EU Banks' Profitability and Risk Adjustment Decisions under Basel III[1]

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Abstract

This paper uses quantitative modeling methods to assess the potential impact of the new capital requirements defined in Basel III and Capital Requirements Directive IV (CRD IV) on European banks. In our analysis we explore the impact of the higher capital requirements on the level of profitability of European banks. More specifically, we try to pinpoint which of the variables will have the most significance. Based on the results of our analysis which employs a simultaneous equations model on 594 banks operating in the European Union in the 2006 – 2011 period, we conclude that higher capital requirements under the CRD IV proposal would cause a decrease in banks' profitability accompanied by a drop in their risk taking. Additionally, we show that a higher level of capital held by banks would cause them to decrease their risky assets held relative to total assets.

Keywords: *bank, Basel III, capital, CRD IV, European Union, profitability, risk*

JEL Classification: G18, G21, G32, G33

1. Introduction

The overall objective of the Basel III capital accord is to strengthen global capital, liquidity and risk assessment rules and consequently enhance the resiliency of the banking sector (BCBS, 2010). The reason for changing and complementing the preceding sets of rules, known as Basel I and Basel II, was to prevent the

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repeat of consequences of market failures, first revealed by the 2007 – 2008 crises, by improving the banking sector's ability to absorb shocks arising from financial and economic stressors. The main methods to accomplish these goals include increasing the quantity and enhancing the quality of capital, expanding risk coverage and introducing liquidity requirements. All of the measurements are supported by defining more tight and precise market discipline and supervision (BCBS, 2011).

The 2007 – 2009 global financial turmoil was exacerbated by a low level of financial market regulatory coordination. However, historical experience has shown that the effort to implement regulations, surveillance and sound macroeconomic policy did not suffice to prevent the financial industry from periodic crises (Reinhart and Rogoff, 2009). Consequently, a similar result might be expected from a new regulatory framework on bank capital requirements defined by the mentioned Basel III and Capital Requirements Directive IV on European banks. There is a debate currently pending about financial market regulation – its recent classical works include Acharya et al. (2010), Dewatripont, Tirole and Rochet (2010), Mandel and Tomšík (2011), Čihák, Demirgüç-Kunt and Johnston (2012) or Lall (2012). Despite the fact that Basel III implies an improvement compared to the Basel II capital accord, we agree with Lall (2012) or Klinger and Teplý (2014) who state that the Basel III regulation is not sufficient and will not prevent financial markets from future crises due to its expected calibration, delayed implementation and strong pressure from the banks' lobbyists.

The pending Eurozone crisis has highlighted the role of bank regulation and its influence on local economics. Therefore, the aim of this paper is to take a closer look at the potential impact of the Basel III regulation on EU banks using quantitative modeling methods. Specifically, we are testing the following hypothesis: that higher capital requirements would not have any effect on the profitability of EU banks because the following effects will cancel each other out: (i) higher interest rates and inelastic demand for loans will lead to higher interest income → slightly higher profitability, (ii) better capitalized banks have access to cheaper source of financing → higher profitability, (iii) less risky assets bring less return → lowering profitability, (iv) equity financing is a relatively expensive form of financing → lowering profitability. To answer the risk- and profitability-related questions, we will employ accommodated simultaneous equations model pioneered by Shrives and Dahl (1992), where risk, profitability and capital are modeled endogenously.

The paper continues as follows. In Section 2 we present a literature review on the profitability-risk-capital simultaneous system. Section 3 presents and reviews the model. Against this backdrop, in Section 4 we provide an empirical research and analyze the impact of higher capital requirements under Basel III on the profitability of EU banks. For this purpose, we will conduct an econometric analysis for 594 European banks in the 2006 – 2011 period and employ the Shrives and Dahl methodology. In last Section, we present our conclusions and state final remarks.

2. Literature Review

In this part, we present a literature review on the profitability-risk-capital relationship. Research papers dealing with this topic are divided into two groups: the first group focusing on a capital-risk relationships and the second group analyzing a capital-profitability relationship. To present this topic more comprehensively, we describe these two streams of literature separately in the following paragraphs. The first group encompasses Shrives and Dahl (1992) investigated whether the imposition of stricter capital requirements reduces risk-taking incentives of banks based on a simultaneous equations model. Their model pioneered the idea that the changes in both capital and risk have endogenous and exogenous components. The results obtained by the authors indicate that changes in the capital level are positively related to the changes in asset risk. Even though their findings were unilateral, Shrives and Dahl (1992) justified potential heterogeneity in a risk-capital relation by the following two-sided argument: (i) if exploitation of the deposit insurance subsidy is a dominating bank behavior, then a negative association between changes in risk and capital should be expected, and a secular trend toward lower capital and higher risk levels; however, (ii) a positive relationship between changes in risk and capital would result if some leverage- and risk-related cost factors drive bank behavior. Therefore, in spite of employing the same principles of the Shrives and Dahl methodology, later works bring diverse results. For instance, Teplý, Matějašák and Černohorský (2009), Awdeh, El-Moussawi and Machrouh (2011), Jokipii and Milne (2011) belong to those studies identifying a positive relationship between the level of capital (alternatively a change in capital or a buffer) and the level of risk (alternatively a change in risk). On the other hand, Jacques and Nigro (1997), Zhang, Wu, and Liu (2008) declare negative risk-capital relationship.

The second group of the literature concentrating solely on the relationship between the level of held capital and bank profitability is limited. Nevertheless, there exist a lot of studies dealing with the banks' profitability as such, where bank capital is very often included as an explanatory variable. The truth is that the majority of these studies reported, from our point of view, an unexpected positive relationship between the level of capital held and the profitability level and Bourke (1989) was the first who reported such an outcome. He rationalizes his findings by speculating that better capitalized banks have the benefit of access to cheaper sources of funds or that the prudence implied by high capital ratios is maintained in the loan portfolio with consequent improvement in profits. Berger (1995) justifies a positive relationship between profitability and capital by adding other two arguments. First, he claims that banks that are expected to have a better performance in the future signal this information through a higher level of held capital. Second, if more periods are taken into account, higher capital levels are a result of retained earnings if the profit is not fully paid out. However, this second argument is not valid to consider within the boundaries of our study as the causality in this case (profit → capital) is both logically and chronologically opposite as analyzed in our case (capital → profit). One of the most recent studies on bank profitability of Kanas, Eriotisc and Vasilioub (2012) contributed to a number of the authors` colleagues reporting a positive capital-profitability relationship.

In the realms of European borders, the topic was pioneered by Molyneux and Thornton (1992) who wanted to verify Bourke's findings by replicating his study for Europe. Their results are consistent with those of Bourke's, which creates an evidence for empirical positive relationship between capital and profitability in Europe. Other studies on banks profitability within Europe include Abreu and Mendes (2001), and Pasiouras and Kosmidoua (2007), while both contribute to those works in which the relationship between the capital ratio and profitability is identified as positive. Nevertheless, the empirical findings regarding the topic of capital-profitability relationship for banks are not unilateral. There exist research papers that confirmed causality that more expensive sources of financing (capital) lead to lower profitability. For instance, Goddard, Molyneux and Wilson (2004) analyzed the dynamics of growth and profitability in European banking sector and found that banks maintaining high capital or liquidity ratios tend to record relatively low profitability ratio and grow slowly. Ngo (2008) reported a negative capital-profitability relation for the US banks. His findings are extremely important for our discussion as we, in our analysis below, similarly consider the triangle profitability-risk capital and model it simultaneously. The results of his study indicates that the capital regulations that instruct banks to concentrate on the management of regulatory capital either diverts banks' attention away from their primary functions – maximizing profit, which lead to a reported negative relation between the level of common equity ratio and profit.

3. Model Description

To arbitrate the conflict between the supporters and critics of capital requirements as for its positive impact on risk reduction and negative impact on profitability within Europe, we alter and use the simultaneous equations model initially developed by Shrives and Dahl (1992) analyzing the relationship among bank capital and risk levels. Our analysis uses the idea of simultaneity pioneered by their work but we extend the model to a considerable extent: we incorporate the profitability equation into the system and increase the number of employed exogenous variables.

Based on the conventional theory, the riskiness of a bank is given by its ability to absorb losses and its profitability is influenced by the costs of its operations. Keeping this logic in mind, the following mechanisms holds: (i) banking regulation requires higher level of capital to create a buffer with a potential to absorb potential losses, and (ii) higher level of held capital, in turn, leads to an increase in costs of financing for banks, what can potentially reduce profitability. As a result of this interconnection, we are going to employ the simultaneous equations model, where capital and risk are included as endogenous variables, to estimate their individual impacts on bank profitability. The approach of simultaneous equations allows us to estimate the effect of higher capital requirements on bank profitability without the danger of neglecting their effect on risk. In designing this model, we were inspired by Ngo (2008) who modeled the impact of Basel II on the profitability and risk for the US banks. In the model, the key role is played by the endogenous variables: profitability, risk and capital that appear as both dependent and explanatory variables.

First, the most common measures of banking profitability are the following: (i) return on average assets: ROAA (net profit/average total assets), (ii) return on average equity: ROAE (net profit/average equity) and (iii) net interest margin: NIM (interest income-interest expenses)/total assets), while each of these measurements has its advantages and disadvantages. Traditionally, ROAA is considered to be a more reliable indicator of profitability than ROAE, in terms of efficiency performance, since it is adjusted for the leverage and an associated risk effect (ROAA = ROAE/leverage). The effect of leverage and corresponding risk is obvious from so called DuPont decomposition of the return on equity (ROE) measure, ROE = Return on assets (Net profit/Assets) x Assets turnover (Sales/Assets) x leverage (represented by Assets/Equity). This decomposition indicates that the higher the leverage, ceteris paribus, the higher the ROE while ROA remains stable. Moreover, in the context of analyzing the effects of increased capital ratios, using ROAA is a better option as it will not be biased by the composition of liabilities (capital and debt), which would be the case with usage of ROAE (ECB, 2010). Based on this definition, it is natural to expect a lower ROAE as a result of higher capital levels. This is because the capital is supposed to serve as a buffer lowering the risk on equity that is usually measured and represented by ROAE. Additionally, we believe that for banks the profitability on all employed capital is a better measure of the effectiveness and ability of profit generation. The averageness of the ratio allows us to control the continuousness of the effect over the whole year. As for NIM, this profitability measure will be used as an exogenous explanatory variable to capture the effect of monopoly power in the market and the ability of bank to earn abnormal interest income (Mejstřík, Pečená and Teplý, 2008). Additionally, NIM has the potential to capture the effect of increased loan rate or decreased volume of provided loans as a result of higher capital requirements.

Second, the level of capital in this model is represented by the capital ratios that are subjected to banking regulation as defined by BCBS (2010) and BCBS (2011): (i) common equity ratio (common equity/risk-weighted assets (CE/RWA)), (ii) Tier 1 capital ratio (Tier 1 capital/RWA) and (iii) total capital ratio (Tier 1 and Tier 2 capital/RWA). To make the picture complete, we should mention that the current bank regulatory framework in Europe is set by the Capital Requirements Directive IV (CRD IV) that implements Basel III for more than 8,300 banks that operate in the EU. On top of the rules required by Basel III, CRD IV introduced a number of additional changes to the banking regulatory framework. Moreover, EBA (2011) required establishing and keeping exceptional and temporary buffers for EU banks to bet met until June 2012. Consequently, EBA (2012) reported that 27 EU banks were facing a EUR 76 billion capital shortfall of as of 30 June 2012. However, we consider this amount as very low and biased since Greek banks, some Spanish banks and other banks under an intensive restructuring were excluded.

Third, there are four main risks in banking: credit, market, operational and liquidity risk.[2] In this analysis, we are concerned with the portfolio risk of banks that can be captured by the ratio of risky assets to total assets in the bank's portfolio. According to Jokipi and and Milne (2011), this ratio reflects the project choice by bank managers and, thus, to some degree the overall asset risk. What is more, this measure of risk is the one on which bank regulators build their capital guidelines.

The specificity of this system lies in the equation representing the capital that follows the logic of a model with bank capital as a call option developed by Chami and Cosimano (2001; 2010). The principles of Shrives and Dahl modeling of capital do not take into account the internal decisions of banks while choosing the optimal level of capital and uses only risk, type of the bank, its size and macroeconomic factors as explanatory variables. In the equation modeling the level of

[2] We refer to the recent works on these risks: *credit risk* (Buzková and Teplý, 2010; Stavárek and Vodová, 2010; Janda, Michaliková and Skuhrovec, 2013), *market risk* (Horváth and Teplý, 2013; Stádník 2013; 2014), *operational risk* (Danhel, Duchackova and Radova, 2008; Rippel, Suchánková and Teplý, 2012; Teplý, 2012), *liquidity risk* (Černohorská, Teplý and Vrábel, 2012; Vodová, 2013).

capital in our work, we take into consideration more sound procedures of banks' decisions that depends on (i) banks' expectation about their future optimal loans that determines the future level of expected capital, which has an consequent impact on interest rates and potentially on banks' profitability levels, and (ii) the fact that the expected levels of capital limit the amount of provided loans since a fraction of the total loans represented by the capital requirements must be held as capital, which can result in lowered profitability of a bank, if it does not decide to increase interest rate on loans significantly (the interest rate effect is captured by the variable NIM discussed below). As a result, employing the equation representing capital as a call option allows us to potentially assess the interconnectedness between banks' profitability and interest rates. In the system of simultaneous equations that consist of three equations (profitability equation, risk equation and capital equation), endogenous variables described above are complemented by a set of exogenous variables to control for other factors with potential significant influence on the explained endogenous variables.

3.1. Profitability Equation

Based on the thorough review of existing literature on stand-alone modeling of bank profitability, we constructed the following equation including micro and macro determinants with probable effects on bank profitability:

$$\begin{aligned} PROF = {} & \alpha_0 + \alpha_1 CAR + \alpha_2 RISK + \alpha_3 PROF_{t-1} + \alpha_4 OE + \alpha_5 ACTMIX \\ & + \alpha_6 NIM + \alpha_7 GDP + \alpha_8 INF + \alpha_9 \ln Assets + \alpha_{10} \left(\ln Assets\right)^2 + \varepsilon_1 \end{aligned} \tag{1}$$

where

PROF	– Profitability of a bank measured by ROAA
CAR	– Common equity/Tier 1/Total capital regulatory ratio included to capture the simultaneity between the level of capital and banks' performance
RISK	– Portfolio risk measured by the risky assets to all assets – the same risk variable as used as a dependent variable in the risk equation
$PROF_{t-1}$	– Lagged profitability included to control for the persistency in the level of profitability
OE	– Operating expenditures measured by operating expenses to total assets. This variable is included to embrace the potential effect of managerial (in)efficiency
ACTMIX	– Activity mix proxied by the absolute value of the ratio of interest income to operating income. This variable is included to control for the level of diversification of bank activities. It is crucial for the risk equation, but the nature of bank's activities can also influence the level of its profitability

NIM	– Net interest margin is supposed to proxy the effect of the monopoly power of the bank. The higher this margin, the higher the power of the bank to monopolistically set prices for its services (i.e. lending rates). To capture the level of competition in the economy, some authors use the Herfindahl index. However, we believe that the Herfindahl index is too general as it captures an overall situation on the market but it does not capture the behavior of individual banks. NIM directly describes the power of the individual bank to set the prices for loans and deposits but also accounts for the competitive conditions on the market
GDP	– Real GDP growth to capture the overall conditions in the economy
INF	– Inflation rate measured by CPI
$\ln Assets$	– Natural logarithm of total assets to control for the size effects on profitability
$(\ln Assets)^2$	– Squared natural logarithm of total assets to control for possible non-linearities in the size-profit relation

3.2. Risk Equation

The risk equation includes variables that are expected to have a significant impact on the portfolio riskiness of the banks:

$$\begin{aligned} RISK = \beta_0 + \beta_1 PROF + \beta_2 CAR + \beta_3 RISK_{t-1} + \beta_4 ACTMIX \\ + \beta_5 C_L + \beta_6 LLP + \beta_7 \ln Assets + \beta_8 (\ln Assets)^2 + \varepsilon_2 \end{aligned} \tag{2}$$

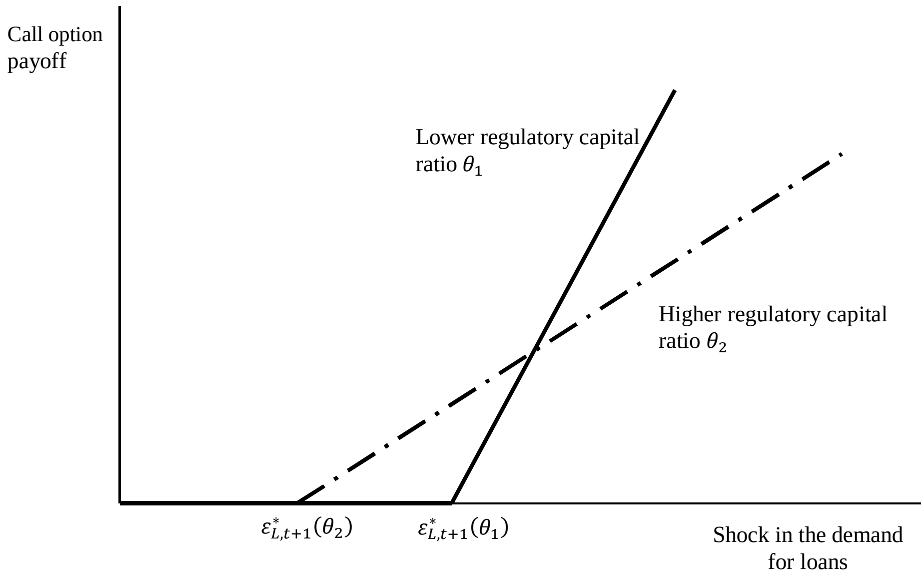
where

PROF	– Profitability of a bank measured by ROAA, the same variable as used as the dependent variable in the profitability equation
CAR	– Common equity/Tier 1/Total capital regulatory ratio included to capture the simultaneity between bank's risk taking and the level of capital choosing
$RISK_{t-1}$	– Lagged risk included to control for the persistency in the level of risk
ACTMIX	– Activity mix measured by the absolute value of the ratio of interest income to operating income. It is an important variable for the risk equation as it controls for the overall level of risk undertaken by banks to the extent that different sources of income are characterized by different credit risk and volatility
C_L	– Ratio of nonperforming loans to assets included to capture the quality of loans on the bank's balance sheet
LLP	– Loan loss provisions to assets ratio included to reflect the financial health of a bank
$\ln Assets$	– Natural logarithm of total assets to control for the size effects on risk
$(\ln Assets)^2$	– Squared natural logarithm of total assets to control for possible non-linearities in the size-risk relation

3.3. Capital Equation

The equation representing the capital follows the logic of a model with bank capital as a call option developed by Chami and Cosimano (2001; 2010). The basic idea behind the choice of capital by banks in this model is that the capital is seen as a call option (Figure 1) in which a strike price $\varepsilon^*_{L,t+1}$ is the difference between the expected optimal future loans L^*_{t+1} and the amount of loans satisfying the condition of current capital level L^*_t (i.e. the strike price is simply a shock to the demand for loans). If no significant increase in demand for loans is expected, the shock to demand is below its critical level $\varepsilon^*_{L,t+1}$ and the payoff of the capital is zero as the capital serves no purpose. But if the future demand for loans is expected to increase considerably, the capital has a positive payoff and the bank wants to hold more capital in order to be able to meet the future loan demand. The payoff is smaller and the strike price is lower when the regulatory capital ratio θ increases. As a result, banks tend to hold more capital in case of the stricter the regulatory requirement and higher the volatility of the demand for loans (i.e. greater and often shocks).

Figure 1
Bank Capital as a Call Option



Source: Authors based on Chami & Cosimano (2001).

The capital equation in this profitability-risk-capital system is represented by the following formula:

$$\begin{aligned} CAR = {} & \gamma_0 + \gamma_1 (\Delta CAR)_{t-1} + \gamma_2 (CAR)_{t-1} (\Delta CAR)_{t-1} + \gamma_3 r^D \\ & + \gamma_4 (CAR)_{t-1} r^D + \gamma_5' C_L + \gamma_6' (CAR)_{t-1} C_L + \gamma_5'' C_D \\ & + \gamma_6'' (CAR)_{t-1} C_D + \gamma_7 \ln Assets + \gamma_8 (\ln Assets)^2 + \varepsilon_3 \end{aligned} \quad (3)$$

where, for the purposes of the empirical testing, following observable variables (representing the original variables in the theoretical model) are used:

CAR	– Capital adequacy ratio – Common equity, Tier 1, total capital regulatory ratio are tested
$(\Delta CAR)_{t-1}$	– Lagged change in the given capital adequacy ratio
$(CAR)_{t-1}(\Delta CAR)_{t-1}$	– Lagged change in the given capital adequacy ratio multiplied by the initial capital adequacy ratio
r^D	– Interest expense ratio (representing the rate on deposits)
$(CAR)_{t-1} r^D$	– Interest expense ratio multiplied by the given capital adequacy ratio
C_L	– Ratio of nonperforming loans to assets (representing noninterest costs of loans)
$(CAR)_{t-1} C_L$	– Ratio of nonperforming loans to assets multiplied by the initial capital adequacy ratio
C_D	– Noninterest expense ratio (representing noninterest costs of deposits)
$(CAR)_{t-1} C_D$	– Noninterest expense ratio multiplied by the initial capital adequacy ratio
$\ln Assets$	– Natural logarithm of assets used to control for the size of studied banks
$(\ln Assets)^2$	– Squared logarithm of assets used to control for the size of studied banks and a potential convexity of this effect

Because of the complexity of the capital equation, based on the theory described above, we present the theoretical expectation about the values of the coefficients in the equation. A decrease in the total capital level in the past (i.e. $(\Delta CAR)_{t-1} < 0$) lowers the strike price of capital (increasing capital is more valuable for banks) which should lead to an increase in the current level of capital. Therefore, we expect that $\gamma_1 + \gamma_2 (CAR)_{t-1} < 0$. Moreover, this impact should be smaller for banks with higher initial level of capital $(CAR)_{t-1} < 0$ (as their strike price is higher), so we expect that $\gamma_1 < 0$ and $\gamma_2 > 0$. A decrease in interest costs r^D and noninterest costs C_D, C_L leads to a higher current optimal level of loans, which decreases the strike price. Hence, the current level of capital should increase and we expect that $\gamma_3 + \gamma_4 (CAR)_{t-1} < 0$ and $\gamma_5 + \gamma_6 (CAR)_{t-1} < 0$. Similarly with the previous case, this impact is expected to be smaller the higher the initial level of capital $(CAR)_{t-1}$, so $\gamma_3, \gamma_5 < 0$ and $\gamma_4, \gamma_6 < 0$.

4. Empirical Results

The system was estimated using both 2SLS and 3SLS in order to check for the robustness of the results. As already noted, all equations are estimated using three types of capital requirement ratios under Basel III (common equity ratio, Tier 1 ratio and capital ratio), which yields three sets of results for each equation and each methodology applied. As for the respective econometric tests, we report the results of the endogeneity of given variables and identification of equations in the Appendix.

Before turning the attention towards analyzing and discussing the results, it is important to note that we model the situation historically and base our conclusions about the potential future impact of Basel III capital adequacy rules on the assumption that the identified behavior would have a persistent character. This means that we assume that banks and bank-related variables would react on similar impulses in the same way in the future as they did in the past, which corresponds to the approaches discussed in Section 2.

4.1. Data Description

The data for empirical modelling were obtained from the BankScope database and cover banks in 27 of the European Union countries (including Romania and Bulgaria joining in 2007) for the period of 6 years (2006 – 2011). The banks were selected according to their specialization and due to the nature of the models applied, only banks with “standard activities”, such as deposits taking and loans providing, were involved in the modelling. These banks include commercial banks, bank holding companies, saving banks, mortgage banks and cooperative banks and we looked at their nonconsolidated financial statements. Altogether, 1 625 banks of the desired type were covered in the database. However, due to the incompleteness of the data, only 594 were finally used for modelling. Due to the fact that the used data are of an accounting type, they are of an annual frequency. The descriptive statistics of the data on banks is presented in the Appendix.

4.2. EU Banks' Profitability

The Appendix provides a complete set of results for the profitability equation (1). Based on the significance of the results and the results of endogeneity tests we will further focus our attention mainly to results employing ROAA as a profitability measure and common equity ratio as a capital adequacy ratio. The most important profitability-capital relation studied in this equation brings results favoring the critics of capital regulation who are afraid of a negative impact of the stricter capital regulation on banks' profitability. Put differently, our model confirmed that there is a negative relationship between the level of capital and profitability measured by ROAA. Concentrating on ROAA, the effects of increased common equity ratio, Tier 1 ratio and total capital are decreasing respectively as both for significance and the absolute value, i.e. common equity ratio has the greatest negative effect on profitability while total capital ratio has the lowest effect in comparison with other two ratios. This can be interpreted in such a way that more capitalized banks perform worse in terms of ROAA than less capitalized banks, while the capital of higher quality enhances the degree of the negative relationship between capital and profitability. More concretely, a one percentage point increase in the level of common equity ratio results into 0.174 percentage points decrease in ROAA.[3] The effect of Tier 1 and total capital ratio is also negative but not significant at standard levels of significance. In our data sample about 60% of the banks included in the modeling do not hold enough common equity capital to satisfy the required level of regulatory common equity ratio of 9.5%. In the case of these banks, fulfilling the regulatory requirement would lead, on average, to a decrease in profitability measured by ROAA by 0.51 percentage points. Our results are similar to Goddard, Molyneux and Wilson (2004) but conflict with a majority of existing literature such as Molyneux and Thornton (1992) or Pasiouras and Kosmidoua (2007) that found a significant positive relationship between capital and profitability. However, validity of our results is strongly supported by the four following arguments. First, the simplest rationale behind this relationship is based on the principle that higher levels of capital are more expensive for banks (as capital is not, unlike debt, a tax deductible source of financing) and therefore lead, ceteris paribus, to lower net income and in turn to lower profitability ratios. Second, the negative relation between profitability and capital is naturally expected as higher capital requirements are supposed to lower bankruptcy costs (risk) and following the logic of the risk-return relationship, also affect the profitability of banks. Third, capital regulations

[3] We quantify the results for 2SLS methodology but 3SLS methodology confirmed the nature of the results but naturally leads to slightly different decimals.

appear to refocus banks' attention from their aim to maximize profit to the effort to manage their regulatory capital in order to avoid potential penalties. Last, our empirical results confirm that some European banks tend to sell their profitable business in order to achieve required regulatory ratios as discussed by, for instance, Fitch (2012), IMF (2012) McKinsey (2013) or Šútorová (2012). On a related note, in spite of the results based on historical data, we believe that the dynamics, creativity and evolution of banks will allow them to eliminate these impacts of the higher capital requirements and keep the profitability at least stable, while carrying on with decreased volume of risky operations in the long-run.

Turning to other explanatory variables included in the profitability equation and focusing on equation's results for ROAA, the estimated coefficients do not bring any surprising results as they are in accordance with generally accepted economic theories. Higher monopoly power of banks (measured by NIM) and better diversified activities have a positive significant impact on European banks' profitability. As briefly mentioned in the introductory part of this section, the coefficient of NIM can be analyzed also from another point of view. Because NIM is a proxy for interest rates spreads and was correctly identified as a variable positively influencing profit, we can consider this variable to be a connecting piece between the level of capital, interest rates and profitability. As a result, we conclude that an increase in the interest rates as a result of increased capital requirements (resulting into other steps taken by banks such as risk reduction – discussed further in this work) will not be big enough (in spite of inelastic demand) to keep the level of profitability of European banks at least stable. Thus, the effect of higher capital levels will be negative, regardless of an increase in the interest rates.[4]

Apart from NIM, a higher level of inflation is also affecting the profitability positively, which means that wages of bank employees and other non-interest costs are growing slower than inflation. Additionally, the favorability of economic conditions measured by real growth of GDP does have a significant relationship with profitability level as expected. On the other hand, the ineffectiveness of management (proxied by operating expenditures) was not proved to be a significant factor influencing banks' performance, which is probably caused by a slight portion of operating expenditures on total bank expenditures. Diversification of banks` operations (represented by the activity mix) declares predominantly a negative impact on profitability, which makes sense as diversification decreases the level of risk and potentially the profitability if portfolio management is not executed carefully.

[4] For detailed empirical results on an impact of higher capital requirements on loan rates in Europe, see Cosimano and Hakura (2011) or Šútorová and Teplý (2013; 2014).

The size effect measured by the volume of assets was identified as significant indicating a convex relationship between assets and profitability. This is contrary to principles of economies of scale, but logically also justifiable, as a convex shape of profitability-assets relationship implies that either very small product specific regional or huge international banks with strong positions achieve higher returns.

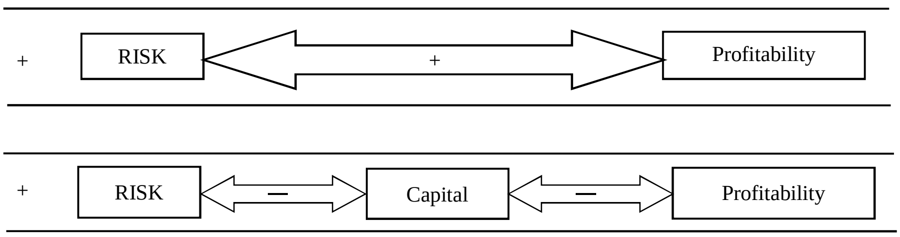
4.3. EU Banks' Risk-taking Behavior

The set of empirical results of the risk equation (2) employing all three types of capital ratios are not presented in the paper but available on request.

The generally known "higher risk ↔ higher return" investment trade-off was fully confirmed in our model via two channels. The first channel is represented by a direct relationship between risk and profitability, where profitability is included as an explanatory variable for the level of risk and risk is included as an explanatory variable for the level of profitability. Here, the higher profitability level has a significant and relatively strong positive impact on the risk level while the same holds true for risk in equation (1). The second channel leads through capital-risk and capital-profitability relationships. The higher all three types of capital ratios are, the less risky banks' assets are, and, considering the results of the profitability equation (1), less profitable the banks are in terms of ROAA, which jointly implies a positive relationship between risk and profitability. The overview of above discussed relationships is captured by Figure 2.

F i g u r e 2

Overview of Risk – Return Relationships Indicated by the Results of Profitability and Risk Equations



Source: Authors.

Regarding solely the effects of capital levels on banks' risk, our results coincide with that stream of existing literature confirming negative capital-risk relationship including Jacques and Nigro (1997) or more recently Zhang, Wu and Liu (2008). In our case, the risk was measured by the riskiness of held assets, so the interpretation of our findings is following: higher level of capital ratios held by banks makes banks decrease risky assets relative to total assets. If we wanted to be more specific, a one percentage point increase in common equity/Tier 1/total capital ratio leads to a decrease in risk weighted assets to total assets by 1.21/0.077/0.068 percentage points.[5] These results can be understood in two ways: (i) lowering risky assets may simply mean that banks, while keeping the same level of capital, decrease their risk weighted assets to fulfill the conditions of capital adequacy regulation, or in a better case (ii) the results support the usefulness of banking regulation, as they confirm that higher capital requirements make banks managers controlled by banks owners to behave more reasonably in regard to undertaking risky operation as they want to avoid the situation when invested capital would be consumed by covering bankruptcy costs, which simultaneously eliminates the moral hazard connected with the insurance of customers deposits in banks. Turning to the hypothesis of Shrives and Dahl (1992) who explain a negative relationship between the risk level and capital by the strategy of banks to exploit the deposit insurance subsidy (meaning that lower capitalized banks take more risk), our results, in principle, confirm this hypothesis. However, we look at this problem from a different perspective as we assume that better capitalized banks are afraid to take greater risks because the exposure of their own funds is higher.

All important variables included in the risk equation have a significant impact on the level of risk. Variables representing the quality of provided loans and the financial health of the bank (C_L and LLP) are significantly positively related to the level of risk. The values of estimated coefficients for size variables (logarithm of assets and squared logarithm of assets) indicate a convex relationship between the size of the bank and its risk profile. In other word, smaller banks take more risk, but after reaching a certain level of assets, they try to decrease their risk taking behavior and if they become a large player start taking even more risk. The activity mix variable representing the diversification of banks' activities was expected to have a negative impact on the level of risk as the diversification is a generally accepted method for unsystematic risk reduction, this expectation was confirmed by our results and portfolio diversification theory principles were met but the results are not significant.

4.4. EU Banks' Capital Reaction

We used the third equation (3) to capture the way banks choose the level of capital that is further utilized to model the levels of profitability and risk. Considering the significance levels, for all three capital ratios the choice of capital

[5] We quantify the results for 2SLS methodology but 3SLS methodology confirmed the nature of the results but naturally leads to slightly different decimals.

in a given period is negatively related (as expected, $\gamma_1 + \gamma_2 (CAR)_{t-1} < 0$) to the prior change in the given capital ratio. This means that banks reacted optimally – increasing the level of their capital level after their previous experienced losses. From the theoretical point of view, this effect should be lower for better capitalized banks, which was confirmed for Tier 1 capital and total capital in our 2SLS and all ratios in 3SLS modeling, as $\gamma_1 < 0$ and $\gamma_2 > 0$. In case of choosing the level of equity, theory based on common equity as a call option was suppressed by the persistency in the level of held common equity ratio, while this persistency effect was higher for worse capitalized banks $\gamma_2 < 0$, which is logical as worse capitalized banks have probably their specific reasons for such a strategy, so increasing the ratio must be motivated by a new regulation (there was not a brand new regulation between 2006 – 2011 regarding the capital adequacy[6]) but they cannot lower it as they would probably break the rules of the regulation valid at a given time.

As for the interest and noninterest costs, most of the coefficients are significant and most of them correspond to the theoretical expectations. The interest expense on deposits has a negative sign for all three cases ($\gamma_3 < 0$) but is significant only in the case of common equity ratio. Almost the same is true for noninterest costs of loans, their increase, as expected, leads to a decrease in the level of Tier 1 capital and total capital (coefficient in the case of common equity ratio is not significant). Additionally, this effect was proved to be lower for better capitalized banks as their reaction is not so substantial. Noninterest costs on deposit, however, bring surprising results. Their decrease should, according to the model, lead to a decrease in the strike price of the capital and thus to an increase in the capital level (i.e. $\gamma_5'' < 0$) but this was not confirmed for European banks' behavior if we look at the only significant result, which is the case of common equity. This means that banks did not increase their level of capital as a reaction to decreased costs of deposits' administration (that could potentially lead to higher future loans), which, nevertheless, does not necessarily reduce the validity of the model as administration costs can be considered just as a marginal factor in loan pricing.

4.5. Further Research Opportunities

Despite the conclusions cited above, we still see a few ways in which our research can be improved. Our paper deals mainly with the points of view of critics and in more detail verifies just potential negative impacts of the new capital

[6] Basel II was published in September 2005.

rules applicable for normal banks within the European Union. Therefore, for future research, we propose extending the current analytical scope provided within this study: (i) to take a closer look at some arguments proclaimed by supporters of stricter capital regulation and quantitatively scrutinize, for example, to what extent the supporters are right when claiming that higher capital requirements decrease social costs via decreased moral hazard; (ii) to look at the capital requirements specific for Systemically Important Financial Institutions (SIFIs) and analyze in more detail the impact of these even stricter rules on given banks; (iii) to examine the impacts of capital requirements separately for more geographic areas (the USA, Asia, Australia) and provide their mutual comparison in order to bring an unrestricted global view on the studied issue; (iv) to extent the observed period and compare our predicted results with real EU banks´ adjustments.

Conclusion

This paper analyzed the potential impact of CRD IV regulation on EU banks based on the quantitative modeling methods. Our analysis employs simultaneous equations model on almost 600 banks operating in the EU in period 2006 – 2011. Inspired by Shrives and Dahl (1992), we created a system of simultaneous equations that consist of three equations (profitability equation, risk equation and capital equation). First, we researched EU banks' profitability. Some critics, especially bankers, are afraid of negative impacts of high capital buffers on banks' ability to generate profits, which was confirmed by our results. We showed that higher capital requirements under the CRD IV proposal for EU banks would cause a decrease in banks' profitability accompanied by a drop in their risk taking. Nevertheless, this negative relationship of the capital level and profitability would not be caused only by the inactivity and expensiveness of funding resources, as many critics tend to point out. We conclude that it would be also caused by less risky operations taken by the banks. This expectation is obvious from a negative relationship between the risk of banks assets and the level of capital ratios identified by our modeling. Second, we modeled risk--taking behavior of the banks. The generally known "higher risk ↔ higher return" investment trade-off was fully confirmed in our model via two channels. The first channel is represented by a direct relationship between risk and profitability in both the profitability and risk equations. The second channel leads through capital-risk and capital-profitability relationships. The higher all three types of capital ratios are, the less risky banks' assets are, and, considering the results of the profitability equation, less profitable the banks are, which jointly implies a positive relationship between risk and profitability. Third, we analyzed the capital-risk relationship of EU banks. In our case, the risk was measured by the riskiness of held assets, so the interpretation of our findings is as follows: higher levels of capital ratios held by banks makes banks decrease their risky assets relative to total assets.

In conclusion, based on the above discussed results of three simultaneous equations we have to reject the above-mentioned hypothesis that higher capital requirements would not have any effect on the profitability of EU banks. However, our results point towards the dominance of the effect of lower returns as a result of lower risk taking of EU banks over higher interest rates and their access to cheaper sources of financing.

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Appendix

Descriptive Statistics of Bank Data

	Common equity ratio %	**Tier 1 ratio %**	**Total capital ratio %**	**C_L**	**C_D**
MIN	–0.47	–0.40	2.92	0.00	0.08
MAX	68.11	203.70	204.00	28.97	289.10
AVG	9.58	14.21	15.81	3.80	6.03
MEDIAN	9.05	11.89	13.30	3.14	13.07
STD	4.96	10.52	10.76	3.14	13.07
Number of obs.	3564	3560	3544	3030	3115
	NIM %	**RISK**	**Activity Mix**	**LLP**	**QE**
MIN	–0.36	9.76	0.00	–7.32	–0.29
MAX	18.40	150.89	892.00	46.82	21.96
AVG	2.65	65.70	4.10	0.68	0.99
MEDIAN	2.70	67.62	2.61	0.46	0.93
STD	1.26	19.25	17.56	1.32	0.72
Number of obs.	3563	3314	3564	3558	3564

Source: Authors based on data from the Bankscope.

Results for the Profitability Equation

Dependant variable *PROF*						
Methodology	*2SLS*			*3SLS*		
Type of capital ratio	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*
Const	7.269*** (1.518)	1.273 (0.872)	1.273 (0.850)	11.725*** (1.491)	1.406 (0.870)	1.371 (0.848)
CAR	–0.174*** (0.035)	–0.002 (0.005)	–0.002 (0.005)	–0.282*** (0.030)	–0.003 (0.005)	–0.003 (0.005)
RISK	0.008*** (0.002)	0.003 (0.002)	0.003 (0.002)	0.007*** (0.019)	0.004* (0.002)	0.003 (0.002)
$PROF_{t-1}$	0.774*** (0.042)	0.615*** (0.023)	0.615 (0.024)	0.722*** (0.041)	0.625*** (0.024)	0.627*** (0.024)
OE	0.014 (0.075)	–0.098 (0.063)	–0.098 (0.063)	–0.018 (0.068)	–0.108* (–0.062)	–0.109* (0.062)
ACTMIX	–0.002 (0.003)	–0.005* (0.003)	–0.005* (0.003)	–0.002 (0.003)	–0.006* (0.003)	–0.006* (0.003)
NIM	0.243*** (0.040)	0.145*** (0.030)	0.146 (0.029)	0.241*** (0.036)	0.137*** (–0.030)	0.138*** (0.029)
GDP	0.024** (0.011)	0.001 (0.009)	0.001 (0.009)	0.022** (0.010)	0.004 (0.009)	0.004 (0.009)
INF	0.072*** (0.020)	0.085*** (0.017)	0.085*** (0.017)	0.073*** (0.017)	0.077*** (0.017)	0.077*** (0.017)
ln *Assets*	–0.815*** (0.162)	–0.260** (0.107)	–0.259** (0.106)	–1.114*** (0.158)	–0.276*** (–0.107)	–0.266** (0.106)
$(\ln Assets)^2$	0.022*** (0.005)	0.009** (0.003)	0.009** (0.003)	0.028*** (0.004)	0.009* (–0.003)	0.009*** (0.003)
R^2	**14.20%**	**35.03%**	**35.01%**	**22.58%**	**35.06%**	**35.00%**

Notes: Standard errors are in parentheses, ***/**/* indicate 1%/5%/10% level of significance.

Source: Authors based on data from the Bankscope.

Results for the Risk Equation

Dependant variable *RISK*						
Methodology	*2SLS*			*3SLS*		
Type of Capital ratio	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*
Const	53.54*** (15.08)	15.88** (7.949)	14.68* (7.800)	84.03*** (14.59)	14.68* (7.928)	14.05* (7.780)
CAR	–1.211*** (0.343)	–0.077* (0.043)	–0.068* (0.042)	–1.992*** (0.329)	–0.071* (0.043)	–0.068* (0.041)
PROF	4.044*** (0.913)	0.803** (0.392)	0.751* (0.392)	2.952 (0.865)	1.105*** (0.390)	1.043*** (0.389)
$RISK_{t-1}$	0.794*** (0.016)	0.779*** (0.016)	0.780*** (0.016)	0.790*** (0.014)	0.762*** (0.016)	0.762*** (0.016)
ACTMIX	–0.008 (0.029)	–0.024 (0.026)	–0.025 (0.026)	–0.013 (0.027)	–0.022 (0.025)	–0.023 (0.025)
C_L	0.342*** (0.096)	0.147* (0.076)	0.144* (0.076)	0.461*** (0.093)	0.194*** (0.075)	0.188** (0.075)
LLP	1.171*** (0.440)	–0.273 (0.226)	–0.290 (0.226)	0.600 (0.414)	0.303 (0.224)	0.301 (0.224)
$\ln Assets$	–2.663* (1.534)	0.623 (0.988)	0.740 (0.982)	–4.827*** (1.493)	0.858* (0.985)	0.933 (0.979)
$(\ln Assets)^2$	0.024 (0.043)	–0.049 (0.031)	–0.052* (0.032)	0.067 (0.042)	–0.058* (0.031)	–0.060* (0.031)
R^2	**70.51%**	**76.66%**	**76.50%**	**61.55%**	**76.63%**	**76.48%**

Notes: Standard errors are in parentheses, ***/**/* indicate 1%/5%/10% level of significance.

Source: Authors based on data from the Bankscope.

Results for the Risk Equation

Dependent Variable: Current Level of Capital *CAR*						
Methodology	*2SLS*			*3SLS*		
Type of capital ratio	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*	*Common Equity Ratio*	*Tier 1 Ratio*	*Total Capital Ratio*
Const	39.483***	109.3***	101.6***	39.619	109.1***	101.5***
	(2.543)	(5.365)	(5.459)	(1.492)	(5.350)	(5.444)
$(\Delta CAR)_{t-1}$	0.152	–0.806***	–0.587***	–0.254**	–0.806***	–0.591***
	(0.131)	(0.075)	(0.085)	(0.108)	(0.074)	(0.084)
$(CAR)_{t-1}(\Delta CAR)_{t-1}$	–0.019***	0.017***	0.012***	0.018***	0.017***	0.012***
	(0.006)	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)
r^D	–0.034***	–0.021	–0.027	–0.016*	–0.018	–0.024
	(0.011)	(0.021)	(0.021)	(0.009)	(0.021)	(0.021)
$(CAR)_{t-1} r^D$	–0.004	–0.006**	–0.027***	0.0016	–0.006**	–0.026*
	(0.004)	(0.003)	(0.006)	(0.0033)	(0.003)	(0.006)
C_L	0.011	–0.290***	–0.297***	0.127***	–0.268***	–0.285***
	(0.025)	(0.052)	(0.053)	(0.023)	(0.052)	(0.053)
C_D	0.019*	–0.014	–0.013	0.004	–0.015	–0.014
	(0.011)	(0.019)	(0.019)	(0.008)	(0.019)	(0.019)
$(CAR)_{t-1} C_L$	0.080***	0.122***	0.113***	0.040***	0.121***	0.112***
	(0.014)	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)
$(CAR)_{t-1} C_D$	0.007	0.011***	0.007*	–0.001	0.011***	0.007*
	(0.005)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
ln *Assets*	–2.958***	–11.24***	–10.261***	–3.08***	–11.23***	–10.25***
	(0.334)	(0.705)	(0.718)	(0.333)	(0.703)	(0.716)
$(\ln Assets)^2$	0.060***	0.318***	0.023***	0.065***	0.318***	0.295***
	(0.0107)	(0.023)	(0.023)	(0.011)	(0.023)	(0.023)
R^2	**43.21%**	**44.28%**	**41.98%**	**40.96%**	**44.28%**	**41.98%**

Notes: Standard errors are in parentheses, ***/**/* indicate 1%/5%/10% level of significance.

Source: Authors based on data from the Bankscope.

Tests for Endogeneity in the Profitability and the Risk Equations in Section 4.2

Hausman test

H_0: The given variable is exogenous
H_A: The given variable is not exogenous (endogeneity present)

Profitability equation				
Type of Capital Ratio		Common Equity Ratio	Tier 1 Ratio	Total Capital Ratio
RISK	t-statistics P-value	2.000 0.045	–0.290 0.769	0.000 0.990
Capital	t-statistics P-value	–3.160 0.002	–1.290 0.197	–1.620 0.105
Risk equation				
Type of Capital Ratio		Common Equity Ratio	Tier 1 Ratio	Total Capital Ratio
Profitability	t-statistics P-value	4.280 0.000	0.300 0.762	0.780 0.433
Capital	t-statistics P-value	–0.910 0.364	–4.440 0.000	–3.950 0.000

Source: Authors.

Based on the endogeneity test, we will focus on the results for equations implementing the common equity ratio as a capital adequacy ratio when interpreting our finding.

Identification of the Equations in Section 4.2

Order Condition for Identification (Necessary Condition)

Profitability Equation

$$PROF = \alpha_0 + \alpha_1 CAR + \alpha_2 RISK + \alpha_3 PROF_{t-1} + \alpha_4 OE + \alpha_5 ACTMIX$$
$$+\alpha_6 NIM + \alpha_7 GDP + \alpha_8 INF + \alpha_9 \ln Assets + \alpha_{10} (\ln Assets)^2 + \varepsilon_1$$

Number of right hand side endogenous variables (g_1) = 2
Number of right hand side excluded exogenous variables (k_1) = 10
$k_1 > g_1 \Rightarrow$ equation 4.2.1 is overidentified

Risk Equation

$$RISK = \beta_0 + \beta_1 PROF + \beta_2 CAR + \beta_3 RISK_{t-1} + \beta_4 ACTMIX$$
$$+\beta_5 C_L + \beta_6 LLP + \beta_7 \ln Assets + \beta_8 (\ln Assets)^2 + \varepsilon_2$$

Number of right hand side endogenous variables (g_2) = 2
Number of right hand side excluded exogenous variables (k_2) = 12
$k_2 > g_2 \Rightarrow$ equation 4.2.2 is overidentified

Capital Equation

$$CAR = \gamma_0 + \gamma_1 (\Delta CAR)_{t-1} + \gamma_2 (CAR)_{t-1} (\Delta CAR)_{t-1} + \gamma_3 r^D + \gamma_4 (CAR)_{t-1} r^D$$
$$+\gamma_5' C_L + \gamma_6' (CAR)_{t-1} C_L + \gamma_5'' C_D + \gamma_6'' (CAR)_{t-1} C_D + \gamma_7 \ln Assets + \gamma_8 (\ln Assets)^2 + \varepsilon_3$$

Number of right hand side endogenous variables (g_3) = 0
Number of right hand side excluded exogenous variables (k_3) = 10
$k_3 > g_3 \Rightarrow$ equation 4.2.3 is overidentified

Rank Condition for Identification (Sufficient Condition)

Rewritten equations to more appropriate forms for rank condition verification:

$$1-\beta_1 PROF-\beta_2 CAR-\beta_0-\beta_5 C_L-\beta_4 ACTMIX-\beta_3 RISK_{t-1}-\beta_6 LLP-$$
$$\beta_7 \ln Assets-\beta_8 \ln Assets^2-0-0-0-0-0-0-0-0-0-0-0-0-0=\varepsilon_2$$

$$1+1-\alpha_1 CAR-\alpha_0-0-\alpha_4 ACTMIX-0-0-\alpha_8 \ln Assets-\alpha_9 \ln Assets^2$$
$$-\alpha_2 PROF_{t-1}-\alpha_3 OE-\alpha_5 NIM-\alpha_6 GDP-\alpha_7 INF-0-0-0-0-0-0=\varepsilon_1$$

$$0+0+CAR-\gamma_0-\gamma_5' C_L-0-0-0-\gamma_7 \ln Assets-\gamma_8 \ln Assets^2-0-0-0-0-0-\gamma_1\left(\Delta CAR\right)_{t-1}$$
$$-\gamma_2\left(CAR\right)_{t-1}\left(\Delta CAR\right)_{t-1}-\gamma_3 r^D-\gamma_4\left(CAR\right)_{t-1} r^D-\gamma_6'\left(CAR\right)_{t-1} C_L-\gamma_5'' C_D-\gamma_6''\left(CAR\right)_{t-1} C_D=\varepsilon_3$$

Matrix of parameters:

$$A=\begin{pmatrix} 1 & -\beta_1 & -\beta_2 & -\beta_0 & -\beta_5 & -\beta_4 & -\beta_3 & -\beta_6 & -\beta_7 & -\beta_8 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & -\alpha_1 & -\alpha_0 & 0 & -\alpha_4 & 0 & 0 & -\alpha_8 & -\alpha_9 & -\alpha_2 & -\alpha_3 & -\alpha_5 & -\alpha_6 & -\alpha_7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -\gamma_0 & -\gamma_5' & 0 & 0 & 0 & -\gamma_7 & -\gamma_8 & 0 & 0 & 0 & 0 & 0 & -\gamma_1 & -\gamma_2 & -\gamma_3 & -\gamma_4 & -\gamma_6' & -\gamma_5'' & -\gamma_6'' \end{pmatrix}$$

Equation of zero restrictions:

$$\Phi=\begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \end{pmatrix}$$

Product of A and ©:

$$A\Phi=\begin{pmatrix} 0 & 1-\beta_5-\beta_3-\beta_6 & 1-\beta_1-\beta_4-\beta_3-\beta_6 \\ -\alpha_2-\alpha_3-\alpha_5-\alpha_6-\alpha_7 & 0 & 2-\alpha_4-\alpha_2-\alpha_3-\alpha_5-\alpha_6-\alpha_7 \\ -\gamma_1-\gamma_2-\gamma_3-\gamma_4-\gamma_6'-\gamma_5''-\gamma_6'' & -\gamma_5'-\gamma_1-\gamma_2-\gamma_3-\gamma_4-\gamma_6'-\gamma_5''-\gamma_6'' & 0 \end{pmatrix}$$

$$\left.\begin{array}{l} rank\left(A.\Phi\right)=3 \\ \text{Number of endogenous variables = 3} \end{array}\right\} \quad 3\geq\left(3-1\right)\Rightarrow \text{ system is overidentified}$$