A COMPARATIVE ANALYSIS OF THE RELATIONSHIP AMONG CAPITAL, RISK AND EFFICIENCY IN THE EUROZONE AND THE U.S. BANKING INSTITUTIONS

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Abstract

In this paper, we investigate the relationship among capital, risk and efficiency in Eurozone and the U.S. banking institutions. We also assess the determinants of bank capital, risk and efficiency providing evidence of how the interrelationship and the managerial behaviors vary per type of bank (retail, commercial and investment banks). Concerning the methodology, we employ the input-oriented CCR model of data envelopment analysis developed by Charnes, Cooper, and Rhodes (1978) to estimate efficiency. We also apply the Z-score to calculate bank risk and the ratio of the value of total equity to total assets as an indicator of bank capital. Moreover, the relationship among capital, risk and efficiency of banking institutions is investigated by employing the three-stage least squares (3SLS) model, developed by Zellner and Theil (1962). Our main findings indicate that risk and capital are positively linked in the U.S. and Eurozone banks. The findings also suggest that efficiency has a negative and significant effect on bank risk in the majority of the banks of our sample. Additionally, we may conclude that the impact of risk and capital on efficiency levels is sensitive to the type of bank. As regards the effect of the variable efficiency on capital, the results are negative for all the banks in our sample.

Keywords: Bank, Capital, Risk, Efficiency, Three-Stage Least Squares

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1. INTRODUCTION

Multiple studies have focused on the interrelationship between risk and efficiency (Williams, 2004; Nguyen & Nghiem, 2015), between capital and risk (Anginer & Demirguc-Kunt, 2014; Tan & Floros, 2013) and between efficiency and capital (Bitar, Pukthuanthong, & Walker, 2018; Le, 2018). However, the existing literature remains inconclusive, which has resulted in a new wave of studies, the study of capital, risk and efficiency of banking institutions as one system. Interestingly, the number of studies investigating this interrelationship is limited (Deelchand & Padgett, 2009; Bashir & Hassan, 2017), while the studies examining this field for Eurozone and the U.S. banking are even more restricted (Fiordelisi, Marques-Ibanez, & Molyneux, 2011b; Ding & Sickles, 2019). Thus, the interrelationship among capital, risk and efficiency of banking institutions is unresolved, as the results concerning the sign of the relationship as well as the direction of causality are conflicting.

Concerning Eurozone and the U.S. banking systems, the recent financial crisis has affected both, with more bank failures occurring in the U.S. However, the speed of recovery of Eurozone banking institutions is considerably lower than that of the U.S. (McLannahan & Arnold, 2017; Ackermann, 2019). This outcome could be attributed to the different characteristics of the economies, the banking systems and the monetary policies of the Eurozone and the United States.[1] Therefore, the financial crisis has indicated how differently banking systems may behave after financial shocks. The different speed of recovery between the two reported country unions is the reason for this selection, as it helps us to investigate how differently interrelationships among capital, risk and efficiency develop over the post-crisis period. To the extent of our knowledge, the only study that compares the results of the abovementioned relationship for the U.S. and European banks is that of Altunbas, Carbo, Gardener, and Molyneux (2007), which employs pre-crisis data while no recent study compares the results between the Eurozone and the U.S. banking systems by employing post-crisis data.

This study attempts to take into consideration the type of bank (retail, commercial and investment) and provides empirical evidence about how the interrelationships among risk, capital and efficiency and the managerial behavior vary per type of bank. We concentrate on different types of banks because the objectives and managerial behaviors may vary across them. To be more precise, retail banks may confront different types of risk, attain more or less capital and operate differently to commercial or investment banks.

In order to clarify these relationships we examine the validity of a set of managerial hypotheses about the expected relationships, following a great number of academic surveys, for instance: Berger and DeYoung (1997), Williams (2004), Fiordelisi et al. (2011b); Fiordelisi and Mare (2014), etc. More specifically, seven hypotheses are tested; regulatory hypothesis, moral hazard hypothesis, bad management hypothesis, cost skimming hypothesis, the hypothesis of the positive relationship between efficiency and capital and the shareholders-managers hypothesis.

For the aforementioned purposes, we employ a data sample consisting of aggregated balance sheets and financial data retrieved from 2706 Eurozone and 581 U.S. banks. It involves data from the period 2013-2015 and the selected types of banks are retail, commercial and investment banks. We investigate separately the relationship of capital, risk and efficiency of both economic unions, Eurozone and the U.S. We also examine the three subgroups of Eurozone and those of the U.S. banks depending on the banking sector (retail, commercial and investment banks). Furthermore, we control for environmental and bank-specific variables which affect or explain the capital, risk and efficiency relationship.

Regarding methodology, at the first step of our study, we employ the input-oriented CCR model of data envelopment analysis developed by Charnes et al. (1978) to estimate efficiency. Afterwards, we apply the Z-score to calculate bank risk and the ratio of the value of total equity to total assets as an indicator of bank capital. In the final step, we examine the relationship among capital, risk and efficiency of banking institutions by employing the three-stage least squares (3SLS) model, developed by Zellner and Theil (1962).

This study contributes to empirical research on the interrelationship among risk, capital and efficiency in multiple ways. Firstly, this study is the first to compare the capital risk and efficiency relationship between Eurozone and the U.S. banks by employing post-crisis data. Moreover, the majority of studies investigate the European banking institutions, while our paper focuses on a Eurozone bank sample. Lastly, we fill in the gap from previous literature by examining separately three banking sectors (retail, commercial and investment banks) and provide evidence of whether the links among risk, capital and efficiency vary per type of bank.

The remainder of this paper is organized as follows: Section 2 reviews the existing literature regarding the links among risk, capital and efficiency of banking institutions; Section 3 presents our hypotheses and Section 4 the research methodology; Section 5 describes the data employed in the study; Section 6 describes our empirical results while Section 7 summarizes the findings and presents the conclusions.

2. LITERATURE REVIEW

The interrelationship among capital, risk and efficiency in the banking industry is an issue of significant importance because of the essential role of the banking institutions in the economy. Thus, a great number of academic surveys have focused over the years on the theoretical and the empirical study of the determinants of risk, capital and efficiency and on the examination of the relationships linking those three variables. However, the existing literature yields conflicting results (Fiordelisi et al., 2011b; Tan & Floros, 2013; Nguyen & Nghiem, 2015; Le, 2018).

The inconsistencies among the results of the literature concerning the relationship between capital, risk and efficiency have led to the simultaneous examination of those three variables as one system. Hughes, Lang, Mester, & Moon (1996) is the first to introduce the theoretical argument of the importance of efficiency in the determination of the relationship between risk and capital. Following that study, Kwan and Eisenbeis (1997) were the first to conduct empirical research on the interrelationship between *capital, risk* and *efficiency* by employing a simultaneous equation framework. The sample of their study is the U.S. banks between 1986 and 1995 and the results indicate that a positive relationship between capital and efficiency and an adverse relationship between efficiency and risk exists. Since then, several authors have focused on the aforementioned relationship but it remains unresolved.

For instance, Tan and Floros (2013), Mosko and Bozdo (2016), Le (2018) employ the three-stage least

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[1] For instance: 1) different monetary policies between European Central Bank (negative interest rates) and Federal Reserve (interest rates positive or close to zero); 2) different levels of post-crisis regulatory flexibility, the U.S. regulatory framework is more flexible than Eurozone's (Lakhani, Reid, & Templeman, 2019); 3) the after-crisis restructure of the Eurozone banking system was significantly lower than that of the U.S. (Jenkins, 2015); 4) large stock of non-performing loans, almost double than that of the U.S. (Binham & Noonan, 2015).

squares technique to examine the relationship among capital, risk and efficiency. More specifically, Tan and Floros (2013) assess a sample that consists of Chinese commercial banks and the reported period is 2003-2009. Their results suggest that risk and efficiency are positively and significantly related, whilst the relationship between bank risk and capital is negative and statistically significant. Mosko and Bozdo (2016) examined the relationship between efficiency, capital and risk in the Albanian banking system from 2002 until 2014. The method applied is the three-stage least squares and their results demonstrate that the relationship between risk and capital is positive and the level of efficiency determines both variables. In a recent study, Le (2018) assesses the relationship among risk, capital and efficiency in Vietnamese banking over the period 2007-2011. The results imply that there is an adverse relationship between risk and capital and a direct association between risk and efficiency. The findings additionally suggest that banking institutions with lower risk and higher efficiency have higher capital.

In this context, Deelchand and Padgett (2009) focus on cooperative banks in Japan and examine the relationship among capital, risk and cost inefficiency during 2003-2006 by employing the two-stage least squares method. The results indicate that there is an adverse relationship between capital and risk and that inefficient banks tend to attain more capital and higher risk. Moreover, Bashir and Hassan (2017) employ the generalized method of moments (GMM) technique to assess the relationship among risk, capital and efficiency during the period 1997-2015 and the findings present differences depending on the Basel Accord of each period. More specifically, Basel II Accord was more effective in decreasing the levels of bank risk than the previous accord, Basel I. Additionally, the impact of higher capital ratios on risk and efficiency is examined by Bitar et al. (2018). The researchers use data for 1992 banks from 39 countries over the period 1999-2013 and their results show that higher capital ratios are negatively related to bank risk and positively related to efficiency.

Concerning the studies focusing on the European, the Eurozone and the U.S. banking institutions, the results are contradictory. It is also rather surprising that the number of those studies is very limited. For instance, Altunbas et al. (2007) investigate the relationship among capital, efficiency and risk for European banks over the period 1992-2000. Their results indicate that inefficient banks tend to have more capital and lower risk levels. Furthermore, their findings show that there is a positive association between risk and capital. They separately tested how the aforementioned relationships are developed by the banking sector and their results suggest that savings and commercial banks do not present great diversification, while co-operative banks' capital responded differently to risk changes.

The causality among risk, capital and efficiency is also assessed by Fiordelisi et al. (2011b) where the researchers employ the Granger-causality methodology in a panel data framework to investigate a sample of European commercial banks between 1995-2007. Their results show that a decrease in bank efficiency may lead to higher risk

and a decrease in capital precedes to lower cost efficiency. Fiordelisi, Girardone, and Radic (2011a) assess the relationships among risk, efficiency, capital and competition in the U.S. investment banks during the period 2000-2008. The findings indicate that an increase in efficiency results in an increase in risk levels, an increase in risk temporally forgoes an increase in capital and lower capital leads to higher risk levels.

In a more recent study, Ding and Sickles (2019) investigate the impact of capital regulations on capital, risk and efficiency in the U.S. market between 2001 and 2016 by employing fixed effects, GMM fixed effects and spatial effects models. The results show that stricter capital requirements lead to lower risk-weighted assets, to more non-performing loans and to changes in managerial practices.

However, it is rather surprising that there is only one study which investigates this relationship for European and the U.S. banking institutions, and the comparison is not with post-crisis data. Williams (2004) assesses the relationships between efficiency, capital and loan loss provisions on European savings banks during the period 1990-1998 and performs a robustness test for the U.S. banks. The findings suggest that there is a direct relationship between inefficiency and non-performing loans and that the managerial behavior problems of European banks are inconsistent with those of the U.S. banks.

Concerning the bank type, there is only limited empirical evidence suggesting that different types of banks present different results in the estimation of the relationship among capital, risk and efficiency. For instance, Altunbas et al. (2007) test separately commercial, savings and co-operative banks and finds consistency between commercial and savings banks, while the results for co-operative banks have major differences.

Overall, the majority of studies supported that there is a link connecting capital, risk and efficiency (Le, 2018; Kwan & Eisenbeis, 1997; Berger & DeYoung, 1997). However, the existing literature concerning these issues remains inconclusive as it yields conflicting results. The differences on the results are mainly focused on the direction of causality as well as the temporal order.

3. HYPOTHESES DEVELOPMENT

In order to clarify these relationships, and before introducing our empirical model, we examine the validity of a set of managerial hypotheses about the expected relationships, following a great number of academic surveys, for instance: Berger and DeYoung (1997), Williams (2004), Fiordelisi et al. (2011b), Fiordelisi and Mare (2014), etc.

3.1. Capital & risk

Null hypothesis H1.0: "Regulatory Hypothesis"

The first hypothesis is based on the *Regulatory Hypothesis*. It indicates that there is a positive relationship between risk and capital (Altunbas et al., 2007; Bashir & Hassan, 2017). More specifically, according to this hypothesis banks are required by the regulators to increase the amount of

bank capital when the undertaken bank risk increases in order to counter the risk of default.

Alternative hypothesis H1.1: "Moral Hazard Hypothesis"

The second hypothesis is the alternative to the regulatory hypothesis; it states that capital has a negative impact on risk (and vice versa) and it is studied as the *Moral Hazard Hypothesis* (Berger & DeYoung, 1997; Williams, 2004; Anginer & Demirgüç-Kunt, 2014). According to this hypothesis, the managers of poorly capitalized banks have moral hazard incentives to take on increased portfolio risks as those banks face more risks as a result of lower capital adequacy.

3.2. Risk & efficiency

Null hypothesis H2.0: "Bad Management Hypothesis"

The third hypothesis examined is the *Bad Management Hypothesis* (Berger & DeYoung, 1997; Williams, 2004). Under this hypothesis, we assume that there is an inverse relationship between risk and efficiency since a decrease in efficiency could provide motivation to the managers to increase the risk levels of the bank and offset the low efficiency levels. Moreover, badly managed banks suffer from higher costs, credit and operational problems and lower efficiency as a result of the inefficient controlling of the operating expenses and of the risk monitoring.

Alternative hypothesis H2.1: "Bad Luck Hypothesis"

Another hypothesis that advocates the negative relationship between risk and capital is the *Bad Luck Hypothesis*, developed by Berger and DeYoung (1997). According to this hypothesis an exogenous event (for instance financial shocks) which cannot be controlled by the bank manager, may cause an increase in risk. For example, an increase in the non-performing loans of the banks. In this case, the costs of monitoring and managing the problematic loans, the bank provisions and the managerial efforts may increase, so the efficiency is reduced. Therefore, an increase in risk results in a decrease in the levels of efficiency (Tan & Floros, 2013; Williams, 2004; Le, 2018).

Although both the Bad Luck and the Bad Management hypotheses suggest that there is a negative association between risk and efficiency, they follow the opposite causality order. As stated in the bad luck hypothesis, the increase in risk occurs before the decrease in the levels of efficiency. According to the bad management hypothesis, the decrease in efficiency comes first.

Alternative hypothesis H2.2: "Cost Skimming Hypothesis"

The fifth hypothesis is the *Cost Skimming Hypothesis*, which is the alternative hypothesis to the Bad Management Hypothesis. In this hypothesis risk and efficiency are assumed to be positively correlated.

Under this hypothesis, banks that do not spend resources on risk monitoring and especially credit risk monitoring (monitoring of non-performing loans as well as of loans) appear to be more efficient

in the short term. On the contrary, they take on higher risk in the medium and long term as this managerial behavior affects the quality of future loans (Altunbas et al., 2007; Bashir & Hassan, 2017; Williams, 2004; Nguyen & Nghiem, 2015).

3.3. Efficiency & capital

Null hypothesis H3.0: "There is a Positive Relationship Between Efficiency and Capital"

The sixth hypothesis of our analysis states that capital affects efficiency positively. According to this hypothesis, the higher capital is, the higher the incentives of shareholders are to carefully monitor the managerial behavior and investment decisions, and thus bank efficiency would be expected to increase (Chortareas, Girardone, & Ventouri, 2011).

Alternative hypothesis H3.1: "Shareholders-Managers Hypothesis"

Last but not least, *Shareholders-Managers Hypothesis* suggests that the relationship between efficiency and capital is negative due to the moral hazard incentives of the bank managers.

4. RESEARCH METHODOLOGY

For the purposes of our survey, we employ a four-step approach. At first, the efficiency of our banking institutions is measured by applying the input-oriented CCR model of data envelopment analysis (DEA) developed by Charnes et al. (1978). This methodology evaluates the ability of a decision making unit (DMU) to convert a number of inputs into outputs.

$$maxZ_0 = \sum_t (u_t \times y_{t0})$$

s.t.

$$j = 1, ..., n$$

$$i = 1, ..., m$$

$$t = 1, ..., s$$

$$\sum_r (u_t \times y_{tj}) - \sum_i (v_i \times x_{ij}) = 0$$

$$\sum_i (v_i x_{i0}) = 1$$

$$v_i \geq \varepsilon \geq 0$$

$$u_t \geq \varepsilon \geq 0$$

where i = inputs; t = outputs; j = decision making units (DMU); v_i = relative importance of input i; u_t = relative importance of output t; ε = non-Archimedean value.

If the DMU_0 is efficient (equal to 1), this means that there is at least one optimal solution to the aforementioned equation and the efficiency of a DMU is higher when the efficiency score increases. In this paper, the selected inputs are staff expenses, the book value of fixed assets and time and demand deposits, while the selected outputs are loans and advances to banks and customers and net interest income.

In the next step of our study, we measure bank capital by employing the ratio of the value of total equity to total assets. This ratio is mainly employed in the literature (Deelchand & Padgett, 2009). Subsequently, we employ the Z-score as the measurement of bank risk, due to the fact that it serves as an indicator of financial stability in the banking industry.

$$Z-score_{(t,i)} = \frac{\frac{equity_{(t,i)}}{total\ assets_{(t,i)}} + ROA_{(t,i)}}{\sigma(ROA)_{(T,i)}}$$

where T = full sample period; t = time; i = bank; ROA = ratio of return on average assets.

In the final step, we examine the relationship among capital, risk and efficiency of banking institutions by employing the three-stage least squares (3SLS) model, developed by Zellner and Theil (1962).

Apart from 3SLS model, various approaches have been employed in the literature, such as the Granger-causality techniques (Fiordelisi et al., 2011b; Williams, 2004). Nonetheless, the results of this model are sensitive to model specification and to the number of lags (Nguyen & Nghiem, 2015). Another technique vastly employed is ordinary least squares, but the 3SLS is preferred, as it supplies consistent estimates of the parameters (Jacques & Nigro, 1997). Furthermore, the ordinary least squares model is not considered as a robust model because it disregards the correlation of error terms across equations (Tan & Floros, 2013).

In our study, we employ the 3SLS model in a panel data framework, selected as it considers potential endogeneity between variables as well as cross-correlation of error terms (Tan & Floros, 2013; Shim, 2013). Additionally, the 3SLS model incorporates the two-stage least squares and the seemingly unrelated regression (SUR) approach and is preferred in many studies (Tan & Floros, 2013; Le, 2018; Nguyen & Nghiem, 2015). The two-stage least squares is also in much of the literature (Deelchand & Padgett, 2009; Kwan & Eisenbeis, 1997), as well as the SUR approach (Altunbas et al., 2007). Moreover, the 3SLS procedure is chosen over the two-stage least squares as it is a "full-information estimation technique which estimates all parameters simultaneously" and thus "because it incorporates the cross-equation correlations, it produces parameter estimates which are asymptotically more efficient than 2SLS" (Jacques & Nigro, 1997, p. 541).

The system of simultaneous equations employed in our paper, in order to investigate the relationship among capital, risk and efficiency, is defined as follows:

$$RISK_{i,t} = \alpha_0 + \alpha_1 CAP_{i,t} + \alpha_2 EFF_{i,t} + \alpha_3 ENV_{i,t} + \alpha_4 LEND_{i,t} + \alpha_5 LIQ_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$EFF_{i,t} = \beta_0 + \beta_1 CAP_{i,t} + \beta_2 RISK_{i,t} + \beta_3 LEND_{i,t} + \beta_4 ENV_{i,t} + \beta_5 SIZE_{i,t} + \beta_6 LIQ_{i,t} + \theta_{i,t} \quad (2)$$

$$CAP_{i,t} = \gamma_0 + \gamma_1 EFF_{i,t} + \gamma_2 RISK_{i,t} + \gamma_3 INT_{i,t} + \gamma_4 PROF_{i,t} + \gamma_5 ENV_{i,t} + \omega_{i,t} \quad (3)$$

where
- *RISK*: the measure of risk,
- *CAP*: the measure of capital,
- *EFF*: the measure of efficiency,
- *SIZE*: the natural logarithm of total assets,
- *PROF*: the ratio of profit before tax to average total assets,
- *INT*: the ratio of gross loans to total deposits,
- *ENV*: the environmental variables: GDP real growth rate (*GDP*), inflation rate (*INFL*), budget balance (*BUDG*), public debt (*PUBD*), unemployment (*UNE*), current account balance (*CURR*) and trade balance (*TRA*),
- *LEND*: the ratio of gross loans to total assets,
- *LIQ*: the ratio of liquid assets to total assets,
- $\varepsilon, \theta, \omega$: random errors,
- i: bank dimension,
- t: time dimension.

The first equation (1) examines whether changes in the level of bank capital and bank efficiency temporarily precede variations in bank risk. The second equation (2) investigates if capital and risk temporarily forego variations in efficiency while the third equation (3) analyzes if efficiency and risk variations reflect changes in the level of bank capital.

In addition to capital, risk and efficiency of the banking institutions, in our study we also control for other variables which both affect and explain the relationship of the above mentioned variables. Firstly, we include environmental variables (*ENV*) as explanatory variables. It is very important to take them into consideration, especially for the Eurozone sample, as it presents a wide diversity of the environmental variables of each Eurozone country. More specifically, the selected factors indicate the country-specific conditions of each bank: GDP real growth rate, inflation rate, budget balance, public debt, the unemployment rate, current account balance and trade balance.

Moreover, following Nguyen and Nghiem (2015), the environmental variables for capital include: 1) an indicator of profitability (*PROF*) which is the ratio of profits before taxes to average total assets; and 2) an indicator of bank intermediation (*INT*) which is the ratio of gross loans to total deposits. The profitability indicator is expected to affect positively the capital ratio, as it is easier for a bank with higher retained earnings (all else being equal) to acquire more capital (Le, 2018). In the same pattern, banks with a higher ratio of gross loans to total deposits are more profitable and therefore attain more capital.

The control variable of the size of the bank (*SIZE*) was employed as an indicator for efficiency and is calculated as the natural logarithm of total assets. According to Drake (2001), it is expected that the size of bank assets and efficiency are positively connected because of economies of scale.

Moreover, following Le (2018) and Nguyen and Nghiem (2015) in both efficiency and risk equations we employ the following indicators; lending specialization (*LEND*) and liquidity (*LIQ*).

Regarding lending specialization, it is measured as the ratio of gross loans to total assets. According to many studies, excessive lending and risk are positively related, as new loan productivity possibly is offered to borrowers who were rejected in the past or do not have sufficient collateral (Le, 2018). Moreover, a greater lending specialization level is positively connected to efficiency as more efficient banks have lower production costs and therefore

can provide loans with lower rates and costs than their competitors (Nguyen & Nghiem, 2015).

Risk and efficiency are influenced by the explanatory variable liquidity. This variable can be calculated by the ratio of liquid assets to total assets (Ben Salah Mahdi & Boujelbene Abbes, 2018) and it is expected to affect risk negatively, as a bank with higher liquidity ratios has greater capability to meet its liabilities (Zhang, Jiang, Qu, & Wang, 2013).

5. THE DATA SET

Our sample comprises of aggregated balance sheet and financial data retrieved from 3287 banks and it is separated into two parts; Eurozone and the United States banks (Figure 1). The types of banking institutions selected are retail, commercial, investment and saving banks and they were preferred as they compose the largest types of banks in the economic unions of our sample. We also adjust our data omitting banks with incomplete or missing annual financial data over the reported period.

The financial data employed in our survey are the following: total expenses of staff, book value of the fixed assets, time and demand deposits, net loans and advances to banks, net loans and advances to customers, interest income, interest expenses, total equity, total assets, ROA, liquid assets, profit before tax, gross loans and total deposits.

The reported period of our study is from 2013 until 2015. This period is selected because the research in the banking field by employing post-crisis data is limited and the examination of the development of the relationships among capital risk and efficiency after the financial crisis is even more limited.

Figure 1. Data sample
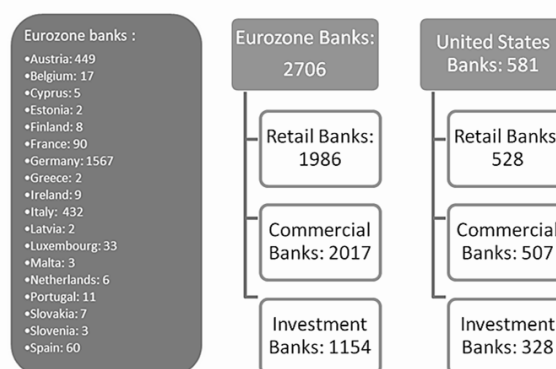
6. EMPIRICAL RESULTS

The results of the estimation of the equations (1), (2), (3), attained by employing the 3SLS procedure for each type of bank, are presented in the following tables. We observe in Table 1 and Table 2 that the *chi2* and *P* variables obtained from the 3SLS model for all bank groups in our sample indicate that the equation systems employed have statistical significance.

6.1. Risk determinants

Tables 1 and 2 present the regression results for the 3SLS estimation for the Eurozone and U.S. samples of banks and their subgroups in regard to the determinants of bank risk.

Table 1. Determinants of risk of Eurozone banks

	Eurozone	*Commercial*	*Retail*	*Investment*
		RISK		
CAP	0.0859***	0.0824***	0.152***	0.0837***
	(0.00162)	(0.00160)	(0.00583)	(0.00179)
EFF	-1.250***	-1.180***	0.521*	-0.745***
	(0.119)	(0.115)	(0.247)	(0.0978)
GDP	0.0277***	0.0234***	0.0215*	0.00189
	(0.00481)	(0.00508)	(0.00883)	(0.00658)
INFL	-0.103***	0.0788***	-0.219***	0.00590
	(0.00854)	(0.00898)	(0.0155)	(0.0111)
BUDG	-0.0202**	-0.0194**	-0.0319**	0.0271***
	(0.00681)	(0.00714)	(0.0116)	(0.00750)
PUBD	0.00132**	0.00245***	0.00503***	-0.00170*
	(0.000431)	(0.000459)	(0.000784)	(0.000699)
UNE	-0.0176***	-0.00432	-0.0367***	0.00379
	(0.00232)	(0.00242)	(0.00374)	(0.00284)
CURR	0.0133**	0.0319***	0.106***	-0.0321***
	(0.00498)	(0.00535)	(0.00997)	(0.00716)
TRA	-0.0109***	-0.0131***	-0.0651***	0.0136***
	(0.00265)	(0.00288)	(0.00573)	(0.00394)
LEND	0.459***	0.344***	0.277***	0.407***
	(0.0308)	(0.0334)	(0.0558)	(0.0371)
LIQ	-0.235***	-0.305***	-0.177***	-0.239***
	(0.0315)	(0.0361)	(0.0498)	(0.0429)
_cons	1.108***	1.029***	0.459***	1.417***
	(0.0602)	(0.0640)	(0.132)	(0.0860)
N	8107	6202	5950	3460
R-sq	0.484	0.537	-0.073	0.624
Chi2 for equation (1)	4509.88	3870.77	2475.94	2701.03
P for equation (1)	0	0	0	0
Chi2 for equation (2)	2249.99	2155.17	1128.46	1491.88
P for equation (2)	0	0	0	0
Chi2 for equation (3)	784.14	529.91	790.02	622.37
P for equation (3)	0	0	0	0

Note: This table presents the regression results for the 3SLS estimation for the Eurozone sample of banks and their subgroups. Standard errors are presented in parentheses. $* p < 0.05$, $** p < 0.01$, $*** p < 0.001$

Table 2. Determinants of risk of the U.S. banks

	The U.S.	*Commercial*	*Retail*	*Investment*
		RISK		
CAP	0.111***	0.163***	0.0968***	0.0767***
	(0.00369)	(0.0108)	(0.00283)	(0.00217)
EFF	-0.0787***	0.292**	-0.0834	-0.195**
	(0.00145)	(0.0916)	(0.0518)	(0.0609)
GDP	0	0	0	0
	(.)	(.)	(.)	(.)
INFL	-0.0213*	0.163***	0.137***	0.204***
	(0.00910)	(0.0163)	(0.00784)	(0.0124)
BUDG	0	0	0	0
	(.)	(.)	(.)	(.)
PUBD	0.0145***	0.0133***	0.0205***	0.0255***
	(0.000746)	(0.00189)	(0.000605)	(0.000445)
UNE	0.0202**	-0.0604***	-0.0290***	-0.0552***
	(0.00685)	(0.0122)	(0.00590)	(0.00465)
CURR	0	0	0	0
	(.)	(.)	(.)	(.)
TRA	0	0	0	0
	(.)	(.)	(.)	(.)
LEND	0.0650**	0.00587	0.0599**	0.122***
	(0.0242)	(0.0448)	(0.0195)	(0.0251)
LIQ	1.01e-10	0.0280	0.0147*	0.0116
	(9.14e-11)	(0.0188)	(0.00739)	(0.00861)
_cons	0	0	0	0
	(.)	(.)	(.)	(.)
N	1743	1521	1584	984
R-sq	0.547	-0.215	0.731	0.883
Chi2 for equation (1)	362382.89	132191.84	549239.52	982547.15
P for equation (1)	0	0	0	0
Chi2 for equation (2)	63271.85	85089.74	74388.87	88502.64
P for equation (2)	0	0	0	0
Chi2 for equation (3)	1591.59	1308.89	1413.60	1598.05
P for equation (3)	0	0	0	0

Note: This table presents the regression results for the 3SLS estimation for the U.S. sample of banks and its subgroups. Standard errors are presented in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001

Concerning the drivers of bank risk (eq. 1), as reported in Table 1 and Table 2, the variable of capital is suggested to have a positive and statistically highly significant (p < 0.001) effect on the risk of all banks in our sample, for both Eurozone and the U.S. banks irrespective of the bank type. Thus, our findings indicate that a rise in capital precedes an increase in bank risk. This finding rejects the second hypothesis as it provides evidence that Eurozone and the U.S. banks do not record moral hazard managerial incentives. Our results are consistent with Fiordelisi et al. (2011b) and Altunbas et al. (2007) as well as Anginer and Demirguc-Kunt (2014). However, Nguyen and Nghiem (2015), Le (2018) and Kwan and Eisenbeis (1997) support the Moral Hazard Hypothesis and seem to suggest that banks take advantage of deposit insurance. Yet, Bitar et al. (2018) and Cathcart, El-Jahel, and Jabbour (2015) support that there is no association between capital and risk.

Furthermore, according to our findings, efficiency appears to have a negative and statistically significant effect (p < 0.05) on bank risk for the majority of the reported samples with the exception of Eurozone retail banks and the U.S. commercial banks. Therefore, an improvement in efficiency foregoes a decrease in bank risk for the majority of the tested bank groups. This outcome concurs with the Bad Management Hypothesis which could be explained by the fact that badly managed banks tend to attain higher risks in order to compensate for lower levels of efficiency, which is in line with the findings of Williams (2004), Fiordelisi et al. (2011b), Deelchand and Padgett (2009), Kwan and Eisenbeis (1997). However, the positive and significant effect of efficiency on bank risk of Eurozone retail banks can be attributed to the existence of cost skimming behavior. This outcome is comparable to Fiordelisi et al. (2011a) findings for investment banks over the period 2000-2008. We should also mention that the α2 parameter of the U.S. retail bank sample is insignificant.

In all banking groups, except the U.S. commercial banks, an increase in the ratio of gross loans to total assets (*LEND*) is directly and statistically significantly related to risk. This result is in line with our expectations as an increase in lending ratios may lead to an increase in the liquidity risk of banks. Those findings are consistent with the results of the study of Le (2018).

Concerning the effect of liquidity on risk, we observe that the ratio of liquid assets to total assets (*LIQ*) has a negative and statistically highly significant effect on Eurozone banks. Thus, the results indicate that an increase in the liquidity levels of Eurozone banks precedes a decrease in the level of risk. This outcome is inconsistent with the results of Altunbas et al. (2007) for European banks during the pre-crisis period. When comparing their findings with our results of the post-crisis period, we notice that Eurozone banks have not yet started to react to an increase in the liquidity level by increasing their lending and investment levels, as they did before the financial crisis. However, the effect on the U.S. banks is non-significant to all the samples except for the U.S. retail banks which

exhibit a positive and significant parameter. We may conclude that Eurozone and the U.S. banks react differently to a liquidity level change and this possibly could be attributed to the fact that the speed of recovery from the financial crisis is lower in Eurozone than in the U.S., the non-performing loans are more in the U.S. and ECB's interest rates are negative (McLannahan & Arnold, 2017). Therefore, our findings indicate that the relationship between levels of liquidity and risk is sensitive to the speed of recovery from the financial crisis.

As regards the effect of environmental variables, we observe that almost all the variables are statistically significant for the Eurozone sample, whilst only the inflation rate (*INFL*), public debt (*PUBD*) and unemployment (*UNE*) are statistically significant for the U.S. sample. More specifically, we notice that the Eurozone investment banks' parameters either are not statistically significant or have different signs compared to the variables of the other Eurozone samples. This finding implies that the risk undertaken by Eurozone investment banks is affected by macroeconomic variables in a different way to that of the other types of Eurozone banks. To be more precise, GDP real growth rate (*GDP*) impacts positively and significantly on the risk of Eurozone banks, but the parameter of Eurozone investment banks is non-significant. This could be explained as banks boost their lending and investing policy during favorable economic circumstances, thus the levels of bank risk increase. Following the same pattern, budget balance (*BUDG*) and trade balance (*TRA*) variables are negative and significant for Eurozone banks, while for the Eurozone investment

banks they are positive and significant. Concerning the current account balance (*CURR*), our findings indicate that it affects positively and significantly Eurozone banks, with the exception of Eurozone investment banks.

Additionally, public debt (*PUBD*) affects positively and significantly the banking risk in the general sample except for Eurozone investment banks, which are affected negatively and significantly. Moreover, the inflation ratio (*INFL*) is statistically significant to both the Eurozone and the U.S. samples but not Eurozone investment banks. Besides Eurozone investment banks and the U.S. general sample, unemployment (*UNE*) affects negatively and significantly the risk of the other banks, while Eurozone retail banks are not-statistically affected, whereas the U.S. general sample is positively and significantly affected.

6.2. Efficiency determinants

Tables 3 and 4 present our findings in regard to the determinants of bank efficiency. We notice that the findings are not statistically significant for general samples of Eurozone and the U.S. banks. However, our findings are statistically significant for the subgroups of commercial, retail and investment banks and the direction of causality is similar per the banking sector, irrespective of the location of banks. Therefore, we may conclude that the type of bank is a very important parameter for the impact of various determinants on bank efficiency.

Table 3. Determinants of efficiency of Eurozone banks

	Eurozone	*Commercial*	*Retail*	*Investment*
		EFFICIENCY		
RISK	0.740	62.45***	-5.648***	0.632
	(0.462)	-8.749	(0.923)	(0.908)
CAP	-0.0433	-4.745***	0.984***	-0.0151
	(0.0370)	(0.674)	(0.181)	(0.0664)
SIZE	0.0822***	2.871***	0.234***	0.128***
	(0.0157)	(0.364)	(0.0603)	(0.0349)
LEND	0.207*	-3.818***	1.734***	0.0952
	(0.0971)	(0.716)	(0.255)	(0.275)
LIQ	0.676**	36.13***	-3.539***	-0.0496
	(0.212)	-4.822	(0.894)	(0.191)
GDP	-0.0161	-1.048***	0.144***	-0.00308
	(0.0125)	(0.145)	(0.0298)	(0.0189)
INFL	0.0533	-4.917***	-1.233***	-0.0439
	(0.0429)	(0.695)	(0.193)	(0.0401)
BUDG	0.00153	0.859***	-0.188***	-0.0572
	(0.0133)	(0.132)	(0.0366)	(0.0460)
PUBD	-0.000296	-0.142***	0.0238***	-0.00226
	(0.000998)	(0.0211)	(0.00422)	(0.00212)
UNE	0.00824	0.293***	-0.213***	-0.0179
	(0.00881)	(0.0482)	(0.0375)	(0.0116)
CURR	-0.00881	-1.878***	0.638***	0.00249
	(0.0120)	(0.276)	(0.117)	(0.0314)
TRA	0.0113	0.946***	-0.442***	0.00348
	(0.00815)	(0.137)	(0.0848)	(0.0141)
_cons	-2.395**	-115.0***	-0.437	-2.451
	(0.790)	(15.33)	(0.562)	-1.680

Note: This table presents the regression results for the 3SLS estimation for the Eurozone sample of banks and their subgroups. Standard errors are presented in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001

Table 4. Determinants of efficiency of the U.S. banks

	The U.S.	*Commercial*	*Retail*	*Investment*
		EFFICIENCY		
RISK	0	3.373***	-11.32**	-4.789***
	(.)	(0.814)	-4.351	(0.884)
CAP	0.0249	-0.551***	1.096**	0.366***
	(0.0938)	(0.138)	(0.410)	(0.0643)
SIZE	0.0776***	0.00399	0.00372	0.00442
	(0.00195)	(0.0127)	(0.00761)	(0.00428)
LEND	-0.0588	-0.0197	0.756	0.631***
	(0.615)	(0.141)	(0.403)	(0.103)
LIQ	-4.92e-10	-0.0976	0.156*	0.0332
	(2.33e-09)	(0.0677)	(0.0750)	(0.0373)
GDP	0	0	0	0
	(.)	(.)	(.)	(.)
INFL	0.0283	-0.548***	1.554**	0.991***
	(0.232)	(0.140)	(0.599)	(0.153)
BUDG	0	0	0	0
	(.)	(.)	(.)	(.)
PUBD	-0.0173	-0.0455**	0.231**	0.121***
	(0.0190)	(0.0147)	(0.0877)	(0.0221)
UNE	-0.0144	0.203***	-0.329*	-0.266***
	(0.175)	(0.0617)	(0.132)	(0.0480)
CURR	0	0	0	0
	(.)	(.)	(.)	(.)
TRA	0	0	0	0
	(.)	(.)	(.)	(.)
_cons	0	0	0	0
	(.)	(.)	(.)	(.)

*Note: This table presents the regression results for the 3SLS estimation for the U.S. sample of banks and its subgroups. Standard errors are presented in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*

An increase in capital affects positively and significantly the efficiency of Eurozone and the U.S. commercial banks. Therefore, our results indicate that commercial banks that have more capital may have higher efficiency than those with less capital and therefore the sixth hypothesis is accepted for the commercial banks group. This outcome concurs with Le (2018), Bitar et al. (2018), Fiordelisi et al. (2011b) and could be explained in the following way: the higher capital is, the higher the incentives of shareholders are to carefully monitor the managerial behavior and investment decisions, and thus bank efficiency would be expected to increase. Moreover, it is more likely that banks with a high capital ratio will reduce their costs (as depositors entrust the banking institution more) and increase efficiency more than those with lower levels of capital (Bitar et al., 2018).

However, the impact of an increase in the capital on the efficiency of Eurozone and the U.S. retail banks, as well as on the efficiency of the U.S. investment banks, is negative and significant. This may be so because when capital increases, so do the agency costs and the total amounts at the disposal of managers, thus leading to efficiency decreases. Hence, the Shareholders-Managers Hypothesis is accepted for retail banks and the U.S. investment banks, and this result is in line with Deelchand and Padgett (2009) and Bashir and Hassan (2017).

Following the same pattern, an increase in risk precedes a decrease in commercial banks' efficiency (statistically highly significant outcome). This finding is in line with Nguyen and Nghiem (2015) and Le (2018) and may be explained by the fact that a bank with high risk operations may need a higher level of resources to produce the same outcome. For instance, it requires more funds to manage loans associated with higher risks in comparison with a lower risk loan portfolio (Kwan & Eisenbeis, 1997).

However, the impact of risk on retail banks and the U.S. investment banks is positively and statistically significant. This outcome is in line with Bashir and Hassan (2017) findings. Thus, the Bad Luck Hypothesis is confirmed for commercial banks and rejected for retail banks and the U.S. investment banks, and hence our findings seem to suggest that the impact of risk on efficiency levels depends on the type of the bank.

An increase in the explanatory variable *SIZE* precedes an increase in the efficiency of Eurozone banks. The outcome is positive, statistically highly significant and consistent with the findings reported by Le (2018), Altunbas et al. (2007), Sufian (2016) and Bitar et al. (2018) indicating that the larger banks are the more efficient they become because of higher economies of scale. We observe the same outcome with the U.S. banks general sample while the outcome of the subgroups of the U.S. banks is not significant. Yet our result is inconsistent with Deelchand and Padgett (2009).

The explanatory variable *LEND* (gross loans to total assets) is positive and statistically significant in most cases (Eurozone general sample, Eurozone retail banks and the U.S. investment banks). This finding complies with previous results (Nguyen & Nghiem, 2015; Bitar et al., 2018; Le, 2018; Altunbas et al., 2007), implying that banking institutions with higher gross loans to assets ratios are more efficient, and banks with higher levels of efficiency increase successfully their lending levels. However, the link is negative and statistically highly significant for Eurozone commercial banks. For the rest of the sample, the outcome is insignificant.

An increase in the liquidity ratio (*LIQ*) is not significant for the efficiency of the investment banks in our sample. The relationship is negative and significant for Eurozone retail banks, while it is positive and significant for the Eurozone general

sample, Eurozone commercial banks and the U.S. retail banks. Ding and Sickles (2019) in their study report results that indicate that there is a positive relationship between liquidity and efficiency.

Concerning the environmental variables, none of the results are significant for the U.S. investment banks as well as for Eurozone and the U.S. general samples. This could be an indication that the type of bank is a very important factor in regards to the effect of macroeconomic variables on efficiency. More precisely, the GDP real growth rate (*GDP*) affects negatively the efficiency of commercial banks while positively affecting the efficiency of retail banks. Similarly, the current account balance (*CURR*) relationship with efficiency is direct for retail banks, yet adverse for commercial banks. All of the above results are statistically significant. Bitar, et al. (2018) show that GDP real growth rate is positively related to bank efficiency levels. On the other hand, an increase in the budget balance (*BUDG*) impacts positively and statistically significant the efficiency of Eurozone commercial banks yet negatively and significantly the efficiency of Eurozone retail banks.

The inflation ratio (*INFL*) affects negatively and highly significantly the efficiency of commercial banks and Eurozone retail banks, while it affects positively and highly significantly the efficiency of the U.S. retail and investment banks. In addition, public debt (*PUBD*) affects positively and significantly the retail banks of our sample and the U.S. investment banks, while it affects negatively the commercial banks of our sample. Last but not least,

an increase in unemployment (*UNE*) impacts positively and significantly on the retail banks of both samples, while the impact is negative and significant on the U.S. investment banks.

6.3. Capital determinants

According to Table 5 and Table 6, the variable efficiency is found to have a negative and significant effect on the capital of all Eurozone banks as well as the U.S. retail and investment banks, while the findings of the rest of the sample are also negative, but not statistically significant. This may be due to the fact that banks tend to use their retained earnings when efficiency increases, and thus capital ratios are diminished while banks tend to adopt the precautionary measure of enhancing their capital when efficiency declines because of regulatory pressure (Nguyen & Nghiem, 2015; Le, 2018; Altunbas et al., 2007; Deelchand & Padgett, 2009; Kwan & Eisenbeis 1997; Bashir & Hassan, 2017).

Moreover, the risk is suggested to have a positive and statistically significant effect on the capital of all the reported groups in our sample. This outcome supports the first hypothesis (the Regulatory Hypothesis) for Eurozone and the U.S. banks regardless of the type of bank, and it is in line with Le (2018), Fiordelisi et al. (2011a) and Fiordelisi et al. (2011b). However, our result is inconsistent with Deelchand and Padgett (2009) findings for Japanese banking system.

Table 5. Determinants of capital of Eurozone banks

	Eurozone	Commercial	Retail	Investment
		CAPITAL		
EFF	-33.43***	-26.54***	-22.53***	-36.99***
	-2.552	-2.804	-3.122	-3.410
RISK	4.801***	4.379***	3.365***	5.198***
	(0.478)	(0.620)	(0.631)	(0.601)
PROF	94.68***	154.7***	54.78***	116.4***
	-7.025	(12.66)	(10.32)	-9.486
INT	0.00262***	0.00258***	0.000838***	0.0356***
	(0.000215)	(0.000286)	(0.000203)	(0.00346)
GDP	0.521***	0.597***	0.150	0.665***
	(0.0808)	(0.0912)	(0.0866)	(0.112)
INFL	-0.0962	-0.348*	0.320	-1.163***
	(0.159)	(0.150)	(0.251)	(0.204)
BUDG	-0.259*	-0.0204	-0.130	-1.005***
	(0.114)	(0.117)	(0.119)	(0.137)
PUBD	-0.0233***	-0.0257***	-0.0376***	0.0676***
	(0.00694)	(0.00748)	(0.00671)	(0.0124)
UNE	0.216***	0.217***	0.155***	-0.180***
	(0.0374)	(0.0387)	(0.0387)	(0.0496)
CURR	-0.463***	-0.557***	-0.774***	0.430***
	(0.0805)	(0.0853)	(0.0793)	(0.119)
TRA	0.213***	0.194***	0.406***	-0.197**
	(0.0425)	(0.0446)	(0.0458)	(0.0661)
_cons	3.876**	4.010*	7.226**	-2.008
	-1.457	-1.601	-2.202	-1.820

*Note: This table presents the regression results for the 3SLS estimation for the Eurozone sample of banks and their subgroups. Standard errors are presented in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001*

Table 6. Determinants of capital of the U.S. banks

	The U.S.	*Commercial*	*Retail*	*Investment*
		CAPITAL		
EFF	-11.19	-12.06	-8.014*	-3.581*
	-8.860	-7.305	-3.301	-1.533
RISK	15.59*	11.83***	14.84***	14.27***
	-6.462	-3.137	-2.710	-1.389
PROF	-15.01	1.537	-21.60	1.780
	(28.98)	(16.51)	(23.63)	(11.29)
INT	0.116	0.211	0.0820*	0.119**
	(0.0937)	(0.136)	(0.0337)	(0.0442)
GDP	0	0	0	0
	(.)	(.)	(.)	(.)
INFL	0.479	-1.815***	-1.908***	-1.761***
	(0.264)	(0.450)	(0.347)	(0.152)
BUDG	0	0	0	0
	(.)	(.)	(.)	(.)
PUBD	-0.321	-0.288*	-0.353***	-0.378***
	(0.185)	(0.113)	(0.0861)	(0.0472)
UNE	-0.424	0.646***	0.289***	0.641***
	(0.228)	(0.163)	(0.0803)	(0.0746)
CURR	0	0	0	0
	(.)	(.)	(.)	(.)
TRA	0	0	0	0
	(.)	(.)	(.)	(.)
_cons	0	0	0	0
	(.)	(.)	(.)	(.)

Note: This table presents the regression results for the 3SLS estimation for the U.S. sample of banks and its subgroups. Standard errors are presented in parentheses. $* p < 0.05, ** p < 0.01, *** p < 0.001$

We also observe that the outcome of the effect of all the reported variables on capital for the U.S. general sample, except for risk, is not statistically significant. Therefore, the type of bank is a very important explanatory variable concerning the U.S. bank capital.

The ratio of profits before tax to average total assets (*PROF*) affects positively and is statistically highly significant for the capitalization of Eurozone banks, while the outcome for the U.S. banks is not statistically significant. Therefore, this finding is in line with Le (2018), Bitar et al. (2018) as well as Kwan and Eisenbeis (1997), and it implies that higher profitability results in the enhancement of bank capital. Shim (2013) mentions that as long as dividend payments tend to become less popular, it is easier for banks to attain more capital. So, when earnings are higher, banks prefer retained earnings as a cheaper solution to external borrowing.

An increase in the ratio of gross loans to total deposits (*INT*) leads to an enhancement of bank capital in the U.S. investment and retail banks as well as all types of Eurozone banks and the general sample. The outcome is statistically significant. This result is explained as banks with higher ratios of gross loans to total deposits are more profitable and therefore attain more capital (Nguyen & Nghiem, 2015; Le, 2018).

Additionally, the environmental parameters reveal some interesting results. Concerning GDP real growth rate (*GDP*), the impact is positive and statistically highly significant only for the Eurozone general sample, Eurozone retail and Eurozone investment banks. We can also observe that the inflation ratio (*INFL*) affects the capital of subgroups of the U.S. banks (retail, commercial and investment banks), Eurozone commercial and Eurozone investment banks negatively and significantly. One possible explanation could be that the higher inflation is, the lower deposits are, because of the deterioration of the value of money (Tan & Floros, 2013).

As regards the budget balance variable (*BUDG*), it affects negatively and significantly only the Eurozone general sample and Eurozone investment banks, while for the rest of the sample the relationship is insignificant. An increase in public debt (*PUBD*) foregoes a decrease in the capital for the U.S. subgroups and of the Eurozone general sample, Eurozone retail banks and Eurozone commercial banks. However, Eurozone investment banks are affected positively and significantly. Additionally, the parameter of unemployment (*UNE*) impacts positively and significantly on the capital of all banks in our sample, except for the U.S. general sample.

Lastly, the findings for the effect of trade balance (*TRA*) and current account balance (*CURR*) on the capital of banks is statistically significant only for the European sample. More specifically, the trade balance parameter is found to be associated positively and significantly for the Eurozone banks, but negatively with European investment banks. On the other hand, an increase in the current account balance leads to a decrease in the capital of the Eurozone sample and to an increase in the capital of investment banks.

7. CONCLUSION

In this study, we investigate the interrelationship among risk, capital and efficiency in a simultaneous equation model. We provide empirical evidence of how the interrelationships and the managerial behaviours vary per type of bank (retail, commercial and investment banks) and per country union (Eurozone, the United States).

Apart from the contribution to the existing empirical research, our findings have important implications for regulators, bank managers and shareholders. Initially, the main result of our study which shows that an increase in the capital may precede an increase in risk supports the Regulatory Hypothesis and may question the effectiveness of

the traditional capital adequacy regulation framework as a measure for the stability of the banking system. Our results also confirm the necessity to consider bank efficiency when implementing measures of financial stability, since an increase in efficiency levels may precede a decrease in capital and risk. Hence, the Bad Management Hypothesis is accepted for the majority of the bank groups in our sample. Additionally, the empirical evidence suggests that the type of banking institutions is a factor that should be considered, especially as an explanatory variable for bank efficiency. More specifically, an increase in risk may precede a decline in the levels of efficiency of commercial banks. Thus, we accept the Bad Luck Hypothesis for commercial banks while there is no similar proof for retail or investment banks. Furthermore, a rise in the capital may forgo a decline in the efficiency of retail and the U.S. investment banks. So, the Shareholders-Managers Hypothesis is accepted for retail and the U.S.

investment banks yet rejected for commercial banks. Therefore, regulators should encourage the decrease of exposure of commercial banks to external shocks, and shareholders of retail and the U.S. investment banks ought to carefully monitor agency costs.

Finally, it is worth mentioning that a limitation of our study is the use of levels of efficiency, capital and risk, while it could be more accurate to explore the changes of the variables. This method could not be applied in our study because of the small reported period (2013-2015). Therefore, our analysis could instigate further research into the development of the interrelationship between risk, capital and efficiency by employing a sample covering more years after the financial crisis and investigation of the changes of the variables. Our approach could also be enriched with the use of capital buffer, tier1 (AT1) debt or Contingent capital (coco bonds) as indicators of capital ratio and with the employment of non-performing loans or unlikely-to-pay loans as indicators of risk.

REFERENCES

1. Ackermann, J. (2019, January 3). Europe suffers from the sorry state of its banks. *Financial Times*. Retrieved from https://www.ft.com/content/497d4d9e-0f3a-11e9-b2f2-f4c566a4fc5f
2. Altunbas, Y., Carbo, S., Gardener, E. P. M., & Molyneux, P. (2007). Examining the relationships between capital, risk and efficiency in European banking. *European Financial Management, 13*(1), 49-70. https://doi.org/10.1111/j.1468-036X.2006.00285.x
3. Anginer, D., & Demirguc-Kunt, A. (2014). *Bank capital and systemic stability* (Policy Research Working Paper). https://doi.org/10.1596/1813-9450-6948
4. Bashir, A., & Hassan, A. (2017). Interrelationship among Basel capital regulation, risk, and efficiency in Pakistani commercial banks. *Business & Economic Review, 9*(2), 165-186. https://doi.org/10.22547/BER/9.2.7
5. Ben Salah Mahdi, I., & Boujelbene Abbes, M. (2018). Relationship between capital, risk and liquidity: A comparative study between Islamic and conventional banks in MENA region. *Research in International Business and Finance, 45*, 588-596. https://doi.org/10.1016/j.ribaf.2017.07.113
6. Berger, A. N., & DeYoung, R. (1997). Problem loans and cost efficiency in commercial banks. *Journal Of Banking & Finance, 21*(6), 849-870. https://doi.org/10.1016/S0378-4266(97)00003-4
7. Binham, C., & Noonan, L. (2015, November 24). Bad loans at Europe banks double that of the U.S. *Financial Times*. Retrieved from https://www.ft.com/content/3ff8b5a0-92cf-11e5-94e6-c5413829caa5
8. Bitar, M., Pukthuanthong, K., & Walker, T. (2018). The effect of capital ratios on the risk, efficiency and profitability of banks: Evidence from OECD countries. *Journal of International Financial Markets, Institutions and Money, 53*, 227-262. https://doi.org/10.1016/j.intfin.2017.12.002
9. Cathcart, L. I., El-Jahel, L., & Jabbour, R. (2015). Can regulators allow banks to set their own capital ratios? *Journal of Banking & Finance, 53*, 112-123. https://doi.org/10.1016/j.jbankfin.2014.11.017
10. Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444. https://doi.org/10.1016/0377-2217(78)90138-8
11. Chortareas, G. E., Girardone, C., & Ventouri, A. (2011). Financial frictions, bank efficiency and risk: Evidence from the eurozone. *Journal of Business Finance & Accounting, 38*(1-2), 259-287. https://doi.org/10.1111/j.1468-5957.2010.02226.x
12. Deelchand, T., & Padgett, C. (2009). The relationship between risk, capital and efficiency: Evidence from Japanese cooperative banks. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1525423
13. Ding, D., & Sickles, R. C. (2019). Capital regulation, efficiency, and risk taking: A spatial panel analysis of US Banks. In M. Tsionas (Ed.), *Panel data econometrics: Empirical applications* (pp. 405-466). https://doi.org/10.1016/B978-0-12-815859-3.00013-5
14. Drake, L. (2001). Efficiency and productivity change in UK banking. *Applied Financial Economics, 11*(5), 557-571. https://doi.org/10.1080/096031001752236825
15. Fiordelisi, F., Girardone, C., & Radic, N. (2011a). Price competition, efficiency and riskiness in investment banking. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1786753
16. Fiordelisi, F., & Mare, D. S. (2014). Competition and financial stability in European cooperative banks. *Journal of International Money and Finance, 45*, 1-16. https://doi.org/10.1016/j.jimonfin.2014.02.008
17. Fiordelisi, F., Marques-Ibanez, D., & Molyneux, P. (2011b). Efficiency and risk taking in European banking. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1512619
18. Hughes, J. P., Lang, W. W., Mester, L. J., & Moon, C. (1996). *Efficient banking under interstate branching* (Federal Reserve Bank of Philadelphia Working Paper No. 96-9/R). https://doi.org/10.21799/frbp.wp.1996.09
19. Jacques, K., & Nigro, P. (1997). Risk-based capital, portfolio risk, and bank capital: A simultaneous equations approach. *Journal of Economics and Business, 49*(6), 533-547. https://doi.org/10.1016/S0148-6195(97)00038-6
20. Jenkins, P. (2015, November 9). What has delayed Europe's bank recovery? *Financial Times*. Retrieved from https://www.ft.com/content/9e6f450c-86d8-11e5-90de-f44762bf9896
21. Kwan, S. H., & Eisenbeis, R. A. (1997). Bank risk, capitalization and inefficiency. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1188

22. Lakhani, K., Reid, J., & Templeman, L. (2019). *How to fix European banking… and why it matters* (Deutsche Bank Research). Retrieved from https://www.dbresearch.com/PROD/RPS_EN-PROD/PROD0000000000488973/How_to_fix_European_banking%E2%80%A6_and_why_it_matters.pdf
23. Le, T. (2018). Bank risk, capitalisation and technical efficiency in the Vietnamese banking system. *Australasian Accounting, Business and Finance Journal, 12*(3), 41-61. https://doi.org/10.14453/aabfj.v12i3.4
24. McLannahan, B., & Arnold, N. (2017, January 15). US bank's profits leave European rivals in the shade. *Financial Times.* Retrieved from https://www.ft.com/content/d5b38c74-d9e0-11e6-944b-e7eb37a6aa8e
25. Mosko, A., & Bozdo, A. (2016). Modeling the relationship between bank efficiency, capital and risk in Albanian banking system. *Procedia Economics and Finance, 39*, 319-327. https://doi.org/10.1016/S2212-5671(16)30330-6
26. Nguyen, T. P. T., & Nghiem, S. H. (2015). The interrelationships among default risk, capital ratio and efficiency: Evidence from Indian banks. *Managerial Finance, 41*(5), 507-525. https://doi.org/10.1108/MF-12-2013-0354
27. Shim, J. (2013). Bank capital buffer and portfolio risk: The influence of business cycle and revenue diversification. *Journal of Banking & Finance, 37*(3), 761-772. https://doi.org/10.1016/j.jbankfin.2012.10.002
28. Tan, Y., & Floros, C. (2013). Risk, capital and efficiency in Chinese banking. *Journal of International Financial Markets, Institutions and Money, 26*, 378-393. https://doi.org/10.1016/j.intfin.2013.07.009
29. Williams, J. (2004). Determining management behaviour in European banking. *Journal of Banking & Finance, 28*(10), 2427-2460. https://doi.org/10.1016/j.jbankfin.2003.09.010
30. Zellner, A., & Theil, H. (1962). Three-stage least squares: Simultaneous estimation of simultaneous equations. *Econometrica, 30*(1), 54-78. https://doi.org/10.2307/1911287
31. Zhang, J., Jiang, C., Qu, B., & Wang, P. (2013). Market concentration, risk-taking, and bank performance: Evidence from emerging economies. *International Review of Financial Analysis, 30*, 149-157. https://doi.org/10.1016/j.irfa.2013.07.016