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An Empirical Analysis on Excessive Reserves in U.S Banking System and Its Application

Lianjiang Lu

Trinity College, lianjiang.lu@gmail.com

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An Empirical Analysis on Excessive Reserves in U.S Banking System and Its Application

By

Lianjiang Lu

Advised by:

William Butos

A Thesis Submitted to the Department of Economics
of Trinity College in Partial Fulfillment of the
Requirements for the Bachelor of Science Degree

Econ 498-99

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Abstract

This paper examines factors that account for excessive reserves held by U.S banks and potential consequences of this phenomenon. This paper shall firstly establish economic rationales to address the current abnormality and then use empirical data to reinforce its argument.

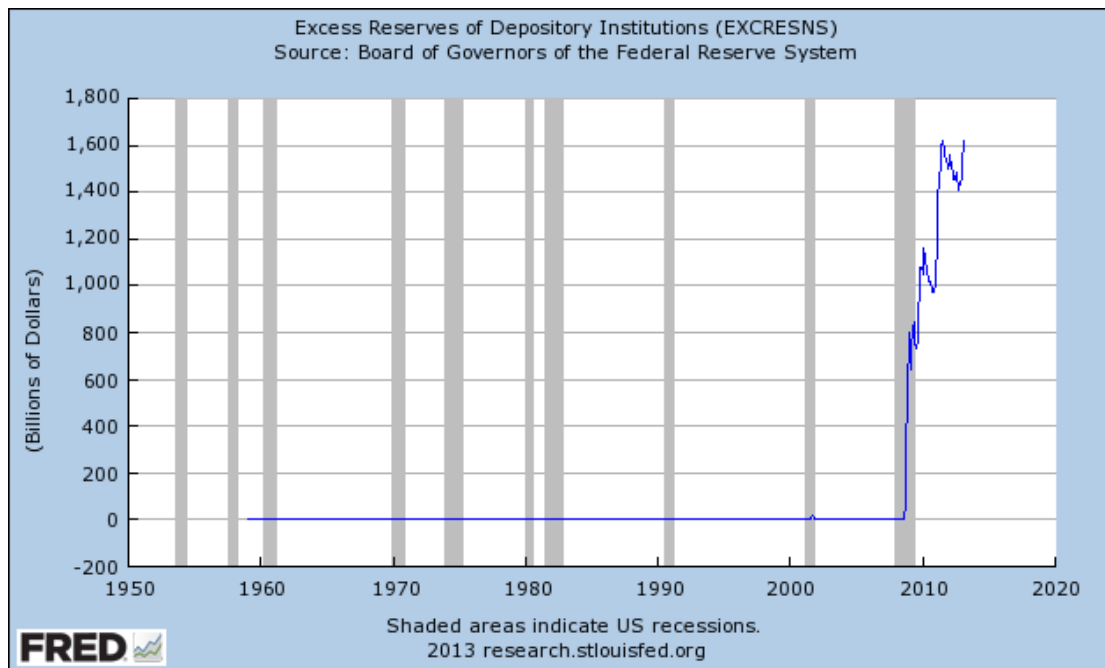
As an empirical analysis, this paper firstly seeks evidence in macroeconomics and adopts time series models using U.S data. This mainly involves regressions to identify determinants of excessive reserves. Furthermore, this paper examines microeconomic factors in order to model for individual banks and unveil their motivations of holding reserves. This mainly involves panel analysis on different U.S commercial banks.

Based on the empirical evidence, this paper will further proposes solutions to current abnormality of excessive reserves.

1. Introduction

Excessive reserves are used to refer reserves held by commercial banks that exceed the mandatory reserve requirement set by the Federal Reserve. According to Economics textbooks, the amount of excessive reserves should generally remain zero. The rationale behind this assertion is simple: since every dollar held as excessive reserve could be turned into lending either to firms or to other banks (through the Federal Funds market), excessive reserves bear only opportunity cost and no profit (before the 2008 financial crisis), and thus should be viewed as negative assets (costs) to commercial banks (Mishkin, 2009). As commercial banks seek to maximize profits while minimizing costs, there is simply no incentive for them to hold excessive reserves. However, the actual excessive reserves start to rocket since September 2008, echoing the full scale onslaught of the financial crisis. The amount of excessive reserves features a historic high of 1618 billion dollars in July 2011. Although it had a decline afterwards, the amount of excessive reserves starts to peak again recently, featuring 1614 billion dollars this February, and may continue to rise. Despite the fact that the crisis has passed for almost five years and many signs of a recovery are shown, there is no indication that this high level of excessive reserves will ever cease. This abnormality certainly attracts significant concerns among economists. Many of them propose different theories that attempt to identify the underlying rationale behind the soaring excessive reserves. We shall firstly review their theories and identify whether these theories successfully accomplish their goals. Then we shall

propose our own theory to account for this abnormality. Finally, we would exploit our theory and seek out its further applications.



Graph: Excess Reserves of Depository Institutions, *Federal Reserve Bank of St. Louis*, 2013

2. Literature Review and Critiques

Literatures concerning the issue of excessive reserves can be mainly categorized into two hemispheres: the macroeconomic hemisphere where literatures focus on the creator of this huge amount of reserves, and the microeconomic hemisphere that focuses on both the incentive of banks to hold these reserves and their ability to digest these reserves.

In the macroeconomic aspect, we firstly have Keister and McAndrews (2009) who take the view point of the Fed. They identify the cause of excessive reserves by using the following rationale. Suppose there are two banks, namely A and B, which locate in different areas and thus facing different amount of lending opportunities. Bank A faces a demand of loans of \$120, while Bank B only faces \$60 dollars demand. However, both banks have only \$100 respectively in their deposit and can thus fund merely \$90 each (\$10 dollars are required reserves). Seeking more opportunities to fully use the money in deposit, Bank B will be more than eager to lend Bank A \$30 so that Bank A can fully saturate all its lending opportunities while Bank B could also make extra profits by collecting the interest on interbank lending. The balance sheets of both Banks are giving below:

Bank A		Bank B	
Reserves 10	Deposit 100	Reserves 10	Deposit 100
Loans 120	Due to B 30	Loan 60	
		Lend to A: 30	

Now suppose the financial crisis occurs, and the market turmoil makes Bank B start to doubt the creditworthiness of Bank A. As a consequence, Bank B will withdraw from maintaining its lending pattern to A. Bank A now faces a constraint in liquidity. It must either borrow from elsewhere or raise its deposit to compensate for the \$30 due

to Bank B. However, since now is the time of a financial crisis, no one is willing to make loans to Bank A or deposit more money in it. The turmoil in market severely endangers entrepreneurs' ability to make accurate predictions. Consequently, many of them would choose to act prudently and hold from investments, just as what Bank B does. The inability of Bank A to raise enough money elsewhere to pay the money due to Bank B forces Bank A to cut its lending to fund its liability. As a result, the total lending to the industry (investment) would decrease from \$180 to \$150 in our system.

Furthermore, as Bank A decreases lending to firms, those firms funded by Bank A will now be disturbed by this contraction of lending. As a consequence, they need to fund their debts using other methods instead of using loans from Bank A. However, they will face the same impasse as Bank A does. As it is virtually impossible for them to raise this money elsewhere, they have to withdraw their deposit in either Bank A or Bank B, thus making the total deposit decreases as well. Suffering from an even more dried-up deposit pool, Bank A and Bank B would further decrease their lending, thus creating a negative chain reaction. As the consequence, the economy faces a severe break-down. Even if Bank B does not completely cut off its lending to Bank A, it will charge a higher interest as the risk premium to counter the newly generated risk by the financial crisis. But a higher interest rate implies a higher cost, which would make some loans of Bank A no longer profitable. Consequently Bank A shall decrease its loans again, leading to a scenario similar to the one stated above. This increase in interest of interbank lending is empirically confirmed during the crisis, There has

been an unusual wide spread of interbank lending interest rates during the crisis (LIBOR)¹. The huge decrease in interbank lending is also confirmed by data released by the Fed. The annual average change rate of interbank lending from 2008 to 2011 is -28.58%.

To counter this devastating contraction in lending, the Fed could adopt two strategies: firstly, it could lower the interest rate to counter the rising risk premium. However, this rather traditional monetary stimulation has several problems. Firstly, lowering the interest rate would increase the danger of inflation, which is usually a mandate of the central bank. In addition, some economists (especially those who work in the Fed) argue that the target interest rate is carefully chosen. Lowering it imprudently is detrimental to the long term economic growth. Keister, McAndrews and Martin (2009) summarize this as “the conflict between maintaining a reasonable interest rate and the need of liquidity”. Finally and the most importantly, monetary policies do not come into effect immediately. Instead, lowering interest rate as stimulation has both the inside lag (time needed to correspond to an economic shock) and the outside lag (time needed for a policy to fully affect the economy). In a dire situation like the 2008 financial crisis, the economy could collapse long before these lags end. Therefore, the Fed must come up with a more efficient measure to stimulate lending behavior. This comes to the second strategy that it can adopt: directly lending money to commercial banks. In our example above, this means the Fed directly credit money to Bank A’s

¹<http://www.thisismoney.co.uk/money/markets/article-1645325/LIBOR-Latest-inter-bank-lending-rate-charts.html>

reserve account.

Bank A		Bank B	
Reserves 10	Deposit 100	Reserves 40	Deposit 100
Loans 120	Due to Fed 30	Loan 60	

As shown in the balance sheets above, the Fed could directly credit \$30 to the reserve account of Bank A. Bank A would use this money to repay Bank B, and owe \$30 to the Fed instead of to Bank B. Bank B, with this repayment, would hold it as reserves, for it only faces the loan opportunity of \$60 and it does not wish to lend money to other commercial banks (because of the increasing risk in a financial crisis). In this scenario, the total investment (lending) is still \$180, which maintains at the pre-crisis level. However, the total reserves increase from \$20 to \$50. Keister and McAndrews claim that this constant lending from the Fed to commercial banks compensates the contraction in interbank lending, and is the main cause of the rise in reserves.

Keister and McAndrews's analysis is indeed plausible. However, it only deals with one aspect of the creation of excessive reserves in macroeconomics, that is, the supply of reserves. Their analysis does not shed a light on the demand of reserves, that is, the digestion power of reserves. The historical high of excessive reserve is caused not only by one aspect, but rather by the gap between the supply of reserves and the

demand of reserves.

Eldin and Jaffee (2009) take a similar point. In addition to their microeconomic view point focusing on Banks' capitalization (which will be discussed later), they point out what Keister and McAndrews state above: a coordination failure. They believe that banks stop lending due to the lack of creditworthy borrowers. However, many borrowers become less creditworthy not because their projects or investments are problematic, but because of the very fact that their lenders are holding back. This creates a snowball effect: if one lender believes that his or her borrowers are not creditworthy enough, he or she would cut loans made to such borrowers. These borrowers, due to the cut back of loans, will now face difficulties in funding, and thus become truly somewhat not creditworthy. These difficulties in funding will be perceived by more lenders and they will consequently hold their lending as well, thus forming a negative cycle. As a consequence, many of such borrowers end up being bailout by the Fed. The bailout money, either by repaying debts to banks or by direct depositing into bank accounts, will eventually become bank deposits. However, banks do not face a simultaneous increase in lending opportunities as in deposit pool. As a result, this money will be stored in reserve account, resulting in an increase in excessive reserves.

Mankiw (2009) reinforces previous ideas by stating that the Fed is in "uncharted water". It has done all traditional anti-crisis measures, and the monetary weapon has

been fully exploited. Indeed, the target interest rate is so low that may be deemed as virtually zero. Apparently Fed cannot set the target interest rate negative, for nobody could be willing to lend under that term. As what Mankiw describes, “Hiding money in mattress is even more attractive than deposit it in banks”. Consequently, the Fed must come up with other scheme to stimulate the economy. This scheme comes to directly crediting money to banks reserve account, with a side effect of creating a substantial amount of excessive reserves. However, Mankiw is certainly hinting on some other aspects except this obvious statement. Under the current situation, holding money seems more attractive than lending it out, thus reducing the general level of lending. The virtually zero interest rate is intended to make borrowing attractive to the private sector. Indeed, according to Jamie Dimon, the president of JP Morgan Chase, the current period might be the best period in decades, for the capital is almost free. Despite the eagerness of borrowing from firms, banks on the other hand lack the incentive to lend. Even in pure monetary terms, loans earn but a small amount of interest, let alone the high risk of lending during financial crisis. The inability of charging a high risk premium on loans would severely decrease the general level of lending. Although Mankiw does not explicitly state this rationale, he is almost certainly suggesting it.

Finally, Sumner (2009) recalls Hall’s discussion on reserve certificates (1983). He argues that the current situation where the Fed starts to pay interest on reserves leads to what Hall calls as “reserves being a perfect substitute for other forms of

government or public debt". To be more specific, he argues that the interest paid on reserves transforms reserve from an asset with negative profits (opportunity cost plus inflation) into somewhat a perfect substitution of the short-term Treasury bills. Surely Treasury bills have higher monetary returns. But essentially both reserves and short term Treasury bills have the same function: serving as liquid assets to counter potential risk. Under this scenario, Sumner argues that it would create a liquidity trap, where banks, instead of making investments, hoard the injected money instead. Differs from Mankiw's point, Sumner is more focusing on the risk control of reserves.

Unlike these previously stated economists who focus on identifying causes of excessive reserves in macroeconomic level, some economists try to account for the excessive reserves in terms of individual bank's motivation of holding these reserves. These theories could be roughly categorized into two aspects. The first aspect focuses on the uncertainty (risk) that individual bank faces when making decisions, while the second aspect pays attention to bank behaviors. To be more specific, the second aspect talks about the conflict between bank incentives as a portfolio manager and the social interest.

In terms of uncertainty and risk, we firstly have Eldin and Jaffee (2009) whom we talked about previously. In addition to their macroeconomic analysis, they argue that banks are holding these excessive reserves either because the regulators do not permit such lending due to banks' low capitalization or banks think that their

capitalizations are too low to make loans. The reason for them to choose the level of capitalization as the judging criterion is simply that capital “does not run”. According to Douglas Elliott (2009) of the Brookings Institution, banks are considered “well capitalized” if its tier 1 capital exceeds more than 8% of its risk-based assets. This view is echoed by Van Roy (2008) who shares a similar view. Van Roy further adds the leverage ratio as a criterion. However, neither under Elliot’s nor under Roy’s judging criteria that major banks in U.S should be considered “risky” during the entire financial crisis. Therefore, in our consideration, we shall adopt a stricter standard in valuing the risk level of banks. This stricter standard is justified, as the scale of 2008 financial crisis is unprecedented from decades. Failures of many esteemed firms and banks could easily raise the safety alert level perceived by both banks and regulators. We shall further discuss later in empirical analysis.

Poole (2012) differs from Eldin and Jaffee, adopts a more subtle view point in terms of the risk that individual bank faces. In his stochastic model, banks face a huge uncertainty in making decisions. For an arbitrary bank in Poole’s model, it has to make a decision at noon on how much money in reserves it wants to hold for the end of the day. If the bank believes what it holds currently (at noon) exceeds the expected reserve requirement at the end of the day, it will put the excessive money on the federal funds market. This act could lead to two potential consequences: the scenario where the amount that bank decides to hold is not sufficient at the end of the day, and the scenario where the amount that bank decides to hold exceeds the requirement.

Under the former situation, this bank must borrow through the discount window at a higher interest rate (discount rate) compared to the Federal Funds rate, and thus suffering from a loss determined by the difference between the discount rate and the Federal Funds rate. Under the latter scenario where what this bank holds exceeds the requirement, It suffers from an opportunity cost of lending out the excessive part. Meanwhile, if the bank believes what it holds at noon is not sufficient, it would borrow from the Federal Funds market to collect enough reserves. This again has two potential consequences, namely what this bank holds at the end of the day is excessive and what it holds is insufficient. If the former is true, then this bank suffers the opportunity cost of lending these excessive reserves through the Federal Funds market. If the latter is true, then this bank suffers a higher cost of borrowing the insufficient part from the discount window. The chance of this arbitrary bank to make either decision is uncertain, and the distribution of this possibility is unknown.

This bank under Poole's model, on the contrast to the Reifler's need and reluctance theory (1930), is a profit maximize under uncertainty. Although the distribution of decision choice is unknown, we can clearly see that all these costs involved in decision making are associated with two rates, namely, the Federal Funds rate and the discount rate. Their fluctuations affect the decision making process of the bank. Therefore, the distribution of the decision choice is affected by the Federal Funds rate and the discount rate. Poole argues further that the external risk will not necessarily cause banks to hold more reserves based on this model, as the decision making is

solely based on two rates and the unknown possibility distribution. The current situation where excessive reserves are commonly held is a result of the low Federal Funds rate. Poole argues that the Discount rate—Federal Funds rate ratio has a positive relationship with the amount of reserves. Since the discount rate is mostly constant, we can claim based on Poole that the federal funds rate has a negative relationship with the reserves. The sharp decrease of the federal funds rate during 2008 to 2009 leads to a sharp increase in excessive reserves, and since the effective Federal Funds rate remains virtually zero, the amount excessive reserves shall not stop increasing.

After the discussion on uncertainty and risk of the microeconomic aspect, we shall move to the other aspect: the conflict between social interest and banks' interest. Goodfriend (2009) and Dasgupta (2009) state that while the social interest is to increase lending and to inject enough liquidity to the economy, banks do not necessarily share this interest. They as profit maximizers care only about revenues and costs. There is simply no incentive for banks to make loans that they deem as not profitable or too risky. Zingales (2009) further proposes a conflict among government's anti-crisis policies. Private firms are confused by those self-contradictory policies and could not form any dependable expectations on future policies. Consequently, they will hold their capital until there is a consistent strategy made by the government. However, Zingales ignores the effect these inconsistent policies would have on commercial banks. In reality, both borrowers and lenders are

confused by the inconsistent policies. As any violation for government regulations leads to heavy punishments, the inconsistency increases the risk that both borrowers and lenders are facing.

In addition to analyses that try to identify cause of excessive reserves, these economists also strive to offer solutions to the problem. Dasgupta, Eldin and Jaffee adopt a regulatory view. They propose a maximum level of reserves. Any bank holds more reserves than this requirement shall be heavily punished. As the Fed is constantly pumping liquidities into the banking system, banks, in order to not exceed the maximum requirement, have to extend lending to not profitable projects and some un-creditworthy borrowers. However, this solution has one apparent drawback: all those loans made under regulatory pressure generate negative profits, delivering another blow to the already devastated banking system. Potentially the Fed may need to bailout banks that go bankrupt due to the very policy of maximum requirement of reserves, and these bailouts would create more reserves to the system, thus potentially forcing more banks to carry out risky lending behavior. Banks may go bankrupt due to the very policy of maximum requirement on reserves that aim at economic recovery. This is exactly what we called previously as inconsistent policies.

Differing from this view, Mankiw and Sumner adopt a more self-motivated view point. They believe that banks hold huge amount of reserves because hoarding money seems more attractive compared to lending. Therefore, if we can make hoarding money less

attractive, lending money (although may still generate negative profits) would become attractive compared to a more spiteful option. Both Mankiw and Sumner advocates for negative interest on excessive reserves (although Mankiw half-jokingly proposes a lottery system of denouncing the effectiveness of some dollar notes). However, as we shall discuss later, the reason why banks do not make loans is that these loans are either too risky or not profitable. Thus making these loans generates negative profits to banks. But not making these loans will also generate negative profits (negative interest on excessive reserves). Moreover, Fed is still injecting even more reserves into the system. This again would potentially force some banks to go bankrupt in exactly the same way as in the regulatory solution.

After this brief review on literatures concerning excessive reserves in U.S banking system, we can see that existing theories all lack certain aspect in the effort of offering an adequately satisfactory solution to this abnormality. Therefore, this paper intends to fulfill the blank left by these previous studies in the following sections

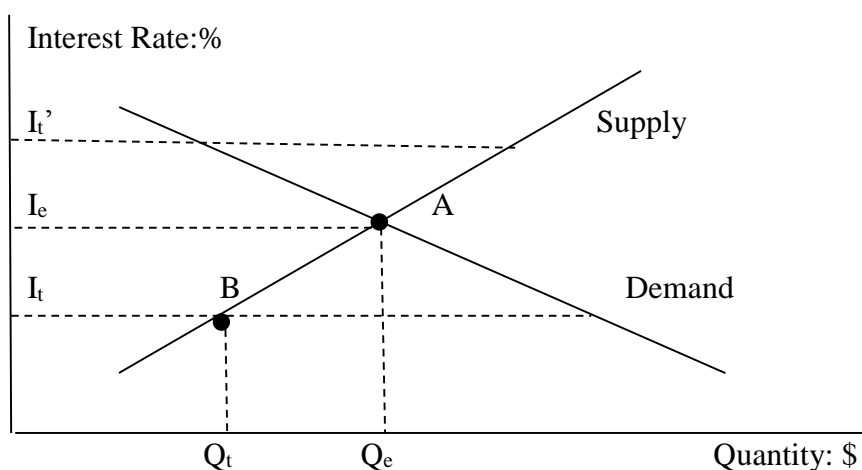
Theoretical Foundation

To fully understand the current abnormality of excessive reserve, we shall separate this issue into two parts, namely, the macroeconomic aspect that focuses on macroeconomic determinants of the excessive reserve, and the microeconomic aspect

that pays attention to individual bank's incentive of holding reserves. We shall firstly start with the macroeconomic aspect.

To conduct a thorough analysis in macroeconomic aspect of excessive reserves, we must take two different aspects into account: the supply of excessive reserves and the demand of excessive reserves. However the demand of excessive reserves is represented by the supply of loans and the demand of the loans.

Let us firstly start with the easiest two: the supply of loans and the demand of loans. Clearly, the quantity of loans supplied increases when the interest rate increases, as the return goes up, and the quantity of loans demanded decreases when the interest rate increases, as the cost goes up. We would have the following graph illustrating these relationships.



Clearly, we can see from the graph that the supply of loans and demand of loans intersects at point A, which is the equilibrium. At this point, the interest rate is I_e and the quantity of loans on the market is Q_e . Before the financial crisis occurred, the target interest rate set by the Fed was arguable equal to or perhaps higher than the equilibrium interest rate, thus did not (or slightly) impeded the effective interest rate to achieve its equilibrium. However, since the financial crisis started, the Fed pushed heavily on the target interest rate to make it lower. As the consequence, the effective interest rate is now blocked by the virtually zero target rate and is far from reaching the equilibrium (point B in our graph). At this point although the quantity of loans demanded is quite high, quantity supplied of loans is unable to keep up due to the low interest rate, thus creating a gap between supply and demand. The actual quantity of loans made is therefore Q_t , which is far below the equilibrium. This is empirically proved by the sharp decrease of Gross Domestic Investment (GDI) since the financial crisis. Note here that the quantity supplied is far from enough to keep up with the quantity demanded. Therefore, the quantity of loans made can be seen as solely depend on supply of loans. We claim that the supply of loans is a function of the lending opportunities, L (to make projections on future lending opportunities), interest rate, I , and the expected future market risk R . That is :

$$S_l = f(I, L, R)$$

The rationale behind this claim is that banks make their decision of lending based on balancing the cost and benefit, which is represented by interest rate and the potential

risk. The role of interest has been discussed above. In terms of the risk, if the risk is high, banks would charge a higher risk premium, making some previously profitable projects no longer attractive. Therefore, the supply curve of loans will shift left if the risk is high and shift right if the risk is low. For the lending opportunities, it serves as an representation of the range of options available to banks. A wider range of alternatives enables Banks to have more information to depend upon when making decisions. Along a wider range of alternatives often come more secured firms that banks are willing to lend to, thus shifting the supply curve to the right. Under the same interest rate, banks will be willing to make more loans. All these factors will be discussed later in model specification. As we stated above, the quantity of loans made solely depends on the supply side of the loans, simply due to the fact that quantity supplied is far exceeded by quantity demanded. Therefore, the quantity of loans made is a function of interest rate, expected risk and lending opportunities. That is :

$$Q_l = f(I, R, L)$$

After the analysis on the Supply and demand of loans, we shall talk about the demand of excessive reserves. Banks hold excessive reserves for two purposes: excessive reserves serve as either financial securities or stores of value. First of all, excessive reserves are deemed as a counter-risk measure. The increase in market risk creates incentives for banks to hold more liquidity as cushion funds. Here we still use expected risk to represent the general risk. We would also include Poole's (2012) notion of uncertainty under this category.

Secondly, banks treat excessive reserves as a store of value, since holding them as reserves is equivalent to hoarding liquidities, plus reserves generate an interest since 2008. Under the current scenario, given certain liquidities in the banking system, banks have three options in addressing these liquidities: as investment in private sector (loans), as investment in public sector (Treasury bonds) and as liquidities held (excessive reserves). As what Hall (1983) correctly points out, excessive reserves are substitution of Treasury bonds. Under current situation, they are also substitutions for loans. As substitutions, the demand of excessive reserves will certainly rise when the demand of Treasury bonds and the quantity of loans made decrease. Note that we focus on the level of excessive reserves instead of the level of reserves. Therefore, the rising demand of reserves generated by an increasing deposit pool is not counted as part of the demand of excessive reserves, since that demand of reserves could never be excessive. To summarize these two points discussed above, we claim that the demand of excessive reserves (D_{ER}) is a function of risk (R), uncertainty (U), quantity of loans made (consisting loans directly to firms Q_1 and loans to other banks Q_2) and demand of Treasury bonds (T). That is to say:

$$D_{ER} = g(R, U, Q_1, Q_2, T)$$

Finally, the supply of reserves consist two parts. According to Keister and McAndrews (2009), either both direct loans and liquidity crediting to banks account by the Fed or both direct loans and bailouts to firms will increase the general level of

reserves. Therefore, the supply of reserves (S_{ER}) is a function of lending to banks (L_b) and lending to firms (L_f). That is to say

$$S_{ER} = h(L_b, L_f)$$

Now we have both the supply function and the demand function of excessive reserves, the amount of excessive reserves shall then be the equilibrium under this scenario. To understand how exactly the supply curve and the demand curve interact, we shall proceed into the empirical study.

Empirical Analysis

A. Time Series Analysis

Before proceeding in identifying what model should be employed in time series analysis, we shall firstly plot the graph of excessive reserves against all independent variables that we wish to consider respectively. From observing we can have a brief idea on how does one specific independent variable correlate with our dependent variable. Therefore, we need firstly identify the independent variables that we plan to use.

Variable specification

Dependent variable:

Excessive reserves: this variable is the total amount of excessive reserves held

in U.S banking system. The accounting measurement is in billion dollars.

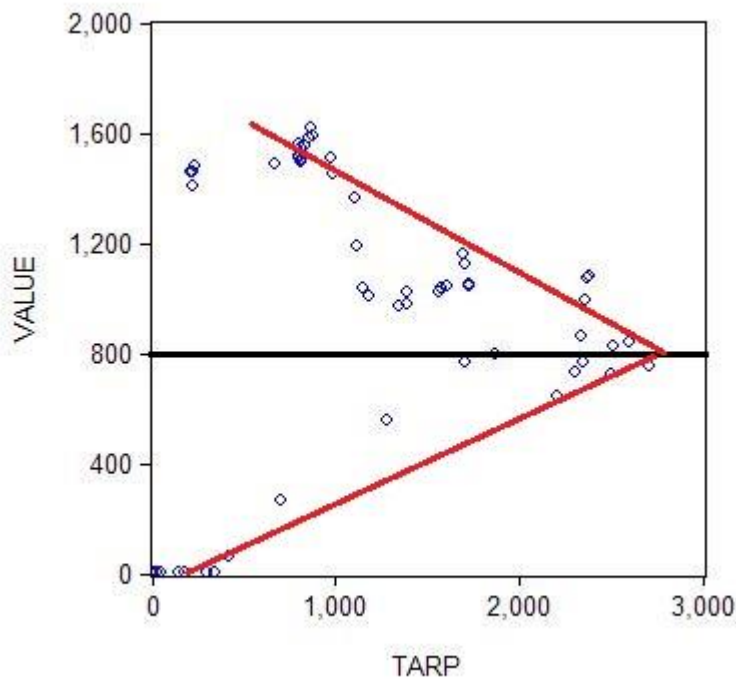
Independent Variables:

1. Supply of reserves

Loans to Banks: this variable represents the total amount of dollars in billion that the Fed credits to commercial banks in the current period. The expected sign of this variable is positive, for a big amount of loans made to banks symbolizes a big amount of money being injected to the system. When keeping other independent variables constant, as this variable increases, the potential maximum amount of excessive reserves should also increase. As the digestion speed and other independent variables remain constant, the amount of excessive reserves should also increase. This variable represents the first component of the supply function of excessive reserves. The rationale of this was shown previously in the literature review section under Keister and McAndrews (2009). The plotting suggests a linearly positive relationship between these two variables (see appendix).

Loans to firms (TARP): this variable is the amount of TARP funds being used as bailouts of firms. It measures the amount of money the Fed lends to firms in billion dollars. Similarly, the expected sign of this variable is also positive, for when keeping other independent variables constant, as the loans made to firms increase, the possible maximum amount of excessive reserves should also

increase. Given the digestion speed constant, the amount of excessive reserves should also increase. This variable represents the second component of the supply function of excessive reserves. The rationale for this was also shown previously in the literature review section under Keister and McAndrews. The plotting does not suggest a clear relationship between TARP and excessive reserves. We thus suspect that this variable may be insignificant. Although the plot does not give a specific form of relationship, we can easily observe a turning point at the reserves' amount equal to 800 billion. The further the amount of excessive reserves diverges from 800, the lower TARP amount would be. This phenomenon is echoed again in terms of gross investment. We believe that this turning point merely symbolizes a shift in bank behavior, and its implication will be discussed later

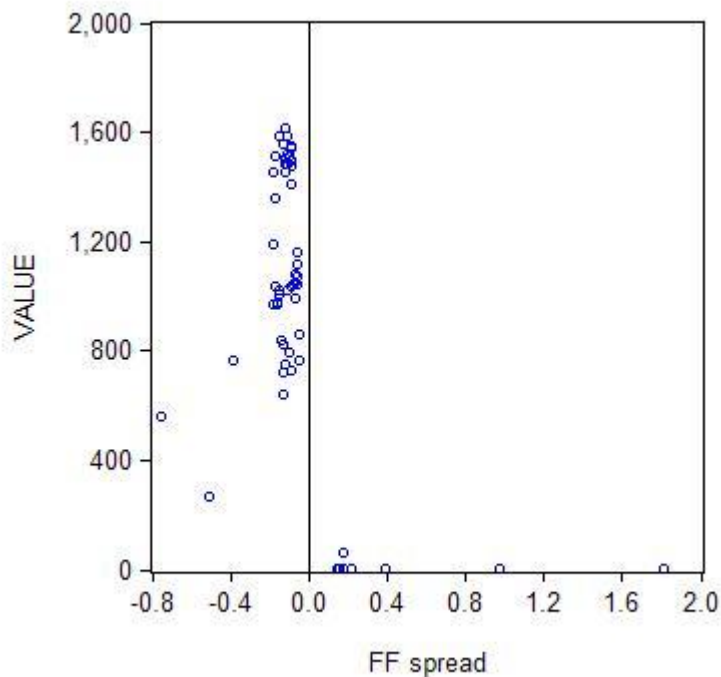


2. Demand of reserves (Digestion of reserves)

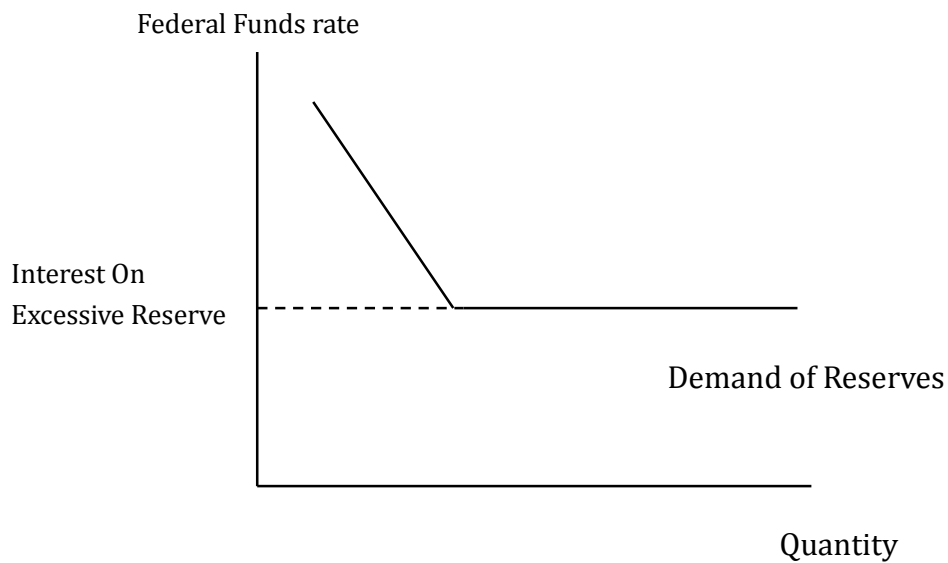
Fear Index: This variable is used to describe the expected risk of the market. It is in fact the value of S&P 500 Volatility Index (VIX), which is an expectation of market volatility. Hypothetically, if the expected risk is high, banks would charge higher risk premium, decreasing amount of loans made. Keeping other variables constant, the decrease in substitutions will lead to an increase in demand of excessive reserves through a decrease in digesting power given the supply of reserves constant. Therefore, the relationship between the fear index and amount of excessive reserves is positive. The plotting suggests no clear relationship, which echoes Poole's (2012) idea that expected risk is of no importance in determining the amount of excessive reserve. We thus suspect this variable to be insignificant (see appendix).

Federal Funds Rate Spread (Ffrate): This variable shows the difference between the federal fund rate and the interest on excessive reserves measuring in 0.1 percentage point. Conventionally, banks borrow from each other at Federal Funds rate to fulfill the requirement of reserves. In theory this variable has a negative relationship with excessive reserves. If the spread between the Federal Funds rate and the interest on excessive reserves is high, the option of investing in the Federal Funds market becomes more attractive compared to holding money as reserves. Since the demand of a substitute increases, the demand of

reserves will decrease, thus forming a negative relationship to the dependent variable. The plot, however, indicates no specific relationship between the spread and the dependent variable.



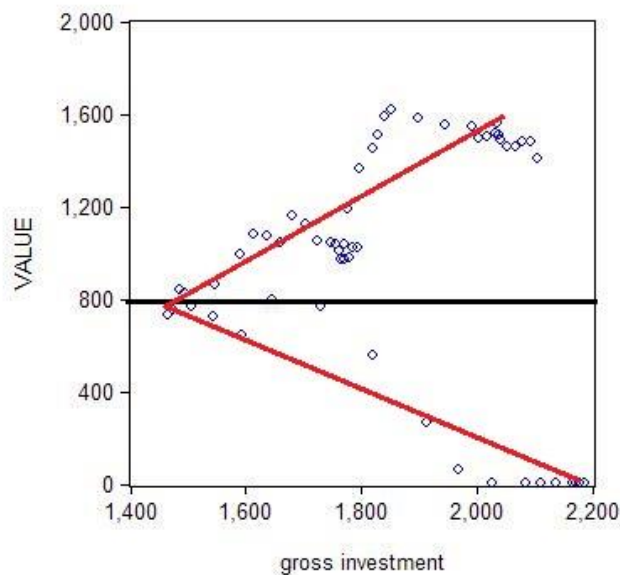
However, if we draw a vertical line at the point where the spread between the Federal Funds rate and the interest on excessive reserves is zero, we can clearly see that once the spread falls below zero, the amount of excessive reserves starts to soar. Therefore, we shall still include this variable. The rationale behind this is quite intuitive: Since holding reserves is more profitable than lending this money to other banks, banks will simply choose to hold an infinitely large amount of reserves as a riskless profitable investment. This can be shown in the following graph.



5 Year Bond Rate Spread: This variable is the spread between the 5 year Treasury bond ratio and the interest on excessive reserves measured by 0.1 percentage point. Since the Treasury bond is a substitute of excessive reserve (discussed in previous sections), an increase in the return of a substitute makes excessive reserves less attractive. Banks will consequently become more eager to exchange their reserves for the substitute. Therefore, it has a negative relationship with the dependent variable. The plotting suggests a negative linear relationship between the Treasury bond spread and the amount of excessive reserves (see appendix).

Gross Investment: This variable measures the gross investments in billion dollars that are made to the private sector. This is a representation of the lending opportunities that determine the supply of loans, which in turn become part of

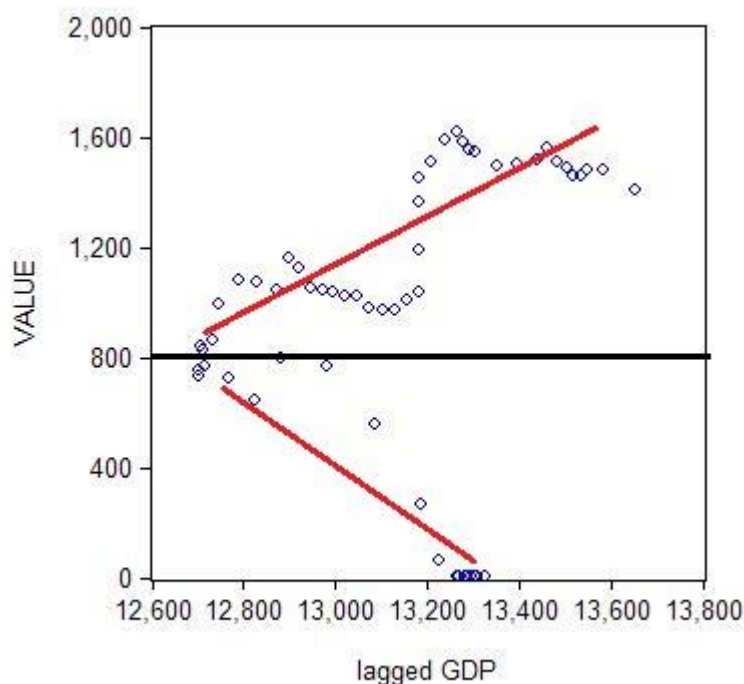
the demand of reserve. According to the rationale stated previously in theoretical foundation section, loans to firms serve as substitutes to the option of holding reserves. Therefore the expected sign would be negative: if this variable increases, it means that the substitute becomes more attractive. Banks will hold fewer reserves as a result. The plotting suggests no clear relationship. However, we again observe a turning point at 800 billion excessive reserves: it marks the lowest point of gross investment. We shall discuss its significance later



Effective Interest Rate Spread: this variable represents the spread between effective interest rate (instead of the target rate) and the interest rate on excessive reserves using the unit of 0.1 percentage point. The effective interest rate is measured using the data of the prime rate. As discussed in previous section concerning the theoretical foundation, represented by a high spread, a high effective interest rate leads to high quantity of loans, which increases the

attractiveness of a substitute of excessive reserves. As the result, there will be a negative relationship between this variable and the dependent variable. The plotting suggests a linearly negative relationship between this variable and the natural log of the dependent variable, thus suggesting a linearly negative relationship between the amount of excessive reserves and $e^{real\ interest\ spread}$. However, scattered points of excessive reserves heavily concentrate on one side of this linear relationship, making us doubt that this variable may be insignificant (see appendix).

Lagged GDP: This variable represents the last period GDP in billion dollars. It serves as a reflection on the general performance of the economy and a representation of the market risk. An increase in lagged GDP reduces risk level perceived by banks, reducing the risk premium they charge and thus increasing the amount of loans. Since banks become more eager to lend out money under this scenario, investment as a substitution becomes more attractive, making the demand of reserve smaller. Therefore, the expected sign is negative. The plotting suggests again a turning point at 800 billion excessive reserves. This alerts us that the abnormality of excessive reserves may include two stages.

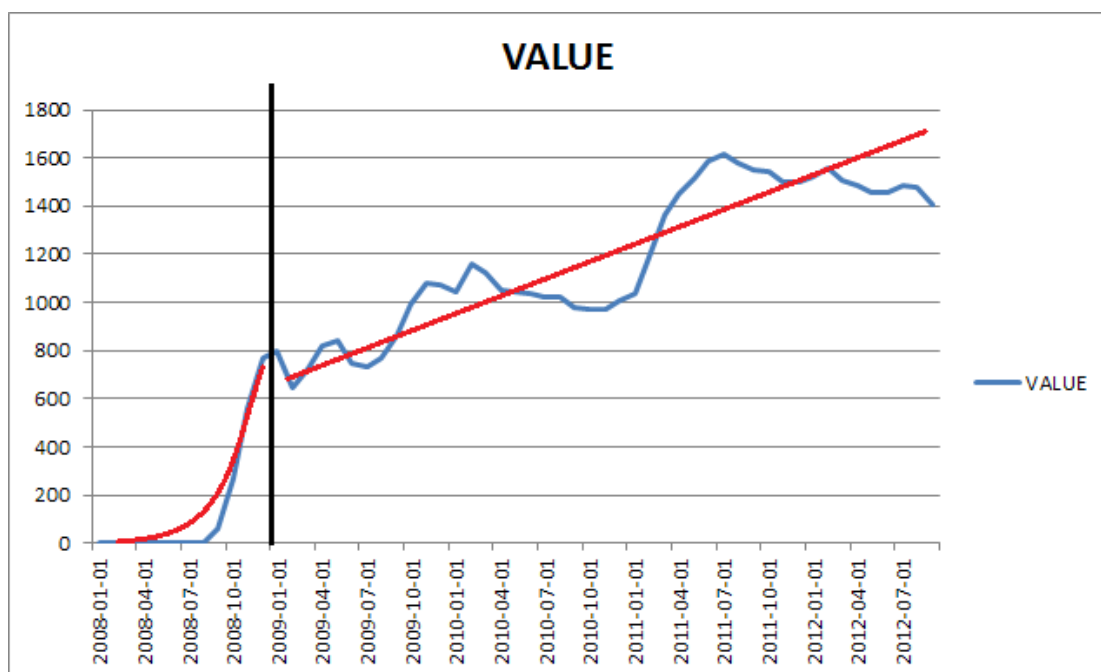


GDP Dummy: This is a dummy variable that returns 1 if actual growth rate of GDP is higher than its potential. When measuring this variable, we compare the actual growth rate of GDP with the long term projection of GDP growth rate. If the actual growth rate is higher, it returns 1, otherwise returns 0. When it returns 1, it shows that the economy is performing better than expected, making banks be more inclined in making optimistic expectations, which leads to an increase in quantity of loans made. As the demand of a substitute increases, the demand of reserves will decrease. Therefore, the expected sign is negative.

Two-Stage Hypothesis

From previous section of variable specifications, we not only assert expected signs of

each non-dummy independent variable theoretically, but also confirm our expectation with empirical data plotting. Moreover, the empirical data seems to suggest a two-stage phenomenon, separated by the turning point where the excessive reserves' amount equals roughly 800 billion dollars. By checking data, this turning point occurs in January 2009, with a specific value of 796.834. It is therefore reasonable for us to seek out how this potential “two-stage” function works by mapping out the amount of excessive reserves against time.



If we draw a vertical line at the point of January 2009, we can clearly see that the curve of excessive reserves is separated into two different parts. The first part witnesses a non-stopping sharp increase in reserves, while the second part embraces more fluctuations. In some sense, the second part is more “rational”. The rationale behind this is quite obvious. Prior to January 2009, the economy witnesses a historical financial crisis with the fall of many firms that were considered as invulnerable

previously. The fear spreads in the economy and banks consequently add up their reserves as liquidity cushions against any potential risks. Once the amount of excessive reserves is deemed as enough to counter potential risks, banks will behave more “rationally”. Their priority no longer sets on countering risks but moves back to profit maximization, which, although still takes risk into account, no longer treat it as the first priority. We could say that in the first stage, reserves are “mandatory” to banks. They do not care about the specific profit on reserves as the potential risk of bankruptcy remains lethal. But once banks are secured, they start to treat reserves as assets, valuing their benefits against costs. Only in the second scenario would all our previously discussed independent variables come into effect. It can be inferred from the graph that the curve in the second stage shows significant features of a linear form.

One may then reasonably questions the rationale behind the number 800 (796.834, to be accurate) as the turning point. That is to say, why do banks deem 800 billion dollars as enough in countering risks caused by the financial crisis? This, however, is quite easy to explain. The main potential risk that banks face is potential bank runs. As long as the liquidity that banks hold is sufficient even under the most extreme scenario of bank run, bank would stop hoarding these reserves for security reasons. When the liquidity is sufficient, the potential risk of bank run is simply reduced to zero. Therefore, banks will stop accumulating reserves as the first priority (end of the

first stage) once the excessive reserves held exceeds the amount of total checkable deposits.

DATE	EX Reserves	Checkable D
2008-01-01	1.647	614.1
2008-02-01	1.614	616.0
2008-03-01	2.644	624.9
2008-04-01	1.737	627.8
2008-05-01	1.837	624.1
2008-06-01	2.224	627.6
2008-07-01	1.912	637.5
2008-08-01	1.875	623.8
2008-09-01	59.482	666.1
2008-10-01	267.156	666.3
2008-11-01	558.808	699.7
2008-12-01	767.318	769.4
2009-01-01	796.834	757.3

From the chart, we can clearly see that the excessive reserves for the first time exceed the total checkable deposits exactly at our turning point. Even though the excessive reserves fall in the month immediately after the turning point, it raises almost instantly, passing the secure point marked by total checkable deposits. This comparison between excessive reserves and checkable deposits corroborates our two-stage hypothesis.

Now it is clear that the abnormality of excessive reserves shall be considered in two stages, and that the second stage is in the linear form. We shall now discuss the form of the first stage.

The First Stage: Exponential Equation

From the graph we could clearly perceive that the curve of excessive reserves exhibits similarities to the graph of an exponential equation. We shall now seek out the rationale behind this equation and give its approximation.

As we stated above, under the first stage, banks treat risk-counteracting as their first priority. We claim that the speed of banks to hoard excessive reserves is related to the amount of total excessive reserves that they already hold.

That is to say:

$$\frac{dRe}{dt} = kRe, \text{ where } k \text{ is a constant}$$

Here Re denotes the amount of excessive reserves, and t denotes time.

To solve this differential equation, we multiply dt/Re on both sides, and thus we have:

$$\frac{dRe}{dt} * \frac{dt}{Re} = k * Re * \frac{dt}{Re}$$

This is simply:

$$\frac{1}{Re} dRe = k * dt$$

Take integral on both sides, we have:

$$\int \frac{1}{Re} dRe = \int k * dt$$

Since excessive reserves are at least zero, Re is never negative, we have:

$$\ln(Re) = k * t + C, \text{ where } C \text{ is a constant}$$

Therefore:

$$Re = e^{kt} * e^C$$

This formula gives our desired exponential form. Further, it does not mean that the amount of excessive reserves is determined by time (as t happens to be our independent variable in our equation). Rather, this formula is defined by the differential equation $\frac{dRe}{dt} = kRe$. The final formula only shows that the amount of excessive reserve is correlated with the time, but not determined by time. This kind of formula is quite common in natural sciences. For example, the population of a certain bacteria colony is also given as a formula of time. However, the population is never determined by time, but rather by its initial population, environmental resources and the number of predators given in a logistic differential equation. The formula of time is simply a transformed result of the differential equation.

Given the final formula $Re = e^{kt} * e^C$ is rather difficult to regress, we shall use the intermediate formula, $\ln(Re) = k * t + C$ for our regression.

Result:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TIME	0.611080	0.101623	6.013177	0.0001
C	-1.623006	0.806611	-2.012130	0.0693

R-squared	0.766743
Adjusted R-squared	0.745538

Due to reasons stated above, we shall not pay too much attention to the t-statistic as the independent variable time is not a determinant. The only result that we value is the R-square value, which is approximately 0.77----a decently high value. Our equation therefore explains 77% of the fluctuations in the first stage. The equation for the first stage is therefore:

$$Re = e^{0.61t} * e^{-1.62}$$

If we resume the differential equation version, that is:

$$\frac{dRe}{dt} = 0.61Re$$

We can see that the speed of banks to increase their excessive reserves is 61% of the amount they already hold. This shall conclude the first stage, and we can now proceed to the second stage. Our final note is that this formula is both a macroeconomic formula and microeconomic formula, as it both deals the aggregate amount of excessive reserves and explains it in terms of individual bank's behavior, which is the proportion factor k that we regressed.

Second Stage: Linear Regression

As we stated previously, the second stage shows certain features of a linear form.

We shall use OLS method to regress for the linear equation of the second stage.

The population relationship is stated as below:

$$\begin{aligned} \text{Excessive Reserves} = & \beta_1 + \beta_{\text{Loans to banks}} \text{Loans to banks} + \beta_{\text{TARP}} + \\ & \beta_{\text{Fear Index}} \text{Fear Index} + \beta_{\text{ffrate spread}} \text{Federal Funds Rate Spread} + \\ & \beta_{\text{5 year T-bil Spread}} \text{5 Year Treasury Bond Spread} + \beta_{\text{Gross Investment}} \text{Gross Investment} + \\ & \beta_{\text{Lagged GDP}} \text{Lagged GDP} + \beta_{\text{GDP Dummy}} \text{GDP Dummy} + \\ & \beta_{\text{Effective Interest Rate Spread}} \text{Effective Interest Rate Spread} + U_i \end{aligned}$$

Result and Interpretation:

After eliminating insignificant variables, we obtain the following result:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOANS_TO_BANK	0.695315	0.045061	15.43053	0.0000
RISK_FEAR__INDEX	5.021329	1.147310	4.376610	0.0001
FF_SPREAD	-81.74178	38.95173	-2.098540	0.0410
T_BOND_SPREAD	-55.75828	28.18680	-1.978170	0.0535
PRIME_SPREAD	-68.5648	27.89117	-2.458306	0.0177
GROSS_INVESTMENT	-0.821486	0.215449	-3.812898	0.0004
LAGGED_GDP	-0.622336	0.174832	-3.559620	0.0008
GDP_DUMMY	-16.71063	22.32691	-0.748452	0.4578
C	5580.974	1906.539	2.927279	0.0052
R-squared	0.986166	F-statistic		499.0061
Adjusted R-squared	0.984190	Prob(F-statistic)		0.000000

Our linear regression generates a really high R-squared value, which states that 98.6% of the variations on dependent variables can be explained by variations on

independent variables. In addition, our independent variables as a group are very significant: the probability that they are significant is higher than 0.9999999. Moreover, all our non-dummy independent variables are significant with signs that confirm with the expected sign.

In terms of the coefficients, we can see that approximately 70% of central bank's lending to commercial banks will become excessive reserves, i.e. the current demand of liquidity could only consume 30% of money injected in the system. Furthermore, although the fear index has a significant t-statistics, it is not that important under current scenario. The coefficient before the risk index is approximately 5, meaning that even if the expected market risk reaches 62.64, the recorded historical high, from current level of 15, it could only raise excessive reserves by 235 billion, which compared to the current level of excessive reserves, is not much. Since the expected risk has been maintained around 20 since October 2009 with few fluctuations, it is very unlikely for expected market risk to soar. The empirical evidence on the relative insignificance of expected market risk confirms our two-stage hypothesis, that banks have already had enough liquidities to counter even the most extreme consequence of any potential risk, and they are unlikely to raise their liquidity level merely due to an increasing risk.

Turning to the coefficient before Gross Investment in Private Sector, we can see from the regression that for a one dollar increase in private investment, 0.82 dollar will be

deduced from excessive reserves, i.e. 82% of the private investments are funded not through lending deposits in banks but through lending excessive reserves. In addition, an increase in lagged GDP will also reduce the level of excessive reserves. However, compared to an increase in gross investment in private sector, an increase in GDP has far less impact, not only for the fact that the coefficient before independent variable Lagged GDP is lower, but also because the practical room for GDP to increase is fairly small. An annual growth rate of 4% (which is quite good in U.S's case could only reduce 328 billion dollars excessive reserves, which again compared to the current total amount of excessive reserves, is still a small portion. Given the slow recovery of the U.S economy, reaching 4% annual growth in real GDP is not an easy task, thus GDP's impact on excessive reserves is restricted in practical level.

Finally, let us move on to the most important three variables: FFrate Spread, Prime Spread and Tbond Spread. The regression coefficients imply that given all other independent variables constant, a 0.1 percentage point increase in the difference between the Federal Funds rate and the interest on excessive reserve leads to 81.7 billion dollars decrease in excessive reserves. Moreover, a 0.1 percentage point increase in the spread between the prime rate and the interest on reserve leads to 68.6 billion dollars decrease in excessive reserves. Further, a 0.1 point percentage increase in the difference between five-year bond rate and the interest rate on excessive reserve leads to 55.7 billion dollars decrease in excessive reserves. Note here the effect that the five-year bond spread has is not as significant as the Federal

Funds spread not only in terms of the value of their respective coefficient. As the five-year bond rate remains relatively stable, the only possibility for the spread to increase is achieved through a decrease on the interest on reserves, which at most could boost up the spread by 0.25%, that is, a 139.25 billion dollars decrease in excessive reserves.

However, this is not true in terms of the Federal Funds spread, for the Federal Funds rate could rise in a comparatively easy manner. For instance, if the Federal Funds spread increases from the current level (around -0.11%) to the pre-crisis level of 5%), we will have a 5.11% increase, leading to a 4174.9 billion dollars decrease in excessive reserves, which will literally saturate all excessive reserves from U.S banking system (i.e. lending will increase). However, this requires an increase in the Federal Funds rate, which will necessarily raise the interest rate. But an increasing interest rate leads to a decrease in five-year bond rate, which increases the amount of excessive reserves. Therefore, the actual effect of the Federal Funds rate spread is diminished by the bond yield spread when the increase of the former involves an increase in interest rate. Similarly, an increase in the bond rate spread leads to a decrease in the Federal Funds spread when the former involves a decrease in interest rate. However, this diminishing effect is mediated by the spread of the prime rate, since the increase in interest rate also increases the spread of prime rate, and a decrease in interest rate leads to the contrary result. Therefore, although the combined effect of the prime rate spread and the Federal Funds rate spread could

potentially be somewhat diminished by the five-year bond spread, it still remains strong judging from the coefficients' values

Now we finish the discussion on time-series data. We shall proceed to the cross section analysis in identifying individual bank's incentive. Note that the first stage already suffices in this respect, thus the cross section analysis shall also focus only on the second stage.

B. Cross-Section Analysis

Variable Specification:

To begin with, we shall identify variables that will be considered in the model and provide corresponding justification with expected signs.

Dependent Variable:

Amount of Excessive Reserves: This variable represents the amount of excessive reserves that a bank holds (in million dollars).

Independent Variables:

Id/If ratio (Ratio): this ratio denotes the ratio of the discount rate against the Federal Funds rate.

As stated in the literature review section, a bank has two sources to fulfill the reserve requirement set by the Fed. It could either borrow through inter-banking transactions, or it could borrow directly from the Fed. The former charges an interest rate which is called the Federal Funds rate, while the latter is often referred to as the discount rate. It is reasonable both empirically and theoretically to assume that the Federal Funds rate, denoted as I_{ff} , is always lower than I_d , which denotes the discount rate, for if the contrary is true, then no bank would choose to borrow through the Federal Funds market.

Furthermore, a bank manager needs to make the decision whether he or she wants to borrow Federal Funds during operating hours based on an expectation on whether his or her banks will have enough reserves at the end of the day. If he decides to borrow through the Federal Funds market, then the potential gain will be the amount borrowed times the difference between the Federal Funds rate and the discount rate, for he fulfills the requirement with a lower cost. However, this option also has a cost. If the manager ends up over-borrowing, that is, after that day's operation, the bank has reserves exceeding the requirement due to the uncertainty of deposit; then there will be a cost for the manager's action. This cost equals the excessive reserve times the Federal Funds rate.

On the other hand, if the manager decides to not borrow, then he could also end up in two different situations: either the reserve is fulfilled without borrowing, or he needs to borrow from the Fed. The first outcome does not have any benefit, while the second has a cost, which equals the insufficient amount times the difference between discount rate and the Federal Funds rate, for he raises the reserves at a higher cost. Apart from these two options, the manager could choose to lend money as Federal Funds to other banks. This action also has two potential outcomes: this bank either fulfills the requirement, or it over-lends, and thus the bank has to borrow from the Fed to fill the gap. If the first outcome comes true, the bank will make a profit equals to the money lent times the Federal Funds rate. If the second is true, then the bank suffers a loss equals the amount borrowed times the difference between the discount rate and the Federal Funds rate. We assume that the probability of each outcome in each strategy is equal, and the potential consequences are list below. Here we denote amount borrowed as B and amount lent as L . We also denote the Federal Funds rate as I_f , discount rate as I_d , and the actual reserve at the end of the day as D ; while the required reserve is R .

	borrow fed fund	do nothing	lend fed fund
50% success	$B \cdot (I_d - I_f)$	0	$L \cdot I_f$
50% fail	$(B + D - R) \cdot I_f - B \cdot (I_d - I_f)$	$(R - D) \cdot (I_d - I_f)$	$(R - D) \cdot (I_d - I_f) - (L \cdot I_f)$

From this chart we can see that a bank manager will almost never choose to adopt the option of doing nothing, for it under no circumstance generates any profit, and it always has a higher cost under the failed condition. Therefore, there are in fact only two options to adopt, and we shall assign a probability, P to the first option, leaving a possibility of $(1-P)$ for the second strategy. As a consequence, the potential benefit for this bank will be: $0.5 * P * B * (I_d - I_f) - 0.5 * P * (B + D - R) * I_f + 0.5 * P * B * (I_d - I_f) + 0.5 * (1 - P) * L * I_f - 0.5 * (1 - P) * [(R - D) * (I_d - I_f) + (L * I_f)]$. We know that a bank's goal is to maximize this benefit. Therefore, we shall take the first derivative of this equation in terms of P . The result is $(2B + R - D) * I_d - 3B * I_f = d/dy$. However, $R - D$ is B . we then have $3B * (I_d - I_f) = d/dy$. From this we can see that as P increases, the profit of the bank will also increase.

However, this does not mean that a manager should always borrow money as a strategy, for it will be obviously foolish to borrow when the current reserves has already far exceeded the requirement when making the anticipation. No manager makes decisions by tossing coins and thus P cannot be changed freely. But from this we could at least conclude that as I_d/I_f increases, the marginal return on borrowing through the Federal Funds market will also increase, making our bank manager more likely to adopt this strategy, which in turn increases the probability of creating excessive reserves (the situation of a failed anticipation). Therefore, we shall conclude that the ratio I_d/I_f is essential in bank manager's decision making, and the expected relationship is positive.

Fear Index (EMR): This variable is used to describe the expected risk of the market. It is represented by S&P 500 Volatility Index (VIX), which is an expectation of market volatility. Hypothetically, if the expected risk is high, banks are more likely to become prudent in lending money as this variable in some extent represents the structural risk which banks could not mitigate through diversification. Since under Basel II, banks are obliged to hold reserves in terms of risk, this structural risk could be a shared factor among banks that drives up the reserves. However, Poole (2012) argues that the structural risk may not necessarily affect the amount of excessive reserves. Therefore, although we expect a positive sign, the actual coefficient could be insignificant.

Lagged GDP: same as in macroeconomic section.

Gross Investment: same as in macroeconomic section.

Net Income/Total Assets Ratio (NTR): This variable is acquired by the ratio of net income over total assets. Here this ratio is a proxy of ROA, which is a comparative measure on how profitable a bank is in terms of its assets. Note that this ratio here is different from ROA in two ways: firstly it permits negative value, and secondly, the denominator is total assets instead of average total assets. A higher ratio indicates that this bank has better investing opportunities. If the general portfolio of a bank is

highly profitable, it would be unattractive for this bank to hold large amount of low-return excessive reserves. Therefore, the expected sign should be negative.

Size: This variable is captured by taking the natural log of the asset value of a bank. Previous studies by Ennis and Wolman (2009) suggest that there is a positive relationship between reserves and the size of the bank. Further, this positive relationship has a decreasing incremental increase. Therefore, it is better suited to take the natural log of the asset as the pure representation of the size of a bank.

DIV: this variable represents the dividend payout ratio. Due to the asymmetric information in capital markets, bank managers prefer to use retained earnings (instead of debt) and issuing equity to fund new projects (Focarelli). If the dividend payout ratio is high, it represents that this bank holds relatively fewer retained earnings. Therefore, the size of projects this bank can fund is diminished, and associated risks are therefore lower. The need for having reserves either as a form of liquidity or as a cushion to counter risk is lower. Thus, the expected sign of this variable is negative.

Regulatory Pressure (Pressure): This variable represents the pressure of regulation a bank is facing. This will be captured by a dummy variable, which returns 1 if the pressure is high and 0 if the pressure is low. Intuitively, the relationship between this variable and the amount of reserve is negative, for banks face regulatory pressures only when they do not have enough reserves to counter potential risks. Here we shall

adopt Van Roy's methodology of calculating this dummy variable. However, given the background of financial crisis, our criterion shall be stricter. It will return 1 if either total capital ratio falls below 13 or if tier 1 capital ratio falls below 8 percent.

Lagged Income-Reserve Ratio (IRR): This variable is calculated by dividing last period income with last period reserves. Estrella (2004) argues that banks are also future-oriented profit-risk optimizers, and their behavior, instead of being stagnant all the time, is in fact a game strategy, which is constantly modified in response to regulations. Estrella argues that banks will firstly acquire the minimum amount of reserves firstly and then add a few risky assets to see how regulators respond to this change. Banks will then make adjustments in accordance with regulators' responses. In this case, past reserves' amount affects the level of current reserves held. If this lagged income-reserve ratio remains low, it indicates that the proportion of reserve is too high, and banks will make adjustment by decreasing reserve amount and add more risky assets. More importantly, from previous discussion, we know that holding excessive reserves seems to be more profitable than interbank lending, since the Federal Funds rate spread maintains negative since 2008. Second Stage banks as profit maximizers would choose to hold more reserves even when the IRR ratio is high, simply for the reason that holding these reserves is more profitable than most lending opportunities. Therefore, the expected sign is positive.

Prime Rate Spread: same as in the macroeconomic section

Unobservable factor (α): This variable is automatically dealt with as we intend to employ the fixed effect panel data analysis. This variable is used to capture the uncertainty that banks face when making decisions. This uncertainty is not risk, for risk can be quantified and observed (thus being rationally dealt with). Rather, this factor represents unquantifiable factors that also affect banks' decision. Further, there can either be correlations between this observable factor and other factors, or such correlation does not exist or is insignificant.

However, the value of unobservable factors will not be show in our result, for we can simply subtract the specific population relationship with its average over time and thus eliminating the undesirable α

Population Relationship:

$$\text{Excessive Reserve}_{it} = \beta_{\text{Ratio}} \text{Ratio}_{it} + \beta_{\text{EMR}} \text{EMR}_{it} + \beta_{\text{NTR}} \text{NTR}_{it} + \beta_{\text{Size}} \text{Size}_{it} + \beta_{\text{DIV}} \text{DIV}_{it} + \beta_{\text{Pressure}} \text{Pressure}_{it} + \beta_{\text{IRR}} \text{IRR}_{it} + \beta_{\text{Prime Rate Spread}} \text{Prime Rate Spread}_{it} + U_{it} + \alpha_i$$

Result:

After eliminating insignificant variables, our final result is the following:

```
. . xtreg reservem averageifidratio emr pressure irr interestrate, i( banknumber) fe
```

```

Fixed-effects (within) regression      Number of obs   =      84
Group variable: banknumber            Number of groups =       6

R-sq:  within = 0.4548                Obs per group:  min =      17
      between = 0.9644                  avg   =      18.0
      overall = 0.3827                  max   =      19

                                         F(5, 63)       =      10.51
corr(u_i, Xb) = 0.1946                 Prob > F        =      0.0000

```

reservem	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
averageifio	80158.45	49144.44	1.63	0.108	-18048.86	178365.8
emr	-199.4582	450.1264	-0.44	0.659	-1098.964	700.0477
pressure	11837.96	21864.58	0.54	0.590	-55530.84	31854.93
irr	-263219	131766.5	-2.00	0.050	-526533.3	95.24952
primespread	-24908.5	9832.38	-2.53	0.014	-44556.95	-5260.057
_cons	209195	35630.17	5.87	0.000	137993.8	280396.2

sigma_u	40623.092					
sigma_e	35601.71					
rho	.56559131	(fraction of variance due to u_i)				

F test that all u_i=0: F(3, 63) = 15.72 Prob > F = 0.0000

..

From the final result, we can see that not only the group of variables selected is highly relevant (high F-value), but each variable (except EMR) is also significant under a 10 percent significance level. Although the R-squared value is not very high, our goal however, is not maximizing R-squared value.

In terms of the result, we can see that a high discount rate—Federal Funds rate ratio indeed leads to higher reserves, as we have expected. In addition, larger banks indeed tend to hold more reserves. Moreover, banks under regulatory pressure tends

to hold 11837 million dollars more as reserves compared to banks exempt from such pressure. Apart from this, a higher prime rate spread will significantly decrease the amount of excessive reserves that a bank holds, which concurs with our expectation. What's more, we find it surprising that on the contrast to our expectation, the coefficient before IRR is negative, meaning that banks holding exceeding reserves in terms of income (low lagged income-reserve ratio) tend to hold even more reserves instead of decreasing its amount. Surely, adjusting reserve level in terms of income takes time, and there might be certain inertia imbedded in bank behaviors. But the more important rationale behind this is that, for banks with high IRR ratio (that is, having "inadequate" reserve level); they face investment opportunities better than holding reserves (reflected in the high income ratio). Therefore, as profit maximizers, these banks would choose investments over holding reserves, leading a low amount of reserves when this ratio is high, thus forming a negative relationship. Therefore, this result is not surprising. Finally, the market risk seems to be insignificant in individual bank's decision making, which concurs with Poole's claim (2012) that external risk may not necessarily affect the amount of excessive reserves.

However, it is reasonable for one to ask: why risk index is significant in time series analysis but not in cross section analysis? i.e. why expected risk is important in macroeconomic aspect of excessive reserves but not important for individual bank? This impasse is simply a result from the Fed's policy. When the expected market risk is high, the Fed tends to inject more liquidity into the market to stabilize and

stimulate the economy. These injections, regardless of its forms either as direct loans to industries or to commercial banks, will all increase excessive reserves' amount. But in terms of individual bank, risk is no longer an important concern; since it has already banked enough liquidity for any risk in stage one. This result also confirms with our two-stage hypothesis.

Now we have finished our discussion in both analyses. We are now prepared to proceed to the final section of application. We have but one main question, namely, what is the Fed's best strategy to saturate all excessive reserves without hurting the economy?

Applications

To answer the proposed question, we need to firstly seek out independent variables over which the Fed has control in the macroeconomic (time series) model. Surely in the first stage, there is nothing that the Fed could do. Stage one is an unstoppable, unchangeable counter-risk behavior that only involves a trigger, that is, whether a financial crisis occurs. In stage two when banks could resume their rationality, the Fed could affect the amount of reserves by four variables: Loans to banks, Federal Funds rate spread, five-year bond spread, and the prime rate spread. The Fed

controls the first independent variable through its operations and exercises a full control over it. For the rest three variables, the Fed could affect them by changing the target interest rate and the interest rate paid to excessive reserves. Let us firstly start with the variable concerning loans made to banks.

The reason why increasing loans made to banks leads to an increase in excessive reserves has been discussed several times in previous sections. Here we shall concentrate on whether the Fed should continue this lending behavior. Fed uses liquidity injection as a counter-crisis measure to boost lending and avoid the liquidity trap. This measure is well-justified in the first stage, where all commercial banks seek for financial security. However, Fed continues its lending behavior in the second stage, which this paper argues as unnecessary. To support our argument, we shall refer to the following chart.

DATE	expected real GDP	real GDP	Gross Investment	percentage	expected growth rate	real growth rate	GDP dummy
2007-10-01	13299.7	13326.0	2277.4	0.17089899			
2008-01-01	13376.9	13266.8	2185.7	0.1647496	0.005804642	-0.004442443	0
2008-04-01	13453.4	13310.5	2165.4	0.1626836	0.005718814	0.003293937	0
2008-07-01	13527.6	13186.9	2086.3	0.15821004	0.005515334	-0.009285902	0
2008-10-01	13598.7	12883.5	1913.0	0.1484845	0.005255921	-0.023007682	0
2009-01-01	13665.3	12711.0	1645.8	0.1294784	0.004897527	-0.013389219	0
2009-04-01	13724.4	12701.0	1495.3	0.11773089	0.004324823	-0.00078672	0
2009-07-01	13780.1	12746.7	1465.6	0.11497878	0.004058465	0.003598142	0
2009-10-01	13833.4	12873.1	1590.4	0.12354445	0.003867896	0.009916292	1
2010-01-01	13884.2	12947.6	1660.4	0.12823998	0.003672271	0.005787262	1
2010-04-01	13935.7	13019.6	1724.7	0.13246951	0.003709252	0.005560876	1
2010-07-01	13987.8	13103.5	1793.3	0.13685657	0.003738599	0.00644413	1
2010-10-01	14041.6	13181.2	1770.9	0.13435044	0.003846209	0.005929713	1
2011-01-01	14101.1	13183.8	1755.9	0.13318618	0.004237409	0.000197251	0

2011-04-01	14163.9	13264.7	1819.0	0.13713088	0.004453553	0.006136319	1
2011-07-01	14228.1	13306.9	1853.8	0.13931118	0.00453265	0.003181376	0
2011-10-01	14292.5	13441.0	1991.1	0.1481363	0.004526254	0.010077479	1
2012-01-01	14355.4	13506.4	2032.2	0.150462	0.00440091	0.004865709	1
2012-04-01	14415.3	13548.5	2041.7	0.15069565	0.004172646	0.003117041	0
2012-07-01	14474.4	13652.5	2080.1	0.15236037	0.004099811	0.007676127	1

In this chart, the GDP dummy will return 1 if the actual growth rate of real GDP exceeds the expected growth rate of real GDP. We can see that since the third quarter 2009, the actual growth rate of real GDP frequently surpasses the expected growth rate made during the pre-crisis period as a long term prediction. This indicates that the economic growth has come back to the pre-crisis level. Furthermore, the real GDP in value also comes back to the pre-crisis level, which is a positive sign of recovery. Finally, although the gross investment in private sector----real GDP ratio is still below the pre-crisis normal level of 17%, it is relatively close (15%). The under-exploited investment opportunities should therefore be $Real\ GDP * (17.08\% - 15.23\%)$, which is 252.571 billion dollars. The amount of this under-exploited investment opportunity is far exceeded by both money injected during the third quarter 2012 and the total amount of excessive reserves. That is to say, the Fed injects more liquidities than needed into the system, which is not well-justified. The money injected to the market through crediting to banks' reserve account in the Fed should equal the under-exploited investment opportunity divided by the effective money multiplier. That is to say:

$$\text{Loans to Banks} = \frac{\text{Real GDP} * 17\% - \text{Gross investment in private sector}}{\text{Effective Money multiplier}}$$

Therefore, under current situation, it would be wise for the central bank to decrease its lending to banks. This would significantly decrease the amount of excessive reserves, for every dollar's decrease in amount of loans made to banks will decrease the amount of excessive reserves by 0.69 dollar. Further, this decrease will not have a severe impact on the economy, for the liquidity lost in the decrease of loans to banks will be amended by using excessive reserves. Therefore, a decrease in loans to banks will not necessarily cause a decrease in gross investment in private sector.

Apart from decrease in lending, the Fed could also affect the amount of excessive reserves through manipulating the target interest rate and the interest paid on excessive reserves. It is understandable that the Fed targets a low interest rate in hope that this could increase commercial banks' lending behavior. As stated previously, the ratio of gross investment to real GDP is still below the normal level (roughly lower by 1.8%). However, a low interest rate would make loans to firms and industries less profitable. After subtracting inflation rate and the risk premium (which is quite high given the current market fluctuations), it is rare that any lending opportunities could still remain profitable. This also explains an empirical fact that the most commercial banks nowadays mainly distribute their loans to big companies and firms, for those firms simply face less risk (difficult to fail) and thus are charged with lower risk premium. Indeed, companies and firms

are eager to borrow from commercial banks, but banks are not willing to lend them.

In addition, even inter-bank lending is devastated by the low interest rate combined with the interest paid on excessive reserves. The difference between the Federal Funds rate (interbank lending interest rate) and the interest rate paid on excessive reserve is negative since November 2009. This makes interbank lending a loss compared with holding excessive reserves. For commercial banks with fewer investment opportunities, instead of lending their excessive deposits to other banks with more investment opportunities, they choose to hold these deposits as reserves, simply for the reason that excessive reserves generate more revenues. From the regression, we know that at the first stage, banks will increase amount of excessive reserves regardless of the cost, and at the second stage, since holding reserves is more profitable, banks as rational thinkers would still choose hoarding money instead of lending. As a consequence, we have banks with fewer investment opportunities holding their money while banks with more investment opportunities could not have enough money to saturate all investment opportunities. This disturbance will severely cripple the economy. Under a low target interest rate and a high interest rate on reserves, excessive reserve becomes a somewhat perfect substitution to commercial lending as well as interbank lending.

However, increasing the target interest rate may have some side effects: firstly, firms will demand less lending from banks, simply due to the rising cost of doing so. Although the supply of loans increases, the demand of loans decreases. It thus remains unclear on how would an increase in interest rate affect the demand of excessive reserves. Furthermore, the amount of decrease in excessive reserves caused by an increase in target interest rate is unknown. Indeed, an increase in interest rate leads to increases in the prime rate spread and the Federal Funds rate spread, but it also decreases the yield of five-year bond and thus its spread. As discussed previously, these two effects diminish each other, leaving the actual effect unknown. Moreover, a contraction policy during the crisis period is extremely dangerous, as it would cause the fear of a deflation. Finally, measures through changing the interest rate take time to implement, and once being implemented, to come into effect. Therefore, a manipulation on target interest rate is not recommended.

Instead of using target interest rate, Fed could also decrease the interest rate paid on reserves, which is 0.25%. Fed could even make the interest rate paid on excessive reserves negative, which in effect makes it a tax. A decrease in interest rate paid on excessive reserves leads to increases in the Federal Funds rate spread, the prime rate spread and the five year bond spread. A 1% decrease in the interest rate paid on reserve will leads to 2060 billion dollars' decrease in excessive reserves. For an individual bank, this would result approximately 250

billion dollars decrease in excessive reserves. Compared with increasing target interest rate, this method has following advantages: firstly, there would be no self-diminishing effect in this scenario. Furthermore, the demand of loans will not decrease, while the supply of loans faces an increase, leading to an increase in gross investment, further decreasing excessive reserves. Finally, there will be no potential fear of a deflation.

In addition to these methods, Fed could adopt some other measures to settle the current problem. The first measure of course is to lower the regulation pressure. From the cross section analysis, a bank under regulation pressure tends to hold approximately 12 billion dollars more as excessive reserves, which seems not much compared to the overall amount of excessive reserves. However, the potential effect cannot be measured in solely monetary terms. Our lowering regulation pressure does not mean to “deregulate” banks, but rather eliminating the contradictory policies that have been implemented since crisis. For example, on the one hand, Fed demands banks to lend more by targeting a low interest rate and questions those banks that are deemed as “not lending”. On the other hand, it pays an interest on excessive reserves that would diminish lending, let alone constant law suits against banks and financial institutions that “did not act prudently and responsively”. Banks would be confused by these contradictory policies, adding the non-monetary cost of their decision. If Fed’s policies could become consistent, it will be less costly for commercial banks to make

expectations on future market behavior, which is exempt from huge fluctuations caused by government's policies under this scenario. The transition from a manipulated economy to a more natural economy will give neutrality to the market, improving the accuracy of banks' prediction (and thus lowering their cost).

Another measure is to sell government bonds to commercial banks in exchange of excessive reserves only. On the one hand, this could decrease the amount of excessive reserves, on the other hand, this would allow the U.S government to avoid current debt crisis by issuing more debts, letting it to have new funding sources and become the biggest Ponzi Scheme in history. To enhance the attractiveness of this option, government bonds sold in exchange of excessive reserves could enjoy some discount in prices.

After the discussion of these previous measures, we therefore recommend a two-stage policy for the Fed to implement. The first-stage policy includes measures of decreasing lending to banks and decreasing interest paid on reserves. These measures should be conducted in a prudent, step-by-step manner to avoid any potential threat of inflation. The judging criterion has been discussed previously. Namely, the Fed should gradually decrease its lending to banks and the interest rate paid on reserves until the Gross Domestic Investment---Gross Domestic Product (GDI-GDP) ratio reaches the historical level

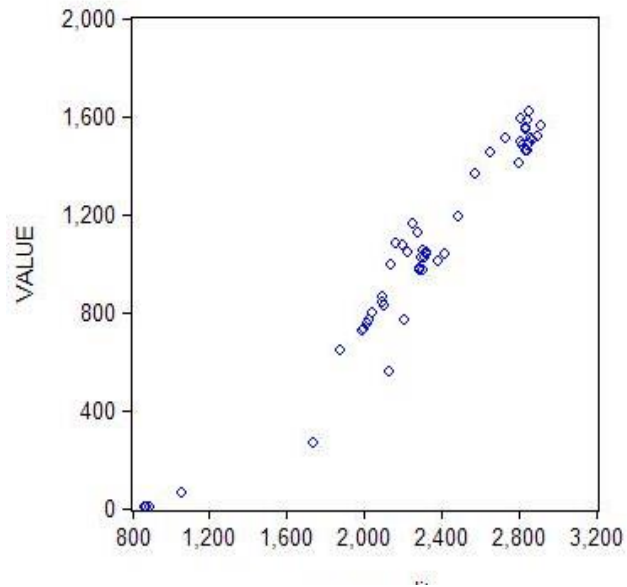
of 17%. A rash implementation of drastically decreasing both the central bank lending and the interest rate paid on reserves is not recommended, for commercial banks could potentially over-react to such policies (since most policies already introduced by the Fed are not consistent, which severely impede commercial banks' ability to make accurate prediction) and respond by drastically releasing reserves they hold, thus resulting a inflation, given the fact that the excessive reserves held far exceeds unsaturated lending opportunities.

Once the investment pattern resumes the healthy state, the Fed can then proceed the second-stage policy. It should offer commercial banks opportunities of trading remaining excessive reserves with treasury bonds at certain discounts. Given that treasury bonds are far more profitable than reserves, commercial banks will be eager to trade their no longer high profitable reserves (due to the consequence of the first-stage policy) with more profitable treasury bonds. Bonds that are used as exchanges for remaining excessive reserves should be diversified in terms of their terms of maturities. This will essentially dilute an immediate threat of inflation (that is, all reserves being released at once) across time, thus mitigating this potential threat to virtually zero. This measure could also serve as an act of saving the U.S government from falling off the budget deficit cliff.

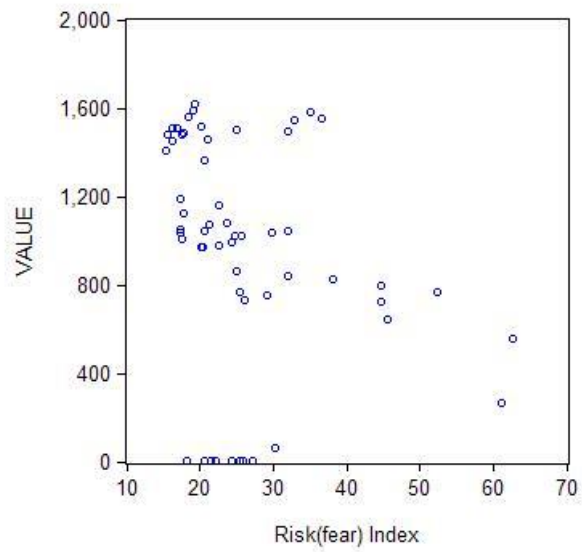
Conclusion

The current abnormality of soaring excessive reserves is mainly caused by the Fed's inappropriate lending policies and a wrongly depressed interest rate. On the one hand, liquidities are constantly injected into the banking system in forms of reserves, on the other hand, low interest rate impedes banks from digesting those reserves in terms of loans to firms, interbank lending (which is utterly destroyed) and investments in Treasury bonds. Individual bank's motivation of holding reserves also echoes those determinants in macroeconomics. Banks choose to hold reserves because any form of investments becomes unprofitable due to the forced low interest rate. To solve the current abnormality, we argue that the Fed should cease its constant injection of liquidity, and lower the interest rate paid on reserves, making it negative if necessary. Furthermore, it should make its policies consistent, and sell Treasury bonds to banks in exchange of reserves.

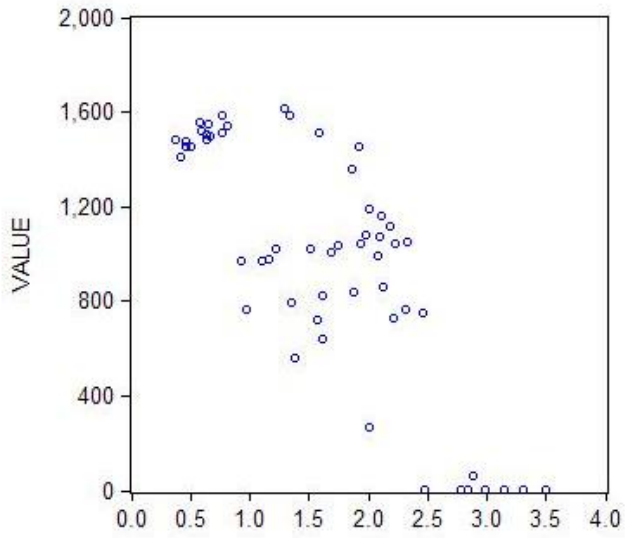
Appendix



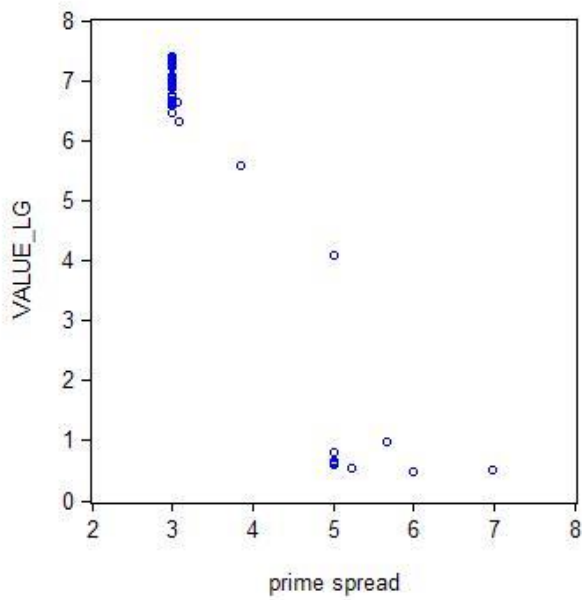
Graph 1: excessive reserves against loans to banks



Graph 2: excessive reserves against expected risk



Graph 3: excessive reserves against Treasury bond spread



Graph 4: natural log of excessive reserves against the spread of effective interest rate

All Data used are collected from:

The Federal Reserve Bank of St. Louis, at <http://research.stlouisfed.org/>

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