



Monitoring of banks by depositors -
Impact of capital, liquidity and government deposit insurance
An Empirical Study on European Banks

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“Rather than justice for all, we are evolving into a system of justice for those who can afford it. We have banks that are not only too big to fail, but too big to be held accountable.”

Joseph E. Stiglitz

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1 Introduction

The 2007-2009 financial crisis has brought to attention the need for regulators to tackle bank risk. In addition to the already existing market monitoring exerted by depositors on their banks, regulators felt the need to increase prudential regulations to prevent another crisis from happening. The Basel Committee, the primary authority responsible for prudential regulations of banks worldwide, tightened its capital requirements and introduced liquidity requirements in order to improve banks' solvency and liquidity positions. The government deposit insurance also was increased in many countries (such as for all the European Union Member states where it was set to €100.000) in an attempt to prevent further bank run and liquidity crisis. Most of the research and regulation acknowledge capital, liquidity and the risk taken on the asset side of the balance sheet as key determinants of a bank's aggregate level of risk.

There as been much research already done on the direct impact of capital, liquidity or government deposit insurance on risk. Many of them arguing that market discipline, exercised by depositors, forced the bank to hold sufficient capital and liquidity levels even without regulation. Many papers also discussed the perverse effect of government deposit insurance which removes any incentive to depositors to monitor the risk of their bank and hence leads to riskier behavior by banks.

Depositor monitoring was, for instance, studied by Goldberg and Hudgins (1996) who proved that depositors were reducing holdings at financial institutions which were failing. Martinez, Peria and Schmukler (2001) proved that liquidity, capital and the level of risk of banks were determinants of the bank's ability to attract depositors. Both papers highlight the primary role of depositors when it comes to monitoring banks.

The literature on capital highlights two ways through which capital levels impact the risk of a bank and the risk of a bank for depositors. First, it leverages capital holders (the more capital they have in the bank, the more they have to lose if the bank fails) hence giving them incentives to reduce the risk of the bank for them and therefore for depositors. It is also important to distinguish the risk for the depositors and the risk for the shareholders of a bank. As depositors are primary claim holders over share holders, an increased level of capital will guarantee depositors will get their money back as long as the bank does not suffer from a loss larger than the total amount of capital it is holding. Allen, Carletti, Marquez (2005) developed a model in which capital is brought in because of market discipline. As a matter of fact, in cases of bankruptcy depositors are the primary claim holders so if the bank loses value it is primarily reflected in its capital. Hellmann, Murdock, Stiglitz (2000) show that more capital relative to deposits increases the likelihood of depositors getting their money back and foster monitoring by investors as they carry more risk.

When willing to protect depositors, it seems adequate for the legislator to require higher levels of capital. The legislator must however keep in mind that, if depositors think that their deposits are covered by a sufficient amount of capital for the bank to absorb a significant loss without reducing the value of deposits, they might reduce monitoring on the bank which might lead to a riskier investment policy by the bank.

Regarding liquidity, the existing research shows that the structure of a bank makes it inherently riskier than any other company. Banks are indeed financed with deposits that are on-demand liabilities while investing in loans that are illiquid. This maturity mismatch mechanically leads to more risk than for any other type of company. From this maturity mismatch comes the possibility of a bank run. It occurs when depositors, worried that their bank will not be solvent, all go to the bank to withdraw their money. In the event of a bank run, banks are forced to sell illiquid assets at a loss and hence go bankrupt even if they were solvent. Some have argued that bank runs are not necessarily related to the fundamentals, as Diamond & Dybvig (1983) while others argue it is. For instance Chari & Jagannathan (1988) consider a model in which bank runs are a form of monitoring. Whatever contention there may be about the nature of bank runs, all agree that holding a higher level of liquidity reduces the likelihood that they will occur. Thus, banks with more liquid assets are safer *ceteris paribus*.

The government deposit insurance, a regulation ensuring that governments will insure deposits to a certain extent, was implemented to prevent bank runs. By insuring deposits, the government assures depositors will not withdraw their money due to panic and hence prevent the phenomenon from happening (see for instance Diamond & Dybvig (1983)). Bryant (1980) proposed an alternative approach with a model in which bank runs can still occur with government deposit insurance because, if the government pays depositors with printed money, they will get their deposits back devaluated and hence have the incentive to withdraw their deposit before it occurs. He also discusses the equilibrium effect of such policy depending on whether the government pays insured depositors with printed money or by taxing the next generation. A major issue arising from this insurance is known as the moral hazard problem (Diamond & Dybvig (1983)). When depositors are not insured against losses their bank may suffer, they are encouraged to monitor it in order to ensure that it does not occur. The moral hazard problem happens as, by insuring depositors, the government removes any incentive they may have to engage in monitoring which leads to riskier banks.

If the literature had exhaustively studied the direct impact of capital, liquidity and government deposit insurance on risk, fewer papers have studied the interaction of those variables together. For instance Calimoris, Heider and Hoerova prove that both capital and liquidity can act as ways to reassure depositors and hence must be considered together in research as well as in regulation.

The novelty of this research will be to consider that capital, liquidity as well as government deposit insurance all serve as ways to reassure depositors against the threat of losing their deposits.

This research is based on the assumption that depositors monitor banks to ensure that they will get their deposits back. Banks, willing to keep their depositors can reassure them in three ways: by decreasing the level of risk of the assets it holds or by increasing capital or liquidity levels. Government deposit insurance will also impact the level of monitoring. As both capital and liquidity can reassure depositors, they act as substitutes to reassure depositors and a very well capitalized bank might hence be less liquid while banks holding a lot of liquidity might

be under capitalized. Banks that are very well capitalized and highly liquid might tend to take more risk than other banks as they are less monitored. As a credible government deposit insurance also reassures depositors against the risk of losing their deposits, we will study how an increase in the government deposit insurance leads to riskier, less capitalized and less liquid banks as the level of market discipline exercised by depositors was reduced.

Those variables were studied separately in most of the previous literature and treated as different problems in the legislation as capital and liquidity were regulated by the Basel agreements but as separate issues while government deposit insurance is, in the European Union, decided by the European Commission for all the member states.

We will empirically test two hypothesis:

First, shareholders prefer high levels of risk, low liquidity and capital positions to maximize their return on equity but depositors, willing to keep their deposit safe, will monitor the bank and require sufficient levels of capital and/or liquidity and/or low levels of risk. We expect a trade off between lower levels of capital and/or liquidity and a riskier investment behavior for investors.

Second, the higher the government deposit insurance, the less binding is the constraint coming from depositors' monitoring. A higher level of government deposit insurance will allow investors to choose lower levels of capital and liquidity while taking more risk on the asset-side of the balance sheet.

To illustrate how capital, liquidity and government deposit insurance are all interacting determinants of the level of risk of a bank, we first created a model in which investors, willing to minimize the level of capital and liquidity while maximizing risk, have to trade off between decreased levels of risk or increased levels of capital or liquidity in order not to suffer from a bank run by depositors. We then add government deposit insurance and show that, by reassuring depositors regarding their deposits, it will allow investors to take higher levels of risk and/or decrease capital and/or liquidity.

We then created a database collecting data regarding capital, liquidity, risk and the level of government deposit insurance for 149 banks from all the member states of the European Union at a quarterly frequency during the time period 2008-2017. And we were then able to test our predictions by running a general estimation in which the risk premium of a bank is explained by its level of capital, liquidity and the government deposit insurance and show that they, indeed, all act as ways to reassure depositors and are substitutes.

In addition to providing a model supported by empirical evidences, helping the reader to understand how both sides of a bank's balance sheet interact to satisfy depositors monitoring, proving that capital, liquidity and government deposit insurance act as substitute ways to reduce depositors monitoring and hence increase the risk is of primary importance for the legislator.

Indeed, regulations regarding capital, liquidity or government deposit insurance are taken separately. It appears that, at the moment, no regulatory requirements on capital nor liquidity are binding as we observe banks that are more liquid and better capitalized than what is

legally required. But if regulation regarding either capital or liquidity was becoming binding, without being for the other variable it would lead to disastrous outcomes. For instance, high liquidity requirements would lead to under-capitalized banks and vice versa. Understanding that increasing government deposit insurance might not only lead to financial institutions taking additional risk in their investment but it might also lead to under capitalization and low liquidity levels. This research highlights the necessity to propose a comprehensive legislation regarding capital and liquidity that are binding for both factors. It also highlights that, when raising government deposit insurance, the legislator should consider imposing binding minimums for capital and liquidity levels in banks.

However the model of this research also demonstrate how, to some extend, both capital and liquidity can be good ways to guarantee deposits. It leads us to argue that it might not be optimal to impose two binding levels of capital and liquidity on the bank depending on their risk but we rather suggest minimum capital (liquidity) levels that are contingent to the liquidity (capital) and risk level of the bank. This leaves the bank the freedom to choose how to optimize its capital, liquidity and risk level while insuring the same minimized level of risk for depositors.

It is important to highlight that it is even more critical to understand the underlying risk of banks than any other company. Unlike other corporations, most of the liabilities of a bank balance sheet come from people who do not want to bear any risk. Contrarily to an investor, when depositors puts their money in a bank they do it with very little concern regarding the return they may be offered yet desire the certitude to have their money back on demand. Banks' added value to depositors totally vanishes if a significant amount of effort must be put forth to ensure that their money is safe.

Due to this, governments often choose to try not to let a bank fail by bailing it out. These bailouts come at a huge cost. M. Flannery & E. Giacomini (2015: 236) pointed out that *“between 2008 and 2011, European governments’ support of troubled banks included €1084.8 billion (8.6% of EU GDP) of guarantees on banks’ bonds and deposits, €322.1 billion (2.5% of EU GDP) of capital contributions, €119.9 (0.9% of EU GDP) of impaired assets purchased, and a €89 billion (0.7% of EU GDP) of liquidity support.”* We know from F. Mishkin (2013) that the 1997 and 2001 banking crises in Indonesia cost on average 57% of the GDP. To give an example for a country in Europe, it was 13% of the GDP for Finland in 1991 and 1995.

Research published by Bourgeot in 2013 for the Robert Schuman Foundation showed an explosion of sovereign debt in Europe due to the bank crisis. As European governments cannot print money to save their bank and raising taxation during a financial crisis is complicated as the economy is already slowed down, the only option left for a government who needs to put money in banks is to get financing through debt. The level of debt was close to 180% of the GDP for Greece at the end of 2013 while it was just above 100% in 2006. Over the same time period, Germany’s debt went from 60% to 80% of the country’s GDP and the overall level of the debt for the Euro area went from just above 60% to close to 100% of the GDP. A report published in 2009 by the European Commission showed that the YOY growth of the European

GDP went from 3% in 2006 to -5% in 2009. Reinhart & Rogoff (2009) showed that 7.3% of the years since the Independence of Belgium were marked by a bank crisis. Finally, a report on the 2009 general assembly of the national bank of Belgium (Belgian central bank) mentions that *“Between august the 1st of 2008 and the 31st of October 2008, credits given by the Euro System to credit institutions rose from €475.5 billion to €839.6 billion”*¹

In addition to raising the government debt, reducing the GDP growth and placing the burden of bankruptcy on depositors, bank failure has many more macroeconomic impacts. When banks are in troubled situations they are reluctant to giving new loans as they already struggle with their liquidity. Many bank crises lead to economic crises as the slowdown in economy due to lack of investment cannot be compensated by government expenses as they are already struggling with skyrocketing levels of indebtedness.

Even out of crisis, when the banking system is not pressured, it is of primary importance for an economy to have sound banks. Gambacorta, Song Shin (2016) indeed showed that better capitalized banks were more able to keep their lending activity up in times of contractionary monetary policies.

This highlights the primary role of safe banks in the economy, not only to enable people to have riskless deposits but also because bank failures put a huge burden on governments and on society as a whole. And it is aligned with those fact that this research was completed.

The main contributions of this paper are, first, its innovative look on market monitoring by depositors being a function of risk, capital, liquidity and government deposit insurance, with capital, liquidity and government deposit insurance acting as substitutable ways to reassure depositors against the risk of the bank. Second, the creation of a database which was done by extracting data from the balance sheet of 149 banks individually. Data at a quarterly frequency over a 10 year span collected regarding the level of risk, capital liquidity and government deposit insurance for depositors of each bank. Third, the empirical tests of our model allowing us to confirm the findings of the literature regarding the direct impact of capital, liquidity and government deposit insurance on risk. Our empirical analysis also allowed us to prove that capital, liquidity and government deposit insurance can all lead to decreased monitoring by depositors and hence allow banks to take more risk. Capital, liquidity and government deposit insurance are substitute to some extent and must be considered collectively when regulating banks.

The main finding of this research when it comes to bank regulation is that, if the Basel Committee decides to make capital and liquidity requirements binding, it must be done such that both requirements are binding else it will either lead to under capitalization or banks with too low levels of liquidity.

The paper will have the following structure. After the introduction, is the literature review, in which we exhaustively cover the research that has been done on the impact of capital,

¹In French in the text. Banque Nationale de Belgique. (2009). “Impact de la crise financière sur la Banque - Question débattue lors de l’assemblée générale de 2009”. Original version: “Entre le 1er août 2008 et le 31 octobre 2008, le crédit octroyé par l’Eurosystème aux établissements de crédit a augmenté de 475,5 milliards d’euros, à 839,6 milliards d’euros”

liquidity and government deposit insurance on risk taking behavior by banks. We also detail the interaction between those variables that have already been found. The second part of this section focuses on the regulation regarding this topic as well as its evaluation.

The third section is a presentation of our model as well as its resolution. We use a simple model in which investors want to maximize the risk taken on the asset side of the balance sheet while minimizing the capitalization and liquidity level of the bank in order to maximize their return on equity. They, however, have to trade off between a sufficient level of capital and/or liquidity or a safer investment policy in order to be able not to suffer from a bank run. We then show how the government deposit insurance will allow investors to reduce capital and/or liquidity levels while increasing the riskiness of the bank's investment policy because of decreased depositors' monitoring.

The fourth chapter is the presentation of the database. In this section we present the proxies used for the capital and liquidity positions of the bank as well as for risk and government deposit insurance. The limits of all those proxies are presented as well as their advantages. Summary statistics regarding all the variables that will be used are also presented.

The fifth section is the empirical analysis. In this chapter, we first confirm the findings of the literature regarding the impact of liquidity, capital and government deposit insurance on risk when the predictors are taken alone. Running a general estimation on the impact of those variables on risk, we then show that there is some elasticity of substitution between capital and liquidity as both serve as ways to reassure depositors against the risk they face when banks take excessive risks.

Finally a conclusion of our findings and the implication it has for the literature and legislation is proposed in the sixth section.

2 Literature review

This research focuses on depositor monitoring depending on the bank's risk, capital and liquidity positions as well as the government deposit insurance.

We will start the literature review by studying the research that was done on the monitoring of banks by depositors and its determinants. Then, as the aim of the paper is to understand how, throughout monitoring, capital, liquidity and government deposit insurance affect the level of risk of a bank, we will study the direct impact of those three variables on risk when taken alone.

As we want to prove that there is interaction between those variables, we will present the research that was done on the interaction between capital and liquidity in banks before focusing on how it is impacted by the government deposit insurance.

The last sections of the literature review will focus on the existing legislation as well as its evaluation.

2.1 Monitoring of banks by depositors

We start by looking at Goldberg & Hudgins (1996) who studied whether the threat of depositors withdrawals was disciplining banks or not by examining the behavior of uninsured depositors in savings and loan associations (S&L hereafter). They empirically checked whether or not the ratio of uninsured deposits to total deposit decreases when an institution approaches insolvency.

They did so using data from quarterly financial reports (1984-1989) of the S&L insured by the Federal Savings and Loan Insurance Corporation (FSLIC).

They used two measures for the importance of uninsured deposits in the balance sheet of the S&L: the ratio of uninsured deposits to total deposits and the ratio of uninsured deposits to total liabilities.

They then used a Maximum likelihood logit model taking into account fundamentals including expenses, incomes, state specific economic and financial trends, liquidity, capital and assets quality to assess the likelihood of failure of each one of those S&L.

Finally they plugged the obtained probability of failure as well as other control variables as the explaining factors in a reduced form model where the dependant variable was one of the two indicators for the relative importance of uninsured deposits in the balance sheets.

They used a linear model and found out “(1) that depositors reduce uninsured holdings at institutions which are failing; (2) that healthy S&L's attract more uninsured deposits than failing S&L's; and (3) that measures of the probability of future failure affect the amount of uninsured deposits that an institution can obtain.” (Goldberg & S.C. Hudgins (1996: 312))

This can be completed by Martinez Peria & Schmukler (2001) who studied how interest rates on deposits and the level of deposits in banks were affected by the banks' fundamentals because of depositors' monitoring as well as the impact of deposit insurance on this monitoring. They also looked at the impact of banking crises (increasing the probability of default and depleting the government deposit insurance fund) on the level of market discipline exercised on banks by

depositors.

To do so they collected data on banks in Argentina, Chile and Mexico during the 80s and 90s with the help of the financial supervisors of those countries. They had data regarding the interest rate paid on deposits, the level of deposits in each bank in each period with the ability to discriminate between insured and uninsured deposits and used a CAMEL model to create a proxy for the global level of risk of the bank. A CAMEL model takes into account capital adequacy, asset quality, management, earnings, and liquidity.

They then created a model for variation of deposits (first difference of the log of the time deposits of each bank in each period) and another one for interest rate. Both of them had as explanatory variable a vector of the fundamentals of the bank.

They tested whether the estimates of the beta coefficients are individually or jointly different from zero and found significant Beta when the fundamentals were used as explanatory factors for the variations of deposits or interest rates.

They ran the regression for each country and an alternative specification with a regression for insured deposits and one for uninsured deposits.

They were able to conclude that (1) deposits respond to bank risk-taking behavior. Better capitalized banks, profitable banks or banks with safer assets are more able to attract depositors and that better capitalized or more liquid banks pay lower interest rates, (2) there are no significant difference in the response of bank deposits to banks' fundamentals for insured or uninsured depositors because the deposit insurance schemes are not fully credible for the countries in the sample, and that (3) in Argentina, the extent of market discipline diminishes during the crisis and increases sharply afterwards. In Chile, the deposits became more reactive to the banks' fundamentals after the government had to intervene on the bank and in Mexico, both interest rate and changes in the level of deposits become more significant after a crisis.

We finally look at C. Calomiris & B. Wilson (1998) who, based on the fact that depositors prefer banks with low risk profiles, study the trade off between low risk assets (contraction of the supply of loans) or high capital positions that banks face.

To do so they collected market data for publicly traded banks in New York City between 1920 and 1940. They had data regarding capital position, asset volatility, value of assets, share price and its volatility and used a Black and Scholes model to evaluate the riskiness of deposits taking into account credit risk spread, capital ratio of the bank and riskiness of bank assets (log deviation of the asset value).

They then present a model in which the assets of the bank can be divided between risky loans and safe reserves with the risky loans bringing in a return that was a direct proportion of the total amount of loans (rate of return "a" time loans). On the liabilities side of the balance sheet the bank can raise equity at a cost that it proportional to the total amount of equity needed (cost "c" time the total equity).

Depositors want a low level of risk on their deposits which can be achieved by increasing the level of capital (at a cost "c") or decreasing the amount of risk loans (at an opportunity cost "a"). Profit maximizing bankers then have to chose the optimal level of capital and risk

bearing loans to maximize profit while retaining depositors.

They ran panel regressions and found out that, as higher risk on deposits led to deposits outflow, banks wanted a low default risk on deposits in the long run and achieved so by either increasing the capitalization of the bank or choosing assets bearing low risk. In times of recession banks were unable to raise capital and hence had to contract the amount of loans they were making in order to mitigate the increase of risk on deposits. They concluded by insisting that it is important to look at both side of the balance sheet (capital in the liabilities and the risk of the assets) as depositors have the same preferences over time on the level of risk they are ready to accept on their deposits but that this optimal level can be achieved in different ways.

In this research we will look at the level of risk of a bank depending on the level of capitalization and liquidity of the bank as well as the deposit insurance based on the assumption that banks are monitored by depositors. We will prove that both capital and liquidity are ways to reassure depositors against the risk they face of losing their deposits and that increasing the level of capital or liquidity of the bank allows the investors to take more risk. We will also prove that capital and liquidity are substitutes as ways to reassure depositors and that their optimal levels of capital and liquidity is affected by the importance of government deposit insurance.

2.2 Capital adequacy

It is now important for us to understand how capital affects the risk depositors face and hence the level of monitoring they will exert on the bank and how this monitoring is going to mitigate the aggregate level of risk of the bank.

Bank capital is what is commonly called equity or net worth for any other type of company. It consists of the difference between the assets and all the liabilities of the bank and is the value of the bank for shareholders. There is no first come first served right to cash flow associated with capital and, in case of bankruptcy, depositors will have the priority to get their claim back over the capital owners.

If a bank is facing a loss of value on its asset side, the first ones to be affected will be the capital holders as the primary losses will be reflected on capital and then deposits.

It is interesting to start this discussion with Orgler, Taggart, Jr (1983) who studied the optimal capital structure for banks.

They start with a model in which interest rates paid on debt are tax deductible while those paid on dividends are not. The return on tax exempt bonds must therefore be lower than the one on equity in order for a corporation to choose both financing options. They argue that it is the case because the agency cost imposed by bondholders is higher than the one imposed by security holders and that an increase in debt increases the likelihood of bankruptcy which increases what they called the bankruptcy cost. As both the agency cost and the bankruptcy cost are firm specific, all firms have different optimal capital levels.

When applying this model to banks, they consider that deposit is the only type of debt. The optimal level of deposits will be defined by the cost of raising deposits for banks, which,

on the one hand, have an interest rate paid to depositors that is tax deductible which makes it more interesting than dividends paid to security holders but forces the bank to provide costly services to deposit holders on the other hand versus the cost to raise capital. One of the main service provided by the bank to depositors is safety. Safer banks will hence be able to attract more depositors and need less equity.

If their model is valid for any type of debt, the authors argue that the cost associated with deposits are highly dependent on of the institutional framework. First, because insured depositors do not have any incentive to require the safety service from their bank hence making capital more expensive compared to deposits and leading to lower levels of capitalization. Second, large banks are perceived as too big to fail even by uninsured depositors and hence can attract deposits at a lower cost than smaller banks leading to bigger banks being less capitalized.

The key take away from this research is that there are significant differences in the role of capital for financial and non-financial firms. In the case of a bank, the optimal level is highly dependant on the regulatory framework as well as of the size of the bank. Based on those findings, it has been decided not to review the whole literature on the capital structure of firms but only to focus on the capital structure of banks. We will also test whether the size of the bank has an impact on our results in the empirical section. The impact of deposit insurance will be further studied later in the literature review and will be integrated in our model and empirical analysis.

A part of the literature focuses on the impact of the tax system on the optimal level of capital as described in the previous model because debt comes with interest rates that are usually tax deductible but also increases the bankruptcy cost (Sundaresan, Wang (2014, 2017); Haugen, Senbet (1978)).

However, as our focus is to understand how capital affects the level of risk of a bank in order to then be able to discuss the optimal regulatory requirement, we concentrate on the other part of the literature on capital which studies the direct impact of capital on the level of risk a bank is willing to take.

The basic theoretical role of capital in banks will be presented using the book “*Modeling monetary economies*” by Champ, Freeman, Haslag (2016) and then other more advanced models or analyses available in the literature will be presented.

The book presents a model in which the liability side of the balance sheet is made of deposits and net worth (bank capital) while the asset side of the bank’s balance sheet is composed of reserves (liquidity) and interest-bearing assets.

Depositors have the first claim on assets in case of bankruptcy. Hence, if the bank suffers any loss it will first be removed from the net worth, preventing depositors from suffering from losses if they are smaller than the amount of net worth brought in by investors. So a higher level of net worth increases the likelihood for depositors to get their deposits back giving them less incentive to monitor the bank.

Because of this the investors are highly exposed to any loss of value in the asset side of

the balance sheet as any loss is subtracted from the net worth and they will hence have more incentive to monitor the bank.

Banks want to hold the least capital possible but market regulation exercised by depositors forces them to hold sufficient levels. The more risk the bank takes in its investment policy, the more capital will be required by depositors.

There is a consensus in the literature that more capital leads to an internalization of the risk by the bank. It can be better understood using Hellmann, Murdock & Stiglitz (2000) who presented a model in which banks can either invest in a prudent asset or in an inefficient gambling asset. The first one offers a high yield for society but a relatively low return for the bank. While the second one offers a high private payoff for the bank, if successful, but brings a high cost to depositors if the gamble fails. By having more capital, the bank exposes itself more to the losses that can potentially occur with the gambling asset. If depositors believe that the bank has too much to lose to choose to invest in the risky asset, they will agree to trust it with their money. On the other hand, a bank with deposits only will not have anything to lose if the gamble fails and will invest in the risky asset.

Another interesting article on why banks hold capital despite it being costly is from Allen, Carletti, Marquez (2005), who, based on the fact that banks choose levels of capital far above the regulatory minimums, created a model in which market discipline determines the level of capitalization of a bank and therefore show that banks can be under capitalized even when meeting with regulatory requirements.

In their model banks loan money to firms with a return greater than one if successful and of 0 if the firm they loan money to fails. They can finance those loans by raising capital or deposits. Capital is more expensive to the bank than deposits.

After lending money, the bank will monitor the firm in order to increase the likelihood of success. This monitoring will take the form of financial advises to the firm and is valuable for the firm as well. However, monitoring comes at a cost for banks and will not always take place. There are two ways to make monitoring interesting for the bank. Either by having them hold high levels of capital as investors will then carry a lot of the cost of default or by increasing the interest rate on loans as it will bring a greater positive return if the loan is successful. As the authors suppose a competitive loan market, the second option is not possible as a firm will always choose the bank with the lowest interest rate to finance itself.

As they observe capital levels above regulatory minimums, the authors have found two ways in which market discipline has forced the investors to bring in more equity. First, on the liability side, depositors want the investors to be carrying enough risk such that they have incentives to monitor the loans and hence guarantee the depositors to have their money back. Second, on the asset side of the balance sheet, firms borrowing money want the banks to have incentives to monitor them as those financial services provided are valuable to them.

In their model, the authors prove that increased levels of capital provide incentive for investors to monitor the bank and are required by depositors and borrowers of the bank.

Another way to look at the dynamic between risk and capital is by analyzing further the

trade off described above. As better capitalized banks have more incentives to exercise monitoring and as depositors are primary claim holders in case of failure, well capitalized banks might be less monitored by depositors and then become riskier.

The relation between capital and risk can be concluded by Peltzman (1970) who argued that, as for any other industry, capital can be invested to bring a return and can be used as a guarantee for the firms' obligation (deposits for instance in the case of a bank). The author empirically proved, using a model in which the level of capital was the dependant variable of a model taking into account the risk of the bank as well as the level of deposits, that the difference between banks and other firms lies in the relative importance of both components saying the capital is primarily held in banks as a way to reassure depositors and hence bring in deposits which can be invested.

We have shown many effects of capital on risk. First, it reassures depositors, as they have a priority claim on the assets, the more capital, the more likely they are to get their money back in case of bankruptcy. Increasing capital should reduce monitoring by depositors and allow for more risk.

Second, capital exposes investors to the risk taken on the asset side of the balance sheet as any loss of value of the assets is first reflected by a decreased level of capital. Because they are exposed, investors will monitor the risk. The aggregate effect of this is however unclear. It can either lead to safer banks as assets are better managed by investors or it can lead to a significant decrease in market monitoring of banks as depositors do trust the investors with the monitoring and do not monitor the assets themselves. Investors being less risk averse than depositors this leads to greater aggregate level of risk.

It is finally interesting to look at Gropp, Heider (2009) who used the cross-section and time-series variations in a sample of large banks in 16 countries to find the determinant of bank capital. They found that *"unobserved time-invariant bank fixed-effects are important in explaining the variation of banks' capital structures."* (Gropp, Heider, 2009:6) Hence arguing that regulation may only be of second order importance in determining the level of capital but that banks' specific characteristics may be the first order determinant which is why we will mostly use fixed effect models in our empirical section.

The importance of a bank having an appropriate level of capital goes far beyond the role of preventing bankruptcy. Gambacorta, Song Shin (2016) in a cross country study found that banks that are better capitalized tend to make more loans and have a smaller cost of debt financing and showed that in times of contractionary monetary policies, better capitalized banks can more easily continue on lending money. So if this paper studies the impact of capital on the riskiness of banks, it is important to understand its full macro-economic impact before proposing new legislation.

2.3 Liquidity adequacy

Liquidity is held by banks in order to prevent a banking panic (also known as bank run). *“A banking panic occurs when bank debt holders at all or many banks in the banking system suddenly demand that banks convert their debt claims into cash [...] to such an extent that banks suspend convertibility of their debt into cash.”* (Calomiris & Gordon who say (1991: 112))

There are two distinctive views in the literature on how a bank run can start. The first one is a model of random withdrawals uncorrelated with the fundamentals of the bank and was first presented by Diamond, Dybvig (1983). They developed a three period ($t=0,1,2$) model with two types of agents (early and late type) who do not know their type in period $t=0$. The proportion of both types of agent is however known.

The early type will want to consume in period $t=1$ and the late type in period $t=2$. In $t=0$ the agents can choose to invest in a productive good with a return $R > 1$ in period two. If the investment is interrupted the return is smaller than one and if the money is not invested it offers a flat return of one.

In $t=0$ agents can not decide whether or not to invest in the productive good as they do not know yet if they will want to consume in period 1 or 2. They hence create a bank which is going to invest a share of the total endowment in the productive good and keep another share as liquidity.

In $t=1$, their type is revealed to depositors and the early type will withdraw deposits, in $t=2$ the late type will withdraw their deposits.

Problems arise when, randomly, a late type depositor wants to withdraw their money in $t=1$ or if the rumor of such an event spreads. The bank then has to sell an investment in the productive good at a loss. As the bank is operating at a loss, all the late types fear not getting their money back and all withdraw at $t=1$, leading to a bank failure as all the investment in the productive good has to be sold at a loss. Obviously if the bank had a margin in term of liquidity, late type depositors would not have been worried but it would decrease the return of the investment on the asset side of the bank's balance sheet.

With their model, they are able to demonstrate that banks can improve risk sharing among people willing to consume at different times. They however also show that there exists an undesirable equilibrium (a bank run) in which all depositors withdraw their deposits immediately even if they do not need to consume and that even solvent banks can fail due to bank runs.

In the second type of model, such as those presented by Chari, Jagannathan (1988) or Calomiris, Heider, Hoerova (2015), the authors argue that bank runs are due to asymmetric information leading to a change in beliefs regarding the health of a bank by depositors. We will describe its logic using Chari, Jagannathan (1988).

In this three-period model some uninformed agents are willing to withdraw money from the bank for personal use, some others will withdraw money because they are aware of fundamental problems of the banks and other uninformed agents, willing to keep their money in the bank, will only decide to withdraw money if they expect the bank to be in a bad fundamental situation. As they are uninformed they will observe the line in front of the bank to establish beliefs on the

health of the bank.

The proportion of informed agents as well as the number of agents withdrawing money for an actual use will vary. Even though panic spreading is the main cause leading to bankruptcy, it can be caused in some cases by the fundamentals.

A bank run will occur when uninformed individuals observe a long line at the bank and hence infer that the bank is about to fail. In some cases it may be caused simply because a large portion of agents want immediate consumption, in other cases it is because the bank has poor fundamentals.

The two models are not exactly opposite. In the random withdrawal model, the first withdrawal by a late type agent could also occur because of poor fundamentals. They however can also differ. For instance, a random withdrawal may also be caused by factors external to the bank unexpectedly raising the demand for money.

There has been much research done in order to establish which model was right in which setting, starting with Calomiris and Gorton (1991) who empirically tested the implication of both models using cross country data on banks.

The asymmetric information theory implies: unusual adverse economic news prior to panics, an interaction “*between the different banks loans portfolios and a systematic disturbance.*” (Calomiris, Gorton (1991)) Shocks on loans of a given type implies an effect on banks having loans of such a type and the length of the shock should be similar to the time needed to resolve the shock observed on the asset side

On the other hand, the random withdrawal theory implies that banks struggle to create liquidity (have illiquid assets) or have too little reserves.

They found that historical evidence is consistent with the asymmetric information mechanism. If the two models are not opposed, it however suggests that regulators should not only focus on liquidity when tackling the issue of bank runs but also understand the interaction it has with the fundamentals of the bank. Which is what we will do in this research by studying the interaction between risk, capital and liquidity.

Chakravarty, Fonseca and Kaplan (2014) then tested experimentally to which extent a bank run was caused by fundamentals in the economy or by random withdrawals. They set an experience in which there were two banks. Each bank was assigned patient and impatient depositors in different proportion. The subjects assigned to bank A were able to observe their bank’s liquidity level before deciding to withdraw or not while the ones assigned to bank B could not. They found out that even when liquidity levels were independent, the behavior of bank A’s depositors significantly affected the ones of bank B and concluded that banking fundamentals are correlated with the likelihood of both a bank run and its contagion but that a bank can still be run even though it has good fundamentals.

However, there is a distinction in how contagions occur if it is caused by pure panic or by fundamentals as in the first case depositors run the bank based on spurious information while they do it based on fundamentals in the second.

Iyer, Puri and Ryan (2016) also proposed an innovative way to understand whether bank

runs are triggered by random withdrawals or because of fundamentals and asymmetric information. They use data at the depositor level to study two crises that an Indian bank faced. One of these crises was based on fundamentals, one was due to a random shock.

They found that, when there is a real liquidity problem with the bank, uninsured depositors, depositors that have loan linkages with the bank, staffers of the bank, depositors whose members of their network had already run the bank, or depositors with a high volume of transactions with the bank are more likely to run, which is not the case when the crises is due to a random shock. They hence concluded that informed depositors will run the bank if they fear for their deposits because of the bank's fundamentals but that even an healthy bank is not safe from a bank run.

If we assume that bank runs are triggered by poor fundamentals, a bank taking more risk is more likely to suffer from a bank run. It is why we expect to test a positive correlation between risk and liquidity in our data. As both capital and liquidity are used by banks to reassure depositors, some sort of substitution is expected between those two variables.

It appears from the literature that bank runs can be triggered by poor fundamentals but also by random shock in the economy which are independent to the banks' fundamentals. In both cases, liquidity will help diminish the likelihood and negative effect a bank run has on a bank.

We can further discuss bank runs with Ippolito, Peydró, Polo & Sette (2016) who introduced the idea of a double bank run. Or a run by depositors on the liability side and a further use of the credit lines by borrowers on the asset side hence further reducing liquidity. They study this phenomena using the impact of the depletion of the European inter-bank funding in August 2007 on Italian banks as the shock was exogenous to the Italian banking industry but hit the different banks differently as they had different levels of reliance on that funding. They then studied whether firms further used the credit lines of banks in troubled situations as they feared banks will reduce future access to credit.

Their results show that there is a double bank run during a liquidity crises but that credit line drawdowns are not higher for banks relying more on inter-bank funding.

It is also interesting to discuss Calomiris and Mason (1997) who used data from banks prior to the 1932 Chicago banking panic to assess whether banks were likely to be solvent and then compared banks that had failed to those that did not to see if they had distinct characteristics. They found that the banks which failed were weaker than the ones which survived hence arguing that panics are a form of supervision. The intuition is that because they know each other's circumstances, solvent banks can survive by helping each other. This provides an argument for fostering banks' liquidity regulation by the banks themselves and not by the government as government insurance causes a negative externality for healthy banks and might prevent monitoring from within the banking industry.

Regarding liquidity it is also interesting to mention Chen, Shen, Kao and Yi Yeh (2018) who found that despite liquidity having a negative effect on banks' profitability, higher liquidity levels lead to better performance using a data set of banks in 12 advanced economies over the

period 1994-2006.

We can conclude by assessing that we should expect a correlation between liquidity and risk. If liquidity decreases the risk of the bank itself by reducing the likelihood of a bank run, it will decrease the level of monitoring both by depositors and by other banks hence allowing riskier behaviors.

2.4 Interactions between capital and liquidity

As this paper aims to explain the interaction between capital, liquidity and government deposit coverage as ways to reassure depositors, the correlation between the two first variables must be studied.

A good starting point is Diamond and Rajan (2000) who presented a model with bankers, depositors and entrepreneurs. For each project, there are many entrepreneurs who can be ranked from the best to the worst to realize the project because of their unique human capital. The bank is able to discriminate among those entrepreneurs for each project. Bankers finance only the best entrepreneur for each specific project. If the banker wants the cash invested in a project back before the end of the project, he must liquidate the project of the entrepreneur and will only be able to start it again with the second best entrepreneur and will hence lose the difference in added value of the human capital of this entrepreneur and the second best entrepreneur for the project.

The bank can finance its loans with capital or with deposits. They prefer to use deposits as it comes at a lower cost. However, in case of troubles on the asset side of the banks (liquidation of projects), depositors will not be willing to renegotiate their contracts due to a collective action problem (they all withdraw at once because they can and are afraid to lose their money if they do not) and this will lead to a bank run.

The authors then showed that, because of this risk of a bank run, it is optimal for banks to hold some capital. Because the owners of capital cannot claim it instantly, it leaves freedom to the bank to renegotiate the terms of the contract and funds from capital will not be run.

This model explains why banks choose to hold capital despite it being costly. Capital is a way to ensure some funding to the bank in case of a bank run. Capital is here held in order to prevent a bank run. So in addition to making banks safer for depositors as proven in section 2.2, capital helps reduce the likelihood of a bank run by not being claimable on demand. As liquidity is also a way to counter the effect of a bank run by insuring that no assets have to be sold at a loss, studying the interaction between capital and liquidity in the empirical section will be interesting as they should be substitutes. Our model will present them as substitutes as ways to reassure depositors but our empirical findings can also serve as evidence aligned with the finding of the model proposed by Diamond and Rajan (2000).

Another interesting approach is proposed by Calomiris, Heider & Hoerova (2015). In their 6 periods model the authors showed that a representative bank can increase the level of liquidity or capital in order to reassure depositors regarding the likelihood of getting their money back after a bad shock to the economy. In the first period capital and deposits are invested in risky

and illiquid loans (with an higher expected return) and in risk free liquidity. In the second period there is a random withdrawal of deposits, uncorrelated with the fundamentals of the bank occurring at a probability π . In the third period the state is revealed to the bank that choose to adjust the level of liquidity by selling loans at a loss; depositors can observe the state by paying a fixed fee. In the fourth period, the bank can increase its holding of safe liquidity and the depositor will choose whether or not to shut the bank down. In the fifth period, the bank can choose to exert monitoring on the loans which comes at a cost but increases its probability of success. It is not observable by depositors but they know it will occur if the bank is sufficiently capitalized. In the sixth period, the outcome of the loan is realized. If successful the depositors get a return of $R > 1$ and the banker has a high positive return; if the loan is unsuccessful the banker gets nothing and the depositors get a return $R_f < 1$.

In their model, the depositors look at the fundamentals of the bank regarding capital and liquidity to then determine what are their chances of getting their money back. Depositors prefer high levels of liquidity as they prevent the bank from suffering from a bank run and are safe if the bad state occurs as well as high level of capital as they are primary claim holders and as more capital gives incentives to the shareholders to exert monitoring. The level of liquidity and capital required by the depositors will be contingent to the realization of a bank run in period two or not as well as to the state of the economy in the third period. Capital and liquidity will act as substitute ways to reassure depositors. Based on this the authors argued that regulations regarding liquidity should not exclude the interactions between both sides of the balance sheet.

The authors however did not provide any empirical section and only briefly studied the impact of government deposit coverage. In this paper a simpler model of interaction between those three variables will be proposed but a comprehensive empirical analysis will then be realized in order to test our findings.

A last and a bit different approach on the interaction between capital and liquidity is presented in Myers and Rajan (1998) who argued that despite liquid assets usually being perceived as good for a bank's health at some level they may prevent the bank from raising capital.

They point out that the more liquid an asset is, the more value it has on short notice. On the contrary, illiquid assets are unlikely to be sold because, even in the event of potential failure, claim-holders will not want the bank to sell them as their current price would be very small. A firm with a high level of liquidity would then face difficulties when trying to raise capital as it will not be able to commit not to sell its assets early but at a lower rate if those are highly liquid and then not able to guarantee investors return in the long run. So, the authors argued that despite being useful to pay depositors on demand, excessive liquidity may prevent banks from raising capital.

In this paper we propose a model in which there is substitution between capital and liquidity. We choose to rationalize it in a similar way as Calomiris, Heider and Hoerova (2015) which is that both serve as ways to reassure depositors regarding the likelihood to have their money

back but our findings could also be used to justify the findings of the other two papers presented in this section as all of them suggest some substitution between the two variables.

2.5 Government deposit insurance

This section will focus on government deposit insurance, or when a government decides to insure some sort of deposits to a certain extent.

As those insurances are primarily aimed at preventing bank run most of the literature focuses on the interaction between them and the share of liquid assets held by banks.

As for capital, we use the book by Champ, Freeman and Haslag (2016) to provide with the basic intuitions behind deposit insurance before moving to different papers for a deeper analysis.

Using a model à la Diamond and Dybvig (1983) with late and early type depositors the authors argued that guaranteeing late type depositors against any loss will prevent them from running even if one late type randomly withdraws money early. Hence, just by insuring depositors, the government guarantees that there will never be bank runs and will never need to pay for it.

The book then mentions an important topic when it comes to deposit insurance: moral hazard. When depositors are not insured against any loss in their bank they monitor it and withdraw their money in case of excessive risk. Once insured, depositors do not have any incentive to monitor their bank and banks will be allowed to increase the rate of return of their asset portfolio by increasing their risk.

Bryant (1980) provided an interesting model to complete this approach. In his model depositors place their money in the bank in time=0, the early type withdraw in time=1, the late type in time=2. There is a share of late type depositors that will learn that they will die in time=1 and hence withdraw early. The share of both type of depositors are known. The share of people who will die early is not known in time=0 but the bank keep sufficient reserves to be able to pay them in time=1.

The bank invests a share of its assets in a productive risky asset that brings an expected return greater than one if kept until time=2, but lower than one if sold at time=1. If the bad state occurs, the productive assets also bring a return lower than one. The rest of the deposits are kept as liquid assets with a flat return of 1.

In time=1 early type and late type learning that they will die withdraw their money.

As the productive assets bear some risk, late type depositors face the risk for the bad state to occurs. A share of late type depositors are informed if this will occur and hence also withdraw their deposits in time=1.

Uninformed late type depositors will withdraw their money early if they observe long lines at the bank which can be caused by the share of people who die early or because of the fundamentals (bad state occurring). This causes a bank run which leads to the sale of the productive assets in time=1 and everyone getting less money than what they had deposited in the bank.

Deposit insurances are optimal as they prevent the problem arising from illiquidity and incomplete information (people withdrawing money because they observe a long line of people who die early, for which the bank had reserves, and think they are informed late type depositors). The deposit insurance is here to prevent those late type depositors from running the bank. If the government has to pay back depositors it can do so by taxing the next generation of individuals or by printing money.

This model provides two keys contributions to the literature. First, deposit insurance does not necessarily prevent a bank run. If the bank fails because of bad fundamentals, the informed depositors can choose to withdraw their deposits and hence create a bank run by uninformed depositors or to get them back from the government deposit insurance. In both cases, as the bank failed and the government had to print money the depositor gets his deposits at a deflated value. However, if all informed depositors but one choose not to run the bank, they will get their money at a deflated value in the next period through the government deposit insurance. But the one deviant depositor will have gotten his money at full value a period earlier. As informed depositors have nothing to lose in the first case by running the bank and can gain in the second by running the bank, if the fundamentals are bad a bank run will be the equilibrium despite the existence of a deposit insurance system.

Second, he also pointed out that the equilibrium effect of deposit insurance will depend on how the government meets its obligation in case of a bank's bankruptcy. If the government pays the depositors by printing money, the assurance will be welfare improving only if it is more interesting to occasionally print money than to force banks to constantly hold sufficient reserves at a cost. This highlights the fact that deposit insurance comes at a cost.

This cost is studied by Merton (1977) who pointed out that the added value of a bank for a small depositor only occurs if its deposit can be treated as a risk-free investment as there is a huge cost for a small depositor in analyzing the risk of its bank. This could be achieved by forcing banks to only invest in risk-free securities but this would prevent them from making productive loans. The alternative is a coverage by a third party that will respect its role of guarantor regardless of the situation. This takes the form of a government deposit insurance.

As for an insurance company facing the risk to pay for the insured good, the government has a cost for the risk of having to pay for insured deposits in case of banks' failures. The author proposed a way to estimate the cost of this deposit insurance for government by treating deposits as loans that are guaranteed (e.g. a loan made to a private company guaranteed by a parent company in case of default).

The author used the Black and Scholes formula created to determine the price of a call on a security to find the cost of insuring deposits for governments.

As a reminder Black and Scholes (1973) came with a model to assess the price of a call based on the length of the call over the interest rate, the value of the security on which the option is written, the final price of the security for a contract over a given length, the current price of the security, the risk free rate over the studied period and the volatility of the final price of the security for a contract of a given length.

The author do not study call options but argue that “*while call options are a very specialized type of financial instrument, it is straightforward to see that the Black-Scholes techniques can be applied to the pricing of corporate liabilities in general.*” (Merton, 1977: 5) The outcome of their model can hence be considered as the cost of the liability that the deposit insurance represents for the government.

He then came with the cost in dollar per dollar insured of insuring deposits given the relative value of deposits to the total assets of the bank and given the “*variance of the logarithmic change in the value of the assets during the term of the deposits*” (Merton, 1977: 9) ranging from 0.00055 to 0.00126 at the time of the paper. According to the EBF European Banking Federation (2017) the value of total deposits in the European Union was €15.9 trillion for 2016. Using the cost of deposit insurance by Merton in 1977 this would lead to a cost of deposit insurance for the European union ranging between €8.745 million euro to €20.034 million euros for the governments.

As we now understand the role of deposit insurance in (partially) preventing liquidity crises as well as the cost this policy represents for the government, it is time to understand how it interacts with the risk of a bank (moral hazard problem) and what will make its use more likely.

A good starting point is Keeley (1990) who aimed to explain why, despite the moral hazard problem, the deposit insurance system has worked so well in the USA for over 50 years but that bank failures have drastically increased in the recent years.

His model asserts that it is due to an increase in competition in the banking industry as many regulations protecting banks from competition have been withdrawn since the mid 60s.

The model claims that without competition, banks can have a high charter value and hence an incentive to control their level of risk providing incentive for risk monitoring despite the moral hazard coming from deposit insurance. However, as the competition rose on the markets, banks had declining charter value and hence more incentives to take risk, leading to an increased number of failures and uses of the deposit insurance by depositors of failed banks.

The author then tested his hypothesis using data on the 150 largest bank holding companies and found that banks with more market power held more capital and had a lower risks of default.

Another paper studying the underlying interactions of the risk of a bank and deposit insurance comes from Gropp and Vesala (2004) who used data on European banks to evaluate the impact of deposit insurance on risk taking by the bank.

They found that it can lead to more or less risk taking as in some cases uncovered depositors will start monitoring the bank more if covered depositors do not monitor it anymore.

They also found that the effect of deposit insurance on the risk taking behavior interacts with three other variables: the banks’ charter values, the effectiveness of monitoring by non-deposit creditors and the bank being “too-big-to-fail.”

Their main empirical findings are that deposit insurance in the EU has reduced banks’ risk taking. This effect is however less prevalent for banks with high charter values. Banks that are too big to fail have not changed their risk taking because of deposit insurance. They also show that banks changed their balance sheet structure toward more insured deposits.

This paper highlights the importance for us to control for the size of the bank in our research when assessing the impact of government deposit insurance on risk.

We now have an idea about the interactions of all our variables with risk. We expect to see an increase of risk coming with an increase in capital, even though this relation may not be linear. An increase of liquidity as well as an increase in government deposit coverage should lead to an increase in risk. We expect some sort of substitution between capital and liquidity as well as between liquidity and government deposit coverage. If the literature had already studied the effect of all those variables on the risk taking behavior of a bank in models, fewer models had considered the interaction between two of those variables and even less between the three of them. The literature also crucially lacks empirical analysis which is what will later be presented in this paper.

2.6 Legislation

As we have discussed the impact of capital, liquidity and deposit insurance on risk, it is fundamental to understand the legislation regarding those variables in the European union before studying its banks.

The first interesting fact is that the interaction between those variables does not seem to have been taken into account by the legislator. As a matter of fact, capital and liquidity coverage are regulated by the Basel Agreements supervised by the Bank for International Settlement and within those agreements they are treated as separated problems as highlighted by Horváth, Seidler and Weill (2014: 342) “*the Basel Committee seems to neglect the possibility that banks’ solvency and liquidity creation might have a reverse causality.*” This issue will be further studied in section 2.7. On the other hand, government deposit insurance is regulated since 2010 at the European Level by the European Commission.

2.6.1 The Basel Agreements

We use the “*History of the Basel Committee*” page of the website of the bank for international settlement to describe the Basel Agreements and their evolution.

The Basel “*Committee, headquartered at the Bank for International Settlements in Basel, was established to enhance financial stability by improving the quality of banking supervision worldwide, and to serve as a forum for regular cooperation between its member countries on banking supervisory matters*” (Bank for International Settlements (2018)) and currently count 45 member institutions from 28 jurisdictions. Most central banks but also other regulatory institutions such as the Federal Deposit Insurance Corporation in the United States.

The first focus of the committee to enhance financial stability was the capital level of the financial institutions. In 1998, the Basel I Agreement was put in place to “*to work towards greater convergence in the measurement of capital adequacy*” and to “*remove a source of competitive inequality arising from differences in national capital requirements.*” (Bank for International Settlements (2018)) It was replaced by Basel II in 2004 which “*comprised three pillars:*

1. *Minimum capital requirements, which sought to develop and expand the standardised rules set out in the 1988 Accord*
2. *Supervisory review of an institution's capital adequacy and internal assessment process*
3. *Effective use of disclosure as a lever to strengthen market discipline and encourage sound banking practices*

”(Bank for International Settlements (2018))

In response to the 2007-2009 financial crisis, Basel III was introduced to complete Basel II. It is expected to be fully implemented by 2019. The Basel III Agreement “*revises and strengthens the three pillars established by Basel II, and extends it in several areas.*” (Bank for International Settlements (2018)) One of the key additions of Basel III was the introduction of liquidity requirements in addition to the capital requirements.

We will start by studying capital regulation under Basel III. Capital is divided into three categories which we define using Basel Committee on Banking Supervision (2010). Tier one capital (including common equity tier 1 capital), tier 2 capital and tier 3 capital which is not used anymore in Basel III. Those three categories of capital consist of funding for the banks that are not redeemable on demand. Tier one capital is the least redeemable capital by its owners (such as common shares or retained earning) and tier 3 is the most redeemable among those (such as long term unsecured subordinated debt). The tier 1 capital is hence the capital that depositors have the highest chance of retrieving in case of bankruptcy and the least redeemable as well as the one exercising the most leverage on investors, then come the tier 2 and the tier 3².

The Basel committee then defined different capital ratio which consist of the eligible capital divided by the risk weighted assets. The risk weighted assets are obtained by weighting the different assets of banks by their level of risk. To do so banks can either rely on internal models or use their legislators' models.

Basel III set regulatory minimums at 6% for the tier 1 capital ratio and 8% for the tier 2 capital ratio. It is interesting to note that it is possible to compute those ratios for our data set before their implementation as well as noting that none of those ratios are binding as banks hold capital levels significantly higher than regulatory standards.

To discuss the legislation on liquidity we use the report “Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools” established by the BIS in 2013. There are two ratios that must be respected by banks.

The first one is the liquidity coverage ratio (LCR) which aims to prevent short term liquidity crises. The LCR is equal to the Stock of HQLA divided by the total net cash outflows over the next 30 calendar days and must be greater or equal than 100%. The HQLA are the High Quality Liquid Assets which are assets that “*should be liquid in markets during a time of stress and, ideally, be central bank eligible.*” (Basel Committee on Banking Supervision, 2013: 13)

²For exact definition of each category of capital see Basel Committee on Banking Supervision for the Bank for International Settlements. (2010). “Basel III: A global regulatory framework for more resilient banks and banking systems”. pp. 13

The second liquidity ratio, the Net Stable Funding Ratio (NSFR), has a time horizon of one year and aims to guarantee the adequacy of the maturity structure of assets and liabilities over this time period.

2.6.2 Government deposit insurance

The legislation regarding government deposit insurance in the European Union is coordinated by the European Commission through the Deposit Guarantee Scheme (DGS). “*The original deposit guarantee schemes directive of 1994 only required a minimum level of harmonisation between domestic deposit guarantee schemes in the EU.*” (European commission, 2018) An amending directive in 2009 required the countries to increase the level of coverage to €50.000 and then to €100.000 in 2010.

2.7 Evaluation of the legislation

We start this section by presenting two papers evaluating the efficiency of the tier 1 ratio as a way to assure sufficient levels of capital in banks.

First Abou-El-Sood (2016: 299) investigates “*the association between the regulatory Tier 1 capital ratio and US bank holding company distress during 2003–2009. The results show that Tier 1 capital ratio is insignificantly negatively associated with bank distress. However, the association is significant when bank holding companies fall below the well capitalization ratio of 6%.*” He does so using “*a logistic regression model is used with a dummy variable denoting the state of failure as the dependent variable and Tier 1 capital ratio as the explanatory variable*” (Abou-El-Sood (2016:294)) 299). This seems to demonstrate that the regulatory standard is a well defined minimum in order to ensure sufficient capital levels in banks but highlights that “*that the regulatory capital is not the only reason banks are put into distress.*” (Abou-El-Sood (2016: 300))

In addition to the papers presented before which suggested some interactions between capital, liquidity and government deposit insurance and hence argue for more comprehensive rather than separated legislation, some papers have analyzed the effectiveness of the ratios proposed by the Basel agreements.

An interesting view on the impact of capital requirements on risk comes from Blum (1999) who used a dynamic framework to argue that increased capital requirements may lead to riskier banks. The logic of his three period model works as follows: a bank can finance its investment by raising capital which is costly or by bringing deposits in. They can then invest in safe or risky assets bringing a larger expected return but leading to a loss in the bad state.

If the capital requirements are increased for a future period and become binding, the bank will therefore be forced to increase its capital level in order to meet those requirements. As raising capital might be prohibitively expensive, the only way to have additional capital tomorrow will be to invest in the risky asset and use the profit of this loan as capital for the next period. Binding future capital requirements increase the added value of an extra unit of capital in the future and therefore give incentives to the bank to take more risk as raising equity is expensive

hence leading to riskier banks today. The conclusion of the paper is that through this dynamic interaction higher capital requirements may lead to riskier behaviors of banks. This paper will not be taken into account in our model as capital requirements appear not to be binding for European banks who all hold capital amounts far above the regulatory limit, however we find this conclusions very interesting if the legislator decides to make these requirements binding.

We then use Balasubramanyan and VanHoose (2013) to evaluate the LCR. They point out that as the denominator of the LCR is the total net cash outflow during the next 30 calendar days which is actually computed by the outflows in the previous period which are highly dependant on deposits. They argue that the *“LCR requirement has mixed effects on the stability of a bank’s deposit base. On the one hand, a bank’s optimal desired deposit path becomes more inter-temporally persistent, but on the other hand, the bank’s desired deposit level becomes more responsive to variations in the spread between security and deposit rates generated by external market shocks.”* (Balasubramanyan and VanHoose (2013: 54)) They become more persistent as the bank wants to maintain the LCR stable above the regulatory minimum but also reactive to market rates as a change in the interest rate paid to depositors will have an impact on the equilibrium level of deposits which will lead to necessary adaptation in the balance sheet of the bank if the ratio is binding.

The last type of critics on the Basel three agreement regards the lack of understanding of the interaction between capital and liquidity. We highlight this using Horváth, Seidler and Weill (2013) who argue that neither researcher nor regulators seems to have questioned whether or not there was reverse causality between capital and liquidity in banks. They use data obtained from the Czech National Bank on Czech banks over the 2000-2010 period and find out that *“capital negatively Granger-causes liquidity creation for small banks, which confirms the financial fragility hypothesis according to which greater capital hampers liquidity creation. However, we also observe that liquidity creation Granger-causes a reduction in capital. We thus support the view that there is a negative, bi-causal relation between capital and liquidity creation.”* (Horváth, Seidler and Weill (2013:360) And hence argue that if liquidity requirements are not bindings, tightening capital requirements might lead to deteriorated levels of liquidity.

Our research will study the interaction between capital and liquidity supposing that both serve as way to reassure depositors against the risk taken by the bank. We will also include the impact of the government deposit insurance in our analysis.

3 Model

3.1 Dynamic of the bank for investors

In our model we have a representative bank with liabilities made off capital brought in by investors and deposits. Capital can be understood as the net worth of the bank, it is the remaining value of the bank once all its obligation have been paid, it belongs to the bank's investors. Liquidity is made off cash as well as liquid assets. Depositors are not remunerated but can freely withdraw their money if they are worried that they will not get it back.

The hypothesis that depositors are not remunerated is a strong hypothesis as remunerating deposits would convince depositors to accept some risk from their bank. By removing interest on deposit we hence exclude the moral hazard problem from our model when including government deposit insurance. As a matter of fact, we will not have depositors highly remunerated by the bank without bearing any risk as they are covered by the deposit insurance hence leading to an incentive for the bank to invest in riskier assets as they are not monitored by their depositors. This will however not prevent us from analyzing the substitution between capital, liquidity and government deposit insurance as ways to reassure depositors against the risk of the bank. We do not include the deposits remuneration as data regarding the remuneration of deposits in banks were not available neither for all the time periods in our model nor for all the banks. It should not be an issue as the deposits are very poorly remunerated since the financial crisis. A paper from Mark Wahrenburg and Bijan Kaffenberger (2015) showed that the average net deposit remuneration for banks in the Euro area was 1.14% per year with a standard deviation of .68 in 2015.

On the asset side, the bank invests those resources in productive illiquid assets ("PA" hereafter) or hold liquidity. For simplicity we assumed that liquid assets have a flat return of 1 as if it was only cash.

There are two kind of PA. A risk free asset with a net return of $1 + r_f$ and a risky asset with an expected net return of $1 + r_f + 0.5r_p$ which gives a net return of $1 + r_f + \alpha + r_p$ if the good state ($s=g$) occurs and a net return of $1 + r_f - \alpha$ if the bad state ($s=b$) occurs. r_f being the risk-free rate, r_p the risk premium remunerating risk and a the level of risk of the risky asset. We set the probability of both state to occur at 0.5. obviously the likelihood of the bad state occurring will have an impact on the risk of a bank in the real world, we however decided to make it exogenous as the riskiness of the assets is already taken into account in our model with the factor a .

Our risk neutral investors have the decision making power regarding the capital, liquidity and risk level of the bank subject to the constraint of keeping deposits in the bank. Depositors will withdraw their money if they fear they will not get it back. To reassure depositors that this will not happen, the bank can decrease the share of risky assets, increase capital level as depositors are primary claim holders or increase the liquidity level as liquid assets or cash are safe and also prevent the bank from facing the cost of a bank run.

This leaves us with a balance sheet as follow:

Balance sheet		
Assets	((expected) net return)	Liabilities
Liquidity	$r=0$	Capital
Risky asset	$E(r)=r_p+r_f$	Deposits
Risk-free asset	$r=r_f$	

With Balance-sheet (BS)=Assets (A)=Liabilities (L).

We have:

$0 \leq \delta = \frac{\text{Liquidity}}{\text{Assets}} \leq 1$, the share of liquidity in the asset side

$0 \leq \phi = \frac{\text{Capital}}{\text{Liabilities}} \leq 1$, the share of capital in the liabilities side. Depositors are primarily claim holders in case of bankruptcy or loss by the bank.

$0 \leq s(r) = \frac{\text{Risky assets}}{\text{Risky assets} + \text{Risk free assets}} \leq 1$, the share of assets invested in the risky asset among the assets invested.

In addition to determining the return of the risky asset, the two states of the world dictate whether a bank run occurs or not.

- If the bad states occurs (s=b) (with a probability of 0.5)
 - The gross return of the risky asset is: $r(\text{risky assets}) = 1 + r_f - \alpha$ with $\alpha > r_f > 0$
 α represents the level of risk of the risky asset.
 - A bank run occurs. This multiply the value of the PA by β ($0 < \beta < 1$).

We made the assumption that a bank run might still occur even if the bank only invest in risk-free assets. It is aligned with Chakravarty, Fonseca and Kaplan (2014) who found out that bank run can be triggered not only by bad fundamentals but also by random withdrawals uncorrelated with the fundamentals of the bank but related to the state of the economy.

When a bank run occurs a share γ (with $0 \leq \gamma \leq 1$) of the productive assets have to be sold at $1-\rho$ (with $0 \leq \rho \leq 1$) to satisfy the customers' demand for liquidity. In order to simplify further calculation we set $\beta = \gamma(1 - \rho)$. Obviously there is no liquidity problem with the assets held as liquidity. The total impact of a bank run on the value of the balance sheet is $(A((1 - \delta)\beta))$. By holding more liquidity, the bank reduces the negative impact of the bank run occurring in the bad state.

We assume that ρ is exogenous to the share of risky assets among the PA. It is obviously a strong assumption and not the case in reality but it will be sufficient to underline the impact of liquidity on the incentive for depositors to monitor their bank.

- If the good state occurs (s=g) (with a probability of 0.5)
 - The gross return of the risky assets will be as follow:
 $r(\text{risky assets}) = 1 + r_f + \alpha + r_p$ with $0 \leq r_p \leq 1$

Our risk neutral investors have the following gross return on equity:

$$1 + E(r_i) = \left\{ A \left[\delta + \underbrace{(1 - \delta)}_{\text{The share of assets invested}} \left(\underbrace{\frac{1}{2} (s(r)(1 + r_f + \alpha + r_p) + (1 - s(r))(1 + r_f))}_{\text{Return in the good state}} + \underbrace{\frac{1}{2} (s(r)(1 + r_f - \alpha) + (1 - s(r))(1 + r_f) - \beta)}_{\text{return in the bad state}} \right) \right] - \underbrace{L(1 - \phi)}_{\text{Total deposits}} \right\} \underbrace{\frac{1}{\phi L}}_{\text{Total capital}}$$

It is obtained by taking the expected future value of the assets minus the total amount of deposits and dividing it by the total amount of capital.

The expected future value of the assets is made of:

- The liquid assets (δA) multiplied by a flat gross return of 1
- The productive assets $((1 - \delta)A)$ with a gross return of:
 - $1 + r_f$ for the risk-free assets
 - $1 + r_f + \alpha + r_p$ if the good state occurs or of $1 + r_f - \alpha$ if the bad state occurs for the risky assets
- Minus $\beta * PA$ if the bad state occurs because of the bank run.

With $A=L$, it can be simplified to:

$$\begin{aligned} \Leftrightarrow 1 + E(r_i) &= \frac{1}{\phi} \left[\delta + (1 - \delta) \left(\frac{1}{2} s(r)(1 + r_f) + \frac{\alpha}{2} s(r) + \frac{r_p}{2} s(r) + \frac{1}{2} (1 - s(r))(1 + r_f) + \frac{1}{2} s(r)(1 + r_f) \right. \right. \\ &\quad \left. \left. - \frac{\alpha}{2} s(r) + \frac{1}{2} (1 - s(r))(1 + r_f) - \frac{\beta}{2} \right) - (1 - \phi) \right] \\ \Leftrightarrow 1 + E(r_i) &= \frac{1}{\phi} \left[\delta + (1 - \delta) \left(1 + r_f + \frac{r_p}{2} s(r) - \frac{\beta}{2} \right) - (1 - \phi) \right] \\ \Leftrightarrow 1 + E(r_i) &= \frac{1}{\phi} \left[(1 - \delta) \left(r_f + \frac{r_p}{2} s(r) - \frac{\beta}{2} \right) + \phi \right] \\ \Leftrightarrow 1 + E(r_i) &= 1 + \frac{1 - \delta}{\phi} \left(r_f + \frac{r_p}{2} s(r) - \frac{\beta}{2} \right) \end{aligned}$$

As investors are indifferent between both risk free investment options (holding only liquidity or investing only in risk free asset):

The flat return of liquidity

$$1 + E(r_i | \delta = 1) = 1$$

Must be equal to the return of the risk free assets minus the cost of a bank run wighted

by its probability to occur:

$$1 + E(r_i | s(r) = 0; \delta = 0) = 1 + r_f - \frac{\beta}{2}$$

We therefore have: $r_f = \frac{\beta}{2}$

This simplification is not realistic as the risk free rate should still remunerate the opportunity cost of reporting consumption. Making it allows us to simplify the resolution of the model. Releasing it does however not change the findings of our model in terms of substitution between capital and liquidity but it changes the rate at which they are substitute. An higher cost of bank run would make depositors prefer liquidity to risk free assets while an increased risk free rate would make them prefer risk free assets.

The expected return can be simplified as follow:

$$1 + E(r_i) = 1 + \frac{1 - \delta}{\phi} \left(\frac{r_p}{2} s(r) \right)$$

It is easy to see that without constraint investors will want the lowest share of capital (ϕ), the lowest share of liquidity (δ) as well as the maximum share of risky assets among PA ($s(r)$).

By minimizing the share of capital, investors allow themselves to leverage the gain they make on the asset side as our model assumes that depositors are not remunerated.

By minimizing the level of liquidity investors increases their return as more assets are invested with a positive (expected) return. This, however, exposes the bank a greater loss if the bad states occurs.

My maximizing the share of risky assets investors will maximize the expected return by benefiting from the risk premium. This, however, exposes the bank to a greater loss if the bad state occurs.

3.2 Introduction of the constraint - the depositors behavior

As all banks in our data have deposits we exclude the possibility to have a pure investment bank with no depositors ($\phi = 1$). As depositors are not remunerated for their deposits, they will accept to place their money in the bank only if they are sure to get their money back even if the bad state occurs.

$$\underbrace{A \left[\delta + (1 - \delta) \left(s(r)(1 + r_f - \alpha) + (1 - s(r))(1 + r_f) - \beta \right) \right]}_{\text{remaining value of the assets after the bad state has occurred}} \geq \underbrace{L(1 - \phi)}_{\text{Value of the deposits}}$$

$$\Leftrightarrow \delta + (1 - \delta) \left((1 + r_f) - s(r)\alpha - \beta \right) - 1 + \phi \geq 0$$

$$\Leftrightarrow (1 - \delta)(r_f - s(r)\alpha - \beta) + \phi \geq 0$$

Depositors prefer higher levels of capital as they are primary claim holders in case of losses of value of the bank

Depositors prefer higher levels of liquidity $((r_f - s(r)\alpha - \beta) < 0$ because $r_f = \frac{\beta}{2}$ & $s(r)\alpha > 0$ as cash is risk-free and reduce the exposure of the bank to a bank run.

Depositors prefer lower shares of risky assets as it exposes the bank to a greater loss if the bad state occurs.

As we can see depositors preferences go in the opposite direction than investors' ones so we can conclude that the constraint will be binding, leading us to:

$$(1 - \delta)(r_f - s(r)\alpha - \beta) + \phi = 0$$

3.3 Equilibrium

We have investors maximizing their return on equity:

$$\max 1 + E(r_i) = 1 + \frac{1 - \delta}{\phi} \left(\frac{r_p}{2} s(r) \right) \quad (1)$$

While ensuring that depositors keep their money in the bank:

$$\text{s.t. } (1 - \delta)(r_f - s(r)\alpha - \beta) + \phi = 0 \quad (2)$$

Which leads us to the maximization of the following Lagrangian:

$$\max L = 1 + \frac{1 - \delta}{\phi} \left(\frac{r_p}{2} s(r) \right) - \lambda \left((1 - \delta)(r_f - s(r)\alpha - \beta) + \phi \right)$$

The investors choose the optimal level of capital (ϕ), liquidity (δ) and share of risky assets ($s(r)$) given the risk free rate (r_f), the risk premium (r_p), the amount of risk of the risky asset (α) and the cost of a bank run (β).

$$\begin{aligned} \frac{dL}{d\phi} &= -\frac{1 - \delta}{\phi^2} \left(\frac{r_p}{2} s(r) \right) - \lambda = 0 \\ \Leftrightarrow \lambda &= -\frac{1 - \delta}{\phi^2} \left(\frac{r_p}{2} s(r) \right) \end{aligned} \quad (3)$$

$$\begin{aligned} \frac{dL}{d\delta} &= -\frac{1}{\phi} \left(\frac{r_p}{2} s(r) \right) + \lambda(r_f - s(r)\alpha - \beta) = 0 \\ \Leftrightarrow \lambda &= \frac{1}{\phi} \frac{\frac{r_p}{2} s(r)}{r_f - s(r)\alpha - \beta} \end{aligned} \quad (4)$$

$$\begin{aligned} \frac{dL}{ds(r)} &= \frac{1 - \delta}{\phi} \frac{r_p}{2} + \lambda(1 - \delta)\alpha = 0 \\ \Leftrightarrow \lambda &= -\frac{r_p}{2\alpha\phi} \end{aligned} \quad (5)$$

From equations 3 and 4:

$$-\frac{1-\delta}{\phi^2} \left(\frac{r_p}{2} s(r) \right) = \frac{1}{\phi} \frac{\frac{r_p}{2} s(r)}{r_f - s(r)\alpha - \beta}$$

As investors would like to maximize risk and minimize capital and liquidity levels but that all variables are substitutes as ways to reassure depositors we will not find an unique optimal level for all of them but many optimal levels given the levels of the other variables.

The optimal level of capital given the level of liquidity and risk:

$$\phi^* = (\delta - 1)(r_f - s(r)\alpha - \beta)$$

The optimal level of liquidity given the levels of capital and risk:

$$\delta^* = \frac{\phi}{r_f - s(r)\alpha - \beta} + 1$$

The optimal share of risky assets (risk level hereafter) given the levels of capital and liquidity:

$$s(r)^* = -\frac{1}{\alpha} \left(\frac{\phi}{\delta - 1} + r_f + \beta \right)$$

Interactions between the endogenous variables:

With $\beta = 2r_f$ and $s(r)\alpha > 0$

- Reaction of the optimal level of capital to changes in liquidity or risk levels:

$$\frac{d\phi^*}{d\delta} = r_f - s(r)\alpha - \beta \leq 0$$

$$\frac{d\phi^*}{ds(r)} = -\alpha(\delta - 1) \geq 0$$

An increase of liquidity leads to lower levels of capital and an increase of risk leads to higher levels of capital because of the monitoring by depositors.

- Reaction of the optimal level of liquidity to changes in capital or risk levels:

$$\frac{d\delta^*}{d\phi} = \frac{1}{r_f + s(r)\alpha - \beta} \leq 0$$

$$\frac{d\delta^*}{ds(r)} = \frac{\phi\alpha}{(r_f - s(r)\alpha - \beta)^2} \geq 0$$

An increase in capital leads to lower levels of liquidity and an increase in risk leads to higher levels of liquidity because of the monitoring by depositors

- Reaction of the optimal level of risk to changes in capital and liquidity:

$$\frac{ds(r)^*}{d\phi} = -\frac{1}{\alpha(\delta - 1)} \geq 0$$

$$\frac{ds(r)^*}{d\delta} = \frac{\phi}{\alpha(\delta - 1)^2} \geq 0$$

An increase in capital or liquidity leads to lower levels of risk because of depositors monitoring

We have a negative relation between capital and liquidity as both can be used as ways to prevent the depositors from running the bank.

If the bank wants to increase its level of risk among the productive assets it must increase capital and/or liquidity to prevent a bank run.

Impact of the exogenous variables:

An increase in the risk-free rate increases the (expected) return of the productive assets hence making liquidity more expensive and less favorable than capital as a way to reassure depositors. In addition to increasing the opportunity cost of increasing liquidity for investors, an increased risk free rate ensures depositors a larger value of the balance sheet *Ceteris Paribus* regardless of the investment decision.

The higher the cost of a bank run (β) is, the more depositors favor liquidity over capital as a way to guarantee their deposits as liquidity allows to mitigate this cost.

The higher the loss on risky asset if the bad state occurs (α) is, the more capital and liquidity are needed to compensate any additional level of risk.

3.4 Conclusion of the model

The model highlights the following mechanisms:

As a lower share of capital over liabilities allows investors to leverage more the gains of the investments made on the asset side of the balance sheet, investors prefer lower levels of capital.

As the liquid asset expected gross return is null, investor want to lowest share of liquidity.

As the risky asset brings in a greater expected return than the risk free asset because of the positive risk premium, investors want the highest share of assets invested in the risky asset.

In our model investors maximizing their expected return want to hold the minimum levels capital and liquidity and hold the maximum share of assets invested in risky assets. they however have to guarantee that depositors do not run the bank. For this not to happen, depositors must be confident they will get their money back even in the bad state occurs. Investors can guarantee this by providing sufficient levels of capital and/or liquidity and/or by reducing the share of assets invested in a risky asset.

Hypothesis 1:

As shareholder prefer high level of risk, low liquidity and capital positions to maximize their return on equity but that depositors, willing to keep their deposit safe, will monitor the bank and require sufficient levels of capital and/or liquidity and/or low levels of risk. We expect a trade off between lower levels of capital and/or liquidity and a riskier investment behavior for investors.

In the empirical section we will show that those three variables act as substitutes as ways to reassure depositors against the risk of losing their deposits if the bad state occurs.

The fact that we have a multitude of plausible equilibria is reflected in the data as well with banks with different level of capitalization, liquidity and risk reflecting the bank specific costs of obtaining capital or maintaining liquidity as well as the risk free rate, the risk premium and the cost of bank run.

3.5 Introduction of the government deposit insurance

The government deposit insurance has two impacts on our model. First, it removes any incentive to any depositors fully insured to monitor the bank as he has the certainty to get its deposits back even in case of a bankruptcy. Second, it decreases the cost of the bank run if the bad state occurs as fully-insured depositors will not run the bank even if they think a bankruptcy might occur leading to a cost of bank run equal to: $A(1 - \delta)(1 - \Psi)\beta$.

With Ψ being the share of the liabilities insured, and our model take the following form:

The gross return on equity for investors:

$$1 + E(r_i) = 1 + \frac{1 - \delta}{\phi} \left(r_f + \frac{r_p}{2} s(r) - (1 - \Psi) \frac{\beta}{2} \right)$$

The constraint set by depositors:

$$A \left(\delta + (1 - \delta)(1 + r_f - s(r)\alpha - (1 - \Psi)\beta) \right) \geq (1 - \phi)L - \Psi L$$

The right side of the constraint express the fact that the remaining value of the assets, if the bad state occurs, must be greater than the capital minus the deposits that are insured anyway. The remaining value of the balance sheet must only cover the uninsured deposits.

Knowing that the constraint is binding, it can be simplified to:

$$(1 - \delta) \left(r_f - s(r)\alpha - (1 - \Psi)\beta \right) + \phi + \Psi = 0$$

And the new equilibrium is obtained by maximizing the following Lagrangian:

$$L = 1 + \frac{1 - \delta}{\phi} \left(r_f + \frac{r_p}{2} s(r) - (1 - \Psi) \frac{\beta}{2} \right) - \lambda \left((1 - \delta) \left(r_f - s(r)\alpha - (1 - \Psi)\beta \right) + \phi + \Psi \right)$$

Which gives us:

$$\frac{dL}{d\phi} = 0 \Leftrightarrow -\frac{1-\delta}{\phi^2} \left(r_f + \frac{r_p}{2} s(r) - (1-\Psi) \frac{\beta}{2} \right) = \lambda \quad (6)$$

$$\frac{dL}{d\delta} = 0 \Leftrightarrow \frac{1}{\phi} \frac{r_f + \frac{r_p}{2} s(r) - (1-\Psi) \frac{\beta}{2}}{r_f - s(r)\alpha - (1-\Psi)\beta} = \lambda \quad (7)$$

From 6 and 7 we have:

$$-\frac{1-\delta}{\phi^2} \left(r_f + \frac{r_p}{2} s(r) - (1-\Psi) \frac{\beta}{2} \right) = \frac{1}{\phi} \frac{r_f + \frac{r_p}{2} s(r) - (1-\Psi) \frac{\beta}{2}}{r_f - s(r)\alpha - (1-\Psi)\beta} \quad (8)$$

Leading to:

The optimal level of capital given the level of liquidity, risk and government deposit insurance:

$$\phi^* = (\delta - 1) \left(r_f - s(r)\alpha - (1-\Psi)\beta \right)$$

The optimal level of liquidity given the levels of capital, risk and government deposit insurance:

$$\delta^* = \frac{\phi}{r_f - s(r)\alpha - (1-\Psi)\beta} + 1$$

The optimal level of risk given the levels of capital, liquidity and government deposit insurance:

$$s(r)^* = -\frac{1}{\alpha} \left(\frac{\phi}{\delta - 1} + r_f + (1-\Psi)\beta \right)$$

- Reaction of the optimal level of capital to changes in government deposit insurance:

$$\frac{d\phi^*}{d\Psi} = (\delta - 1)\beta \leq 0$$

- Reaction of the optimal level of liquidity to changes in government deposit insurance:

$$\frac{d\delta^*}{d\Psi} = -\frac{\phi\beta}{(r_f - s(r)\alpha - (1-\Psi)\beta)^2} \leq 0$$

- Reaction of the optimal risk level to changes in government deposit insurance:

$$\frac{ds(r)^*}{d\Psi} = \frac{1}{\alpha}\beta \geq 0$$

The conclusions on the impact of the different variables on the equilibrium are the same as in the previous section but we can see that higher level of deposit insurance lead to lower levels of capital, liquidity and higher levels of risk. Leading to:

Hypothesis 2:

The highest the government deposit insurance, the less binding is the constraint coming from depositors' monitoring. An higher level of government deposit insurance will allow investors

to choose lower levels of capital and liquidity while taking more risk on the asset-side of the balance sheet.

To sum up we expect to observe the following reactions in our data (keeping the value of all the other variables equal):

- An increase in the level of capital increases the level of risk the bank takes.
- An increase in the level of liquidity increases the level of risk the bank takes.
- An increase in the level of government deposit insurance increases the level of risk the bank takes.
- An increase in the level of liquidity decreases the level of capital.
- An increase in the level of capital decreases the level of liquidity.
- An increase in the level of government deposit insurance decreases the level of capital.
- An increase in the level of government deposit insurance decreases the level of liquidity.

4 Presentation of the database

Data were collected regarding 149 banks based on the list of supervised institution as of January 1st 2018 provided by the European Central banks ³. The original list counts 187 banks but some were excluded as relevant data were missing. You can find the list of included and excluded banks in the annexes.

The European central bank defines a supervised institution as a credit institution, a financial holding company, a mixed financial holding company in participating Member state as well as branches of credit institutions established in non-participating Member States. We have data regarding banks in the 28 members states of the European union as well as Iceland and Norway.

Our goal is to use our data to test the model presented above, meaning that we will need data regarding the capital and liquidity positions, the risk faced by investors and the level of government deposit insurance.

The data were collected at a quarterly frequency from January 1st 2008 to December 31st of 2017 which represents 40 observations per variable for each bank. Unfortunately, data were not available for every period for some banks, so descriptive statistics will be presented for every variable.

In order to test the predictions of our model, information was collected regarding risk, liquidity and capital positions for each bank using Bloomberg terminals, while the government coverage was extracted from the World Bank and Eurostat. The different proxies will now be explained.

³European central bank. (2018). "Who supervises my bank?". Retrieved from <<https://www.bankingsupervision.europa.eu/banking/list/who/html/index.en.html>>

To contain our analysis to banks with a normal behavior the data were trimmed and outliers removed. Outliers are defined by Ghosh-Dastidar & Schafer (2006: 487) as “*observations that deviate from the specified data model. Generally speaking, outliers are all of those observations that appear to be extreme or unusual with respect to the rest of the observed data, and to prior subject-matter knowledge about what values are plausible. The presence of outliers may indicate that the data model does not have sufficiently heavy tails, or that there are misreporting and misrecording errors in the data. Outliers, for either reason, may exert undue influence on the results of statistical analyses, so they need to be identified prior to performing data analyses.*”

As our model focuses on banks supervised by depositors we removed the four observations with a level of deposit equal to 0. As some of our ratios used deposits at numerator or denominator, those were leading to extreme values which were not fitting in the model.

4.1 Capital position:

As a reminder the relevance of capital here is not its absolute value but the relative importance of capital to the total liabilities as described by the variable ϕ in our model.

As there has been much debate in the literature regarding the optimal way to measure the capital position of a bank we will propose three different ratios to test our model.

The first one is the one used by the regulator, the *tier 1 ratio* that is, as explained by Baker & Wurgler (2015: 318) “*defined as common stock plus retained earnings divided by risk-weighted assets*” which has a numerator denoting the capital for which depositors have a high priority profile in case of bankruptcy and is weighted at the denominator by the size of the asset size with respect to the risk of those assets. The higher the tier one ratio is, the most likely a depositor is to have his money back in case of bankruptcy. By weighting the assets by their risks, the ratio also considers the likelihood of a bankruptcy.

This ratio is inconvenient, however, to test our model because of the correlation of its denominator with the studied variable, the risk of a bank. For instance, if the assets side of the bank gets riskier, the tier one ratio will mechanically decrease while our goal is to assess how capital is used to reassure depositors to prevent withdrawals when a bank takes additional risk.

Bloomberg terminals allow us to directly download quarterly observation of the tier one ratio for every bank. Unfortunately, as stated above, observations are missing for some of them at some dates. We end up with 2,737 observations with a mean of 14.32, a standard deviation of 7.95 and values included between -6.1 and 212.4 which will allow us to observe significant variation in our empirical analysis. The negative values are due to the fact that a bank can have a negative equity, it is when the outstanding obligations of the bank are bigger than its assets. If a negative equity is a bad sign for the bank it does not mean insolvency yet. As a matter of fact the two observations with a negative equity have a risk premium of 10.72 and 11.42 which is below the average of our sample.

The tier 1 ratio has been criticized by many for several reasons. First, as European banks

are allowed to use internal models to compute the risk weights of their assets Rima Turk-Ariss (2017: 1) points out that those can be manipulated and “*provides prima facie evidence on the extent of risk weight heterogeneity across broad asset classes and by country of counterparty for major banks in the European Union*”. It is indeed easy for banks to increase their tier one ratio by decreasing the risk weight they put on their assets, hence making them look safer than they are.

Second, an high tier 1 ratio does not necessarily seems to be associated with safer banks. By studying US banks Heba Abou-El-Sood (2015: 292) “*reveal that the association between the core (Tier 1) capital ratio and bank failure becomes significant only if the bank holding company has a Tier 1 capital ratio of less than 6%*”. Mark J. Flannery and Emanuela Giacomini (2015: 236) demonstrated that “*During the recent financial crises, many large banks’ losses were absorbed by their sponsoring governments, despite the fact that these banks complied with Basel standards for adequate capital. We illustrate a serious supervisory problem by demonstrating that large European banks’ reported regulatory capital measures often far exceeded their loss-absorbing capacity during 1997–2011.*”

Two alternative ratios uncorrelated to the risk of the asset side of the balance sheet were created to solve the problem of the correlation between the risk premium and the denominator of the tier one ratio. This also provides results which are robust to the critics regarding the tier 1 ratio itself.

The first ratio created is the equity/liabilities ratio. This ratio represents the share of the liabilities that comes from equity. It is the illustration of the liability side of the balance sheet of our model as well as the model used by Calomiris, Heider and Hoerova (2015) in their model explaining the importance of the interactions between the equity and the liquidity position of banks.

We have a total of 3,392 with a mean of 0.08, a standard deviation of 0.05 and values included between -0.05 and 0.65. Against the negative value occurs when a bank has more outstanding debt to reimburse than assets.

The final ratio is the *core capital coverage ratio* created by dividing the tier one capital by the total deposits. As a reminder the tier 1 capital includes “*equity capital and published reserves from post-tax retained earnings*” (Definition of the Bank for international settlement). This ratio is directly related to the intuition of our model. If banks do indeed increase capital coverage to reassure depositors and prevent money withdrawal when they take additional risk, the share of the deposits that is covered by capital should be most important to depositors. This is consistent with the findings of Olivier De Jonghe and Özde Öztekin (2015: 154) who “*examine the dynamic behavior of bank capital using a global sample of 64 countries during the 1994–2010 period.*” and showed that “*banks achieve deleveraging primarily through equity growth (rather than asset liquidation).*”

We initially have 2,354 observations. However as bank with really low levels of deposits led to really high values of the ratio (as high as 800) we decided to remove the 49 above 1. This threshold was selected as our model hypothesizes that banks are supervised by depositors and

hence need to have a significant amount of deposits. The 49 banks removed from the sample had a share of deposits in the total liabilities varying between 0 and 9.6% with a mean of 2.6%, leading us to believe that the fear of a run by depositors was not a constraint on those banks. In addition to that those depositors had very little incentive to monitor as all of their deposits were covered by, at least, the same amount of capital. It leaves us with 2,305 observation with a mean of 0.14, a standard deviation of 0.1 and values included between -.1 and 0.99.

The latest two ratios differ from the Tier 1 ratio as they do not use any risk weight which will allow us to better study the impact of capital on risk.

The core capital coverage ratio and the equity to liabilities ratio seem to be the best ratios to test our model as they are not biased by the level of risk as the tier 1 ratio. Studying this latest ratio is however still interesting as it is the one used by the legislator.

By comparing the results obtained when using the core capital coverage ratio versus the equity to liability ratio will allow us to see what truly matters to depositors when they assess the level of capital of their bank is the amount of deposits covered by capital or simply the relative importance of the capital position in the balance sheet. As stated in the literature review there are two roles of capital for bank regulation. First, it leverages the investors hence encouraging them to monitor the bank themselves making it safer for depositors as well. Second, as depositors are primarily claim holders in case of a loss it increases their chance of having their money back. The equity to liability ratio tests the first effect while the core capital coverage ratio tests the second.

As those ratios are aimed at measuring the same component of our model we expect them to be highly correlated, hypothesis that can be verified with the following data

Table 1: Correlations between the capital indicators

	T1R	Equity/liabilities	Core capital cvg ratio
T1R	1.0000		
Equity/liabilities	0.3389	1.0000	
Core capital cvg ratio	0.2950	0.3431	1.0000

To conclude we remind to the reader of the importance of capital in a bank's balance sheet, as a matter of fact equity represents up to 65.9% of the balance sheet of the bank in our dataset with a mean of 8.01%.

4.2 Liquidity position:

The same remark as the one made for capital holds here. We do not focus on the absolute value of liquidity but their relative importance in the balance sheet as expressed by the variable (δ) in our model.

As data regarding the liquidity coverage ratio proposed in the Basel Agreements were not available for the totality of the time series for most of the banks we use the *loans to deposits ratio* (LTD hereafter) obtained by deviding the Total Loans by the Total deposits and provided

directly by Bloomberg. As stated by Jan Willem van den End(2013: 2202) *“Deposit-taking and lending by banks are closely related. Both activities reflect the liquidity transformation function of banks and share a similar overhead (Kashyap et al, 2002). Hence it is useful to analyze loans and deposits in tandem, as is done through the Loan-to-Deposit (LTD) ratio. It is a core indicator for liquidity mismatch risk. The LTD ratio measures the coverage of loans with stable funding, usually deposits from households and non-financial companies. When loans exceed the deposit base, banks face a funding gap for which they have to access financial markets. So a high funding gap implies a high dependence on market funding, which can be more volatile and/or expensive than retail funding, in particular if it concerns unsecured market funding”*⁴

As data regarding the short term debts which the bank will have to repay are available, the *Loans to Deposits and Short-term debts ratio* ($\frac{Loans}{Deposits+STDebts}$) was created in order to take into account the exit of cash about to happen due to short term debts. As high LTD or Loans to Deposits and Short-term Debts ratios means a low level of liquidity the ratios are multiplied by -1 in order to simplify our analysis. The greater our ratios, the more liquid the bank is.

As a reminder total loans include commercial loans, consumer loans and other loans. Deposits are the amount received by customers and the short-term debts include bank overdrafts and short term debts which refer to financial obligations due within 12 months.

However as both our ratios have deposit as a denominator, the ratio is biased toward extremely high values for banks with really low levels of deposits. If it would have been interesting to study the impact of liquidity on depositors’ monitoring for bank with really low share of deposits, it is however not feasible with those ratios. We hence remove from our data the 5% of banks with the lowest share of deposits, it is the banks with less than 7% of deposits.

After that transformation, data regarding the LTD ratio leave us with 2,772 observations with a mean of -1.41, a standard deviation of 0.86 and values included between -10.9 and -0.1. The same transformation on data regarding the loans to deposit and short term debt ratio leave us with 2,729 observations, a mean of -1.09, a standard deviation of 0.53 and values included between -9.11 and -0.02.

4.3 Risk:

The third variable affecting the decision of depositor to keep or withdraw their money from the bank is the level of risk investors are facing. Risk neutral investors wants to maximize this risk to increase the risk premium but it is reflected in the likelihood of depositors not to get their money back which is why they do want it minimized. In the empirical section we will run regression with risk as a dependant variable. As investors want to maximize the risk they take we will see how an increase in capital and/or liquidity reduces the level of monitoring and hence allows them to take riskier behaviors. An indicator of the risk faced by investors is hence here presented.

⁴J-W. Van den End. (2016). “A macroprudential approach to address liquidity risk with the loan-to-deposit ratio”.The European Journal of Finance. Vol. 22, Issue 3 (2016)

Bloomberg provides quarterly data regarding the risk premium defined as the “*average additional return required by an investor as compensation for investing in equities rather than a risk-free instrument. Risk premium is the product of the country risk – premium and applied beta.*” With the country risk premium being the “*expected market return value based on the total accumulated investment risk for the country or region selected in country risk. The risk premium is only computed for countries or region which have a known risk-free rate*”.

We use the “*Recueil de notes – FIN8506 – Evaluation du prix des actifs*” from Raymond Théoret (ESG UQAM) to remind that the Beta comes from the CAPM model and is computed as follow

$$E(R_i) = R_f + [E(R_m) - R_f]\beta_i$$

With $\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$; R_f , the risk-free rate and R_m , the rate of the market (based on historic return of the reference market). The β is the relation between the volatility of the security and the volatility of the market. It represents the linear relation between the quantity of risk and the expected return of a security. The market risk premium is $E(R_m - R_f)$ and the risk premium of the security is the market risk premium time the Beta.

3,416 observations were extracted with a mean of 10.4, a standard deviation of 4.43, a minimum of -0.32 and a maximum of 40.34. As a reminder a Beta of 1.0 means that the security moves exactly like the market. (Distribution in annexes - Database18).

It is important to stress that this ratio is the level of risk beared by investors and not the risk on the asset side of the balance sheet exclusively which differs from the one proposed in our model. It is however the best proxy that we could find and the impact of using such a proxy will be detailed in the empirical section.

4.4 Government deposit coverage:

The government deposit insurance is defined by the OECD glossary of statistical term (2004) as “*A formal scheme normally established by law that is designed to limit the losses of depositors in the event of bank failure(s). Typically, the scheme is intended to support the confidence in the financial system of small-scale depositors and thus reduce the risk of systemic crises being caused by panic withdrawals of deposits*”

We selected European countries as the European commission created the Deposit guarantee schemes (DGS) which “*reimburse a limited amount to compensate depositors whose bank has failed*”(European commission (2018)) in 2009. The DGS was then modified as follow: “*an amending directive in 2009 required EU countries to increase their protection of deposits firstly to a minimum of €50,000, and then to a uniform level of €100,000 by the end of 2010.*”

However, the level of coverage were widely differing in European countries before this harmonization (going from the equivalent of €14,000 in Croatia to €100,000 in Italy) and the different countries did not implement the changes at the same date. We will hence be able to obtain variation between countries as well as see how the amplitude of the increase in government

deposit insurance affects banks' behavior.

A database from Asli Demirgüç-Kunt, Edward Kane, and Luc Laeven (2013) for the world bank allows us to know the exact date of change between €50,000 and €100,000 for each country in which there are banks studied in this paper while another database CESIFO Group Munich (2011) gives us the value of the maximum deposit covered before the implementation of the €50,000 coverage. For some reason France was excluded from this latest database so we used info provided by Cbanque. Data on Iceland, Norway Slovakia and Slovenia were not available.

For the countries using a different currency than Euro we took the exchange rate at the date of the change in coverage as provided by the European Central Bank to have the equivalent of the amount covered in Euro and assumed it stable over time.

This leaves us with 3,299 observation, a mean of 90,535.28, a standard deviation of 22,352.34 and values included between 14,000 and 100,000. On the sub-sample before 2013, when the European Commission forced the level to €100.000 in all the countries we have 1,497 observations with a mean of 79,142.22, a standard deviation of 29,388.06 and values included between 14,000 and 100,000. At the time many countries had already complied with the new European regulation even if they had lower levels of deposit insurance before.

4.5 Database summary

Reminder regarding the different ratios used:

$$\text{Tier One Ratio} = \frac{\text{Tier 1 capital}}{\text{Risk Weighted assets}}$$

$$\text{Equity to Liability ratio} = \frac{\text{Equity}}{\text{Liabilities}}$$

$$\text{Core capital coverage ratio} = \frac{\text{Tier 1 capital}}{\text{Total deposits}}$$

$$\text{Loans to deposits} = \frac{\text{Loans}}{\text{Deposits}}$$

$$\text{Loans to deposits and short term debt} = \frac{\text{Loans}}{\text{Deposits and Short term debts}}$$

Risk Premium, computed using the CAPM model.

Government deposit insurance in EURO equivalent

Table 2: Summary statistics

	Obs	Mean	Std. Dev.	Min	Max
Risk Premium	3,416	10.3935	4.432319	-.3229849	40.33675
T1R	2,737	14.32007	7.946595	-6.1	212.4
Equity/liabilities	3,392	.0801572	.0499491	-.0467019	.6493341
Core capital cvg ratio	2,305	.1429788	.0964956	-.0958495	.985998
LTD	2,772	-1.413899	.8551421	-10.8992	-.1001278
-Loans/(deposits+ST debt)	2,729	-1.087198	.5284503	-9.111333	-.022205
Deposit insurance	3,299	90535.28	22352.34	14000	100000

5 Empirical analysis

In the section we will prove the hypothesis of our model which are that:

1. As shareholder prefer high level of risk, low liquidity and capital positions to maximize their return on equity but that depositors, willing to keep their deposit safe, will monitor the bank and require sufficient levels of capital and/or liquidity and/or low levels of risk. We expect a trade off between lower levels of capital and/or liquidity and a riskier investment behavior for investors.
2. The highest the government deposit insurance, the less binding is the constraint coming from depositors' monitoring. An higher level of government deposit insurance will allow investors to chose lower levels of capital and liquidity while taking more risk on the asset-side of the balance sheet

Before focusing on testing those hypothesis, we start by looking at the impact of capital, liquidity and government deposit insurance on the risk premium.

To do so, we use the risk premium as a dependant variable and see how it is affected by our capital and liquidity proxies as well as by the level of government deposit insurance and find a significant impact of all those variables on risk. It will allow us to understand which one of our proxies are the most appropriate in order to run the general estimation.

The risk premium is different than the variable $s(r)$ on our model as it represents the remuneration of risk for the shareholders of the bank. The highest the risk premium, the more the security of the bank bears risk, with this risk being remunerated.

As Orgler, Taggart, Jr (1983) suggested that the size of the bank has an impact on its structure, we will always test whether fixed effect models are needed or not.

We then focus on testing our two hypothesis by running a general estimation where risk is the dependant variable and is explained by capital, liquidity and government deposit insurance.

Our hypothesis that those variables are substitutes as ways to reassure depositors are confirmed by running this general estimation. As the explanatory variables are substitutes we observe a greater predictive power of our model when including them all. We test our hypothesis by analyzing the reactions of the R-square, the estimators and their confidence levels when proposing specifications where one explanatory variable at a time is removed.

As the goal of this research is to determine the impact of our explanatory variables on risk, throughout the level of monitoring by depositors, those findings will be the most relevant.

The aim of this section will not be to quantify to which extend the variables replaced each other when it comes to preventing monitoring from depositors. As a matter of fact there are other factors influencing the impact of capital and liquidity on risk and all of the variables used as predictors are proxies. The goal of this paper is to prove that there are significant interactions between the three factors and that future legislation and research should take that into account when proposing regulations or models.

5.1 Impact of capital, liquidity and deposit insurance on risk

5.1.1 Impact of capital on risk

The impact of capital on risk is the trickiest variable to analyze. An increase in our proxy for risk, the risk premium, can be observed after an increase of capital for different reasons. As risk premium represents the level of risk for investors, an increased risk premium could be due to the fact that investors are more leveraged and hence carry more of the risk of the bank, or could be explained by the decreased level of depositors monitoring which allows investors to raise the overall level of risk. The coefficients found here are hence an overestimation of the real effect that capital has on monitoring.

In order to ensure that the observed effects are indeed due to depositor monitoring, an alternative specification using the total deposits as a dependant variable will be run. We observe that better capitalized banks are more able to attract deposits hence confirming that increased level of capital decreases the level of monitoring by depositors and hence allow investors to take more risk.

According to our model we were expecting a positive relationship. An increase in capital decreases the level of monitoring by depositors and allow investors to take more risk. However, a quadratic relation is obtained between risk and any of the significant capital ratio we use. With first an increase in capital leading to higher risk premium which then decreases with the highest values of capital. This could be explained in two different ways. First, as investors bring in more capital, they are allowed by depositors to take more risk. Then comes a point at which they become too leveraged and start monitoring the bank themselves as they have more at stake. Second, as demonstrated by our model, high levels of capitals lead to low level of liquidity as both those factors are substitutes as ways to reassures depositors. So very high levels of capital probably lead to low levels of liquidity which has a mixed impact on risk. The general estimation will confirmed that this quadratic relation is observed because of the interaction between capital and liquidity as taken into account in our model.

As we know that capital interacts with liquidity and government deposit coverage it is likely that some of the ratio not found significant here would become significant when we include the other variables in our model.

Tier 1 ratio

It was needed to test our model with the tier one ratio as it is the one provided by the legislator. However, because of the problem already presented in the chapter "database": the denominator of the tier 1 ratio is himself weighted by risk, we do not find any significant result, even when including a quadratic coefficient. Therefore, we will focus our analysis on the other 2 proxies used to compute capital adequacy.

Equity to liability ratio

The Hausman test is used to determine whether a random effect model or a fixed effect model should be used. As explained by Hausman (1978), this test tests whether the unique errors (u_i) are correlated with the regressors or not. As we found that they are we decided to use a fixed effect model. A detailed explanation of what the fixed model is is proposed in the annexes.

The Wald interaction test is then used in order to define if a time fixed effect is needed as described in Wooldridge (2013). This test allows us to know if a variable is relevant for a model or if it could be removed without meaningfully affecting the model. The null hypothesis is that the parameter is not affected by the variable, here time. A p-value equal to 0 is obtained and the null hypothesis is hence rejected. A time fixed effect is included in our model.

A Modified Wald test for group-wise heteroskedasticity is finally used and, as the p-value is equal to 0, we will present robust estimators.

As a reminder robust estimators are needed when heteroskedasticity is observed in the model.

We use Wooldridge (2013: 268) to remind that heteroskedasticity happens “*whenever the variance of the unobserved factors changes across different segments of the population, where the segments are determined by the different values of the explanatory variables*”.

The final model takes the following form:

$$RP_{it} = \beta_0 + \beta_1 ELR_{it} + \beta_2 ELR_{it}^2 + \beta_3 ELR_{it}^3 + \alpha_i + \delta_1 T_1 + \dots + \delta_T T_T + u_{it} \quad (9)$$

With for each bank i at time t :

RP_{it} = risk premium

ELR_{it} = equity to liability ratio

α_i = bank fixed effect

δ_t for $t=1, \dots, T$ = time fixed effect for each quarter studied

u_{it} = error term

We run the a linear, a quadratic and a cubic regression but no significant results were found. However, when controlling for the liquidity the quadratic relation becomes significant, confirming our hypothesis of substitution.

The non-significant results of our regressions can be found in the annexes.

Core capital coverage ratio

Using the Hausman test, it has been decided to use a fixed effect model. The Wald interaction test led us to the use of a time fixed effect and estimators robust to heteroskedasticity will be presented. We run a linear, quadratic and cubic regression. The quadratic specification gives the most significant estimators.(The three regressions can be found in the annexes).

The model takes the following specification:

$$RP_{it} = \beta_0 + \beta_1 TIC_{it} + \beta_2 TIC_{it}^2 + \alpha_i + \delta_1 T_1 + \dots + \delta_T T_T + u_{it} \quad (10)$$

With for each bank i at time t

RP_{it} = risk premium

$T1C_{it}$ = Tier 1 capital coverage ratio.

α_i = bank fixed effect

δ_t for $t=1, \dots, T$ = time fixed effect for each quarter studied

u_{it} = error term

As we run a fixed effect model we look at the within R square. The regression was run on 2,303 observations for 122 banks as data for 28 banks were missing. The coefficients on dates are not presented.

Table 3: Impact of the tier 1 capital coverage ratio on risk

	Quadratic
Core capital coverage ratio	15.22* (7.974)
Core capital coverage ratio square	-16.62** (8.294)
Constant	5.622*** (1.054)
r2	0.222
N	2303

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The Constant coefficient (β_0) is computed as:

$$\beta_0 = \frac{1}{N} \sum_{i=1}^N \hat{a}_i$$

Again the β_1 coefficient is significant at a 90% confidence level while the β_2 is at a 95% confidence level with values confirming a quadratic relation.

We have an R-sq within of 22.2% which makes us believe that the level of capital brought in by investors significantly affects the level of risk of a bank.

As we used a fixed effect model, it is important to remind the reader that the coefficient estimate the deviation of the dependant variable from its time average explained by the deviation of the explanatory variables from their time average.

Direct measure of the impact of capital on monitoring

If we were able to identify a correlation between the core capital coverage ratio and the risk premium we cannot be sure that the increase of the risk premium is not simply due to the fact that investors are more leveraged. To test for the direct impact of safe capital in the bank on banks' monitoring we run a regression with the total level of deposit as a dependant variable and the level of core tier one capital as the predictive variable. As those two variables are obviously positively correlated to the size of the bank's balance sheet we will include the total liabilities as a control. It would have been ideal to use our core capital coverage ratio as a predictor, however, as this ratio has the level of deposits as a denominator it would be mechanically correlated to the dependant variable.

We run a random effect model with the amount of deposits as a dependant variable and the amount of tier one capital as the explanatory variable. Running a random effect model was decided after running an Hausmann test, it means that the variation across banks is uncorrelated with the independent variables of the model. We also control for the size of the balance sheet and the risk premium. A time fixed effect is added and robust estimators are presented. The coefficients on the time fixed effect are not presented:

$$TD_{it} = \beta_1 T1C_{it} + \beta_2 TL_{it} + \delta_3 RP_{it} + \alpha + \delta_1 t_1 + \dots + \delta_T t_T + u_{it} + \varepsilon_{it}$$

With for each bank i at time t :

TD_{it} = total deposits

$T1C_{it}$ = tier 1 capital

TL_{it} = total liabilities

RP_{it} = risk premium

α = bank fixed effect (which is uncorrelated with the predictors)

δ_t for $t=1, \dots, T$ = time fixed effect for each quarter studied

u_{it} = between banks error term (cross section error term)

ε_{it} = within bank error term (time series error term).

Table 4: Impact of capital on the deposits

	Linear
Tier one capital	5.558*** (0.542)
Total liabilities	0.135*** (0.043)
Risk Premium	-2.19818e+11 * (1.264e+11)
Constant	5.31573e+12 (3.404e+12)
r2	0.693
N	2352
Standard errors in parentheses	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$	

We see that a better capitalized bank attracts depositors more easily as we have a positive coefficient significant at a 99% confidence level and a within R-square of 69%. Confirming the intuition of our model.

Impact of capital on risk - conclusion

We were able to identify a significant proxies for the impact of capital on risk showing a quadratic relationship between the risk premium and the core capital coverage ratio. If we control for the level of liquidity in the bank the equity to liability ratio becomes significant as well.

It is interesting to understand the differences between those ratios. The literature highlights two reasons for which depositors prefer more capitalized banks. First, investors are more leveraged in a more capitalized bank and hence have more incentives to monitor the risk of the bank themselves. Second, in case of bankruptcy, depositors are primary claim holders and hence prefer higher levels of capitals to increase their chances of having their money back.

The equity to liabilities ratio represents the share of equity in the balance sheet and hence the extend to which investors are actually monitored while the core capital coverage ratio represents the share of deposits covered by core capital. The fact that the core capital coverage coverage ratio is more significant than the equity to liability ratio may be a sign of the preponderance of the importance of having their deposits covered by capital rather than having the investors leveraged for depositors.

Our significant ratio led us to a quadratic relation which can be explained in two ways. It could either be that, in a first time, more capital leads to less monitoring by depositors but also increases the leverage on investors still willing to take additional risk which leads to an higher risk premium before reaching a point where investors decide to start monitoring the bank themselves even though depositors do not proceed to do so (in a binding way) anymore.

Or, as capital and liquidity act as substitutes to reassure depositors, the quadratic relation may be due to the fact that very high levels of capital lead to lower levels of liquidity in order to maintain an equal level of monitoring by depositors. Our general estimation will confirm the latter hypothesis.

5.1.2 Impact of liquidity on risk

A quadratic relation is also expected here as a higher levels of liquidity will primarily allow investors to take more risk as monitoring decreases but at some point will mechanically decrease the riskiness of the asset side of the balance sheet as liquid assets are bearing very little risk. As liquidity is a substitute for capital in our model low levels of liquidity lead to high levels of capital which has an offsetting impact on the level of monitoring and hence the risk. The coefficients telling us by how much an increase in liquidity decreases the level of monitoring are hence underestimation of its real effect.

Loan to deposits ratio

After using a random effect model as suggested by the Hausman test and adding a time fixed effect as well as using robust estimators no significant result could be found. The ratio will not further be used.

Loans to deposits and short term debt ratio

The Hausman test this time suggests the use of a random effect model. A control for the time will also be used as suggested by the Wald test and robust coefficient will be presented. A linear, a quadratic and a cubic regression were run and the linear one was the best fit (see regressions in annexes). We hence have the following specification:

$$RP_{it} = \beta_1 LR_{it} + \beta_2 LR_{it}^2 + a + \delta_1 t_1 + \dots + \delta_T t_T + u_{it} + \varepsilon_{it}$$

With for each bank i at time t

RP_{it} = risk premium,

LR_{it} = loans to deposit and short term debt ratio

a = fixed effect (which is uncorrelated with the predictors)

δ_t for $t=1, \dots, T$ = time fixed effect for each quarter studied

u_{it} = between banks error term (cross section error term)

ε_{it} = within bank error term (time series error term).

The regressions are run on 2,727 observations across 132 banks. The coefficients on the date are not presented.

Table 5: Impact of liquidity on risk

	Quadratic
Loans to deposits and ST debts	1.873*** (0.657)
Loans to deposits and ST debts square	0.197*** (0.077)
Constant	7.699*** (0.826)
r2	0.192
N	2727

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Our coefficients are significant at a 99% confidence level. The most liquid a bank is, the less it is monitored by depositor and the riskier it gets. We will see how those variables interact when including capital in the next sub chapter. It is interesting to note that those coefficient are an underestimation of the increase of risk due to the decreased level of monitoring by depositors. As a matter of fact, increasing the level of liquidity in a bank makes it safer and should hence decrease the level of risk if it was not for the increase of risk coming from the decreased level of monitoring by depositors.

We have an R-sq within of 19.21% which makes us believe that the level of liquidity has a significant impact on the level of risk of a bank.

Impact of liquidity on risk - conclusion

Results obtained using the loans to deposits and short term debt ratio leads us to coefficient significant at a 99% confidence level on confirming our hypothesis.

We have a quadratic relationship with two positive coefficients, the most liquid a bank is, the most it is allowed to take additional risk. The highest the level of liquidity, the less depositors monitor the bank.

It is important to note that the estimator found are underestimation of the real effect of the increase of risk allowed by decreased depositor monitoring as increasing liquidity because increased liquidity in a financial institution mechanically decrease its level of risk by reducing the likelihood of a bank run.

5.1.3 Impact of government deposit insurance on risk

For this variable, we use the level of government deposit insurance in each country as an explaining variable.

Using an Hausman test we determine that a random effect model is the most appropriate, a Wald test detected a time fixed effect which we will control for and robust estimators are presented.

A linear and a quadratic model are used but the linear one gives us better predictions (see both model in annexes).

The final model takes the following form:

$$RP_{it} = \beta_1 GC_{it} + a + \delta_1 t_1 + \dots + \delta_T t_T + u_{it} + \varepsilon_{it}$$

With for each bank i at time t :

RP_{it} = risk premium

GC_{it} = government deposit insurance.

α = bank fixed effect

δ_t for $t=1, \dots, T$ = time fixed effect for each quarter studied.

u_{it} = between banks error term (cross section error term)

ε_{it} = within bank error term (time series error term)

The regression is run on 3158 observations spread across 138 banks, coefficients on on date are not presented.

Table 6: Impact of government deposit insurance on risk

	Linear
depoins	-0.0000422*** (0.000)
Constant	8.031*** (0.525)
r2	0.2135
N	3158

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Against the expectations of our model we find a significant negative coefficient. It could be due to two reasons. Either, as argued by Gropp and Vesala (2004) who say that in some case an increase in deposit insurance might lead to more monitoring from uninsured depositors and hence safer bank. Or it could simply be that deposit insurance inherently make the bank safer by preventing a bank run and that this effect offset the increase of risk taken by investors. We will test for those two hypothesis in the next subchapter where the share of deposit will be used as a dependant variable and prove that an increase in deposit insurances does lead to less monitoring.

The within R-square is 21.35% which lead us to believe that the amount of deposit covered has a significant impact on risk and we will hence use it in the general estimation.

The direct impact of government deposit insurance on monitoring

In order to ensure that despite observing an increase in the risk premium after an increase in the deposit insurance we test the impact of the deposit insurance on the share of deposit.

The share of deposit is obtained by deviding the total amount of deposit by the total liabilities. A random effect model is run using a time fixed effect and robust estimators are presented. The coefficients on date are not presented:

$$SD_{it} = \beta_1 GC_{it} + \beta_2 RP_{it} + \alpha + \delta_1 t_1 + \dots + \delta_T t_T + u_{it} + \varepsilon_{it}$$

With for each bank i at time t:

SD_{it} = share of deposits

GC_{it} = government deposit insurance

RP_{it} = risk premium

α = fixed effect (which is uncorrelated with the predictors)

δ_t for $t=1, \dots, T$ = the time fixed effect for each quarter studied

u_{it} = between bank error term (cross section error term)

ε_{it} = the within bank error term (time series error term)

Table 7: Impact of government deposit insurance on monitoring

	(1)
Government deposit insurance	0.000000630** (0.000)
Risk Premium	-0.00178 (0.002)
Constant	0.456*** (0.032)
r2	0.16
N	3024

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We see that an increase in the level of government deposit insurance leads to an increase in the share of deposits. The coefficient is significant at a 95% confidence level.

Surprisingly, risk premium gives us a negative coefficient. This is however not statistically significant at a 90% confidence level.

This confirm our hypothesis that increasing the level of government deposit insurance decreases the monitoring by depositors

We hence have that increasing the level of government deposit insurance does indeed decreases the risk of the bank by decreasing the likelihood of a bank run but allows investors to take riskier behavior as they are less monitored by depositors.

5.1.4 Impact of capital, liquidity and deposit insurance on risk - conclusion

A significant relation between capital and risk was found using the core capital coverage ratio with the level of risk increasing at first with an increase of capital but then decreasing.

The loans to deposits and short term debt ratio shows an increase in risk when the level of liquidity increases as suggested by our model.

As we assume that those two variables interact together we will only be able to assess their exact effect on risk in a general estimation where they are both used hence controlling for their interaction.

An increase in government deposit insurance leads to a decrease in Risk which goes against the prediction of our model. However, it may be because an increased level of government deposit insurance makes the banks safer by preventing bank run and that this effect is offsetting the increase of risk taken by investors which is confirmed by table 7.

5.2 General estimation

Our model helped us to understand the in balance sheet interactions between capital, liquidity and the risk taken with the productive assets. We were also able to establish how it was affected by the government deposit insurance.

We now focus on testing the implications of our model. We use the risk premium as a dependant variable, it differs from the share of risky assets ($s(r)$) in our model as the risk premium represents the additional remuneration ($1 + r_i$) of investor because of the risk they face. We will be able to observe how it is affected by capital, liquidity and government deposit insurance in a general estimation.

Our model is run using capital, liquidity and government deposit insurance, as predictors of the level of risk a bank will take. One variable at a time will then be removed in order to test the elasticity hypothesis by observing whether or not it changes the impact of the other two predictors on risk premium.

For our specifications the coefficients that were found to be the best determinants of the risk premium in our previous estimations will be used. This is: the core capital coverage ratio, the loans to deposits and short term debts ratio and the level of government deposit insurance.

We do not use the same quadratic specifications as the one found significant when only taking one of the factor into account to explain risk as when the other predictors are included the results do not become more significant by including them, hence aligning our empirical analysis to the prediction of our model. It is a strong sign that the hypothesis of substitution between capital and liquidity is true. As a matter of fact really high levels of capital (liquidity) then lead to low levels of liquidity (capital) hence having an opposite effect on the level of risk which justify the quadratic relation found when not controlling for the other explaining variable.

There will be three ways through which the level of elasticity between our explanatory variables can be tested. First, looking at the R-square, as a matter of fact this indicator tells us which part of the change in the dependent variable are explained by our model. So if we have two variables that act as substitutes, adding one of them in the model should add much significance to our model.

Second, our coefficients that used to be quadratic should also evolve toward strictly positive,

more significant and greater coefficients.

In order to understand those intuitions lets take the following example:

Y is the dependant variable and is positively correlated with X and Z. However X and Z are substitutes and hence negatively correlated. So an increase in X leads to a direct indrease in Y but also to a decrease in Z which itself leads to a decrease in Y

An observed increase in X or Z should lead to an increase in Y, however as increasing X reduces Z and inversely we do not observe such a relation but rather a quadratic one when not controlling for the other explanatory variable.

So by running the regression with only X or Z as explanatory factor we obtain quadratic estimators as found with the impact of capital or liquidity on risk. Non quadratic regressions are not significant even thought the relation should be linear if we were controlling for the other explanatory factor (X or Z). Hence comparing the linear regression between X or Z on Y (using linear relations only) and between X and Z on Y will lead to a significantly higher R-square and greater and more significant coefficients.

In summary if two variables are substitute adding one in the regression should:

- Lead to a greater R-square
- Lead to greater coefficients
- Lead to more significant coefficients

We use a fixed effect model with a time fixed effect and present robust estimators.

In this table the tier one capital coverage ratio (CAP) is used as a proxy for the level of capital, the loans to deposits and short term debts ratio for the liquidity position (LIQ) and the government coverage per GDP per capita (GC) for the government coverage. The constant here is C. The coefficient on date are not presented.

$$RP_{it} = \beta_0 + \beta_1 T1C_{it} + \beta_2 LR_{it} + \beta_3 GC_{it} + \alpha_i + \delta_1 t_1 + \dots + \delta_T t_T +$$

With for each bank i at time t: RP_{it} = risk premium

$T1C_{it}$ = tier one capital ratio

GC_{it} = government deposit insurance

α_i = bank fixed effect

δ_t for $t=1, \dots, T$ = time ficed effect

u_{it} = error term

Table 8: General estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CAP	1.842 (3.139)			21.16*** (7.041)	19.31*** (6.694)	1.520 (3.252)	
LIQ		0.628 (0.387)		3.285*** (0.695)	3.171*** (0.716)		0.597 (0.374)
GC			-0.0000436*** (0.000)	-0.0000422*** (0.000)		-0.0000466*** (0.000)	-0.0000465*** (0.000)
C	6.758*** (0.777)	7.148*** (0.755)	8.497*** (0.598)	9.805*** (1.196)	8.436*** (1.129)	8.409*** (0.931)	8.815*** (0.896)
r2	0.216	0.188	0.214	0.273	0.235	0.252	0.219
N	2303	2727	3158	1947	2101	2141	2493

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In order to test our hypothesis, which are that capital, liquidity and government deposit insurance are substitutes as ways to reassure depositors against the risk of their bank, we will look at the substitution of all those variables together.

Substitution between capital and liquidity

Neither capital nor liquidity, when taken alone, are significant linear predictors of the risk premium. This is true whether we include the government coverage (specification (6) and (7)) or not (Specification (1) or (2)). However, when controlling for the other variable (going from specifications (1) and (2) to specification (5) or from specifications ((6) and (7) to specification (4)) we obtain greater and significant coefficients as well as a bigger R-square.

Looking at the results obtained in regressions (1) and (2) compared to those of regression (5) leads us to results confirming our hypothesis of substitution between capital and liquidity. The coefficient on capital, taken alone, is 1.842 and not significant at a 90% confidence level but goes up to 19.31 and significant at a 99% confidence level when controlling for liquidity. While the coefficient on liquidity goes from 0.628 not significant at a 90% confidence level to 3.171 significant at a 99% confidence level. The R square goes from either 21.6% for capital or 18.8% for liquidity to 23.5%. This confirms that capital and liquidity are two different ways to reassure depositors and that they are substitutes.

If we control for the government deposit insurance the coefficient on capital goes from 1.52 and not significant at a 90% confidence level to 21.16 and significant at a 99% confidence level while the coefficient on liquidity goes from 0.597 and not significant at a 90% confidence level to 3.285 and significant at a 99% confidence level. The R-square goes from 25.2% for capital and 21.9% for liquidity to 27.3% in the general estimation.

It is interesting to note that adding government deposit insurance leads to even greater coefficient suggesting substitution between this variable and the other two as well but does not

affect the findings of our hypothesis of substitution between capital and liquidity.

Impact of the government deposit insurance on capital and liquidity

Adding the government deposit insurance in the regression does not make the coefficient (equation (6) and (7) versus (1) and (2)) on capital nor liquidity significant. However comparing (5) with (4) we find an impact of adding the government deposit insurance in the regression. The impact of capital on risk increases from 19.31 to 21.16 and the impact of liquidity goes from 3.17 to 3.86, all while still being significant at a 99% confidence level. The within R-square also goes from 23.5% to 27.3%. This confirms our hypothesis that a higher government deposit insurance will impact the level of monitoring of banks by depositors and allow them the bank to have lower capital or liquidity levels.

As explained in sub chapter 5.1.3 the negative coefficient is due to the fact that despite allowing the bank to take more risk by reassuring depositors an increased government deposit insurance ultimately leads to lower risk premium as this effect is offset by the decreased risk of a bank run.

Effect of all variables

We use the fourth specification to understand the impact of all variables on risk in an estimation controlling for the substitutions between capital, liquidity and government deposit insurance.

A deviation of 1 from its time series average the core capital coverage ratio leads to a within bank deviation for its time series average of the risk premium of 21.16 and is significant at a 99% confidence level. As a reminder the core capital coverage ratio has values between -0.1 and .98 and a standard deviation of 0.096. An increase in the core capital coverage ratio of 0.096 leads to an increase in the risk premium of 2.03 or almost half of the standard deviation of the risk premium (4.43)

A deviation of 1 from its time series average the loans to deposits and short term debt ratio leads to a within bank deviation for its time series average of the risk premium of 3.285 and is significant at a 99% confidence level. The loans to deposits and short term debt ratio has values included between -9.11 and -0.022 with a standard deviation of 0.53. An increase in the loans to deposits and short term debt ratio (time minus 1) of 0.53 leads to an increase in the risk premium of 1.74 or a bit more than a third of the standard deviation of the risk premium.

A deviation of 1 from its time series average of the government deposit insurance leads to a within bank deviation for its time series average of the risk premium of -0.000422 and is significant at a 99% confidence level. It may seem really low but some countries (such as Belgium) went from a deposit insurance of €20,000 to €100,000. An increase of the deposit insurance of €80,000 should lead to a decrease of the risk premium of 3.38. The decrease of this risk premium is probably due to the decreased risk of a bank run as depositors are insured. We are

expecting a riskier behavior by the bank as they are not monitored as much by depositors.

General estimation - conclusion

We were able to confirm our hypothesis of substitution between capital and liquidity as ways for investors to reassure depositors when increasing the level of risk they take for the bank by proving that those two explanatory variables have significantly more explaining power when taken together as they are substitutes.

We also showed that including the government deposit insurance in our analysis increases the impact of capital and liquidity on risk leading us to believe that they are substitute as well.

5.3 Empirical analysis - conclusion

We started by looking at the impact of the three variables of our model on risk when taken alone. We found out that increased levels of capital led to increased level of risk first before decreasing the risk premium. Higher liquidity levels led to higher risk premium at an accelerating pace. The highest the government deposit insurance, the less risky the bank was. This was however due to the decreased probability of a bank run as an alternative specification showed that increased government deposit insurance led to more deposits in banks.

As we expect those variables to be substitutes we then ran a general estimation and looked at how the coefficients were changing when removing one of the explaining variable of our model.

We found that higher level of capital and liquidity led to riskier banks confirming our hypothesis of decreased monitoring by depositors and were able to show that they were substitutes as ways to reassure depositors against the risk they face to lose their deposits because of the risk the bank takes.

An increased level of government deposit insurance led to lower risk level in opposition to the prediction of our model. It is because the increase of risk taken by bank after an increase in government deposit insurance has decreased the level of monitoring by depositors is offset by the decrease of risk due to the decreased likelihood of a bank run. Despite having a coefficient against our expectation for that reason we observe that adding the government deposit insurance allows the bank to decrease its level of capital or liquidity.

We can hence confirm our two hypothesis:

1. As shareholder prefer high level of risk, low liquidity and capital positions to maximize their return on equity but that depositors, willing to keep their deposit safe, will monitor the bank and require sufficient levels of capital and/or liquidity and/or low levels of risk. We expect a trade off between lower levels of capital and/or liquidity and a riskier investment behavior for investors.
2. The highest the government deposit insurance, the less binding is the constraint coming from depositors' monitoring. An higher level of government deposit insurance will allow

investors to chose lower levels of capital and liquidity while taking more risk on the asset-side of the balance sheet

6 Conclusion

In this paper an innovative model based on the assumption that depositors monitor a representative bank was proposed to assess the impact of capital, liquidity and government deposit insurance on the level of risk a bank takes. In this model, investors are trying to maximize their return on equity. Since our risk premium is obtained using a CAPM model, every increase in risk is remunerated. More expected profit hence comes with more risk. This is done under the constraint of having depositors withdrawing their money if they fear not getting their deposits back. To reassure depositors a bank can choose a safer investment policy or increase capital and/or liquidity levels. Banks hence have to compromise between increasing their expected profit by risk or decreasing capital or liquidity as those two latest variables are ways to reassure depositors regarding the likelihood to have their money back. The government deposit insurance also affects the equilibrium value of those variables since, when it increases, it leads to less monitoring and hence an higher level of risk and/or lower level of capital and/or liquidity.

Data regarding the capital, liquidity and risk positions from the balance sheet of 149 banks in 30 European countries were extracted as well as data regarding the level of government deposit insurance. The database was then used to test the predictions of our model. We found results aligning with the existing literature on the direct impact of capital, liquidity and government deposit insurance on monitoring. In our data set higher levels of capital, liquidity and government deposit insurance were associated with a higher level of risk. It goes along our hypothesis that they can all be used as a way to reassure depositors against the risk they face of losing their money when the bank follows a riskier investment strategy.

Even if an increase of those three factors is supposed to make banks safer *ceteris paribus* (if they were not affecting the risk taking behavior) we show that there is a global equilibrium in which banks adjust their level of risk to the level of monitoring they face.

The results of both the model and the empirical section are that capital, liquidity and government deposit insurance are all indeed ways to reassure depositors but the main contribution of this research is that capital and liquidity are substitutes as ways to reassure depositors. We also show that, introducing the government deposit insurance will also allow bank to decrease capital and/or liquidity position and increase risk.

If a bank wants to increase its level of risk it can chose to increase its liquidity level or its capital level or both of them to a lesser extent. Introducing the government deposit insurance will also impact the optimal levels of risk, capital and liquidity.

Those findings are highly relevant when it comes to studying the existing legislation on banks' risk. At the moment, regulation regarding capital, liquidity and the government deposit insurance are done separately. Neither the regulation on capital requirements nor the one on liquidity requirements seem to be binding at the moment as monitoring by depositors set minimum levels higher than those required by the Basel committee. Our findings however highlight that, if it is decided to tighten those requirements and to make them binding, it will be essential to do so for both capital and liquidity at the same time. As a matter of fact, increasing solely liquidity requirements would lead to under capitalized bank. The opposite is

true if it is decided to raise capital requirement only. We also showed that any change in deposit insurance should probably be accompanied by changes in regulation on capital, liquidity and risk tolerance in banks in order to maintain bank as safe as they were before or to make them safer.

Finally, we were able to demonstrate that there are different possible combinations of capital, risk and liquidity for banks to guarantee deposits and that legislation setting regulatory levels on one variable contingent to the level of the other factors might be more appropriate as it would leave the freedom to the bank to optimize its capital, liquidity and risk levels while keeping the risk for depositors constant at the required level.

Although neither the optimality nor the feasibility of alternative legislation has been studied in this paper, we have however showed some gaps in the existing one.

A major flaw of this research is that it does not take into account the remuneration that depositors get on their deposits. Depositors might agree to expose their savings to more risk if this risk is remunerated and this was not studied in this paper as the primary objective was to establish the interaction between risk, capital, liquidity and deposit insurance. Because of that we totally excluded the moral hazard problem coming from deposit insurance from our analysis and further research should study the effect including it would have on our results.

There has already been an immense amount of literature regarding the best way to regulate banks but as the recent financial crisis has shown there is still room for improvement. Bank crises are terrible catastrophes in which millions of people lose large sums, their jobs and much more, government debt surges and the economy as a whole faces a huge slowdown because the access to credit is restrained, monetary policies are compromised and counter-cyclical programs are made complicated by the rising level of government indebtedness. It is because of those observations that this thesis was written.

7 References

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8 Annexes

8.1 List of bank

Banks with data available

Erste Group Bank AG (Austria)	lic)	Deutsche Pfandbriefbank AG (Germany)
Raiffeisen Bank International AG (Austria)	Komerční banka, a.s. (Czech Republic)	Deutsche Zentral-Genossenschaftsbank AG (Germany)
UniCredit Bank Austria AG (Austria)	Danske Bank A/S (Denmark)	Landesbank Baden-Württem- berg (Germany)
AXA Bank Europe SA (Bel- gium)	Jyske Bank A/S (Denmark)	Landesbank Hessen-Thürin- gen Girozentrale (Germany)
Belfius Banque SA (Belgium)	Nykredit Realkredit A/S (Denmark)	Landeskreditbank Baden- Württemberg-Förderbank (Germany)
BNP Paribas Fortis SA (Bel- gium)	Sydbank A/S (Denmark)	Landwirtschaftliche Renten- bank (Germany)
Dexia NV (Belgium)	Luminor Bank AS (Estonia)	Münchener Hypothekenbank eG (Germany)
KBC Group NV (Belgium)	AS LHV Group (Estonia)	Norddeutsche Landesbank Girozentrale (Germany)
First Investment Bank (Bul- garia)	SEB Pank AS (Estonia)	NRW.Bank (Germany)
UniCredit Bulbank Bulgaria (Bulgaria)	OP Financial group (Finland)	Volkswagen Bank Gesellschaft mit beschränkter Haftung (Germany)
Erste Steiermärkische Bank d.d. (Croatia)	BNP Paribas SA (France)	Alpha Bank AE (Greece)
Privredna Banka Zagreb d.d. (Croatia)	Crédit Mutuel Group (France)	Eurobank Ergasias SA (Greece)
Zagrebacka Banka d.d. (Croatia)	Groupe Credit Agricole (France)	National Bank of Greece SA (Greece)
Bank of Cyprus Holdings Public Limited Company (Cyprus)	HSBC France (France)	Piraeus Bank SA (Greece)
Co-operative Central Bank Ltd (Cyprus)	La Banque Postale (France)	Kereskedelmi és Hitelbank Zrt. (Hungary)
Hellenic Bank Public Com- pany Ltd (Cyprus)	RCI banque (Renault Crédit Industriel) (France)	OTP Bank Nyrt. (Hungary)
Česká spořitelna, a.s. (Czech Republic)	SFIL (Société de Financement Local) (France)	Arion banki hf (Iceland)
Československá obchodní banka, a.s. (Czech Repub-	Société Générale SA (France)	Íslandsbanki hf. (Iceland)
lic)	Aareal Bank AG (Germany)	Landsbankinn (Iceland)
	Bayerische Landesbank (Ger- many)	AIB Group plc (Ireland)
	Commerzbank AG (Germany)	
	DekaBank Deutsche Girozen- trale (Germany)	
	Deutsche Apotheker- und Ärztebank eG (Germany)	
	Deutsche Bank AG (Ger- many)	

Bank of Ireland Group plc (Ireland)	HSBC Bank Malta Plc (Malta)	Všeobecná úverová banka, a.s. (Slovakia)
DEPFA BANK Plc (SIX) (Ireland)	ABN AMRO Group N.V. (Netherlands)	Abanka d.d. (Slovenia)
Ulster Bank Ireland Limited (Ireland)	Coöperatieve Rabobank U.A. (Netherlands)	NOVA LJUBLJANSKA BANKA D.D., LJUBLJANA (Slovenia)
Banca Carige SpA - Cassa di Risparmio di Genova e Imperia (Italy)	ING Groep N.V. (Netherlands)	Banco Bilbao Vizcaya Argentaria, SA (Spain)
Banca Monte dei Paschi di Siena SpA (Italy)	N.V. Bank Nederlandse Gemeenten (Netherlands)	Banco de Crédito Social Cooperativo SA' (Spain)
Banca popolare dell'Emilia Romagna SC (Italy)	Nederlandse Waterschapsbank N.V. (Netherlands)	Banco de Sabadell, SA (Spain)
Banca Popolare di Sondrio (Italy)	DNB BANK ASA (Norway)	Banco Santander SA (Spain)
Banco BPM Gruppo Bancario (Italy)	SPAREBANK 1 SMN (Norway)	Bankinter SA (Spain)
Iccrea Banca Spa Istituto Centrale del Credito Cooperativo (Italy)	SR-bank (Norway)	BFA Tenedora de Acciones, S.A. (Spain)
Intesa Sanpaolo SpA (Italy)	Bank Polska Kasa Opieki SA (Poland)	CaixaBank S.A. (Spain)
Mediobanca - Banca di Credito Finanziario SpA (Italy)	Bank Zachodni WBK SA (Poland)	Kutxabank (Spain)
UniCredit SpA (Italy)	Powszechna Kasa Oszczędności Bank Polski SA (Poland)	Liberbank (Spain)
Unione di Banche Italiane SCpA (Italy)	Banco BPI SA (Portugal)	Unicaja Banco S.A. (Spain)
Luminor Bank AS (Latvia)	Banco Comercial Português SA (Portugal)	AB Svensk Exportkredit - group (Sweden)
ABLV Bank (Latvia)	Caixa Económica Montepio Geral (Portugal)	Kommuninvest - group (Sweden)
AS SEB banka (Latvia)	Caixa Geral de Depósitos SA (Portugal)	Länsförsäkringar Bank AB - group (Sweden)
Swedbank AS (Latvia)	Novo Banco (Portugal)	Nordea Bank - group (Sweden)
Luminor Bank AB (Lithuania)	Banca Comerciala Romana SA (Romania)	SBAB Bank AB - group (Sweden)
Banque et Caisse d'Epargne de l'Etat, Luxembourg (Luxembourg)	Banca Transilvania (Romania)	Skandinaviska Enskilda Banken - group (Sweden)
BGL BNP Paribas (Luxembourg)	BRD-Groupe Sociéte Générale SA (Romania)	Svenska Handelsbanken - group (Sweden)
Sociéte Générale Bank Trust (Luxembourg)	Slovenská sporiteľňa, a.s. (Slovakia)	Swedbank - group (Sweden)
Bank of Valletta Plc (Malta)	Tatra banka, a.s. (Slovakia)	Barclays Plc (United Kingdom)
		Coventry Building Society (United Kingdom)
		Credit Suisse International (United Kingdom)

HSBC Holdings Plc (United Kingdom)	Swedbank AS (Estonia)	bourg S.A. (Luxembourg)
Lloyds Banking Group Plc (United Kingdom)	Nordea Kiinnitysluottopankki Oyj (Finland)	Commbank Europe Ltd (Malta)
Mizuho International Plc (United Kingdom)	Kuntarahoitus Oyj (Finland)	MDB Group Limited (Malta)
Nationwide Building Society (United Kingdom)	Banque Centrale de Compensation (LCH Clearnet) (France)	Volksholding B.V. (Netherlands)
RBC Europe Limited (United Kingdom)	Bpifrance (Banque Publique d'Investissement) (France)	Caixa Central de Crédito Agrícola Mútuo, CRL (Portugal)
Standard Chartered Plc (United Kingdom)	CRH (Caisse de Refinancement de l'Habitat) (France)	Santander Totta (Portugal)
The Co-operative Bank Plc (United Kingdom)	Erwerbsgesellschaft der S-Finanzgruppe mbH Co. KG (Germany)	Biser Topco S.à.r.l. (Slovenia)
The Royal Bank of Scotland Group Public Limited Company (United Kingdom)	HASPA Finanzholding AG (Germany)	UniCredit Banka Slovenija d.d. (Slovenia)
UBS Limited (United Kingdom)	HSH Beteiligungs Management GmbH (Germany)	ABANCA Holding Financiero (Spain)
Virgin Money Plc (United Kingdom)	State Street Europe Holdings (Germany)	Ibercaja Banco (Spain)
Yorkshire Building Society (United Kingdom)	UniCredit Bank Hungary Zrt. (Hungary)	Citigroup Global Markets Europe Limited (United Kingdom)
	Citibank Holdings Ireland Limited (Ireland)	Credit Suisse Investments (UK) (United Kingdom)
<u>Non Used banks :</u>	Credito Emiliano Holding SpA (Italy)	Goldman Sachs Group UK Limited (United Kingdom)
BAWAG Group AG (Austria)	AB SEB bankas (Lithuania)	J P Morgan Capital Holdings Limited (United Kingdom)
Raiffeisenbankengruppe OÖ Verbund eGen (Austria)	Swedbank AB (Lithuania)	Merrill Lynch UK Holdings Ltd (United Kingdom)
Sberbank Europe AG (Austria)	Deutsche Bank Luxembourg S.A. (Luxembourg)	Mitsubishi UFJ Securities International PLC (United Kingdom)
Volksbanken Verbund (Austria)	J.P. Morgan Bank Luxembourg S.A. (Luxembourg)	Morgan Stanley International Ltd (United Kingdom)
Bank of New York Mellon (Belgium)	Precision Capital S.A. (Luxembourg)	National Australia Group Europe Limited (United Kingdom)
Investar (Belgium)	RBC Investor Services Bank S.A. (Luxembourg)	Nomura Europe Holdings PLC (United Kingdom)
DSK Bank Bulgaria (Bulgaria)	State Street Bank Luxem-	
RCB Bank Ltd (Cyprus)		

8.2 Empirical analysis

8.2.1 Reminder on the fixed effect model in panel dataset

As most of the regressions in the empirical sections are done using a fixed effect model, a short reminder is proposed to the reader in order to understand the specifications. This is done using the slides “Partie 5 - Méthodes d’estimation sur données de panel” of Murielle Dejemeppe for the course “LECON2033 - Microéconométrie” during the academic year 2017-2018.

Lets take the following model:

$$y_{it} = \beta_0 + \beta_1 x_{it} + a_{it} + u_{it}$$

For each unit i observed over T periods t .

a_i is the fixed effect associated to each unit i .

$u_{i,t}$ is the error term.

We can find:

$$\bar{y}_i = \beta_0 + \beta_1 \bar{x}_i + \bar{a}_i + u_i$$

Where:

$$\bar{y}_i = \frac{1}{T} \sum_{t=1}^T y_{it}$$

$$\bar{x}_i = \frac{1}{T} \sum_{t=1}^T x_{it}$$

And from those we can write:

$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it} + \ddot{u}_{it}$$

Where:

$$\ddot{y}_{it} = y_{it} - \bar{y}_i$$

$$\ddot{x}_{it} = x_{it} - \bar{x}_i$$

$$\ddot{u}_{it} = u_{it} - \bar{u}_i$$

Hence eliminating the fixed effect.

This allows us to find the within coefficient estimating the temporal variation of x and y within each cross unit.

$$\hat{\beta}_1 = \frac{Cov(\ddot{x}_{it}, \ddot{y}_{it})}{Var(\ddot{x}_{it})}$$

8.2.2 Best specifications

Table 9: Impact of the equity to liability ratio on risk

	Linear	Quadratic	Cubic
equity to liabilities ratio	6.334 (7.558)	18.32 (13.398)	29.94 (18.216)
eqliabsq		-34.70 (22.100)	-114.2 (77.133)
eqliabcu			105.0 (85.933)
Constant	6.292*** (0.765)	5.693*** (1.003)	5.339*** (1.088)
r2	0.182	0.185	0.186
N	3390	3390	3390

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Impact of the tier 1 capital coverage ratio on risk

	Linear	Quadratic	Cubic
Core capital coverage ratio	1.842 (3.139)	15.22 * (7.974)	21.46* (11.340)
corecapsq		-16.62** (8.294)	-39.25* (22.575)
corecapcu			18.34 (12.923)
Constant	6.758*** (0.777)	5.622*** (1.054)	5.250*** (1.206)
r2	0.216	0.222	0.223
N	2303	2303	2303

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Impact of liquidity on risk

	Linear	Quadratic	Cubic
liqind	0.631** (0.310)	1.873** (0.657)	1.978* (1.124)
liqsq		0.197** (0.077)	0.240 (0.330)
liqcu			0.00386 (0.026)
Constant	6.655*** (0.671)	7.699*** (0.826)	7.754*** (1.032)
r2			
N	2727	2727	2727

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Impact of government deposit insurance on risk

	Linear	Quadratic
depoins	-0.0000422*** (0.000)	0.000145** (0.000)
depoinsq		-1.40e-09*** (0.000)
Constant	8.031*** (0.525)	4.109*** (1.448)
r2		
N	3158	3158

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$