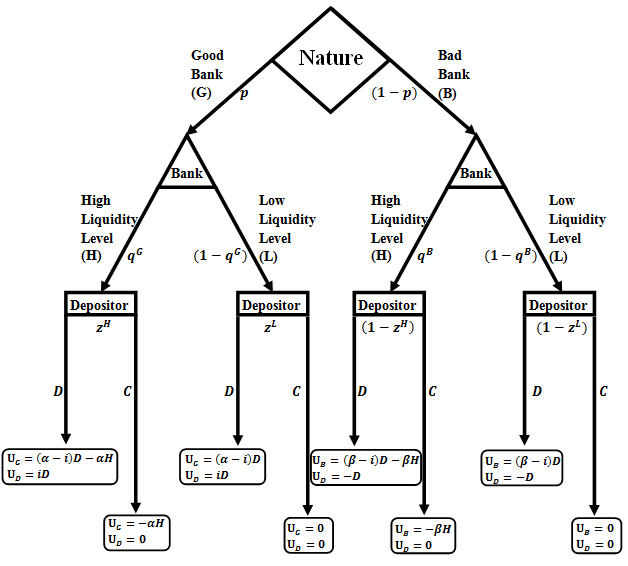
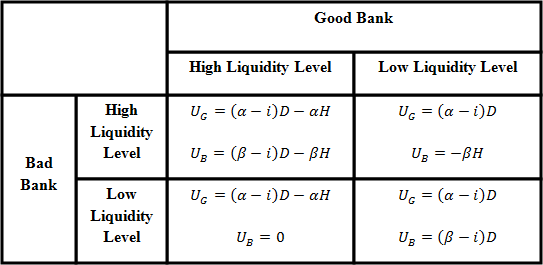
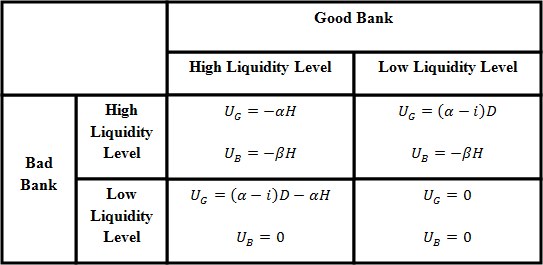
**Liquidity Signalling in Banking**ERASMUS UNIVERSITY ROTTERDAM  
Erasmus school of Economics  
Department of Economics  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
Supervisor: Suzanne Bijkerk  
  
Name: Sem Huizer  
Exam number: 351685  
E-mail address: 351685sh@student.eur.nl  
**Table of Content**  
Table of Content 1  
1. Introduction 2  
2. Related Literature 5  
3. Model Setup 8  
4. Model Analysis 11  
 4.1 Prior beliefs of the depositor 11  
 4.2 Posterior beliefs and the action of the depositor 11  
 4.3 Utility of the bank 15  
 4.4 Comparing the utilities of the bank 17 4.5 Results of the analysis 20  
5. Conclusion and discussion 24  
References 26 **1. Introduction**  
  
In the last years there have been severe problems in the banking system. On top of the crisis, the financial system of several countries threatened to collapse. Banks all over the world had invested in securitized products based on the U.S. housing market. When the housing market in U.S. went down, some people could not pay their mortgage anymore. The securitized products were based on pools of financial assets split up into different risk categories. It became very hard to tell what their value was on the balance sheets of banks.   
  
This uncertainty about the quality of banks can lead to a bank run by depositors on the financial system, also on banks which are essentially sound. This happened in the fall of 2008, when there were runs on banks like Fortis/ABN Amro and ING. The financial system in the Netherlands had to be saved, because a collapse brings very high costs to the economy (Matthews & Thompson, 2008). But saving the financial system is also very expensive for governments.  
  
Because bank runs are very costly, it is important to model the behaviour of banks and depositors, when the quality of a bank is uncertain. This is certainly the case since the financial crisis, because governments are installing new banking regulation and other policy measures to create a more stable financial system in future.   
  
There are several theoretical papers written about the banking system. Sharpe (Sharpe, 1990) developed a signalling model about banks and corporations which want to be financed. This model was corrected by Von Thadden (Von Thadden, 2004). Chemmanur and Fulghieri (Chemmanur & Fulghieri, 1994) described a signalling model about investment banks and entrepreneurs. Diamond and Dybvig (Diamond & Dybvig, 1983) developed a model about bank runs and how to prevent them. But there are not many other models developed about the relation between the quality of banks and the behaviour of depositors. This makes it an interesting topic for theoretical research.   
  
Banks are financial intermediaries: they take deposits and hand out loans. For depositors it is possible to pool the risk of loaning money with other depositors and there are economies of scale in monitoring borrowers. In this way borrowers have to pay a lower interest rate. The interest rate a bank pays to depositors is less than the interest rate they receive from borrowers. The difference between these interest rates is the profit for the bank. If a bank holds more liquidity it can hand out less loans and it will receive less interest. Holding liquidity is costly because the bank could have earned interest if it invested the same amount in loans. Only banks who are of good quality can afford to hold high levels of liquidity. They earn a higher return and are more able to sacrifice some of that return to hold a high liquidity level. In this way good quality banks can signal their quality to depositors by showing high liquidity levels.  
  
In this paper, we examine theoretically the influence of liquidity signalling on the behaviour of banks and depositors. We analyze if banks will use liquidity to signal their quality to depositors and how depositors will behave if this happens. In this thesis we answer the question:  
  
*What is the influence of liquidity signalling on the behaviour of banks and depositors?*  
  
There exists information asymmetry between banks and depositors: banks know much more about the quality of their loans than depositors. Banks know in which assets they have invested and what the quality of the assets is. Without deposit insurance risk-neutral depositors want the interest they receive to be in line with the risk profile of the bank. But they cannot verify the quality of the bank. Banks can signal their quality by the liquidity level they hold. Holding liquidity is expensive, because of the opportunity costs of not investing. It is more expensive for banks with good investment opportunities, with higher a expected return, than for banks with bad investment opportunities. We should expect good quality banks to hold less liquidity than bad quality banks. But this does not meet the empirical results of Koudstaal and van Wijnbergen (Koudstaal & Van Wijnbergen, 2011). They found that banks which were valued higher by the market have a higher liquidity ratio. More liquidity apparently signals quality to investors, analysts and depositors. In this thesis we will use a signalling model like the model of Spence (Spence, 1973) to analyze liquidity signalling by banks to depositors. We develop a basic model where banks can be of good or bad quality. They can signal their quality to depositors by showing a low or a high liquidity level. Showing a high liquidity level is more costly for good quality banks than for bad quality banks, but they can afford to show a higher liquidity level . The depositors do not know the quality of a bank, but know the probability of a good quality bank in the bank population. The depositors observe the liquidity signal and decide whether to deposit their money or keep it in cash.   
  
The analysis of our model shows that liquidity signalling by banks depends on the probability of a good bank within the bank population. There will be a pooling equilibrium where both types of banks show a low liquidity level, if this probability is high enough. The depositor then will choose to deposit with only based on his prior beliefs. A separating equilibrium arises if the probability of a good bank is low enough. Based on his prior beliefs the depositor will choose to keep cash. In this equilibrium a good bank will show a high liquidity level and a bad bank will show a low liquidity level. Good banks will only distinguish themselves from bad banks when this is necessary and otherwise will not receive a deposit.  
  
The remainder of the paper will be as follows. In section 2 the related literature about the role of liquidity in banking and microeconomic banking models with signalling will be reviewed. Section 3 describes the setup of model and the assumptions, and section 4 shows the analysis of the model. Section 5 concludes and discusses our findings.  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
**2 Related Literature**  
  
In this section, we will discuss the related literature. The literature can be divided into two parts: the first part is about the role of liquidity in banking, and the second part is about signalling models within banking literature.  
  
**The role of liquidity in banking**  
There are few empirical papers about the signalling role of liquidity for banks. Koudstaal and   
Van Wijnbergen (Koudstaal & Van Wijnbergen, 2011) investigate empirically whether liquidity has a signalling role for banks on the stock market. According to their results, banks with a higher liquidity ratio have a higher market to book ratio: they have a positive value premium. The liquidity ratio may work as a signal of the quality of a bank to investors and potentially also to depositors. They reason that keeping liquidity is costly and therefore only good quality banks can afford this. We use this proposition in the assumptions of our model. Lucas and McDonald (Lucas & McDonald, 1992) give another theoretical reason for good quality banks to hold more liquidity. With holding a high liquidity level, they can avoid going to the debt market when they have to pay depositors. This is because of adverse selection in the debt market: if a bank goes to the debt market, than it will be seen as a bad quality bank which cannot get funding in another way. By avoiding this with holding more liquidity banks can signal that they are of good quality. A difference with our model is that the actions of depositors are drawn from nature and not determined by the other variables in the model. The empirical results of Lucas and McDonald (Lucas & McDonald, 1992) support the proposition that good quality banks hold more liquidity.  
   
Myers and Rajan (Myers & Rajan, 1998) have a different view on liquidity at banks. They argue that more liquidity might be bad for financial institutions. More liquidity will make it harder to credibly commit to an investment strategy that protects investors, because there is more freedom to act at the expense of the creditor. With illiquid assets this is much harder, because the assets are harder to trade. Therefore more liquidity will lead to a lower valuation by investors. Their conclusion is in contrast with that of Koudstaal and Van Wijnbergen (Koudstaal & Van Wijnbergen, 2011), and Lucas and McDonald (Lucas & McDonald, 1992). Wagner (Wagner, 2007) states that more liquidity will lead to more risk taking by banks, because it makes bank runs less costly. Less risky banks will hold less liquidity. Besancenot and Vranceanu (Besancenot & Vranceanu, 2011) implicitly share the same view on liquidity as Myers and Rajan (Myers & Rajan, 1998) and Wagner (Wagner, 2007). Bad quality banks can imitate good quality banks by taking more risk and get the same return as good quality banks in this way. Good quality banks have to distinguish themselves by also taking more risk to the point it will be too costly for bad quality banks to imitate them. Because more risk usually means less liquidity, liquidity is a riskless asset, good quality banks hold less liquidity than bad quality banks. Bhattacharya and Gale (Bhattacharya & Gale, 1985) extend the model of Diamond and Dybvig (Diamond & Dybvig, 1983) about banks runs. According to their conclusion banks hold liquidity to mitigate the problems of bank runs. The quality of banks is not included in their research.   
  
There is no unanimous view on the role of liquidity in banking. There is empirical and theoretical evidence that more liquidity is a signal for good quality banks, because they can only afford to hold a high liquidity level. But some theoretical models have the opposite conclusion.  
  
**Signalling models in banking literature**  
The paper of Spence (Spence, 1973) about job market signalling was the first to introduce a signalling model. In the job market, a jobseeker knows his ability, but an employer cannot see this immediately when he hires him. But jobseekers can signal their ability by taking education. In this way employers can determine the difference between jobseekers with different abilities. The situation is comparable to the situation of banks and depositors: banks know their quality, but depositors cannot observe the bank’s quality. Banks can signal their quality by showing liquidity to depositors. Lucas and McDonald (Lucas & McDonald, 1992) use liquidity to signal the quality of a bank, but the model in their paper is quite different from our model. The banks signal to the debt market instead to depositors and there are multiple periods. The model in Besancenot and Vranceanu (Besancenot & Vranceanu, 2011) has the same structure as our model, but in this model the shareholders of the bank are the receivers of the signal.  
   
Sharpe (Sharpe, 1990) models the other site of the bank’s balance sheet. Banks handout loans to firms and receive signals about the quality of the firms. In this multi-period model, the banks with loans to specific firms know the exact quality of the firm. Outside banks only receive a signal about the quality of the firm. Inside banks have monopoly power in the second period. Von Thadden (Von Thadden, 2004) corrects the model of Sharpe (Sharpe, 1990). According to his paper, there are no pure strategy equilibria in this model, but only equilibria in mixed strategies.  
   
In the model of Chemmanur and Fulghieri (Chemmanur & Fulghieri, 1994) investment banks evaluate entrepreneurs for investors, where the investors cannot determine the quality of the entrepreneur. They transmit the signals of entrepreneurs to investors. The quality of the signal depends on the evaluation standard the bank chose. In this model investment banks are considered as brokers between entrepreneurs and investors.   
  
Signalling models about banking can simulate situations where banks are considered to attract funding, invest in firms or act as a broker. The models describe situations similar to the situation in which banks have to attract depositors. We therefore are of the opinion that a signalling model can also be used to simulate the relationship between banks and depositors.  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
**3. Model Setup**  
We develop a model in which a bank wants to attract money from a depositor. The model takes the form of a Bayesian sequential signalling model, comparable to the model of Spence (Spence, 1973).  
  
**Timeline of the model**  
1. Nature draws type for bank . Bank can either be a good bank with the probability or a bad bank with the probability .  
2. Bank observes and chooses liquidity level , which can be either high or low, where .  
3. The depositor observes , but not and chooses to keep his money in cash or make a deposit (action choice).  
4. The payoffs are realized.  
  
**Description of the model**  
Bank wants to attract money from the depositor to invest it for return. Nature draws type for bank and the banks observes its type. The type is drawn from the set of types , where is a good bank and is a bad bank, and . The probabilities of the types are and .   
The strategy of bank consists of showing liquidity level to the depositor. The bank can choose from the set of liquidity levels . is a high liquidity level and is a low liquidity level, and . The conditional probabilities for the strategies are for a good bank and for a bad bank.   
  
Good banks earn a return of on their investments and bad banks earn a return of on their investments, where . The costs of holding a low liquidity level are zero for every bank. The costs of holding a high liquidity level are the opportunity costs for not investing: the return the bank could have made when it had invested the money. These costs are for good banks and for bad banks.  
  
The depositor wants to deposit his money to earn interest. If he brings his money to a good bank he earns an interest of over his deposit. If he brings his money to a bad bank he will lose his deposit , because the bank will be restructured.  
  
**Assumption 3**   
  
**Assumption 4** *There is no deposit insurance.*  
The depositor observes , but not . The depositor updates his beliefs about the type of the bank according to Bayes’ rule and uses the liquidity level he observes:   
The strategy of the depositor is choose an action from the set of actions . is deposit, the money gets deposited at the bank. is cash, the money does not get deposited at the bank. His strategy is determined by his posterior beliefs about the type of the bank. The conditional probability for the strategy of the depositor is .   
  
After this the payoffs of the bank and the depositor are realized. The bank earns a return on the investment if he receives a deposit and the depositor earns interest from the good bank or loses his money, because of a restructuring of the bad bank.   
  
The payoff for the bank is:   
, if the bank is a good bank;  
, if the bank is a bad bank.  
  
**Assumption 5**    
   
  
The payoff for the depositor is:  
   
If , the bank is a good bank and the depositor will earn interest on his deposit .  
If , the bank is a bad bank and the depositor will lose his money.  
  
The model is visualized in the model tree in Illustration 1.   
  
*Illustration 1- Model tree*

**

**Determination of   
the type of the bank  
  
  
  
  
Signal  
  
  
Posterior beliefs   
of the depositor  
  
Action of the depositor  
  
  
  
Payoffs**

**4. Model Analysis**  
  
In this section, we will examine all possible equilibria of the model. We apply the perfect Bayesian equilibrium concept to analyze the model. There are four possible equilibria: two pooling equilibria and two separating equilibria. In a pooling equilibrium, both types of banks show the same liquidity level and the depositor cannot distinguish between different types of banks based on the liquidity level. In a separating equilibrium, both types of banks show a different liquidity level and the depositor can distinguish between the different types of the banks based on the liquidity level. We will examine which equilibria exist by backward induction and under which conditions they will arise.   
  
**4.1 Prior beliefs of the depositor**  
First we examine the prior beliefs of the depositor about the type of the bank. This are the beliefs of the depositor before the bank shows its liquidity level:  
If the liquidity levels of the banks do not offer additional information on the type of the bank, the posterior beliefs of the depositor are equal to its prior beliefs. This is the case if both types of banks show a high or a low liquidity level(pooling equilibrium). In this case the action of the depositor depends on his expected payoff of depositing in comparison to the payoff of keeping his money in cash, which depends on the value of :   
If the expected payoff of depositing is larger than zero(the return of keeping his money in cash), the depositor will choose to deposit his money. If it is smaller than zero, that the depositor will keep his money in cash. For the value of this means that if:  
 ,   
the depositor will choose to deposit if , and if the depositor will choose to keep his money in cash.   
 **4.2 Posterior beliefs and the action of the depositor**  
We will examine the posterior beliefs of the depositor about the type of the bank for all possible situations. We will also examine which action the depositor will take in all possible equilibria, given his posterior beliefs and his utility function.   
  
(I) Action of the depositor when   
  
(A) When both types of banks show a high liquidity level   
Beliefs about the probability of a good bank:   
Beliefs about the probability of a bad bank:   
The posterior beliefs are equal to the prior beliefs.  
  
The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . His beliefs about the probability of a bad bank are . The expected utility of depositing is:   
This is larger than zero, because . The depositor will choose to deposit.  
  
(B) When both types of banks show a low liquidity level   
Beliefs about the probability of a good bank:   
Beliefs about the probability of a bad bank:   
The posterior beliefs are equal to the prior beliefs.  
  
The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . His beliefs about the probability of a bad bank are . The expected utility of depositing is *=.*  
This is larger than zero, because . The depositor will choose to deposit.  
  
(C) When good banks show a high liquidity level and bad banks show a low liquidity level   
Beliefs about the probability of a good bank when observing a high liquidity level:   
  
Beliefs about the probability of a bad bank when observing a low liquidity level:   
  
The depositor updates his beliefs about the type of the bank.  
  
(a) The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to deposit, because .  
(b) The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to keep cash, because .  
  
(D) When good banks show a low liquidity level and bad banks show a high liquidity level   
Beliefs about the probability of a good bank when observing a low liquidity level:   
  
Beliefs about the probability of a bad bank when observing a high liquidity level:   
  
The depositor updates his beliefs about the type of the bank  
  
(a) The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to keep cash, because .   
(b) The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to deposit, because .  
(II) Action of the depositor when   
  
(A) When both types of banks show a high liquidity level   
Beliefs about the probability of a good bank:   
Beliefs about the probability of a bad bank:   
The posterior beliefs are equal to the prior beliefs.  
  
The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . His beliefs about the probability of a bad bank are *.* The expected utility of depositing is  
  
This is smaller than zero, because . The depositor will choose to keep cash.  
  
(B) When both types of banks show a low liquidity level   
Beliefs about the probability of a good bank:  
Beliefs about the probability of a bad bank:   
The posterior beliefs are equal to the prior beliefs.  
  
The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . His beliefs about the probability of a bad bank are *.* The expected utility of depositing is   
This is smaller than zero, because *.* The depositor will choose to keep cash.  
  
(C) When good banks show a high liquidity level and bad banks show a low liquidity level   
Beliefs about the probability of a good bank when observing a high liquidity level:  
  
Beliefs about the probability of a bad bank when observing a low liquidity level:   
  
The depositor updates his beliefs about the type of the bank  
  
(a) The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to deposit, because .  
(b) The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to keep cash, because .  
  
(D) When good banks show a low liquidity level and bad banks show a high liquidity level   
Beliefs about the probability of a good bank when observing a low liquidity level:  
  
Beliefs about the probability of a bad bank when observing a high liquidity level:   
  
The depositor updates his beliefs about the type of the bank  
  
(a) The depositor observes a high liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to keep cash, because .   
(b) The depositor observes a low liquidity level. His beliefs about the probability of a good bank are . The depositor will choose to deposit, because .  
 **4.3 Utility of the bank**  
We will examine the utility of the bank in all possible situations, given the action chosen by the depositor.  
  
(I) Bank’s utility when   
  
(A) Utility of the bank when both types of banks show a high liquidity level   
The depositor will to choose deposit. The utility of the bank is:   
Good bank:   
Bad bank:   
  
(B) Utility of the bank when both types of banks show a low liquidity level   
The depositor will choose to deposit. The utility of the bank is:   
Good bank:   
Bad bank:   
  
(C) Utility of the bank when good banks show a high liquidity level and bad banks show a low liquidity   
(a) The bank is a good bank and shows a high liquidity level. The depositor will choose to deposit. The utility of the bank is .   
(b) The bank is a bad bank and shows a low liquidity level. The depositor will to keep choose cash. The utility of the bank is .  
  
(D) Utility of the bank when good banks show a low liquidity level and bad banks show a high liquidity level   
(a) The bank is a good bank and shows a low liquidity level. The depositor will choose to deposit. The utility of the bank is .   
(b) The bank is a bad bank and shows a high liquidity level. The depositor will choose to keep cash. The utility for the bank is .   
  
(II) Bank’s utility when   
  
(A) Utility of the bank when both types of banks show a high liquidity level   
The depositor will choose to keep cash. The utility of the bank is:   
Good bank:   
Bad bank:   
  
(B) Utility of the bank when both types of banks show a low liquidity level   
The depositor will choose to keep cash. The utility of the bank is:   
Good bank:   
Bad bank:   
  
(C) Utility of the bank when good banks show a high liquidity level and bad banks show a low liquidity   
(a) The bank is a good bank and shows a high liquidity level. The depositor will choose to deposit. The utility of the bank is .   
(b) The bank is a bad bank and shows a low liquidity level. The depositor will choose to keep cash. The utility of the bank is .   
  
(D) Utility of the bank good banks show a low liquidity level and bad banks show a high liquidity level   
(a) The bank is a good bank and shows a low liquidity level. The depositor will choose to deposit. The utility of the bank is .   
(b) The bank is a bad bank and shows a high liquidity level. The depositor will choose to keep cash. The utility of the bank is .   
 **4.4 Comparing the utilities of the bank**  
Now we will compare the different utilities the bank has, taking into account the posterior beliefs of the depositor. We will examine whether an equilibrium exists and under which conditions it will arise. We do this by analyzing what happens if a bank deviates and under which conditions deviating is profitable.  
  
(I) Case when   
  
(A) Pooling equilibrium in which banks show a high liquidity level   
The depositor will choose to deposit. The bank has an incentive to deviate and to show a low liquidity level when this increases the utility of the bank. This is always the case for both types of banks. If a bank deviates, the depositor does not know the type of the bank, because he only expects banks to show a high liquidity level. The beliefs of the depositor about the type of the bank that shows a low liquidity level are the same as the beliefs about a bank that shows a high liquidity level. The depositor will take the same action: he will choose to deposit. Deviating increases the utility of a good bank from to and the utility of a bad bank from to .  
This equilibrium is not stable, because both types of banks have an incentive to deviate and to show a low liquidity level.   
  
(B) Pooling equilibrium in which banks show a low liquidity level   
The depositor will choose to deposit The bank has an incentive to deviate and to show a high liquidity level when this increases the utility the of bank. This is never the case for both types of banks. If a bank deviates, it will still get a deposit, but it will have to pay the costs of showing a high liquidity level. Deviating decreases the utility of a good bank from to and the utility of a bad bank from to .  
 This equilibrium is stable, because both types of banks have no incentive to deviate and to show a high liquidity level.   
  
(C) Separating equilibrium in which good banks show a high liquidity level and bad banks show a low liquidity   
(a) The good bank shows a high liquidity level. The depositor will choose to deposit. The bank has an incentive to deviate and to show a low liquidity level when this increases the utility of the bank. If a good bank shows a low liquidity level, the posterior beliefs of the depositor are equal to the prior beliefs:. The depositor will choose to deposit, because . If a good bank deviates and shows a low liquidity level, it will stil get a deposit. This will increase the utility of the bank from to . A good bank has an incentive to deviate a show a low liquidity level.   
(b) The bad bank shows a low liquidity level. Because a good bank will deviate and show a low liquidity level, the posterior beliefs of the depositor are equal to the prior beliefs, when he observes a low liquidity level: . The depositor will choose to deposit, because The bank has an incentive to deviate and to show a high liquidity level when this increases the utility of the bank. If a bad bank deviates and shows a high liquidity level it, will still get a deposit. This will decrease the utility of the bank from  *to* . A bad bank has no incentive to deviate and to show a high liquidity level.   
This equilibrium in not stable because good banks have an incentive to deviate and to show a low liquidity level.   
  
(D) Separating equilibrium in which good banks show a low liquidity level and bad banks show a high liquidity level   
(a) The bank is a good bank and shows a low liquidity level. The depositor will choose to deposit. The bank has an incentive to deviate and to show a high liquidity level when this increases the utility of the bank. If a good bank deviates and shows a high liquidity level, it will not get a deposit. This will decrease the utility of the bank from  *to* , conditional on the action of the bad bank. A good bank has no incentive to deviate and to show a high liquidity level.   
(b) The bank is a bad bank and shows a high liquidity level. The depositor will choose to keep cash. The bank has an incentive to deviate and to show a low liquidity level when this increases the utility of the bank. If a bad bank deviates and shows a low liquidity level, it will get a deposit. This will increase the utility of the bank from to . A bad bank has an incentive to deviate a show and to show a low liquidity level.  
This equilibrium is not stable. A bad bank has an incentive to deviate, because it will increase the utility of the bank.   
  
(II) Case when   
  
(A) Pooling equilibrium in which banks show a high liquidity level   
The depositor will choose to keep cash. The bank has an incentive to deviate and to show a low liquidity level if this increases the utility of the bank. This is always the case for both types of banks. The utility of a good bank increases from to when it deviates. The utility of a bad bank increases from to when it deviates.  
This equilibrium is not stable, because both types of banks have an incentive to deviate and to show a low liquidity level.   
  
(B) Pooling equilibrium in which banks show a low liquidity level   
The depositor will choose to keep cash. The bank has an incentive to deviate and to show a low liquidity level if this increases the utility of the bank. If a good bank deviates, shows a high liquidity level and gets a deposit, its payoff will be . If a bad bank deviates and shows a high liquidity level it will not get a deposit, because than it will become a pooling equilibrium in which the depositor will not deposit. The payoff of the bank will be . The dominant strategy of a bad bank is to show a low liquidity level. The good bank has an incentive to deviate. The depositor knows this and will choose to deposit if he observes a high liquidity level.   
This equilibrium is not stable, because a good bank has an incentive to deviate and to show a high liquidity level.   
  
(C) Separating equilibrium in which good banks show a high liquidity level and bad banks show a low liquidity   
(a) The good bank shows a high liquidity level. The depositor will choose to deposit. The bank has an incentive to deviate and to show a low liquidity level if this increases the utility of the bank. If a good bank deviates and shows a low liquidity level, it will not get a deposit. This will decrease the utility of the bank from to . A good bank has no incentive to deviate and to show a low liquidity level.  
(b) The bad bank shows a low liquidity level. The depositor will choose to keep cash*.* The bank has an incentive to deviate and to show a high liquidity level if this increases the utility of the bank. If a bad bank deviates and shows a high liquidity level, it will not get a deposit, because it will become a pooling equilibrium in which the depositor will not deposit. This will decrease the utility of the bank from to . A bad bank has no incentive to deviate and to show a high liquidity level.   
This equilibrium is stable. Both types of banks have no incentive to deviate, because it will decrease the utility of the bank.   
  
(D) Separating equilibrium in which good banks show a low liquidity level and bad banks show a high liquidity level   
(a) The good bank shows a low liquidity level. The depositor will choose to deposit. The bank has an incentive to deviate and to show a high liquidity level if this increases the utility of the bank. If a good bank deviates and shows a high liquidity level, it will not get a deposit. This will decrease the utility of the bank from to , conditional on the action of a bad bank. A good bank has no incentive to deviate and to show a high liquidity level.   
(b) The bad bank shows a high liquidity level. The depositor will choose to keep cash. The bank has an incentive to deviate and to show a low liquidity level if this increases the utility of the bank. If a bad bank deviates and shows a low liquidity level, it will become a pooling equilibrium. The depositor will not deposit. This will increase the utility of the bank from to . A bad bank has an incentive to deviate and to show a high liquidity level.   
This equilibrium is not stable. A bad bank has an incentive to deviate, because it will increase the utility of the bank.   
**4.5 Results of the analysis**In this part we put the outcomes of all possible equilibria together. For all existing equilibria we will give the payoffs of the bank and the depositor. We will discuss the returns for both types of banks.  
  
(I)Results when   
  
*Illustration 2- Bank utility diagram when*   
  
  
  
(A) Pooling equilibrium where banks show a high liquidity level   
The depositor will choose to deposit. This equilibrium is not stable, because both types of banks have an incentive to deviate and to show a low liquidity level. This will increase their utility.  
  
(B) Pooling equilibrium where banks show a low liquidity level   
The depositor will choose to deposit. This equilibrium is stable. Both types of banks no incentive to deviate, because this will decrease their utility.   
  
The utilities of the bank and the depositor are:  
The bank is a good bank: and   
The bank is a bad bank: and   
  
(C) Separating equilibrium where good banks show a high liquidity level and bad banks show a low liquidity   
The depositor will choose to deposit if he observes a high liquidity level and will choose to keep cash if he observes a low liquidity level. This equilibrium is not stable, because a good bank has an incentive to deviate and to show a low liquidity level.  
  
(D) Separating equilibrium where good banks show a low liquidity level and bad banks show a high liquidity level   
The depositor will choose to deposit if he observes a low liquidity level and will choose to keep cash if he observes a high liquidity level. This equilibrium is not stable, because a bad bank has an incentive to deviate and to show a low liquidity level.   
  
(I)Results when   
  
*Illustration3- Bank utility diagram when*  
  
A) Pooling equilibrium where banks show a high liquidity level   
The depositor will choose to keep cash. This equilibrium is not stable, because both types of banks have an incentive to deviate and to show a low liquidity level.  
  
(B) Pooling equilibrium where banks show a low liquidity level   
The depositor will choose to keep cash. This equilibrium is not stable, because a good bank has an incentive to deviate and to show a high liquidity level. In this way it will get a deposit and it will increase its utility.  
  
(C) Separating equilibrium where good banks show a high liquidity level and bad banks show a low liquidity   
The depositor will choose deposit if he observes a high liquidity level and will choose to keep cash if he observes a low liquidity level. This equilibrium is stable. Both types of banks have no incentive to deviate, because this will decrease their utility.   
  
The utilities of the bank and the depositor are:  
The bank is a good bank: and   
The bank is a bad bank: and   
  
(D) Separating equilibrium where good banks show a low liquidity level and bad banks show a high liquidity level   
The depositor will choose to deposit if he observes a low liquidity level and will choose to keep cash if he observes a high liquidity level. This equilibrium is not stable, because a bad bank has an incentive to deviate and to show a low liquidity level.  
In summary we find than when the ratio of good banks is low in comparison to the interest rate on a deposit, a separating equilibrium arises where good banks show high liquidity levels and bad banks low liquidity levels. But when the ratio of good banks in comparison to the interest rate is high, a pooling equilibrium arises where both types of banks show a low liquidity level.  **5. Conclusion and discussion**There exists information asymmetry between banks and depositor: banks know their quality, but depositors cannot determine the quality of a bank. But it is possible for banks to give signals about their quality by showing a certain liquidity level. In this paper, we developed a signalling model to investigate liquidity signalling by banks to depositors. The liquidity signalling model has two stable equilibria: a pooling equilibrium in which both types of banks show a low liquidity level, and a separating equilibrium in which a good bank shows a high liquidity level and a bad bank shows a low liquidity level. Which equilibrium will arise depends on the ratio of good banks within the bank population. There will be a pooling equilibrium if this ratio is high enough for the depositor to choose to deposit based on his prior beliefs. In this equilibrium both types of banks will show a low liquidity level. There will be a separating equilibrium if this ratio is low enough for the depositor to choose to keep cash based on his prior beliefs.  
  
The results show that it is possible that good banks show a different liquidity level than bad banks, and that in this way depositors can distinguish between them. This is only the case when the ratio of good banks is low enough for the depositor to choose to keep cash based on his prior beliefs. This is rational, because a good bank only needs to show a high liquidity level when he will not get a deposit without doing that. The perception of depositors with regard to the ratio of good banks might be lower in the case of financial uncertainty, like in a financial crisis. Our model predict that the different types of banks will show a different liquidity level, when there is more financial uncertainty.   
  
If we compare our results to the empirical paper of Koudstaal and van Wijnbergen (Koudstaal & Van Wijnbergen, 2011), we also find that good quality banks show more liquidity than bad quality banks. But we find that only when the ratio of good banks is low enough for the depositor to choose to keep cash based on his prior beliefs. Where Koudstaal and van Wijnbergen analysed the effect on the market value of banks, we analyse the effect of liquidity on the behaviour of depositors.   
  
One of the limitations of our model is that the liquidity levels are binary. We have done this to make the model less complicated, but it is more realistic that the liquidity levels are continuous. Also in reality, the quality of a bank is continuous. There are not only two types of banks. Another limitation is that the interest rate banks have to pay to depositors is equal for every bank. It is more realistic that good banks pay a lower interest rate than bad banks, because for the depositor the probability of losing money by a restructuring of the bank is smaller. Finally, the only players in our model are banks and depositors, but normally there are also bondholders and shareholders, who also have an interest in the quality of the bank. Another omission of our model is that there is no deposit insurance For further research, we recommend to extent the model to better meet banking conditions in real live situations.

# References

Besancenot, D., & Vranceanu, R. (2011). Banks' risk race. *International review of Economics and Finance* , pp. 784-791.

Bhattacharya, S., & Gale, D. (1985). Preference shocks, liquidity, and central bank policy. *Caress Working Paper* , pp. 1-36.

Chemmanur, J. T., & Fulghieri, P. (1994). Investment Bank Reputation, Information Production, and Financial Intermediation. *The Journal of Finance* , pp. 57-79.

Diamond, D. W., & Dybvig, P. H. (1983). Bankrun, Deposit Insurance, and Liquidity. *The Journal of Political Economy* , pp. 401-419.

Koudstaal, M., & Van Wijnbergen, S. (2011). *The Value of Liquidity: empirical evidence from the U.S. banking sector.* Working Paper.

Lucas, D. J., & McDonald, R. L. (1992). Bank Financing and Investment Decisions with Asymmetric Information About Loan Quality. *The Rand Journal of Economics* , pp. 86-105.

Matthews, & Thompson. (2008). Bank Regulation. In Matthews, & Thompson, *The Economics of Banking* (pp. 187-189). Chichester: John Wiley & Sons, Ltd.

Myers, S. C., & Rajan, R. G. (1998). The paradox of Liquidity. *The Quarterly Journal of Economics* , pp. 733-771.

Sharpe, S. A. (1990). Asymmetric Information, Bank Lending and Implicit Contracts: A Stylized Model of Customer Relationships. *The Journal of Finance* , pp. 1069-1087.

Spence, M. (1973). Job Market Signaling. *The Quarterly Journal of Economics* , pp. 355-374.

Von Thadden, E.-L. (2004). Assymmetric information, bank lending and implicit contracts: the winner's curse. *Finance Research Letters* , pp. 11-23.

Wagner, W. (2007). The liquidity of bank assets and banking stability. *Journal of Banking and Finance* , pp. 121-139.