research shows that additional costs related to necessity to increase the size of bank risk capital do not impact negatively on ROE ratio of the analyzed banking sectors. The obtained results do not confirm the negative implications accompanying Visegrad Group countries banking sectors. Finally, while analyzing the values of coefficients of determination (r^2), it should be stated that, ceteris paribus, size of bank risk capital to a satisfactory degree explained volatility of return on equity ratio.

Table 2. Regression models of stage 2 (source: own work).

France	Germany	Italy	Euro Area
$y = 0.00000001310x + 1.1600$	$y = 0.00000005707x - 23.3994$	$y = 0.00000003946x - 8.0010$	$y = 0.00000001999x - 28.1808$

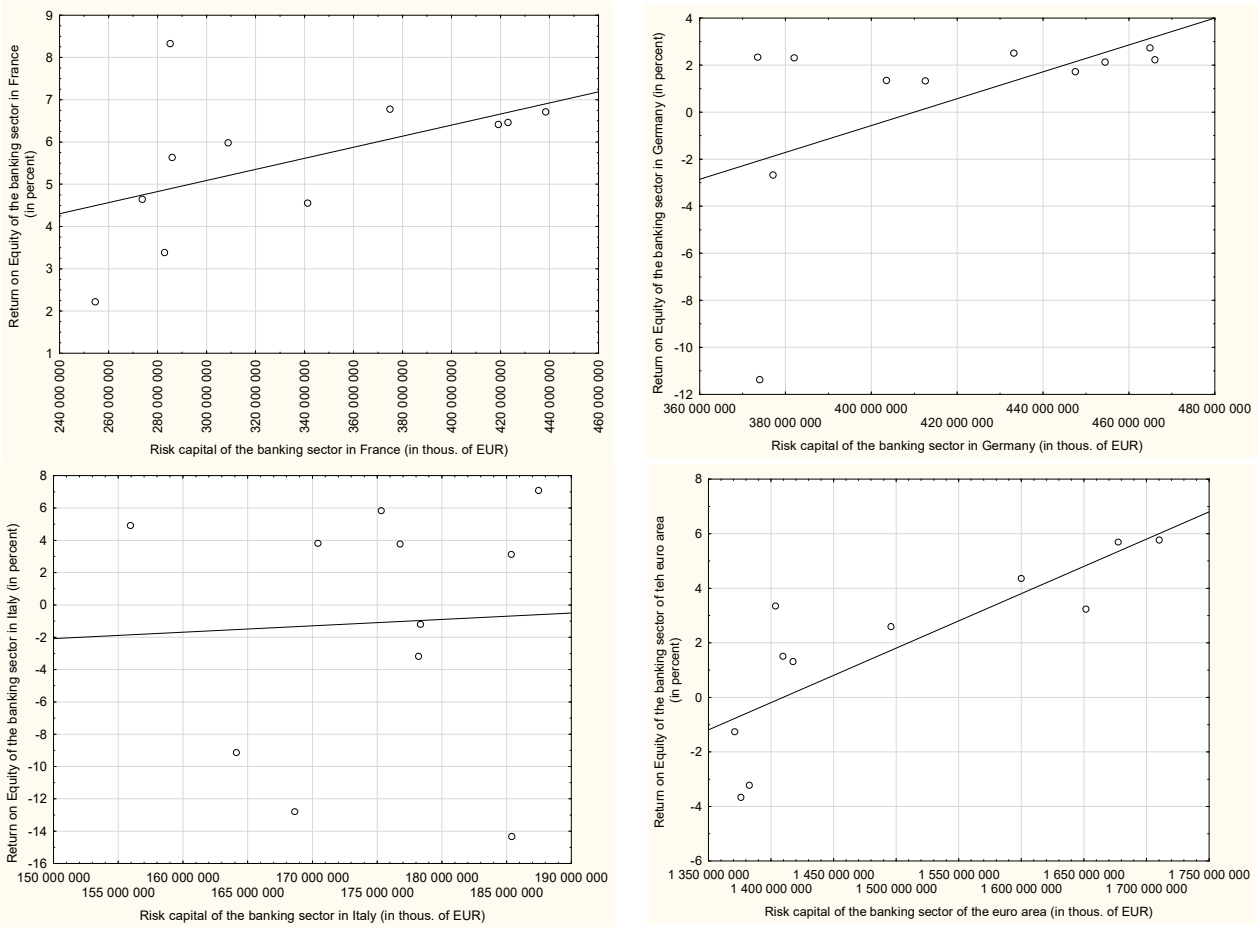

Figure 5. Two-dimensional scatterplots of stage 2 (source: own work).

The third stage of the research was concentrated on the dependencies between the cost income ratio (CIR) and risk capital. We used the same procedure as before. The research provides weak correlations between the analyzed variables in all banking sectors (see

Appendix A). The obtained values of descriptive statistics, determined by the regression models (see Table 3), as well as the observation of two-dimensional scatterplots (see Figure 6) indicated that dependencies are so insignificant that they do not allow to inference based on them.

Table 3. Regression models of stage 3 (source: own work).

France	Germany	Italy	Euro Area
$y =$ $0.000000009505x + 66.3200$	$y =$ $0.000000006599x + 71.4101$	$y =$ $-0.00000007571x + 77.5979$	$y =$ $-0.0000000000218x + 65.1612$

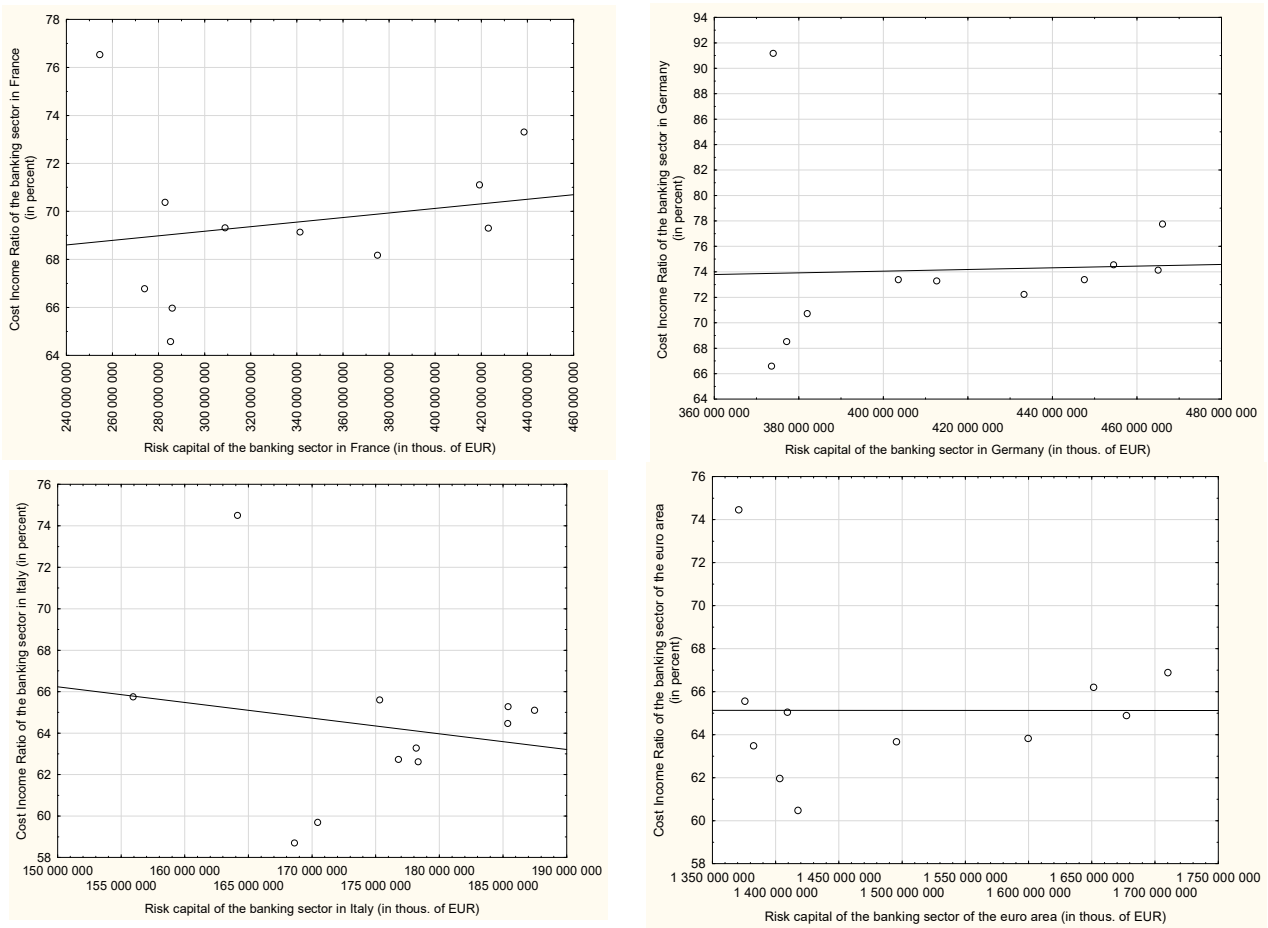

Figure 6. Two-dimensional scatterplots of stage 3 (source: own work).

5. Discussion and Conclusions

The conducted analysis and assessment of dependencies between profitability of the biggest banking sectors of the euro area countries and the size of bank risk capital indicate the existence of the following relations:

- an increase of bank risk capital was related to a growth of return on assets of banks and credit institutions in France, Germany and in the aggregated euro area banking sector; in the case of France and the whole euro area, this dependence was strong, while in the German banking sector it took the form of a moderate correlation; a lack of relation was observed for the Italian banking sector;
- an increase in a level of own funds also resulted in an improvement in return on equity in the aggregated sector of the euro area (strong correlation); a moderate positive

correlation was identified in France and Germany; while in the Italian banking sector there was no correlation between the examined features, and therefore return on equity was independent of the size of bank risk capital and profitability was strongly determined by macroeconomic factors;
- regression analysis of the profitability, measured by the cost income ratio in relation to the size of risk capital, did not allow for unambiguous conclusions, because in all analyzed banking sectors there were almost no correlations.

Therefore, the conclusions do not allow for explicit confirmation or rejection of the adopted research hypothesis. This results from the fact that risk capital has a varying impact on profitability of the analyzed euro area banking sectors. Analyzing dependencies between the value of own funds and return on assets and then return on equity, positive—strong or moderate—correlations were identified (except in the Italian banking sector). The aggregated banking sector of the euro area has the most recognizable features, where a strong positive relation between risk capital and profitability was observed. At the same time, it can be concluded that a need to increase their capital collateral does not burden profitability of the euro area banking institutions, which is undoubtedly a positive aspect. In turn, the weakest information was provided by an analysis of the Italian banking sector, because at all stages there was observed a lack of correlation between the analyzed variables. Nevertheless, the obtained findings have important implications for regulators and policymakers, particularly in euro area countries.

The research results confirmed conclusions from the studies conducted by Bitar et al. among OECD countries during 1999–2013 period, which took into account 1992 banks (Bitar et al. 2018). They proved that risk and non-risk based capital ratios increase banks' profitability, however risk-based capital ratios do not decrease bank risk. This undermines the validity of the methodology of risk-weighted assets used in capital adequacy ratios calculation. The Authors stated that higher capital at risk increases bank efficiency, but not all types of capital have such ability. Only higher quality capital (common equity) reduces risk and improves profitability. Similar results were obtained by Altunbas et al., who did not find a positive relationship between capital and inefficiency as well as bank risk-taking (Altunbas et al. 2007). Lee and Hsieh provided more detailed results. First of all, taking into account types of banks, investment banks have the lowest and positive capital effect on profitability, while commercial banks reveal the highest reverse capital effect on risk. Second, banks in low-income countries have a higher capital effect on profitability. Banking institutions in lower-middle income countries have the highest reverse capital effect on risk, while banks in high-income countries have the lowest values (Lee and Hsieh 2013).

Taking into account that the results from the conducted research presented in the article and previous publications indicate differentiation, and any further extension of their subjective scope does not fundamentally change the observed relations of risk capital effectiveness, it can be assumed that:
- the sectoral approach to the analysis of effectiveness of bank risk capital does not allow for unambiguous conclusions regarding assessment of the observed changes direction,
- the analysis of effectiveness of bank risk capital in the European Union requires concentration on national banking sectors and banks, mainly systemically important financial institutions, because they often have a significant share in a total level of sectoral effectiveness of bank risk capital,
- the research results indicate that in the conditions of ongoing regulatory changes in banks, diversity of risk capital effectiveness determinants may increase, which justifies extension of subjective scope of the conducted research and might be a basis for further Authors' in-depth research.

The obtained results presented in the paper clearly justify the interest of effectiveness of bank risk capital. Their ambivalence confirms complexity of the problem and the literature review points directly to the multithreaded nature of the research subject. Banks' operational activity, as it is commonly indicated, is in fact related to the transformation of

bank risk. Banks, taking over the risk of their depositors, should estimate probability of incurring losses in the lending process in the case where a borrower loses creditworthiness. Therefore, the key skill of each bank is to manage the risk arising in its operating activities. However, this issue, widely discussed in publications (Tursoy 2018; Van Greuning and Bratanovic 2020; Bojinov 2016), has a speculative nature. Each bank generates a specific sum of risk. This problem was reflected in the Basel Accords focused from the very beginning (the 1980s) on the problems of banks' capital adequacy. The latest set of capital regulations, carried out under the auspices of the Basel Committee on Banking Supervision, is a wide-ranging reform that significantly determines the functioning of financial institutions, especially banks all around the world. However, opinions on this issue are not uniform. In particular, an impact of changes in the capital requirements calculation on the operational activity of banks and increased influence of supervisory authorities are mainly questioned. It is indicated that the new regulations will bring regulatory and economic capital closer together, which will result in better capital security of bank risk. On the other hand, it is emphasized that benefits generated by banks will be reflected in the rapid increase of their costs, which will be difficult to compensate by appropriately high revenues. The article is embedded in this research field, which undoubtedly contributes to its originality. The issue of risk capital effectiveness raised to the rank of sectoral research indicates the necessity to conduct further, in-depth research at a micro level (individual banks).

The conclusions resulting from the research should also be contrasted with the relevant ex-post and ex-ante studies. The new Basel regulations were implemented at different time intervals, which may affect the final formulated conclusions. Moreover, the obtained results also need to be exemplified in the context of the main objective of the Basel reform, which is to increase bank's stability by better linking capital requirements with the real risk, which should also eliminate incentives for manipulation, such as regulatory arbitrage. The problem is particularly important in the context of new threats destabilizing financial system and the world economy. The coronovirus pandemic turned out to be a significant case study. During the COVID-19 pandemic, short-term fluctuations in a level of bank risk capital were expected. The macroeconomic conditions of the world economy and nation states have changed quite significantly. In these circumstances, a deterioration in banking performance and a decrease of bank assets quality could be expected, which should result in an increase in a level of risk capital in credit institutions. On the other hand, the strength of the decline in bank risk capital effectiveness should be determined by the length of the isolation period of the global economy. The formulated conclusions require a new research project, justifying the purposefulness of the research conducted in this publication.

Author Contributions: Conceptualization, I.P. and A.N.; methodology, A.N.; software, A.N.; validation, I.P. and A.N.; formal analysis, I.P. and A.N.; resources, I.P. and A.N.; writing—original draft preparation, I.P. and A.N.; writing—review and editing, I.P. and A.N.; visualization, A.N.; supervision, I.P. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by the University of Economics in Katowice.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this work have been produced by the Authors mainly from the European Central Bank database.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

	France	Germany	Italy	Euro Area
		Results of stage 1		
Constant of regression (b)	−0.1485	−0.9950	−0.7043	−1.8718
Regression coefficient (a)	0.000000001382	0.000000002510	0.000000003740	0.000000001333
Correlation coefficient (r)	0.7656	0.6660	0.0660	0.8742
Coefficient of determination (r^2)	0.5862	0.4435	0.0044	0.7643
Standard error of estimation	0.0827	0.1111	0.5776	0.1044
The value of t-student statistics	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -1.1238$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 3.5706$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -2.5356$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 2.6784$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -0.2131$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 0.1984$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -5.039$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 5.4016$
The value of the F statistics	12.749	7.1739	0.0394	29.1775
p-value	0.0060 < 0.05	0.0253 < 0.05	0.8471 > 0.05	0.0004 < 0.05
		Results of stage 2		
Constant of regression (b)	1.1600	−23.3994	−8.0010	−28.1808
Regression coefficient (a)	0.00000001310	0.00000005707	0.00000003946	0.00000001999
Correlation coefficient (r)	0.5115	0.5112	0.0495	0.8157
Coefficient of determination (r^2)	0.2617	0.2614	0.0024	0.6654
Standard error of estimation	1.5683	3.7915	8.1384	1.9978
The value of t-student statistics	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = 0.4632$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 1.7859$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -1.7474$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 1.7846$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -0.1718$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 0.1485$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = -3.9633$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 4.2305$
The value of the F statistics	3.1894	3.1847	0.0221	17.8968
p-value	0.1078 > 0.05	0.1080 > 0.05	0.8852 > 0.05	0.0022 < 0.05
		Results of stage 3		
Constant of regression (b)	66.3200	71.4101	77.5979	65.1612
Regression coefficient (a)	0.000000009505	0.000000006599	−0.00000007571	0.00000000002180
Correlation coefficient (r)	0.1908	0.0387	0.1788	0.0008
Coefficient of determination (r^2)	0.0364	0.0015	0.0320	0.0000
Standard error of estimation	3.4858	6.7412	4.2557	3.7982
The value of t-student statistics	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = 0.0000$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 0.5742$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = 2.9993$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 0.1161$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = 0.0111$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = 0.5989$	$t_{\alpha 0} = \frac{\hat{\alpha}_0}{S(\hat{\alpha}_0)} = 4.8201$ $t_{\alpha 1} = \frac{\hat{\alpha}_1}{S(\hat{\alpha}_1)} = -0.0024$
The value of the F statistics	0.3399	0.0135	0.2971	0.0000
p-value	0.5742 > 0.05	0.9102 > 0.05	0.5989 > 0.05	0.9981 > 0.05

Note

[1] The following types of capital among own funds were identified (Czerwińska and Jajuga 2016):

- Tier 1 capital—bank's core capital which is referred as business continuity capital, covering ordinary share capital Tier 1, also known as Common Equity Tier 1 (CET1) as well as Additional Tier 1 capital, which includes some types of hybrid instruments;
- Tier 2 capital—defined as bank's supplementary capital, including subordinated loans, as well as certain categories of reserves (general risk provisions and excess reserves over expected losses for the loan portfolio).

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