Moral hazard after the financial crisis: Have European banks learned their lesson?

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Master's Thesis

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Abstract:

The moral hazard issue is associated with excessive risk-taking. On the one hand, the excess risk is shifted to the creditors. On the other hand, the excess risk leads to the vulnerable banking system and reduces banks' ability to resist the crisis. Moral hazard helped fuel the financial crisis. After the 2008 financial crisis, the introduction of Basel III is expected to strengthen banking stability. So, this paper intends to explore whether the moral hazard still exists around European banks after the financial crisis in 2008 with the conditions of the implementation of Basel III. The moral hazard problem is detected by analyzing the risk-shifting types. The risk-shifting types are conducted by observing the relationship between the Z-score changes and the changes in capital structure components. Also, the panel data is contributed by 142 banks in Europe from 2013 to 2018. This paper found that the moral hazard existed for all the collected samples. For the large banks' samples, the existing moral hazard issue cannot be explained by the present risk-shifting type. Moreover, the moral hazard problem of small banks' samples is caused by the other debt-based risk-shifting.

Key words: Moral hazard, risk shifting, European banks, capital structure

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1. Introduction

By providing the liquidity of funding, banks play a significant role in connecting funds among households, entrepreneurs, and governments. A stable and sound banking system is the key to social stability in Europe. Taking excessive risks will make the banking system more vulnerable when a crisis comes. Throughout history, banking crises have often been linked to recession (Atkinson and Blundell-Wignall, 2010). Identifying and managing risks from banks is particularly important, not only for banking systems itself but also for maintaining the stability of funding in the other industries and the entire business environment.

Risk management is an essential topic for banks. However, moral hazard is a common issue in banks, which can be detected by previous studies (Berndt and Gupta, 2009, Dam and Koetter, 2012, Duran and Lozano-Vivas, 2015, Zhang et al., 2016). Moral hazard generally happens during asymmetric information situations. When a party to a contract takes the risk but does not need to suffer the consequence from the risk taken. The moral hazard problem emerges in the banking industry because of a conflict of interest between shareholders and creditors. Specifically, the shareholder is likely to take more risks from loans, but those risks will shift to depositors (Jensen and Meckling, 1976). Besides, moral hazards exist when the higher loan growth rates and the increase in nonperforming loans exceed a certain level in banks, and as a consequence, bank managers tend to take more risk than the optimal level (Zhang et al. 2016).

Generally, if moral hazard exists in the banking industry, the banking system has to take excessive risk compared to the optimal risk level. It might lead to the banking system being too vulnerable to resist the crisis attack. Duran and Lozano-Vivas (2015) find out that moral hazard took place by transferring the risk to non-depository creditors in 15 European countries from 2002 to 2009. Additionally, by involving deposit insurance schemes, moral hazard mainly contributed by the mutually owned cooperative banks in the German banking industry from 1995 to 2006 (Dam and Koetter, 2012). However, the moral hazard investigation from Duran and Lozano-Vivas (2015) is based on data from ten years ago. The research of Dam and Koetter (2012) only focuses on the banks in Germany. There is a limited explanation for moral hazard in European banks in recent years, especially after the financial crisis.

Besides, there are some studies shows that risk preference varies depending on the size of the banks. According to Kwan and Eisenbeis (1997), Hakenes and Schnabel (2011), the relatively worse performing and smaller banks take higher risks because of the competition. However, since the "too big to fail" implicit protection, large banks attempt to achieve higher returns, thus taking a

higher risk (Nier and Baumann, 2006). These debatable issues around big and small banks inspire this paper to explore the moral hazard problem for large banks and small banks in Europe.

Moreover, Basel III was introduced after the 2008 financial crisis. New regulations proposed more stringent and specific regulatory requirements on the banking industry, especially on the capital requirement and liquidity-based ratio to banks worldwide. So, this research will include related variables based on Basel III, to explore what is the influence on banks' performance and moral hazard problems along with these new regulations in Europe in recent years.

This study aims to make up for the gap in moral hazard research in European banking in recent years. Also, this paper tends to compare big and small banks in Europe to check whether the moral hazard exists after the financial crisis. This study intends to examine whether European banks from 2013 to 2018 have incurred a moral hazard. This study refers to the moral hazard test method form Duran and Lozano-Vivas (2015). In order to detect the moral hazard, there is a need to investigate whether risks from the equity side have shifted into the debt side. Besides, this paper used panel data, including 142 banks' samples, around 26 European countries. By analyzing these panel data, this research found out that moral hazard did exist from 2013 to 2018 years among the collected banks in Europe, regardless of large banks' samples or small banks' samples. Moreover, the primary risk-shifting way for these samples is based on the decreasing risk on the equity side and the increased risk from the non-deposit debt side.

The remainder of this paper will be organized as follows. The literature review belongs to the second chapter, including theoretical background and previous empirical evidence about moral hazard. The third chapter is the methodology part, which includes variables description, model specification, and data. The result part will be constructed in the fourth chapter. Last but not least, the discussion and conclusion will be conducted in the fifth chapter.

2. Literature review

In this literature review part, a theoretical foundation will be introduced. The following contents in this section will include theoretical background and an overview of relevant literature. Moral hazard theory, Prospect theory, and Basel III related background will be presented in the theoretical background part.

2.1 Theoretical Background

2.1.1 Moral hazard theory

The moral hazard theory is the first theory for the theoretical background of this paper. Moral hazard is like "I might take risks that you then have to bear" according to Dowd (p142, 2009). In

the early ages, moral hazards emerged in the insurance industry. “Moral hazard” is a loss-increasing behavior under insurance (Pauly, 1968). In the perspective of moral hazard, people are presumed that they will make less preventive efforts, after they invested insurance; similarly, adverse selection including the moral hazard factor where higher-risk people including those who have deceptive intention, will purchase more insurance (Rowell and Connelly, 2012). Although the moral hazard initiated by Arrow (1963), for describing the inefficiency caused by the risk shifting or the insufficient risk evaluation, but he did not involve a moral parties’ relevant concept.

Moreover, Nier and Baumann (2006) think banks tend to expose moral hazard due to the operation model of banking, because banks collect money from depositors and invest in more risky loan assets. However, the private solvency target of banks may ignore the interests of depositors and the whole society. As a result, to avoid bankruptcy, banks need to have certain risk buffers, to withstand the loan defaults losses caused by such high-risk investments.

Furthermore, many previous literatures show that mortgage securitization such as subprime mortgages are associated with moral hazard before the financial crisis period (Dowd p142, 2009, Duffee, 2009, Mian and Sufi, 2009, Keys et al., 2009, Keys et al., 2010, Malekan and Dionne, 2014). Securitization is an innovative financial product, which consists of various types of contractual debt. After the repackaging, financial institutions can sell it to third parties namely, investors. Since that was an innovation product, there was relatively loose regulation before the financial crisis in 2008. Banks sell loans to investors in order to transfer the loan default risk to potential investors. Since the ultimate risk is not undertaken by banks, banks might monitor less to borrowers’ credit quality (Malekan and Dionne, 2014).

2.1.2 Prospect theory

Prospect theory as the second theoretical background of this study can provide another explanation for moral hazard by behavioral finance. From the Prospect theory point of view, people tend to be risk-averse when they face affirmative return, but they become risk-seeking in affirmative loss (Kahneman and Tversky, 1979). In the banking industry, when shareholders notice that they can shift the risk to creditors, if there is a higher probability to lose money, shareholders are likely to take more risk in order to cover the previous potential loss, since people are risk-seeking in the loss domain.

Moreover, some researchers also find that the realistic banks’ behaviors are in line with prospect theory, that is when the nonperforming loans are too high, banks tend to take more risk and seek for further returns to compensate for the previous loss (Jensen and Meckling, 1976 and Zhang et.al, 2016). Higher nonperforming loans lead to moral hazard which is consistent with the prospect theory.

2.1.3 Basel III related background

Furthermore, the Basel III related background is also included in this theoretical background part because the regulations of Basel III are playing a supervisor's role in controlling risk-related issues

in the banking industry. After the 2008 financial crisis, Basel III was posed as a reform and a supplement to Basel II. Basel III posed by Basel committee, is an international regulatory framework to banks around the world[1]. Additionally, the Basel III regulation framework works from 1st January 2013 to 1st January 2019.

The main functions of Basel III are to act as the regulation and supervision response for banking-based financial institutions. In other words, Basel III aims to strengthen the regulation and enhance risk management among banks and enhances the stability and soundness of the banking industry. There are three pillars in Basel III, which are the strategic function for the Basel framework. The first pillar[2] of Basel III is the minimum capital requirements, liquidity, and leverage limitation; the second pillar describes the supervisory review process[3]; and the third pillar[4] aims to enhance risk disclosure and market discipline. In addition, within the first pillar, there are some strategic ratios requirements[5]. These requirements incorporate three respects, which are the capital requirement, the leverage requirement, and the liquidity requirement, respectively.

However, although the Basel regulatory framework has been reformed several times, the recent version still presents some flaws. Bodellini (2019) considers that the "one-size-fits-all-driven" concept which means the same ratio requirement for all sizes of a bank is the main criticism for current Basel regulation. He argues that there should be conscious different requirements for different levels of market participants, then the regulation will become more efficient. Atkinson and Blundell-Wignall (2010) also argue that Basel III cannot promise that the financial entities are treated equally. Additionally, they point out that the Basel committee also should consider whether the shadow banking system should be included in the new Basel regulation system. Lastly, they think the Basel framework still needs to tackle the concentration issue on the risk-weighted asset framework.

Moreover, this paper will also involve the Basel III ratios-related elements as explanatory factors based on the available data. Since the intervention between macroeconomics and capital

[1]Basel III: international regulatory framework for banks. Available at www.bis.org

[2]The Basel Framework https://www.bis.org/basel_framework/index.htm?m=3%7C14%7C697

[3] Pillar 2 framework - Executive Summary https://www.bis.org/fsi/fsisummaries/pillar2.htm

[4] Pillar 3 framework - Executive Summary https://www.bis.org/fsi/fsisummaries/pillar3_framework.htm

[5] Source are form "Bank for International Settlements (BIS) " https://www.bis.org/

requirement influences banks' different risk-taking behavior (Slovik et al., 2011), the required ratios are expected to play a critical supervised role in moral hazard under Basel III.

2.2 Overview of relevant literatures

Firstly, Dam and Koetter (2012) explore whether the increase of risk-taking is due to the bailout expectations by predicting the expectations of bailout under policy conditions. They find that the financial safety net, such as deposit insurance schemes in banking, causes moral hazard in the German banking industry from 1995 to 2006, through the structural econometric model. Mutually owned cooperative banks drive up the moral hazard. By contrast, the government-owned, regional saving banks show a weak result on moral hazard. Additionally, the specific intervention on the bank's management or the restriction in its business, leads to moral hazard behaviors, efficiently reducing compared to using warning strategies. Moreover, he also finds that the multiple interventions cause more moral hazard behaviors since banks treat such interventions as the symbol of its important status that they have a chance to be saved when a crisis comes.

Secondly, Duran and Lozano-Vivas (2015) found moral hazard in 15 European countries from 2002 to 2009. The main finding of their research is that banks transfer the risk to non-depository creditors. Besides, they find that banks carry out the other debt-based risk transfers no matter whether there is a buffer involved or not. Usually, moral hazard is hard to observe, but Duran and Lozano-Vivas (2015) come out with a method to measure and reflect the moral hazard that happens in banks. They point out that banking's financial structure can be divided into three-parts: equity, deposits, and non-depository debt claims. Equity represents the shareholder's right and obligation. Deposits and non-depository debt claims stand for the creditors' rights and obligations. Once moral hazard happens, shareholders will shift the risk to the creditors. To be specific, the risk brought to form the equity part will significantly reduce, and the risk from other parts will significantly increase.

Thirdly, institutions with well-capitalized and low non-performing loans are linked with taking lower risk. According to the study of Kwan and Eisenbeis (1997), the well-capitalized company can operate more efficiently than the less capital banking organization. Besides, poorly performing companies are more likely to risk-taking than the better performers; this finding is in line with the moral hazard. In general, large banks have a higher probability of becoming well-capitalized firms than small banks because of the better reputation and large size. Zhang et al. (2016) believe that the rising non-performing loans ratio is caused by the increase in riskier loan lending, and this motivation might cause a moral hazard. The further loan quality deterioration generates a vulnerable financial system.

Furthermore, large banks can pursue a more massive unusual risk when they realize the safeguard, but at the same time, the small banks also intend to take more risk because of a disadvantageous position on the competition. Nier and Baumann (2006) point out governments' worries about the moral hazard that appears for large banks due to the type of implicit insurance. Since the sizable social cost might emerge due to bank failure, governments would instead save the potential failing bank than let the crisis contagion to other economic sectors. Also, Dávila and Walther (2020) think that large banks are able to make aggressive decisions at the ex-ante stage. For instance, increase the leverage level, since large banks notice that their decision makes a difference to the likelihood and magnitude of a bailout. Also, small banks might increase the leverage when the aggressive leverage decision from large banks raises the implicit bailout subsidy for the entire banking sector. Moreover, Hakenes and Schnabel (2011) point out under Basel II, the right to choose between the standardized and internal ratings-based approaches offer advantages to large banks but force smaller banks to take higher risk due to the competition. Therefore, less supervision for small banks provides opportunities to take more risks in order to compete with large banks.

According to the literature above, moral hazard seems easy to emerge in the banking industry due to the asymmetric interest between shareholders and depositors or other creditors. On the one hand, large banks might count on the government to bail out, and due to this implied insurance, large banks also tend to take more risk. On the other hand, small banks have to face a rat race because of its' relatively low capital foundation than the large banks and thus have to take more risk to survive. At the same time, the recent moral hazard issue should also consider the influence of Basel III, the new regulation factor after the crisis. Therefore, the following study allows us to find out what is the current moral hazard situation in the banking industry of Europe in a condition with Basel III intervention. The hypotheses for this research are as below:

Hypothesis 1: Moral hazard is still present in European commercial banks even after the introduction of Basel III.

Hypothesis 2: There is no significant difference between large and small European commercial banks in the moral hazard issue.

3. Methodology

In this methodology chapter, variables description, model specification, and data will be specified. Variables description introduces the all variables in this research, which incorporates the main variables, Basel III related variables, bank-specific variables, and related macroeconomic variables. The model specification part introduces how the whole study operates and provides a risk-shifting

table to interpret further results. The data part presents a summary of the related statistic value of all the variables.

3.1 Variables description

3.1.1 Main variables

Firstly, the Z-score $(ZS_{j,t})$, Equity to assets ratio $(E_{j,t})$, deposits to total assets ratio $(D_{j,t})$, and non-depository debt to total assets ratio $(OF_{j,t})$ will be introduced as the main variables. Since, in this paper, the observation of the moral hazard should be detected by how the overall risk indicator and the capital structure components shifting.

Z-score is used as a proxy for overall risk measurement, as many researchers did (Stiroh, 2004; Mercieca et al., 2007; Duran and Lozano-Vivas, 2015). It is essential to know that Z-score is an inverse proxy. Specifically, the higher the Z-score, the less the risk for a bank. Z-score is on behalf of the distance of insolvency for every bank. In other words, Z-score implies how stabilizable a bank is. And the higher the Z-score, the fewer probabilities a bank tends to go into bankruptcy.

In the equation of Z-score, the subscripts j and t stand for bank j at time t; $ZS_{j,t}$ stands for the Z-score; and $E_{j,t}$ is the equity to assets ratio, which is an indicator of capitalization; ROA is the return on average assets ratio, standing for the profitability for a bank; σ^{ROA} means the standard deviation for ROA, which measures the volatility of a bank's profit.

$$ZS_{j,t} = \frac{E_{j,t}+ROA_{j,t}}{\sigma^{ROA}{}_{j,t}} \quad (1)$$

The capital structure for a bank can be divided into three parts, which are equity $(E_{j,t})$, , deposits debt $(D_{j,t})$, and non-depository debt $(OF_{j,t})$, according to the study of Duran and Lozano-Vivas (2015), and Shrieves and Dahl (1992). Referring to previous studies, this paper also uses those three components of the capital structure for a bank. Equity to assets ratio $E_{j,t}$ stands for equity part; customer deposits to total asset ratio $D_{j,t}$ stands for deposits debt; and non-depository debt to total assets ratio $OF_{j,t}$ stands for an indicator of non-depository debt. Furthermore, referring to the study of Gropp and Heider (2010), the non-depository debt is constituted by senior long-term debt, subordinated debt and other debenture note. Since there is a data missing limitation, the non-depository debt in this study incorporates long term borrowing debt, short term borrowing debt and securities.

Since this paper presumes that the capital structure in a bank is composed of $E_{j,t}$, $D_{j,t}$, and $OF_{j,t}$. Duran and Lozano-Vivas (2015), Freixas and Rochet (2008) assume that risk transfer means that the increase of the overall risk is not supported by additional capital. Therefore, the relationship among each element in the capital structure of a bank can be described as: $\Delta E_{j,t} + \Delta D_{j,t} + \Delta OF_{j,t} \equiv 1$ (Duran and Lozano-Vivas,2015).

3.1.2 Basel iii related variables

Secondly, this study aims at investigating whether the moral hazard exists after the financial crisis of 2008, and Basel III acts as the reformed regulation and supervision for banking-based financial institutions. So, the Basel III related variables are included in the following regression.

According to "Bank for International Settlements (BIS)"[6] , capital ratio (CAP) reflects the capital requirement; leverage ratio (LEV) reflects the leverage requirement; and liquidity ratio (LIQ) implies the liquidity requirement on Basel III. All those indicators form Basel III are expected to curb the risk-taking and maintain the stability of banks.

3.1.3 Bank-specific variables

Thirdly, in order to observe the risk shift on banks, the bank-specific variables should be used as the overall risk internal influenced factors. Therefore, in the following contents, size factor (Ln_size), return on average assets (ROA), loans-to asset ratio(LA), loan loss provisions ratio (LLP), cost-to-income ratio (CIR) and capital buffer (BUF) will be introduced.

The size factor (Ln_size) is one of the most critical factors in our risk related regression. Firstly, size is associated with the operating cost for a bank. Economics of scale is a macroeconomics concept, which implies that if there is an increasing size of an enterprise, the production cost of this

[6] Bank for International Settlements (BIS) https://www.bis.org/

Capital requirement: The capital requirement in Basel III is required as 4.5% of risk-weighted assets for the common equity ratio. Minimum Common Equity Tier 1 (CET1) is a range of 4.5 % to 6% from 2013 to 2019. Moreover, the Minimum Total Capital maintains 8% around these seven years. Leverage requirement: Banks must hold the leverage ratio of more than 3%, and this leverage is calculated by dividing primary capital (Tier 1 capital) by the average combined assets of the bank. Liquidity requirement: this requirement forces banks to hold adequate high-quality liquid assets to offset 30-days-related total net cash outflows. Banks must meet two liquidity ratios under Basel III, the net stable funding ratio (NSFR) as the long-term quota. Besides, the liquidity coverage ratio (LCR) measures the short-term problems. However, since the data limitation, this study only can use capital ratio (CAP), leverage ratio (LEV) and liquidity ratio (LIQ) as the related variables for Basel III.

enterprise might tend to decrease. Likewise, if the size of a bank is large enough in the banking industry, the financial cost for this bank will be less expensive since there are more economic opportunities based on the large bank's reputation and customer connection (Hughes et al., 2001). Besides, large banks have a better capacity to manage the risk and tackle the negative issue associated with the customers since large banks are more diversified on the business line (Zribi and Boujelbène, 2011). Additionally, because of "too big to fail," large banks have higher probabilities of being bailed-out by the government but also face more strict supervision. For those internal and external reasons, different sized banks take different risk levels and hold different risk attitudes.

This paper will take the natural logarithm of the total assets as the indicator of size, which is recorded as Ln_size. The previous studies from Duran and Lozano-Vivas,(2015) and Chaibi and Ftiti,(2015) also use this transformation. Because using the natural logarithm transform avoids the large variance bias caused by a large number of total assets, and it is beneficial to explain the coefficient of the regression.

Return on average assets (ROA) is an essential internal financial indicator because it reflects profitability for banks. In the pecking order theory from Myers and Majluf (1984), the financial priority for companies is posted. The order of collecting funding for a company should start with a firm's internal financing, secondly debts, and raising equity should be the last choice. When the internal source is sufficient, banks have less demand to finance by debt or equity, so the less risk a firm takes. Therefore, higher ROA leads to less risk-taking. The study from Chaibi and Ftiti (2015) also use return on average assets as one of the factors to estimate risk for banks.

This paper intends to use loans-to asset ratio (LA) and Loan loss provisions ratio (LLP) as loan measurement indicators in the loans associated factors part. According to Chaibi and Ftiti (2015), the credit risk for the bank-based economies, such as Germany, depends on the loans-to asset ratio. In contrast, for a market-based economy, such as French, the loan loss provisions ratio significantly influences banks' risk.

Loans-to-asset ratio (LA) is a proxy to measure loan risk. Since the percentage of loans-to - assets is one of the determinants of risk (Casu et al., 2016), the loan-to-asset ratio can reflect some instability of a company. The higher the ratio indicates that, the more debt is involved in that company. So, the higher loans-to -asset ratio, the riskier it is to invest in that company. Loan loss provisions ratio (LLP) is based on Loan loss provisions divided by the total asset. This ratio implies potential loan loss. Therefore, higher LLP is associated with a higher risk level.

The cost-to-income ratio (CIR) is an efficiency ratio for banks operating. This ratio is based on a firm's operating expenses divided by its operating income. "Bad" management hypothesis from Berger and DeYoung (1997) mention that poor management of costs in a bank influences the future risk for a bank and especially impacts the non-performing loan part. The higher the Cost-to-income ratio means, the less efficiency for a bank to operate. Hence, the higher CIR ratio is concerning a positive impact on risk.

Capital buffer (BUF), a compulsory amount of capital, a bank should hold that as a contingent reserve. Referring to Duran and Lozano-Vivas (2015), the definition of the buffer should be the difference between the equity-to asset ratio and the minimum regulatory capital ratio required. According to "Basel III phase-in arrangements"[7] , the minimum total capital is 8% from 2013 to 2019.

According to Duran and Lozano-Vivas (2015), the deposit insurance (DI) variable is a significant variable to measure the deposit insurance level protecting the depositors in a bank. However, this paper did not include the DI variable, since the " Directive 2014/49/ EU"[8] was adopted in 2014, which states that countries from the European Union must ensure a consistent level of protection for depositors, and require banks to list the types of deposits protected. Besides, because of the limited available data, this paper did not use the following three variables which are, official supervisory power (SUPERV), private monitoring (PRIMON), and restrictions on bank activities (REST) as Duran and Lozano-Vivas (2015) used . All those three variables' data come from the paper of Barth et al., (2001), but that database does not cover the data from 2013 to 2019.

3.1.4 Macroeconomic-related variables

Lastly, this study expected that some macroeconomic factors would influence the changing risk for banks. So, Growth of GDP (GDP_G) and the economic freedom index (DOF) as the independent macroeconomic variables will be discussed.

Gross Domestic Product (GDP) provides an economic snapshot of an economy in a particular period. GDP can reflect the general market situation of a country and provide a symptom to predict the business cycle. However, most of the researchers tend to use the GDP growth instead of the

[7] Basel III phase-in arrangements: https://www.bis.org/bcbs/basel3/basel3_phase_in_arrangements.pdf

[8] Directive on deposit guarantee schemes, from https://ec.europa.eu/info/business-economy-euro/banking-and-finance/financial-supervision-and-risk-management/managing-risks-banks-and-financial-institutions/deposit-guarantee-schemes_en

GDP as the macroeconomic indicator. Because the GDP growth can adjust the non-sustainability over time, it causes less bias in the regression and provides a better regression result. Previous studies from Ali and Daly (2010), Louzis, et al. (2012) and Castro (2013) prove that the growth rate of GDP (GDP_G) as the macroeconomics indicator is a salient determinant for credit risk for banks. The results from those studies claim that credit risk decreases when GDP growth increases.

Compared with regulation, the market forces can alleviate the moral hazard of lenders more efficiently in the originate-to-distribute mortgage loan market (Keys et al., 2009). Chortareas et al. (2013) find out higher overall efficiency and cost advantage for a bank if its economy's financial freedom is higher, which is measured by the economic freedom index (DOF). This paper tends to use the degree of freedom index to measure the market openness level in a country. The Heritage Foundation database provides a related degree of freedom index. The higher the score of a country, the higher the economic freedom level a country has, and this paper predicts that the higher the degree of freedom index, the less will be risk-taking.

In Table 1, we can have an overview on definition of variables, and the data resource for the main variables, the Basel III related variables, the bank-specific variables, and related macroeconomic variables.

Table 1. Variables definition

Name	Definition	Data resource
Main variables		
ΔZS	Changes in Z-score, reflects risk measurement indicator, as an inverse indicator, the higher Z-score implies higher stability for a bank and lower risk $ZS_{j,t} = \frac{E_{j,t} + ROA_{j,t}}{\sigma^{\mathrm{ROA}}{}_{j,t}}$	Bank Focus
ΔE	Changes in equity to assets ratio, reflects the changes in capitalization level	Bank Focus
ΔD	Changes in deposits to total assets ratio, reflects the changes in deposit level	Bank Focus
ΔOF	Changes in non-depository debt to total assets ratio, reflects the changes in non-deposit debt level	Bank Focus

Basel III related variables

CAP	Capital ratio: total capital adequacy ratio (as reported)	Bank Focus
LEV	Leverage ratio: equity divided by liability;	Bank Focus
LIQ	Liquidity ratio: liquid asset divided by total asset ratio	Bank Focus

Bank-specific variables

Ln_Size	Bank size, reflects market value of a bank; by natural log of total asset	Bank Focus
ROA	Return on average assets, reflects profitability of a bank; by return on average asset ratio	Bank Focus
LA	Loan to total assets ratio, reflects the proportion of loan in asset; by Net loan divided by total assets	Bank Focus
LLP	Loan loss provision ratio: by loan loss provision divided by total assets	Bank Focus
CIR	Cost-to-income ratio, reflects the efficiency on a bank operation; by operating expenses divided by operating income	Bank Focus
BUF	Buffer mandatory reserve deposits with central banks; by Equity-to-assets ratio minus minimum regulatory capital ratio required (8%)	Bank Focus

Macroeconomic-related variables

GDP_ G	Growth rate of GDP, reflects economic development in a country	World bank
DOF	Index of economic freedom, reflects the level of freedom in each economic market	Index of degree of freedom

3.2 Model specification

The moral hazard is hard to observe. However, Duran and Lozano-Vivas (2015) have posed the moral hazard testing method by observing the risk-shifting. From the perspective of Duran and Lozano-Vivas (2015), when the moral hazard of a bank occurs, the overall risk of the bank increases, with the decrease of risk-taking in the equity side or performance as a decrease of shareholder's wealth. At the same time, the risk of changing depositor debt or non-depositor's debt increases.

This study refers to the moral hazard testing method from Duran and Lozano-Vivas (2015), to determine the occurrence of moral hazard by proving the occurrence of risk transfer from the equity side to the debt side. Besides, this study also involves other risk-influenced variables into the estimation. These risk-influenced parts include the bank-specific variables, the Basel III related variables, and macroeconomic-related variables.

Duran and Lozano-Vivas (2015) and Shrieves and Dahl, (1992), suggested that the partial adjustment model should be used to capture the endogen part of the main variables since it can reflect the internal decision for banks. Moreover, the exogenic component can reflect the unanticipated external shock in banks, which can be indicated by an error term. Also, Shrieves and Dahl, (1992), and Heid et al., (2003) post a reason why the delta changed form in the main variables are used, instead of using the levels of the main variables. Because of the level form variables in the negative correlation can introduce the distribution of risk preference instead of the moral hazard incentives.

Therefore, the changed form for each main variable is conducted as following:

$$Y = [\, ZS;\ E;\ D\ and\ OF\,]$$
$$\Delta Y_{j,t} = a * \left(Y_{j,t} - Y_{j,t-1}\right) + e_{j,t} \qquad (2)$$

$\Delta Y_{j,t}$ reflects the changes in different main variables. And it can be the changes of overall risk index, the Z-score ($\Delta ZS_{j,t}$), the changes in Equity to assets ratio ($\Delta E_{j,t}$), the changes in customer deposits to total assets ratio ($\Delta D_{j,t}$), and the change in non-depository debt to total assets ratio ($\Delta OF_{j,t}$). $Y_{j,t}$ is the target value at t period, and $Y_{j,t-1}$ is the one period lag value of the target observation. $e_{j,t}$ is an error term, which reflects the random outside shock. a is the speed of adjustment. The subscript j stands for bank j, and t implies a period t.

In order to discover whether the risk will be shifted or not, the following regressions will be run.

$$\Delta ZS_{j,t} = a_0^E + a_1^E \Delta \mathrm{E}_{j,t} + a_2^E \mathrm{CAP}_{j,t} + a_3^E \mathrm{LEV}_{j,t} + a_4^E \mathrm{LIQ}_{j,t} + a_5^E Ln_{Size\_j,t} + a_6^E \mathrm{ROA}_{j,t} + a_7^E \mathrm{LA}_{j,t} + a_8^E \mathrm{LLP}_{j,t} + a_9^E \mathrm{CIR}_{j,t} + a_{10}^E \mathrm{BUF}_{j,t} + a_{11}^E \mathrm{GDP\_G}_{j,t} + a_{12}^E \mathrm{DOF}_{j,t} - \Delta ZS_{j,t-1} + u_{j,t}^E \quad (3)$$

$$\Delta ZS_{j,t} = a_0^D + a_1^D \Delta \mathrm{D}_{j,t} + a_2^D \mathrm{CAP}_{j,t} + a_3^D \mathrm{LEV}_{j,t} + a_4^D \mathrm{LIQ}_{j,t} + a_5^D Ln_{Size\_j,t} + a_6^D \mathrm{ROA}_{j,t} + a_7^D \mathrm{LA}_{j,t} + a_8^D \mathrm{LLP}_{j,t} + a_9^D \mathrm{CIR}_{j,t} + a_{10}^D \mathrm{BUF}_{j,t} + a_{11}^D \mathrm{GDP\_G}_{j,t} + a_{12}^D \mathrm{DOF}_{j,t} - \Delta ZS_{j,t-1} + u_{j,t}^D \quad (4)$$

$$\Delta ZS_{j,t} = a_0^{OF} + a_1^{OF} \Delta \mathrm{OF}_{j,t} + a_2^{OF} \mathrm{CAP}_{j,t} + a_3^{OF} \mathrm{LEV}_{j,t} + a_4^{OF} \mathrm{LIQ}_{j,t} + a_5^{OF} Ln_{Size_j,t} + a_6^{OF} \mathrm{ROA}_{j,t} + a_7^{OF} \mathrm{LA}_{j,t} + a_8^{OF} \mathrm{LLP}_{j,t} + a_9^{OF} \mathrm{CIR}_{j,t} + a_{10}^{OF} \mathrm{BUF}_{j,t} + a_{11}^{OF} \mathrm{GDP\_G}_{j,t} + a_{12}^{OF} \mathrm{DOF}_{j,t} - \Delta ZS_{j,t-1} + u_{j,t}^{OF} \quad (5)$$

$\Delta ZS_{j,t}$ is the changes in overall risk for j in t period; a_0^E, a_0^D and a_0^{OF} are the interceptions for each regression. $\Delta E_{j,t}$,$\Delta D_{j,t}$, $\Delta OF_{j,t}$, are the changed form of individual j at t period for equity-to-assets ratio, deposit to total assets ratio, and non-deposit to total assets ratio, respectively. for the panel data sample, subscript j stands for bank j, and t implies a period t. Capital ratio ($CAP_{j,t}$), leverage ratio ($LEV_{j,t}$) and liquidity ratio ($LIQ_{j,t}$) are three control variables from Basel iii. Bank-specific variables includes bank's size ($Ln_{Size\_j,t}$), return on average assets ($ROA_{j,t}$), loan to total assets ratio ($LA_{j,t}$), loan loss provision ratio ($LLP_{j,t}$), cost-to-income ratio ($CIR_{j,t}$), and capital buffer ($BUF_{j,t}$). Two Macroeconomic-related variables are Growth rate of GDP ($GDP\_G_{j,t}$) and Index of economic freedom ($DOF_{j,t}$). $\Delta ZS_{j,t-1}$ stands for the changes in overall risk for j in t-1 period. $u_{j,t}^E$, $u_{j,t}^D$ and $u_{j,t}^{OF}$ are the error term for those regressions, respectively.

Table 2. Risk shifting types

Risk shifting types		System ΔE	System ΔD	System ΔOF
(1)	Both sides	$a_1^E > 0$ (s)	$a_1^D < 0$ (s)	$a_1^{OF} < 0$ (s)
(2)	Deposit based	$a_1^E > 0$ (s)	$a_1^D < 0$ (s)	$a_1^{OF} > 0$ (s.or.ns.)
(3)	Other debt based	$a_1^E > 0$ (s)	$a_1^D > 0$ (s.or.ns.)	$a_1^{OF} < 0$ (s)
(4)	Unclassified	$a_1^E > 0$ (s)	a_1^D (ns.)	a_1^{OF} (ns.)
(5)	Not risk shifting	$a_1^E < 0$ (s)	$a_1^D > 0$ (s.or.ns.)	$a_1^{OF} > 0$ (s.or.ns.)
(6)	Unclear	Other conurbations		

Note: According to Duran and Lozano-Vivas (2015), the risk-shifting types can be classified as follows : (1) Both sides mean risk form equity shift into both deposits based and other debt-based areas. (2) Deposit based means risk form equity only shift to deposits based. (3)Other debt-based means risk form equity side only shift to other debt-based areas. (4) Unclassified means risk form equity shift to unclassified fields. (5) Not risk-shifting means there is a not risk shifting. (6) Unclear means it is not clear for the risk shifting. Also, (s) means significant; (s.or.ns.) means significant or non-significant.

Generally, equity side risk decrease, and overall risk increase are the main focus of this research. So, this research mainly uses risk increased banks ($\Delta ZS_{j,t} < 0$) as samples, which are Z-score-decreasing banks, since the Z-score is an inverse indicator . Therefore, it is more straightforward to interpret the relationship between overall risk and equity side ratio changes. To be specific, $\Delta E_{j,t} < 0$, the equity ratio decreased over year, followed by $\Delta ZS_{j,t} < 0$, the overall risk increased, since $ZS_{j,t} < ZS_{j,t-1}$, the smaller $ZS_{j,t}$ value the more the overall risk for a bank.

This table includes six different situations to interpret the possible results from the regressions. This paper intends to discover moral hazard occurring by whether risk-shifting happens or not. In other words, when the moral hazard occurs, overall risk increases, following equity side risk decreases but increases risk in either deposit side or non-deposit side, or both deposit and non-deposit side increase their risk at the same time. Since Z-score is an inverse index, the smaller $\Delta ZS_{j,t}$ means the risk in a bank is increased. So, when $a_1^E > 0$ and significant means the overall risk increase is associated with equity side risk decrease. However, $a_1^D < 0$ or $a_1^{OF} < 0$ implies that deposit or non-deposit side risks increases, and overall risk also increases.

The first situation is that risk shifting happens from equity side to both deposit and non-deposit side. Therefore, the coefficient of changes in equity-to-assets ratio should be positive and significant ($a_1^E > 0$) . The coefficient of the changes in deposit to total assets ratio ($a_1^D < 0$) and the changes in non-deposit debt to total asset ratio ($a_1^{OF} < 0$) should be both negative and significant.

The second situation is that the risk shifting only happens from equity side to deposit side but not to the non-deposit debt side. Therefore, the coefficient for equity part ($a_1^E > 0$) still should be positive and significant. At the same time, only the deposit part's coefficient ($a_1^D < 0$) is negative and significant but the coefficient for non-deposit part (a_1^{OF}) can be positive and significant or non-significant.

Other debt based situation as the third situation, the coefficient of the changes in equity-to-asset ratio ($a_1^E > 0$) should be positive and significant, besides, the coefficient of the changes in non-deposit debt to total asset ratio ($a_1^{OF} < 0$) should be negative and significant. Moreover, the coefficient of the changes in deposit to total assets ratio (a_1^D) can be either positive and significant or non-significant.

Unclassified is the fourth situation, when the overall risk increases, and the equity side risk declines. But the deposit and non-deposit debt side risks do not change significantly in statistical aspects.

Therefore, the coefficient of equity part ($a_1^E > 0$) is positive and significant. However, both deposit side (a_1^D) and non-deposition debt side (a_1^{OF}) show non-significance.

According to Duran and Lozano-Vivas (2015), the fifth situation is that the moral hazard cannot be observed. When equity side risk increases significantly ($a_1^E < O$ (s)), the overall risk also increases. But (i) both deposit and non-deposit side significantly decrease and ($a_1^D > O\ (s)\ and\ a_1^{OF} > O$ (s)); (ii) either one of the deposit and non-deposit debt ratio statistic significantly decreases and another one does not change significantly (($a_1^D > O\ (s)\ and\ a_1^{OF}\ (ns.)\ , or\ \ a_1^{OF} > O, a_1^D\ (ns.)$); (iii) both changes in deposit and non-deposit sides are not statistically significant.

For the rest of the situations, they can be classed as unclear in the sixth row of table 2. Since other outcomes are not allowed to conclude by the method posted by Duran and Lozano-Vivas (2015).

Hence, refer to table 2 "Risk shifting types", we can find out whether the banks in Europe present moral hazard by comparing the related coefficients in equations of (3), (4) and (5). In the following section, referring to the different bank sizes, this subsequent research separates all European commercial banks into large banks' samples and small banks' sample. By comparing two subgroups, the moral hazard related issues for all banks and between different sizes of banks will be conducted.

3.3 Data

The purpose of this study is to make up for the gap of moral hazard research in European banking during recent years. This research collects the data from 2013 to 2018, 6 years in total. Commercial banks from 26 European countries contribute to the estimated data. Although the recession caused by the financial crisis in 2008 is from the fourth quarter of 2008 to the third quarter of 2010, according to Grigoraş and Stanciu (2016). But the data from 2010, 2011, and 2012 have dropped since Basel III was posted as a new regulation to supervise commercial banks, which started from 2013 until the year 2019.

All banks' specific data are collected form Bank Focus[9]. In terms of the macroeconomic-related data, GDP is obtained from The World Bank, and the index of economic freedom comes from The Heritage Foundation[10]. Because of missing data, Malta is the only country lacking all GDP data for

[9] Bank focus database: https://bankfocus-bvdinfo-com.ru.idm.oclc.org/

[10] Economic freedom index databased: https://www.heritage.org/index/

the six years. Moreover, since the miss data for the GDP in 2019, so the year 2019 related data was dropped.

In order to compare the moral hazard in commercial banks in the European Union, this study divided banks into two groups by size. According to the size determination criteria provided by the European central bank (ECB)[11], this study classed banks with the total value of the banks' assets exceeding €30 billion as large banks' samples, otherwise as small banks' samples. In the database of this study, there are a total of 671 commercial banks as subjects. Within these subjects, there are 90 significant banks (large banks), and the rest of 581 banks are defined as small banks. However, since the requirement of the balanced panel data sample, after samples selection on table 3, the total bank number becomes 142, and the large banks number is 33. The number of small banks' is 109.

Table 4 presents a summary of variables to all banks' samples. The statistical information for all commercial banks is shown in that table. The statistical data includes the mean, median, standard deviation, the minimum value, and the maximum value of the observation.

In order to have a better comparison, this paper combines the summary of data for two banks' subsamples into Table 5. It shows an overview of variables to large banks' samples and the review of variables to small banks' samples. There are 195 observations for large banks' samples and 655 observations for small banks' samples. All of those observation are from 2013 to 2018.

The pairwise correlation coefficients among all banks' variables are presented in Table 6. In this table, the correlation coefficients between each of the variables can be found. The other pairwise correlation coefficients of large banks and small banks samples are shown in Table 8 and Table 9 in the appendix.

[11]What makes a bank significant?

https://www.bankingsupervision.europa.eu/banking/list/criteria/html/index.en.html

Table 3. Samples selection and filtering

Order	Reason for sample filtering	Number of remaining observations	Total banks number	Large banks number	Small banks number
1	Raw data from 2010 to 2019	6710	671	90	581
2	The time range of Basel III from 2013 to 2019	4697	671	90	581
3	Winsorizing process to reduce the outliers Aim at ΔD, D CIR, LEV, in 99%.	4697	671	90	581
4	Force into a balance data, drop all missing variables, available balance data (time range from 2013 to 2018)	850	142	33	109

Note: By using the Winsorizing process in the 99% level, data below the 1st percentile from variables of ΔD, D CIR and LEV, will be set as the same data of the 1st percentile.

Table 4. Summary of variables to all banks' samples

Name	Obs.	Mean	Median	St.dev.	Minimum	Maximum
Main variables						
ΔZS	850	-0.83025	-0.68805	3.796272	-39.2426	33.9047
ΔE	850	0.093624	0.025001	4.950408	-59.51	56.74
ΔD	850	-0.32465	0.001	4.291564	-30.0085	16.859
ΔOF	850	-0.00073	0	0.125629	-1.5043	2.8935
Control variables from Basel iii						
CAP	850	21.62376	17.77	13.86511	3	199.9
LEV	850	14.80829	10.615	22.33539	1.15	228.57
LIQ	850	34.00568	30.38	20.75325	0.38	98.91
Bank-specific variables : microeconomic factors						
ln_SIZE	850	10.42395	10.062	1.804699	5.42054	14.5575
ROA	850	0.647988	0.51	7.239883	-58.01	193.45
LA	850	56.11002	58.765	19.97628	0.17	93.5
LLP	850	0.003941	0.0015	0.00775	-0.0141	0.0673
CIR	850	63.33224	60.81	19.21224	8.96	133.02
BUF	850	4.870341	1.035	14.00697	-8.39	91.99
Macroeconomic related variables						
GDP_G	850	0.023411	0.046534	0.080853	-0.17061	0.147028
DOF	850	68.49353	68.3	5.636499	53.2	80.4

Note: ΔZS is the changes in Z-score; ΔE is the changes in capital to total asset ratios. ΔD is the change in customer deposits to total asset ratio. ΔOF is the changes in non-depository debt to total assets ratio. CAP means capital ratio. LEV means leverage ratio. LIQ means liquidity ratio. Ln_SIZE is a natural logarithm from SIZE. ROA means the return on average asset ratio. LLP means the loan loss provision ratio. LA means loan to total asset ratio. CIR means the cost-income ratio. BUF means capital buffer mandatory reserve deposits with central banks. GDP_G is GDP growth rate. DOF is the index of economic freedom for each country. The period for all related variables above is from 2013 to the 2018 year.

Table 5. Summary of variables to large banks and small banks

Name	**Obs.**		**Mean**		**Median**		**St.dev.**		**Minimum**		**Maximum**	
Size of banks	Large *banks*	*Small banks*	Large *banks*	*Small banks*	Large *banks*	*Small banks*	Large *banks*	*Small banks*	*Big banks*	*Small banks*	*Big banks*	*Small banks*
Main variables												
ΔZS	195	655	-0.284322	-0.9927844	-0.4783	-0.7631	2.182442	4.14494	-6.8417	-39.2426	9.498	33.9047
ΔE	195	655	0.574718	-0.049603	0.2	-0.03	2.61408	5.44949	-14.52	-59.51	13.98	56.74
ΔD	195	655	-0.0000215	-0.4212986	0.0093	0	0.1766143	4.884563	-1.8984	-30.0085	0.5694	16.859
ΔOF	195	655	-0.0033995	0.0000646	-0.0033	0	0.0383327	0.1415979	-0.2052	-1.5043	0.3553	2.8935
Control variables from Basel iii												
CAP	195	655	18.07764	22.67948	16.5	18.2	5.693331	15.33232	6.08	3	37.1	199.9
LEV	195	655	9.679949	16.33505	8.08	11.32	6.113953	25.027	2.57	1.15	44.11	228.57
LIQ	195	655	29.9421	35.21545	29.48	30.83	15.59221	21.92282	2.27	0.38	74.23	98.91
Bank-specific variables : microeconomic factors												
ln_SIZE	195	655	13.0245	9.649742	12.8991	9.50413	0.6588187	1.217589	12.029	5.42054	14.5575	12.3431
ROA	195	655	0.5646154	0.6728092	0.55	0.49	0.8805231	8.234794	-2.91	-58.01	4.77	193.45
LA	195	655	47.88785	58.55785	53.65	61.88	18.27786	19.81859	10.72	0.17	89.25	93.5
LLP	195	655	0.0026256	0.0043325	0.0011	0.0016	0.0040641	0.0085092	-0.0042	-0.0141	0.0254	0.0673
CIR	195	655	64.49251	62.98681	61.84	59.91	13.82082	20.54222	31.75	8.96	104.86	133.02
BUF	195	655	1.206103	5.961221	0.08	1.45	6.590373	15.38229	-6.18	-8.39	53.1	91.99
Macroeconomic related variables												
GDP_G	195	655	0.0171683	0.0252689	0.035122	0.046534	0.0783205	0.0815576	-0.170607	-0.149704	0.142318	0.147028
DOF	195	655	68.65128	68.44657	68.5	67.9	6.113441	5.490602	53.2	53.2	80.4	80.4

Table 6. Pairwise correlation coefficients among all variables

Variables	ΔZS	ΔE	ΔD	ΔOF	CAP	LEV	LIQ	ln_SIZE	ROA	LA	LLP	CIR	BUF	GDP_G	DOF
ΔZS	-														
ΔE	0.4545	-													
ΔD	-0.0192	-0.0062	-												
ΔOF	-0.0074	0.0044	-0.0074	-											
CAP	-0.0319	-0.0384	-0.051	-0.0094	-										
LEV	-0.0551	-0.0589	0.0117	-0.0011	0.4121	-									
LIQ	-0.0099	0.0503	-0.0265	-0.0146	0.3341	0.0473	-								
ln_SIZE	0.0746	0.073	0.0522	-0.0087	-0.1515	-0.16	-0.0993	-							
ROA	0.4156	0.3843	0.0022	-0.0014	0.0185	-0.0032	0.0144	0.0145	-						
LA	-0.0082	0.0073	0.0229	-0.0183	-0.0072	0.0228	-0.0229	-0.1187	0.0182	-					
LLP	0.0642	0.0118	0.0241	0.0975	-0.0141	-0.0022	-0.0574	0.0176	0.0159	0.1675	-				
CIR	-0.0329	-0.0471	-0.0049	0.0248	0.0551	0.0309	-0.0775	0.0212	0.0663	-0.14	-0.0135	-			
BUF	-0.1528	0.2058	0.0379	-0.0173	-0.0146	0.0142	0.039	-0.1459	0.0921	0.0695	-0.0507	-0.0667	-		
GDP_G	-0.3935	0.0679	0.0557	-0.0019	0.0188	0.0138	-0.0093	-0.0011	0.0143	0.0357	-0.0832	0.0658	0.0054	-	
DOF	-0.0166	0.0328	-0.0954	0.0292	0.0593	0.0709	-0.0968	0.0385	-0.0045	-0.0107	-0.0239	-0.0039	-0.0091	0.1613	-

Note: Note: This table shows the pairwise correlation matrix among all commercial banks' data.

4. Results

In this section, the robustness regression results of whether commercial banks in Europe present moral hazard will be analyzed and discussed. This paper attempts to detect whether significant moral hazard still existed around commercial banks in Europe after the financial crisis. Therefore, based on the previous literature reviews, the first hypothesis is, "Moral hazard is still present in European commercial banks even after the introduction of Basel iii." The second hypothesis tries to explore whether moral hazard is different between small banks and large banks in Europe. The second hypothesis of this paper is that "There is no significant difference between large and small European commercial banks in the moral hazard issue.**"**. The results are shown in Table 7 and they are obtained by using a 26 European banks' sample from 2013 to 2018.

4.1 Moral hazard in all commercial banks

Regarding hypothesis 1, the results show that a significant moral hazard existed around all commercial banks in Europe, even with the Basel III related variables included in the regression.

Regression results from table 7, presents that the coefficient of ΔE is positive (0.281) and shows 99% statistical confidence. The coefficient of ΔD is 0.0136 but non-significant. ΔOF has a negative coefficient -1.981 with 90% significance. In Table 6, the moral hazard in all commercial bank samples belongs to the other debt-based risk-shifting type in the aspect of risk shifting type. To be specific, the other debt-based situation presents that the coefficient of the changes in the equity-to-asset ratio (a_1^E) should be positive and significant. Besides, the coefficient of non-deposit debt to total assets ratio (a_1^{OF}) should be negative and significant. The coefficient of the changes in deposit to total assets ratio (a_1^D) can be either positive and significant or non-significant. Therefore, the results from all banks' samples are in accordance with the other debt-based risk-shifting statement.

However, the Basel III related factors cannot significantly influence the results based on all commercial banks' samples. The Basel III related factors are capital requirement, leverage requirement, and liquidity requirement. The coefficients of capital ratio (CAP), leverage ratio (LEV), and liquidity ratio(LIQ) did not show any significant influence among regression (1), (2), and (3).

Besides, the average return on assets (ROA) as the only bank specific factor shows a meaningful effect on the changes in overall risk. The average return on assets (ROA) presents a very significant and positive correlation with the changes in Z-score, by observing the regression (1), (2) and (3), regardless of the changes in equity ratio, deposit debt to total asset ratio or non-deposit debt to total

asset ratio as the independent variables. The higher ROA means the greater profitability of a bank. So, the result shows the greater profitability for a bank, the higher the risk changing speed for all banks in Europe. However, the other bank-specific variables did not show any significant effect on the result. Those non-significantly influencing variables are bank size (ln_Size), loan to total asset ratio (LA), loan loss provision ratio (LLP), cost-to-income ratio (CIR), and capital buffer (BUF).

Besides, in the macroeconomic related variables aspect, the growth rate of GDP (GDP_G) also shows a strongly negative statistical significance for those three regressions. This significant sign means the GDP growth rate has a sensitivity for overall stationery for the banking system in Europe. The higher the growth rate of the GDP, the fewer changes in risk in the banking system. But the variables of the index of economic freedom (DOF) did not show a significant influence on those results.

4.2 Moral hazard in large and small commercial banks

The moral hazard issue between large and small European commercial banks is different. According to the results, both large banks' samples and small banks' samples present a moral hazard problem. However, the type of risk-shifting between those two samples is different. For the large banks' samples, the moral hazard is caused by the unclassified risk-shifting. But for the small banks' samples, the moral hazard appears by the other debt-based risk-shifting.

4.2.1 Result for large commercial banks

In the large banks' group, the results from the regression on (4),(5) and (6) present an unclassified risk-shifting outcome. This outcome means that moral hazard still exists in the large banks' group. Nevertheless, there is no comprehensible specific risk-shifting way. From the result of regression (4), the coefficient of change in equity ratio (ΔE) is 0.441, which shows a positive, and 99% strongly significant level. It means that the equity ratio decreases and the overall risk increases. However, the coefficient of the changes in deposit to the total asset ratio (ΔD) on regression (5) and the changes in non-deposit debt to total assets ratio (ΔOF) on regression (6) both did not show any significant sign in the statistical aspect. Hence, referring to the risk-shifting type in Table 2, this situation belongs to unclassified risk-shifting.

However, the Basel III related factors, such as capital ratio (CAP), leverage ratio (LEV), and liquidity ratio (LIQ), did not appear to have a significant influence on the samples for large banks. Since the coefficients of the Basel III did not show any significant level.

According to the results, some bank-specific factors show a meaningful effect on the changes in overall risk for the large banks. Firstly, the average return on assets (ROA) appears strongly as a significant explanation for the changes in the overall risk measure index and the Z-score changes. Secondly, the independent factor capital buffer (BUF) also expresses the significant negative influence on Z-score changes in large banks. The interpretation of those buffer-related coefficients is that, when the buffer increases, the changes in the Z-score decreases. For large banks, when the buffer mandatory reserve deposits with central banks grow, the risk changing speed of the large banks is reduced. Thirdly, the Cost-to-income ratio (CIR) shows a slightly positive significant influence on overall risk changes in regression (4). The higher CIR implies, the higher efficiency of a bank operation to associate the higher risk changing speed of the entire risk for large banks in Europe.

Lastly, in terms of the related macroeconomic factors, the growth rate of GDP (GDP_G), instead of the index of economic freedom (DOF), is the only factor that presents a strongly significant explanation for the overall risk changes of large banks. The negative coefficient of GDP_G means when the growth rate of GDP rises, the changes in the overall risk of large banks will decrease.

4.2.2 Result for small commercial banks

Regression results from the small banks' sample presents a moral hazard issue by the other debt-based risk-shifting. In the regression (7), the coefficient of the changes in equity to asset ratio (ΔE) is positive (0.271) and shows 99% statistical confidence. That means the overall risk increase is followed by the decrease of the equity side risk. This unilateral interpretation depends on the collected samples mainly using risk increased banks. Besides, the change for the non-deposit debt to total assets ratio (ΔOF) in regression (9) has a negative significant result (-1.954), and the coefficient of the change in the deposit to total assets ratio (ΔD) in regression (8) does not reveal any significant level. So, these results of small banks' samples are in line with the other debt-based risk-shifting statement in Table 2.

The Basel III related factors still did not significantly influence the overall risk changes for small banks' samples. The coefficients of capital ratio (CAP), leverage ratio (LEV), and liquidity ratio (LIQ) did not show any significant level.

Among all other overall risk influential factors, the average return on assets (ROA), the growth rate of GDP (GDP_G), and buffer factor (BUF) show significant influence in the changes of the Z-score. Likewise, the higher average return on assets (ROA) or a higher buffer factor (BUF) are associated with more significant changes of risk for the small banks in Europe. The higher growth rate of GDP (GDP_G) links with fewer changes in risk for small banks.

Overall, there are three main conclusions compared to all these regression results. First of all, as responding to hypothesis one, the moral hazard did exist in commercial banks in Europe from 2013 to 2018, even under the introduction of Basel III. To be specific, this moral hazard in all collected commercial banks is because of other debt-based risk-shifting. Furthermore, both large banks' samples and small banks' samples present a moral hazard problem. But the type of risk-shifting between those two samples is different. The result shows the moral hazard for small banks is caused by other debt-based risk-shifting. But for the large banks' group, there is an unclassified finding on risk-shifting type, therefore, the moral hazard issue around large banks cannot be clearly confirmed. Last but not least, the existence of moral hazard for all collected commercial banks in Europe from 2013 to 2018, is mainly due to the collected small banks in Europe. For the large banks' group, the result of moral hazard belongs to the unclassified domain. However, for the small banks' group existing moral hazards constructed by the other debt-based risk shifting is found, which in line with the result form the entire banks' samples.

Table 7. Results

Sample group	All banks' samples			Large banks' samples			Small banks' samples		
Regression	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Variables	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**	**ΔZS**
ΔE	0.281***			0.441***			0.271***		
	-5.76			-6.04			-5.49		
ΔD		0.0136			-0.157			0.0185	
		(-0.63)			(-0.25)			-0.7	
ΔOF			-1.981*			-2.868			-1.954*
			(-2.02)			(-0.49)			(-1.98)
CAP	-0.022	-0.00652	-0.00616	-0.118	-0.174	-0.163	-0.0114	0.00736	0.00724
	(-0.84)	(-0.26)	(-0.25)	(-1.57)	(-1.96)	(-1.70)	(-0.42)	-0.29	-0.28
LEV	0.0302	0.0401	0.0402	0.00534	0.0545	0.0453	0.0293	0.0387	0.0391
	(-1.61)	(-1.75)	(-1.75)	-0.09	-0.77	-0.6	-1.52	-1.63	-1.64
LIQ	-0.0336	-0.0349	-0.0347	0.00566	0.0104	0.00258	-0.0362	-0.036	-0.0349
	(-1.45)	(-1.38)	(-1.39)	-0.27	-0.38	-0.09	(-1.32)	(-1.20)	(-1.17)
Ln_Size	0.202	0.259	0.448	1.921	1.712	1.858	0.281	0.231	0.435
	(-0.61)	(-0.54)	(-0.85)	-1.78	-1.26	-1.25	-0.72	-0.44	-0.75
ROA	0.224**	0.271***	0.271***	1.122***	1.363***	1.343***	0.217*	0.258***	0.258***
	（-2.7）	（-3.79）	（-3.78）	-5.08	-4.58	-4.4	-2.59	-3.56	-3.55
LA	-0.00779	-0.0116	-0.0123	0.0347	0.0231	0.0251	-0.00488	-0.00796	-0.00918
	(-0.52)	(-0.69)	(-0.73)	-0.95	-0.48	-0.52	(-0.28)	(-0.41)	(-0.47)
LLP	6.688	6.784	9.3	9.614	-5.509	-7.483	-17.24	-13.71	-10.71
	（-0.34）	（-0.32)	（-0.43）	-0.21	(-0.12)	(-0.17)	(-0.87)	(-0.65)	(-0.48)
CIR	-0.0121	-0.0115	-0.011	0.0448*	0.0425	0.043	-0.0209	-0.0185	-0.0177
	(-0.91)	(-0.75)	(-0.71)	-2.28	-1.97	-1.98	(-1.34)	(-0.99)	(-0.94)
BUF	-0.0414	0.106	0.107	-0.454***	-0.346**	-0.343**	-0.00076	0.157*	0.158*
	(-0.35)	(-1.2)	(-1.19)	(-8.89)	(-3.42)	(-3.38)	(-0.01)	-2.34	-2.34
GDP_G	-18.55***	-17.66***	-17.70***	-15.41***	-17.47***	-17.47***	-21.09***	-19.13***	-19.20***
	(-9.89)	(-9.75)	(-9.76)	(-8.74)	(-8.16)	(-8.15)	(-7.57)	(-7.05)	(-7.04)
DOF	-0.182	-0.119	-0.106	0.151	0.088	0.097	-0.235	-0.0762	-0.0561
	(-1.68)	(-0.87)	(-0.78)	-1.72	-1.04	-1.1	(-1.41)	(-0.34)	(-0.25)
L.d_z	-0.153***	-0.199**	-0.198**	-0.0993	-0.0627	-0.0466	-0.163***	-0.210**	-0.210**
	(-3.69)	(-3.32)	(-3.31)	(-1.61)	(-0.63)	(-0.51)	(-3.40)	(-3.17)	(-3.18)
_Cons	12.05	6.172	3.229	-38.50*	-30.33	-32.85	15.24	3.235	-0.174
	-1.34	-0.51	-0.26	(-2.22)	(-1.40)	(-1.37)	-1.23	-0.18	(-0.01)
N	850	850	850	195	195	195	655	655	655

Note :T statistics in parentheses: * p<0.05, ** p<0.01, *** p<0.001

5. Discussion and conclusion

Moral hazard implies that one party takes excess risk, and another party has to bear the consequence from that risk, because of the information asymmetry and the conflict of interest between shareholders and creditors. Thereby, the moral hazard issue is a common issue in commercial banks. However, a less moral hazard market is a relatively fair financial market, which is the foundation for creating a healthy investment environment. Besides, detecting and managing moral hazards is essential to protect the banking system from crisis attacks. A less moral hazard economy can use the taxpayers' funds properly, instead of flowing to the unnecessary bailout. Therefore, this primary purpose of this study is to explore whether banks in Europe still have existing moral hazards after the financial crisis and compare the moral hazard problems between large and small banks.

The panel data based on 142 banks in Europe from 2013 to 2018 years were collected. Large banks were classified by the standard of significant banks from ECB. The total value of a bank that exceeds €30 billion can be counted as a large bank. The large bank samples include 33 banks, while the small banks' samples have 109 subjects. All of those samples are from 26 countries in Europe. This study refers to the moral hazard test method of Duran and Lozano-Vivas (2015). They provide a detecting risk-shifting method, which compares the relationship between changes in Z-score and the changes in capital structure components to detect moral hazard issues. Besides, this study involved bank-specific factors, Basel III related factors and macroeconomic-related factors as the expression for the changes of overall risk. In order to observe what the influence will be for the changes of risk after the Basel III implementation, capital ratio (CAP), leverage ratio (LEV), and liquidity ratio (LIQ) are the representative variables for Basel III.

Eventually, this study detects three major conclusions. Firstly, the moral hazard exists around all banks' collected samples. The other debt-based risk-shifting is the reason for that moral hazard. Furthermore, both large banks' samples and small banks' samples present a moral hazard problem. But the type of risk-shifting between those two samples is different. For Large banks' groups, the moral hazard issue cannot be classified by the current risk-shifting type. The moral hazard problem in small banks' samples can be attributed to the other debt-based risk shifting. Lastly, the main contribution of the moral hazard for the entire banks' samples depends on the small banks' samples.

The first discussion for this paper is around the results. By using 15 European countries from 2002 to 2009 samples, the research of Duran and Lozano-Vivas (2015) found that the moral hazard problem in banks transfers the risk from the equity side to non-depository creditors. The finding of this study is similar to the conclusion posed by Duran and Lozano-Vivas (2015). Although this study involved the bank-specific factors, the Basel III related factors and the macroeconomic-

related factors as the explained factors for overall risk changes, and used data consisting of 26 European countries from 2013 to 2018. A similar finding is that the other debt-based risk-shifting type of moral hazard exists for all the collected commercial banks' samples and the small banks' samples.

Secondly, according to the relevant literature, there are two possible reasons to explain the existing moral hazard for small banks. First of all, the rat race for funding resources between large banks and small banks (Hakenes and Schnabel, 2011) might force the small bank to take excess risk. It might cause a moral hazard for small banks. Besides, according to the perspective of Kwan and Eisenbeis, (1997) that the relationship between operational efficiency and capitalized level perspective, the relative lower operational efficiency and relatively weakened capitalized level might also lead the small banks over taking and shifting the risk.

Thirdly, the unclassified risk-shifting moral hazard for large banks samples, might be because of the implicit insurance issue for large banks (Nier and Baumann, 2006). "too big to fail" poses an implicit opportunity for large banks to take excessive risk and transfer risk. However, due to the limitation of the samples' size for the large banks, this study still cannot detect the risk-shifting reason.

Additionally, from the results of the entire banks' samples, Basel III did not make plenty of effort to inhibit the moral hazard problem from 2013 to 2018. Specifically, from the finding of this paper, large banks group and small banks group present different risk-shifting types in moral hazard problems under three Basel III requirement factors. It seems like the Basel III implementation also does not make a massive difference in restricting the risk-shifting in this study. From this sense, with the same opinion of Bodellini (2019), Atkinson and Blundell-Wignall (2010), policymakers should provide diverse regulations for different sizes of banks rather than "one-size-fits-all-driven" regulation. Moreover, policymakers of banking regulation can consider the potential flaws of the risk shifting on the banking industry.

In short, the finding based on the commercial banks' samples of 26 European countries from 2013 to 2018, presents that the moral hazard still exists even after the financial crisis. Due to the concern about the economic impact of the coronavirus crisis and the new norm, exploring whether European banks had excessive risk-taking in recent years due to moral hazard issues might be a meaningful topic. Although the limitation of the sample number, it is possible to lead to the bias of the results. Hoping the finding from this study can provide a reference for further policy development after the corona crisis.

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Appendix

Table 8 Pairwise correlation among large banks' variables

Variables	**ΔZS**	**ΔE**	**ΔD**	**ΔOF**	**CAP**	**LEV**	**LIQ**	**ln_SIZE**	**ROA**	**LA**	**LLP**	**CIR**	**BUF**	**GDP_G**	**DOF**
ΔZS	-														
ΔE	0.4738	-													
ΔD	0.158	0.1238	-												
ΔOF	-0.1607	-0.0442	0.0306	-											
CAP	-0.0567	-0.0556	-0.0498	-0.0533	-										
LEV	0.1474	0.1405	-0.023	-0.065	0.4034	-									
LIQ	0.0824	0.2023	-0.0163	-0.1469	0.2638	0.1379	-								
ln_SIZE	0.0249	-0.0911	-0.0112	-0.0011	-0.0392	-0.0443	0.2564	-							
ROA	0.1027	0.2185	0.2783	-0.1971	0.1425	-0.0445	-0.0661	-0.1924	-						
LA	-0.0027	0.1796	0.0952	-0.0692	-0.0733	-0.0863	0.0797	-0.2418	0.0859	-					
LLP	0.2313	0.1268	0.0867	-0.003	0.1449	0.1524	-0.0406	0.1829	-0.0375	0.1965	-				
CIR	-0.0309	-0.2573	-0.0251	0.0404	0.1567	0.1215	-0.1355	0.1365	-0.0064	-0.5736	-0.0274	-			
BUF	-0.0596	0.4895	-0.0068	0.0599	0.0867	-0.0347	0.0404	-0.387	0.3021	0.2932	-0.0896	-0.2371	-		
GDP_G	-0.4688	0.0492	-0.0128	0.0268	0.0398	0.031	0.0004	-0.0543	0.0998	0.0442	-0.0498	-0.0376	0.1534	-	
DOF	0.0847	0.2591	-0.0467	0.1629	0.1524	0.2171	0.0875	-0.1183	-0.1926	-0.0381	0.1156	-0.1315	0.149	0.2179	-

Table 9 Pairwise correlation among small banks' variables

Variables	**ΔZS**	**ΔE**	**ΔD**	**ΔOF**	**CAP**	**LEV**	**LIQ**	**ln_SIZE**	**ROA**	**LA**	**LLP**	**CIR**	**BUF**	**GDP_G**	**DOF**
ΔZS	-														
ΔE	0.4508	-													
ΔD	-0.0243	-0.0094	-												
ΔOF	0	0.0069	-0.0071	-											
CAP	-0.0192	-0.0301	-0.0464	-0.0098	-										
LEV	-0.0537	-0.0598	0.0173	-0.0014	0.4026	-									
LIQ	-0.0109	0.042	-0.0237	-0.0088	0.3341	0.03	-								
ln_SIZE	0.0204	0.0616	0.0334	0.0007	-0.0701	-0.1037	-0.057	-							
ROA	0.4332	0.3955	0.0021	0.0002	0.0166	-0.0037	0.0163	0.0363	-						
LA	0.0117	-0.0007	0.0361	-0.0191	-0.0382	-0.0005	-0.0736	0.1483	0.0168	-					
LLP	0.0602	0.0093	0.0286	0.1012	-0.0365	-0.0198	-0.0713	0.1446	0.0164	0.1492	-				
CIR	-0.0362	-0.0293	-0.0065	0.025	0.0539	0.032	-0.0658	-0.0232	0.0711	-0.0566	-0.009	-			
BUF	-0.1493	0.1992	0.0455	-0.0219	-0.041	-0.0028	0.0229	-0.0322	0.0906	0.0102	-0.0634	-0.0483	-		
GDP_G	-0.3897	0.0752	0.0651	-0.0048	0.0108	0.0077	-0.0169	0.0696	0.0128	0.0224	-0.0953	0.0881	-0.0195	-	
DOF	-0.0364	-0.0023	-0.1119	0.0202	0.0553	0.069	-0.1407	0.0734	0.0017	0.0018	-0.0455	0.0237	-0.0295	0.1448	-