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Credit Market Imperfections, Financial Crisis and the Transmission of Monetary Policy

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CREDIT MARKET IMPERFECTIONS, FINANCIAL CRISIS AND THE TRANSMISSION OF MONETARY POLICY

SUBMITTED TO

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Abstract

This paper uses U.S. macroeconomic data drawn from 2001 to 2010 in order to test for the operation of a credit channel of monetary transmission. Using a combination of a VAR and ADL time series frameworks, evidence is found for the impairment of the credit channel during the crisis period relative to the period which preceded it. Evidence is also found against the presence of a "credit crunch" during the crisis, and *supporting* evidence is found for the existence of a "credit trap." This analysis indicates a significant role for credit market imperfections in the transmission of monetary policy, and holds policy implications for the potential impact of future monetary expansions conducted in the setting of a financial crisis.

I. Introduction

A problem which is central to the subject of economics, and to financial economics in particular, is the asymmetric distribution of information. In the context of contracts or transactions, asymmetric information can introduce frictional costs which, in aggregate, can have a significant impact on the ways that markets function. Numerous examples of this phenomenon have been documented, beginning most famously with the "market for lemons." Over time, knowledge of the problems which can stem from asymmetric information has significantly expanded – though the relative importance of such issues to the general economy largely remains unknown.

Credit market frictions are an important example of the costs which exist as a result of asymmetric information, and can play a significant role in determining the cost of borrowing for firms which seek external financing. In turn, these frictions may influence the transmission of monetary shocks – since an expansionary policy targeting lower interest rates will be expected to impact aggregate demand primarily through borrowing and investment – creating a "credit channel" in which monetary policy affects output in part by causing a shift in the supply of loans.[1]

The recent course of monetary policy has been dramatic to say the least. In its response to the Subprime lending crisis, the Federal Reserve first moved to lower short term interest rates – long the traditional outlet for an expansionary monetary policy. As rates approached their lower bound, however, and as financial markets continued to flounder, the Fed was forced to develop new additions to its toolkit.[2] One such program was a large scale expansion of the Reserve's balance sheet – a policy which was designed to inject liquidity into the banking sector, to flatten

[1] Oliner and Rudebusch (1996).
[2] Sarkar (2009).

the term structure of interest rates, and to stimulate both demand for and the supply of loans.[3] In light of the unprecedented nature of this program, it is no surprise that the transmission mechanism of monetary policy – a subject which has sparked much controversy – has once again attracted a high degree of academic attention.

The Federal Reserve's move to expand its balance sheet, a program known as "quantitative easing," was justified by the belief that, in the short run, an unexpected shift in the money supply will have an impact on national output. A large body of empirical research has documented this phenomenon, but for the most part, publications of this nature have remained conspicuously silent about the mechanism, or combination of mechanisms which might transmit a monetary shock to the real economy. [4] It is only over the past two decades that this question has been subjected to rigorous examination. The result has been the genesis of a number of theories designed to explain this process – but despite the widespread attention which this topic has received, even today there is no clear consensus regarding the exact nature of the transmission mechanism of monetary policy.

Among the various explanations of this mechanism, the most widely known is that proposed by Friedman (1970), as derived from Fisher's quantity theory of money. The mechanism which Friedman describes is based on the assumptions that both the demand for money and velocity of money are stable, and the prices are sticky in the short run. As Friedman argues, if the monetary base expands – via open market operations or otherwise – those in possession of new money will hold excess cash relative to other assets. In attempt to readjust their portfolios to their previous allocations, these individuals will spend that excess cash,

[3] Bernanke (2009).
[4] Bernanke and Gertler (1995).

causing a rise in aggregate demand.[5] However, while this explanation is entirely sensible, it is also somewhat vague. Thus, a large number of more detailed transmission mechanisms have been conceived in an attempt to expand on Friedman's work.

These are the so called "neoclassical channels," the most widely accepted of which is the "Interest rate" or "cost" channel. Within this view, an expansion of monetary policy will lead to a rise in the price of interest bearing assets, which necessarily implies that the yields associated with those assets, (or interest rates), will fall. If, in turn, the demand for loanable funds is sensitive to changes in the interest rate – also the cost of borrowing – a fall in rates will lead to marginally greater demand for loanable funds, a greater volume of investment, and higher national output. [6]

Other explanation for the transmission of monetary policy rely on the existence of credit market imperfections, and are popularly known as the "credit channel." As opposed to the neoclassical channels, this view emphasizes the fact that non-deposit sources of financing for banks represent imperfect substitutes, that companies' balance sheets are important determinants of the terms of borrowing, and that banks' specialized knowledge of borrowers make them the best suited providers of financial intermediation.[7]

While the empirical literature demonstrates a clear role for the interest rate channel as well as a close long run relationship between money growth and nominal GDP,[8] investigation into the nature (or even the existence) of the credit channel has yielded mixed results. A consensus on this subject has yet to emerge, and even more controversial is whether the *relative* significance of different channels of monetary transmission will remain static as real economic

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[5] Friedman (1970).
[6] Other potential effects stem from consumer wealth creation, shifts in inflation expectations, and the export stimulus which may arise through a depreciation of the currency.
[7] Boivin et al. (2010).
[8] As is discussed further within Section III.

variables shift. This question, in particular, has been drawn into focus as a result of the recent financial crisis. While there is a developed literature exploring changes in the transmission mechanism over time, fewer studies have addressed the potential impairment of that mechanism within the context of a financial crisis.

This paper seeks to address the relative importance of the credit channel during the recent financial crisis as compared to the period which preceded it. This question is explored by modeling the relationships between monetary policy, key macroeconomic variables, financial indicators, and the money multiplier in VAR and ADL time series frameworks.

This study considers a wide range of variables related to the transmission of monetary policy. These include: the money multiplier, changes to the monetary base (M0), M1, the federal funds rate, 10 year treasury rates, current inflation, expected inflation, unemployment, the LIBOR/OIS spread, BBB corporate bond/treasury spreads, a proxy for bank asset values and volatility, a proxy for collateral asset values and collateral asset volatility. The data was collected on a bi-weekly frequency, covering a period ranging from 2001 to 2011, and was drawn from the Federal Reserve Bank of St. Louis' online database, Bloomberg, and the Federal Reserve Board of Governors.

The dependent variable used within this study was the money multiplier, which is defined as the ratio between M1 and M0. Because movement in M1 is determined by bank lending, the currency ratio, and changes in the monetary base, this variable may be used to isolate the effects of movement in M0 on bank lending – so long as the other determinants of M1 are controlled for. As the credit view predicts, an expansion of M0 will lead to a rise in both bank lending and M1, independent of a change in interest rates. Thus, if there is a credit channel of monetary transmission – and given an adjustment lag – movement in M0 should have no impact on the money multiplier. The empirical portion of this investigation tests for this result, however, it must also be acknowledged that it is possible for M0 to have no predictive power over the multiplier even in the absence of a credit channel. This result might be found, for instance, if bank lending expanded for unrelated reasons during a period of monetary expansion – or, conversely, if lending coincidentally declined during a monetary contraction.

Based on a combination of Granger causality tests, VAR impulse responses and time series analysis, I find that innovations in M0 are not a significant predictor of change in the money multiplier over the period ranging from December, 2001 to August, 2007. This is consistent with the existence of a functional credit channel during this time. Conversely, I find that the monetary base *was* a significant predictor of changes in the money multiplier during the period ranging from August, 2007 to December, 2010. This shift relative to the period preceding it is consistent with the credit channel of monetary transmission being impaired during the recent financial crisis.

Findings for the relationship between bank capital and movement in the multiplier cast doubt on the hypothesis that a "capital crunch" was responsible for this impairment. Returns to the W5000 index, however, are found to positively relate to movement in the multiplier for both the crisis and pre-crisis periods. This result supports the hypothesis that a "credit trap" may have manifested during the crisis.

The rest of this paper proceeds as follows. The next section provides an overview of the money multiplier and the recent trends in its components. Section III develops the distinction between the credit channel and neoclassical transmission mechanisms, and Section IV explores the theories of credit channel impairment. Section V discusses the background of the subprime mortgage crisis. Section VI describes the data set, followed by descriptions of the study's methodology in section VII, and results in section VIII. Section IX concludes, and poses questions for further research.

II. The Money Multiplier

The primary dependent variable used within this investigation is that of the "money multiplier." In light of this paper's focus on the transmission of monetary policy via the credit channel, use of the money multiplier as a dependent variable, (as opposed to bank loans, for example), may at first seem somewhat surprising. The basis for this choice then merits further explanation, and is addressed within this section. I begin by defining the money multiplier, discussing the roles of the "currency" and "excess reserve" ratios, and describe the trends in each of these factors over the course of recent history.

A. Definition

The money multiplier is a conceptual representation of the fact that, depending on one's definition, there may be a great deal more "money" circulating in the economy than there is currency. To the layman, this statement may seem an odd one; money as it is popularly conceived of consists purely of coins and paper, which can of course be physically be counted. Economists, however, define money not simply as currency, but based on its primary role and function – to serve as a medium of exchange. Because cash is not always used for this purpose – the lion's share of payments being made by check – the question of "what constitutes money?" is a surprisingly difficult one to answer.[9] Of course, some components of money, (such as

[9] Baumol and Blinder (2006).

currency), are fairly easy to identify. But if checks are used for payments, shouldn't checking account balances be included as "money" too? And what of savings accounts which will transfer funds automatically to checking accounts should the account holder write a check? Clearly, an argument could be made for a definition of money which includes both of these; however, another problem arises when expanding the definition of money – choosing when to stop. Unfortunately, there is no clear demarcation between money and its *close substitutes*.[10] As a result of this fact, the U.S. government has *several* official definitions of the money supply, three of which are explored below.

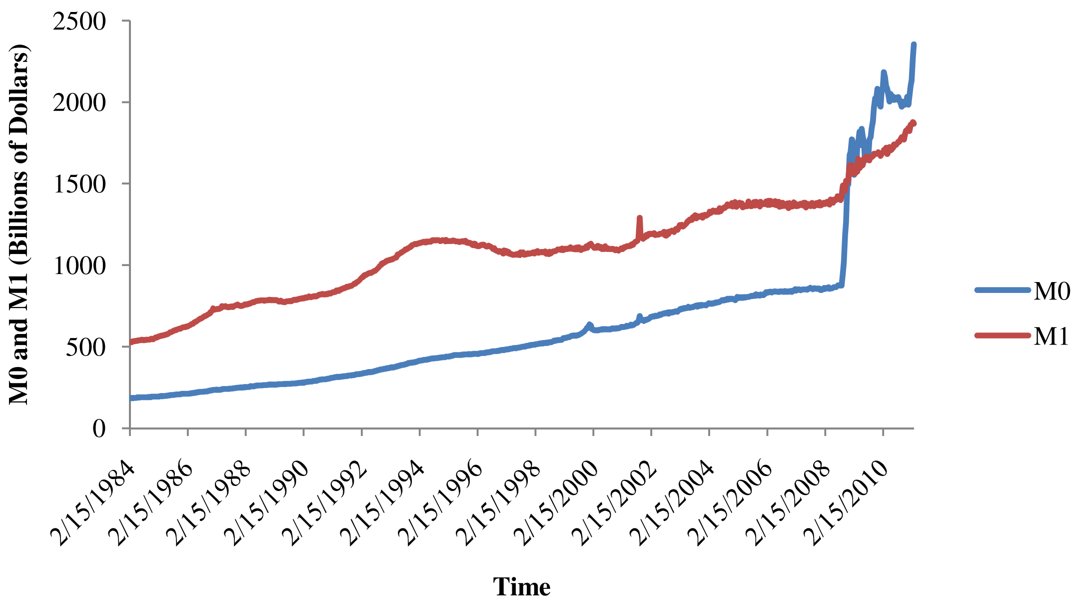
The most obvious definition of money includes only the coins and paper money which exchange hands in our economy. Following intuition, then, this is the conceptual basis for the U.S. government's narrowest definition of money – "MB" or the "monetary base." The second definition of money, "M0" also includes coins and paper money, but expands to encompass commercial banks' reserves with the central bank as well, since deposits of this nature hypothetically also consist of currency (or an even more liquid digital equivalent). Movement in M0 is directly controlled by the policies of the Federal Reserve, whose open-market operations – the sale and purchase of assets – either give banks more reserves or take reserves away.[11] The trend in M0 over the course of recent history has been consistently upward, though much more variation has appeared in this series over the course of the past few years. This can be seen in Figure 1, which depicts the level of M0 over time.

A third definition of money is that of "M1." As compared to M0, M1 consists of coins and paper money held outside the vaults of depository institutions, traveler's checks, conventional checking accounts, and certain other checkable deposits in banks and savings

[10] Baumol and Blinder (2006).
[11] Baumol and Blinder (2006).

institutions.[12] Though M1 does not include commercial banks' deposits with the Federal Reserve, the level of M1 has typically been greater than that of M0. Similar to M0, the level of M1 has consistently risen over time, as is depicted in Figure 1.

Figure 1: M0 and M1 over time



The difference between M0 and M1 is a result of the system of "fractional reserve banking" in which banks accept deposits, retain a fraction of those funds, and lend away the balance. Consider an economy in which banks retain all of depositors' funds. In this case, M1 will equal the total sum of currency, and M0 and M1 will be equivalent. Within a fractional reserve system, however, banks may choose to keep only a portion of their total deposits, lending out the difference. If banks *do* choose to lend, a greater quantity of coin and paper money will circulate outside of vaults while the total value of initial deposits still remains the same. Based on the definition of M1, then, banks have the power to create more M1 money by lending. This

[12] Baumol and Blinder (2006), as well as the Federal Reserve Bank of St. Louis "Monetary Trends" publication, (May, 2011).

is the central concept of the money multiplier, which states that for a change in the monetary base – and holding all else equal – the resulting impact on M1 will be the product of a scalar.

A natural question which arises in light of this phenomenon is: exactly *how much* more M1 money will exist than there is currency? Or in other words, what will be the *level* of the money multiplier? The answer to question is "it depends." Since bankers are free to choose how much to hold in reserve – either deposited with the central bank or otherwise – all of the factors which influence bank behavior will play a role in determining the multiplier. But while it may be difficult to predict the multiplier precisely, by making simplifying assumptions, it is possible to find some clues. If we assume that lending is profitable and that banks are profit maximizers, we can predict that banks will lend as much as they are able to. Two factors will restrain lending behavior. First, banks must retain sufficient reserves to meet the needs of depositors should they demand their money.[13] Next, they must meet Federally dictated reserve requirements.

In the special case that banks lend until constrained by reserve requirements, the money multiplier can be explicitly calculated. In this case, an expansion of bank reserves implies that banks will hold *excess* reserves beyond what is required by regulation. Those funds will be used for new loans, and (as seems likely) the recipients of those funds will deposit them with a bank. A fraction of these new deposits will be held in reserve per the requirement, and the difference will once again be loaned away. The chain of deposit/loan creation will only end when there are no more *excess* reserves for banks to loan, suggesting that the total change in the M1 money supply affected by an expansion of reserves will be the sum of a geometric series. If this is the case, the theoretical money multiplier will be the reciprocal of the reserve requirement "r":

$$\Delta M1 = \frac{1}{r} \Delta M0$$

[13] Calomiris and Wilson (1998).

This formula, of course, constitutes a gross simplification of real world conditions. As previously mentioned, the reserve ratio which banks ultimately choose to adhere to will be a function of the variables which affect bank lending. Among these are monetary policy and all the rest of the real economic variables which play a role in determining output. However, if these variables are controlled for, movement in the money multiplier (all else equal) will reflect changes in aggregate lending.[14] It is this argument which justifies use of the multiplier as this investigation's primary dependent variable.

It is also important to note that the above formula for the money multiplier can be reorganized as follows:

$$Money\ multiplier = \frac{1}{r} = \frac{\Delta M1}{\Delta M0}$$

As such, the multiplier can be measured at any point in time as the ratio between M1 and M0. I refer to measurements of the multiplier calculated in this way as the "realized" or "empirical" money multiplier – which has trended downwards over the course of recent history.[15] This variable is plotted over time in Figure 2, which depicts both a general downward trend in the multiplier as well as a dramatic decline which occurred over the course of the recent financial crisis. While intuition dictates that a relationship of some kind likely exists between the crisis and this contraction, there are several theories as to what explicitly might have happened.

Because a similar decline in the money multiplier occurred over the course of the Great Depression, a review of data from this period may inform investigation of the recent crisis. As can be seen in Figure 3, reproduced from Friedman and Schwartz (1963), the monetary base expanded over the course of the Depression while the "money stock" declined.[16]

[14] So long as the currency ratio is also held constant - as discussed shortly.
[15] Unless specified, future use of the term "money multiplier" will refer to the *empirical* money multiplier.
[16] Friedman and Schwartz (1964) define the "money stock" in the same way as M1 is described here.

In considering what caused either collapse, it is useful to recall that the multiplier functions through a cycle of loan and deposit creation. This implies two potential complications which might lead to a breakdown in the multiplier: A) individuals or borrowers may choose not to deposit currency, or B) banks may be either unable or choose not to issue new loans.

Figure 2: The money multiplier, 1984-2010

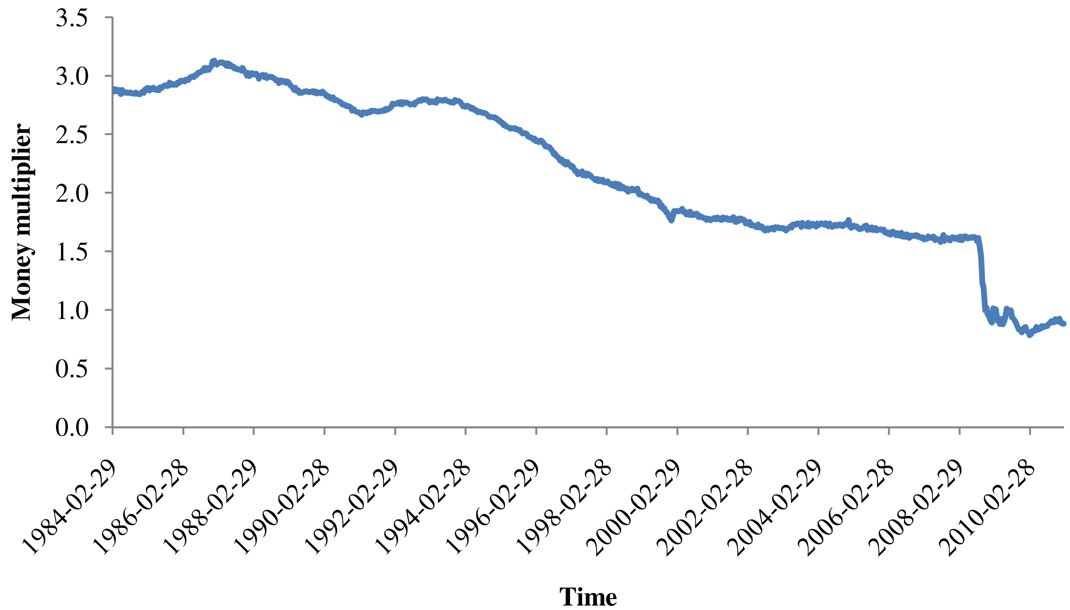
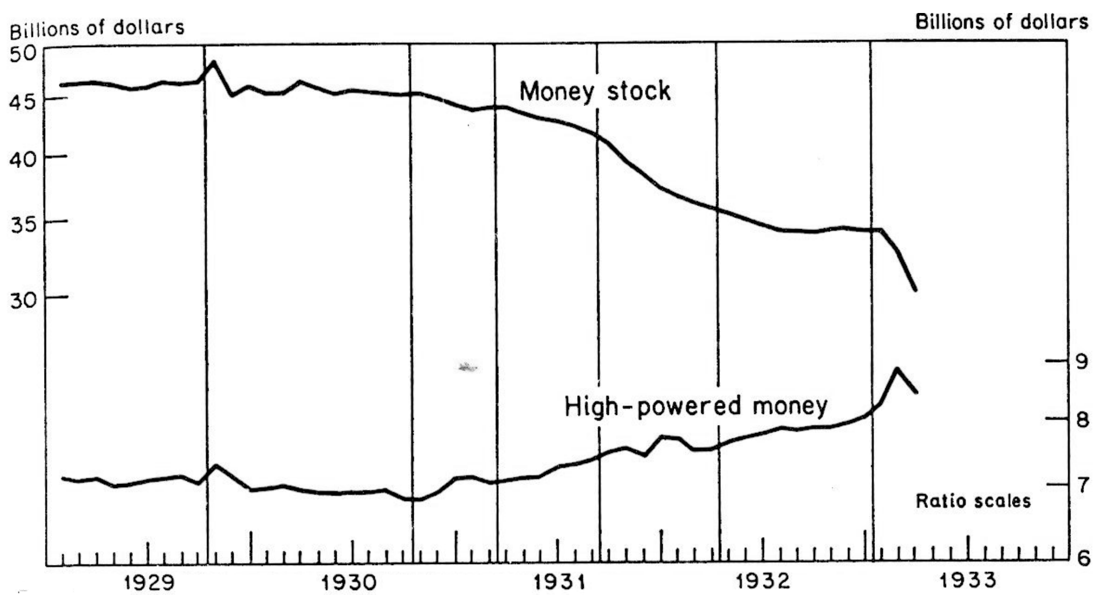


Figure 3: The stock of money, 1929-1933

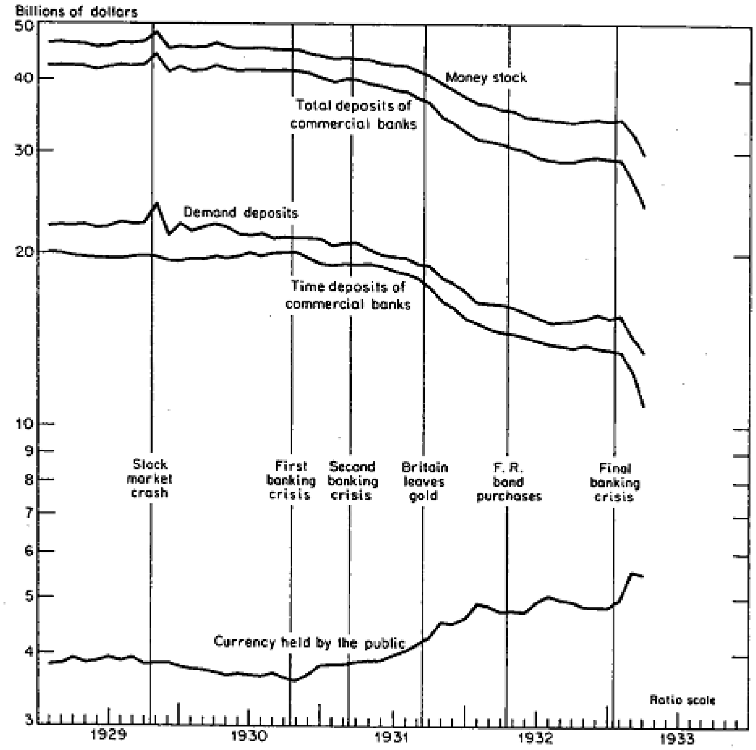


B. The Currency Ratio

Until now, this discussion of the multiplier has assumed that, as banks create new loans, the recipients of those loans will in turn create new deposits – or, in other words, that individuals will always choose to deposit money instead of holding currency. This, of course, is not always the case. In reality, the fraction of money which individuals choose to hold as currency, (versus deposit), is also a variable factor. In aggregate, this is the fraction of M1 which consists of currency, or the "currency ratio" – movement in which can have a large impact on the level of the money multiplier. If, for example, firms and households choose to hold *all* of their money as currency, (currency ratio = 1), banks will hold no deposits and the money multiplier will equal one. By contrast, if the currency ratio is equal to zero, the level of M1 will be a function of the average reserve ratio adopted by banks in aggregate– as will be the money multiplier. Unsurprisingly, the observed currency ratio falls somewhere between these two extremes. In addition, and significantly, the currency ratio need not be static. Thus, if the currency ratio were to shift closer towards a value of one, this would lead to a decline in the money multiplier.

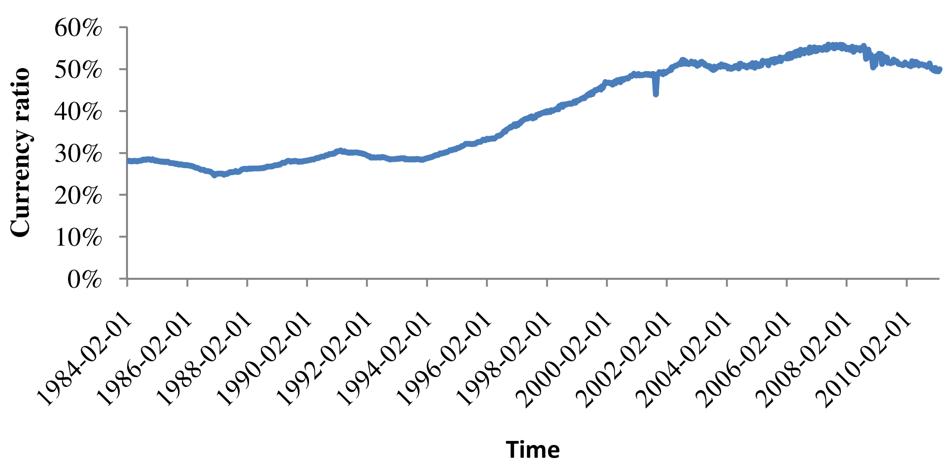
In the case of the Great Depression, Friedman and Schwartz (1963) find evidence that the currency ratio did in fact rise. Figure 4 is reproduced from Friedman and Schwartz (1963), and depicts the money stock, currency, and commercial bank deposits over the period of 1929 to March, 1933. Here, it can be seen that as the money stock, demand deposits, and time deposits fell, currency held by the public increased. This indicates that the collapse in the multiplier which occurred during the Depression can be attributed, at least in part, to a rise in the currency ratio. This story is consistent with Figure 9, which shows the growth rate of the deposit-currency ratio from 1919-1941 and can be found in the Appendix. As can be seen for the early 1930's, growth of this ratio was largely negative.

Figure 4: Money stock, currency and commercial bank deposits



Data from the recent crisis, however, does *not* indicate a large role for growth in the currency ratio in explaining recent declines in the multiplier. Figure 5 plots the currency ratio over time. As can be seen, the currency ratio was largely stable over course of recent years. Given that this is the case, this factor is assumed to be constant within the estimated model.

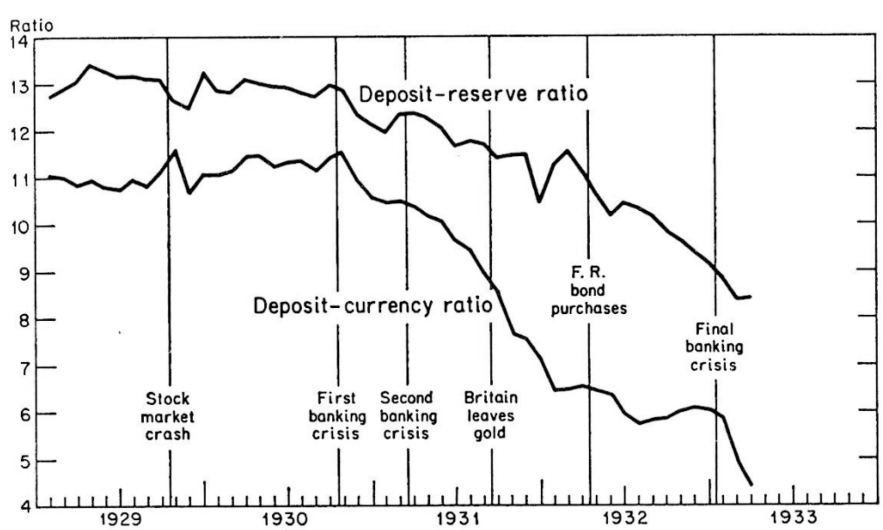
Figure 5: Currency ratio over time



C. Excess Reserves

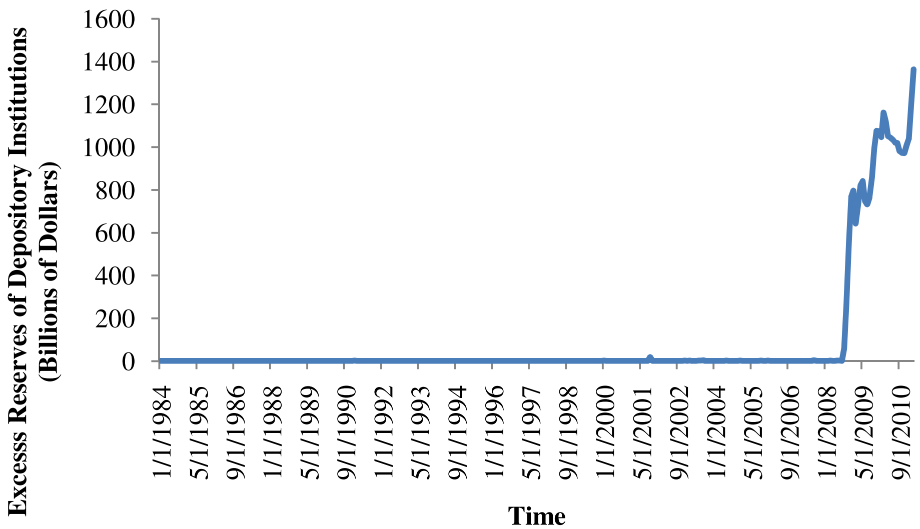
As in the case of a change in the currency ratio, shifts in loan supply or loan demand can also lead to movement in the multiplier. If banks either are unable or choose not to lend deposited funds, this will result in both a decline in the money multiplier and a rise in the excess reserves held by banks. Friedman and Schwartz (1963) find evidence that, in addition to a rise in the currency ratio, the quantity of loans (denominated in dollars) relative to deposits declined during the Great Depression. In their study, bank lending is not addressed in terms of excess reserves, but rather through the lens of the deposit-reserve ratio. Figure 6, also reproduced from Friedman and Schwartz (1963), depicts the downward trend which occurred in the deposit-reserve ratio over the period of the Depression. As it indicates, banks issued fewer loans for each dollar of deposits that they held. Together with the rise of the currency ratio, this phenomenon may explain the Great Depression era collapse of the money multiplier. However, and while this finding is certainly useful, it is also important to note that this analysis fails to distinguish between a fall in loan supply versus a fall in loan demand – either of which could have produced a trend along these lines in the deposit-reserve ratio.

Figure 6: Determinants of the stock of money



Data from recent years show that a similar phenomenon occurred over the course of the Subprime crisis. Figure 7 plots banks' excess reserves with the Federal Reserve over time, and shows that, whereas banks typically minimized their holdings of excess reserves in the years preceding the crisis, the series shows a sharp upward spike beginning in 2008.

Figure 7: Excess reserves over time



This implies that lending was in some way impeded during this period, in turn leading to a fall in the money multiplier. As mentioned previously, there are two explanations for a decline in lending of this nature. The first is a contraction of the loan supply. Alternatively, this trend might also be explained by a fall in loan demand. The process of distinguishing between these is discussed further in sections IV and V, each of which explores the relationship between monetary policy and the multiplier.

III. The Channels of Monetary Transmission

A. Neoclassical Channels

Broadly speaking, the transmission mechanisms of monetary can be divided into two inclusive categories: those stemming from a neoclassical framework, or "neoclassical channels," and those which are based in credit market imperfections. These are aptly named the "non-neoclassical channels." The former category is derived from the neoclassical models of investment put forth by Jorgenson (1963) and Tobin (1969), the income models of consumption postulated by Brumberg and Modigiliani (1954), Ando and Modigliani (1963) and Friedman (1957), and the Mundell-Flemming IS/LM model.[17]

As one of the greatest proponents of Monetary economics, the works of Milton Friedman have greatly influenced economic thought concerning the relationship between change in the money supply and output. Friedman (1970) describes the transmission of change in monetary growth to income and spending in terms of stable demand for money, and through Fisher's quantity theory of money (MV = PT). As opposed to the Keynesian view, Friedman asserts that the velocity of money is fairly stable and that, because prices are sticky, movement in the money supply can impact total output. The transmission mechanism which Friedman proposes falls along these lines: first, growth in the monetary base – whether produced via open market operations or otherwise – will raise the cash holdings of firms and households relative to their other assets. If those individuals have consistent wealth allocation preferences, this implies that they now hold excess cash, and will try to adjust their portfolios by buying other assets. Of course, one individual's spending is another's income, implying that those selling assets will now hold excess cash, and as a result will seek to adjust their portfolios...and so on. While all people

[17] Boivin et al. (2010).

together cannot change the amount of cash that all hold, each individual will attempt to do so on a personal basis – causing a rise in asset value that spreads from asset to asset. Cumulatively, the introduction of excess cash into the portfolios of certain individuals will lead to a rise in Aggregate Demand (AD), and (given sticky prices) subsequently to a rise in output.[18]

While entirely sensible, Friedman's hypothesized AD transmission mechanism provides only a vague explanation for the path that new money will follow as it diffuses from the cash accounts of balance sheets to its final impact on output. As a result, an abundance of theories have been penned seeking to describe the relationship between monetary variables and *components* of national output more specifically – and as based on classical economic classical economic theory. These are the "neoclassical" channels, a semi-exhaustive list of which can be found below. These include the:

I. **Interest Rate Channel**: the direct interest rate or "cost" channel involves the impact of interest rates on the cost of capital, and therefore on business and household investment decisions. Should general short term interest rates rise, so too will individual firms' and households' cost of capital, leading to a decline in aggregate investment. Because a monetary expansion will lead to a rise in the value of interest bearing assets, so too will that expansion be linked to the level of interest rates.
II. **Inflation expectations channel**: Boivin et al. (2010) finds that a shift in monetary policy may (at times) credibly signal the Federal Reserve's commitment to pursue a specific policy over the course of an extended period of time. If this is the case, that signal will reduce (raise) inflation expectations and therefore have an impact on the level of real interest rates. This, in turn, will lead to a contraction (expansion) of investment, and overall aggregate economic activity.
III. **"Consumer wealth" or "consumption" channel**: an expansionary (contractionary) monetary policy will have the effect of increasing (decreasing) the average value of interest bearing assets. Higher (lower) levels of wealth will then lead to greater (reduced) levels of consumption.
IV. **Export stimulus channel**: A monetary shock may, as previously described, have an impact on inflation expectations. If such a shift occurs, it will be reflected in international exchange rates. An expansionary (contractionary) shock will then lead

[18] Friedman (1970).

to a devaluation (appreciation) of the currency, and subsequently to marginally more (less) competitive pricing for exports.

V. **Term structure channel**: If movement in the federal funds rate signals a long term policy commitment to financial markets, the term structure of interest rates will adjust to reflect this fact. If the policy commitment conveyed is expansionary (contractionary) long term rates will fall (rise), leading to an expansion (contraction) in those segments of investment which are sensitive to changes in long term interest rates.

VI. **Tax burden channel**: because changes to the federal funds rate are enacted through the sale or purchase of government securities, changes in policy will have the effect of either reducing or expanding the interest expense which the Federal government will eventually have to repay. Thus, an expansionary policy will reduce the government's expected future interest expense, lower the expected future tax burden for citizens, and lead to higher levels of consumption.

VII. **Tobin's q channel:** If monetary policy is eased and interest rates are lowered, demand for stocks will increase and stock prices rise. For firms whose equity will then be in greater demand, the cost of capital will have fallen, thereby leading to increased investment spending and a rise in aggregate demand.[19]

While these channels are not the focus of this investigation per se, a motivating factor for research on the credit channel is that empirical studies of aggregate spending have failed to identify a quantitatively important effect of the cost of capital variable.[20] That is, the neoclassical explanation of monetary transmission fails to fully describe the impact of monetary shocks on aggregate output – and further, several of the puzzles which the neoclassical view cannot explain seem to hint at the potential importance of a credit channel.

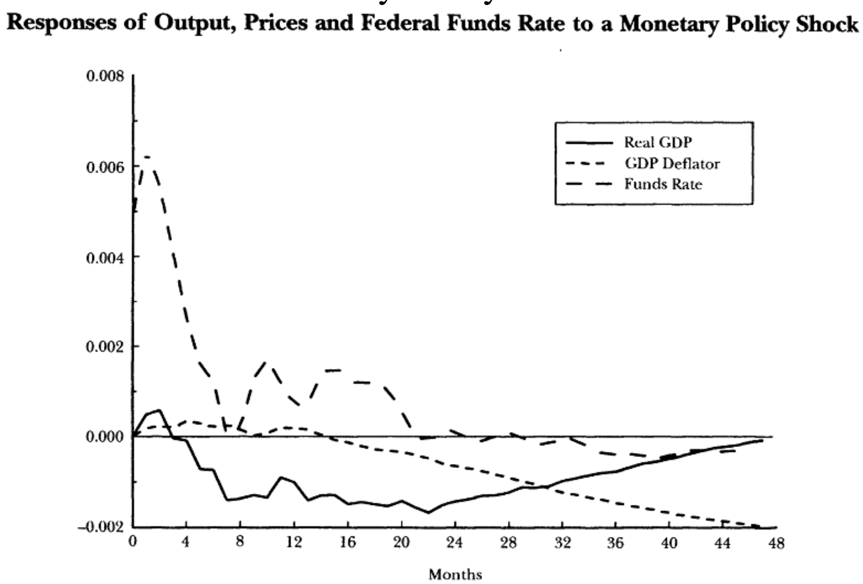
First among these is the so called *magnitude puzzle* of monetary policy. More specifically, and as Bernanke and Gertler (1995) finds, the real economy is powerfully affected by monetary policy changes which induce relatively small movements in open-market interest rates. Simultaneously, and as previously mentioned, empirical studies have typically *not* found

[19] Boiven et al. (2010).
[20] Bernanke and Gertler (1995).

commensurately strong relationships between the cost-of-capital and various components of private spending.[21]

Another issue stems from the *timing* of policy effects. Bernanke and Gertler (1995) find that the interest rate spike associated with an unanticipated monetary tightening is largely transitory in nature. According to their analysis, the federal funds rate will have virtually reverted back to trend after eight to nine months following the shock, as shown by Figure 8.

Figure 8. Responses of Output, Prices and federal funds Rate to a Monetary Policy Shock.



Reproduced from Bernanke & Gertler (1995).

However, reactions in the various components of spending which are associated with this shock do not, for some, begin to appear until after much of the interest-rate effect has passed. This puzzle in particular provides evidence for the potential impact of a *supply* shock to credit, since we would expect a *demand* shock to dissipate quickly with the normalization of interest rates.

[21] Bernanke and Gertler (1995).

A final issue is the *composition puzzle*. More specifically, while monetary policy has its most direct effects on short-term rates, the most rapid and strongest (in percentage terms) effect of a monetary shock is on residential investment. This is puzzling because residential investments are longer lived, and should therefore be sensitive to long-term real interest rates, not short term. Rather than residential investment, we would have expected that the most significant impact of a monetary shock would arise through spending on assets with shorter lives, such as inventories and consumer durables.[22]

B. The credit channel:

B.i Overview of the channel

As previously described, credit market imperfections sometimes interfere with the smooth functioning of financial markets. For firms, this will introduce a wedge between the cost of internal funds and that of external finance – which Bernanke and Gertler (1995) describes as the *external finance premium* (EFP). This premium is a reflection of deadweight costs associated with principal agent problems, and can be formulated as follows:

$$EFP = r_{firm} - E[R_{bank}]$$

If a monetary shock has the effect of either expanding or reducing the size of the external finance premium, a credit channel will then exist in which credit market imperfections have a direct influence on the impact of monetary policy. More specifically, and in the event of a monetary shock which leads to a shift the EFP, lending and M1 will respond to movement in M0 in a way which cannot solely be attributed to a change in the level of interest rates. According to the credit view, a change in monetary policy which lowers or raises the level of interest rates will

[22] Bernanke and Gertler (1995).

tend to change the EFP in the same direction.[23] Thus, controlling for movement in interest rates, a change in M0 will be expected to have no impact on the level of the money multiplier, (given an adjustment lag in which a change in lending can occur). By contrast, if a monetary shock does *not* affect the EFP – or if the credit view does not hold – then the only adjustment which will occur in M1 via lending will be the result of a shift in the general level of interest rates. If this is the case, and if movement of interest rates are controlled for, the expected relationship between change in M0 and the money multiplier will be strictly negative. But why, as the credit view holds, should the policy of the central bank have an effect on the external finance premiums of private credit markets? In this section I describe two possible linkages, the "balance sheet channel" and the "lending channel."[24]

B.ii The balance sheet channel

The balance sheet channel arises from the problems of asymmetric information which occur between banks and potential borrowers. Here, banks must take steps to ensure that, once a loan has been issued, firms employ that capital in a way which is consistent with the interests of the bank. The potential conflict of interests is mitigated through mechanisms such as monitoring (the cost of which will be passed on to borrowers through the external finance premium), contracts, and the use of firms' assets as collateral. This final method, collateralization, is especially significant in that firms which boast a stronger balance sheet will be in a better position to reduce the potential conflict of interest – either by co-financing a greater share of a hypothetical investment,

[23] Bernanke and Gertler (1995).
[24] Bernanke and Gertler (1995).

or by offering additional collateral to guarantee their liabilities.[25] If monetary policy impacts the state of potential borrowers' balance sheets, monetary shocks will then be directly linked to the level of the external finance premium.[26]

Monetary policy may influence firms' and households' balance sheets in a number of ways. First, and to the extent that borrowers have outstanding short-term or floating-rate debt, a rise in short term interest rates will directly lead to a rise of interest expenses. Because many firms rely heavily on short-term debt in order to finance both inventories and working capital, this effect can be potentially quite significant.[27] Next, a contractionary monetary policy will lead to an aggregate decline in the value of both interest bearing and overall assets. This decline will weaken the potential borrower's collateral position – leading to higher costs of capital for those firms which must use collateral in order to mitigate asymmetric information.

A monetary shock may also impact balance sheets indirectly. For companies which market their goods to other firms, if a monetary tightening leads to reduced spending by customers (for either cost-of-capital or balance sheet reasons), revenues will decline while fixed and quasi-fixed costs (such as interest and wages) will not adjust in the short run. [28] The resulting difference between the firm's uses of cash and cash inflows will then erode the firm's net worth and creditworthiness over time.[29]

Of course, the balance sheet channel need not function solely in the context of *contractionary* monetary policy. As Benmelech and Bergman (2009) notes, "by injecting

[25] Bernanke and Gertler (1995).
[26] Bernanke and Gertler (1995).
[27] Bernanke and Gertler (1995).
[28] Bernanke and Gertler (1995).
[29] Bernanke and Gertler (1995).

liquidity into the banking sector, monetary policy [may] shift banks' lending calculus as they know that increased aggregate lending will influence collateral values."

Importantly, this view implies that firms which depend on banks for external finance will be disproportionately affected by the course of monetary policy. Dependence on bank financing may occur if the costs of accessing public credit markets – including fees associated with the provision of audited financial information, and/or intangible costs incurred through the divulgence of key business model details – are prohibitively expensive. For borrowers which are unable to meet these costs, (primarily of smaller firms), the impact of monetary policy via a balance sheet channel will be especially pronounced.[30]

Oliner and Rudebusch (1996) investigate the balance sheet channel on the basis of this implication. Because the balance sheet channel view predicts a disproportionate effect of monetary policy for small firms versus large, Oliner and Rudebusch (1996) compares the relationship between internal funds and investment decisions for large and small manufacturers. As they find, the link between internal funds and investment *does* become closer following a monetary contraction for small firms, but does not for larger firms. This finding supports the existence of a broad credit channel; however, during episodes of monetary easing, Oliner and Rudebusch are unable to identify any significant change in the link between liquidity and investment from that prevailing at other times.[31]

The asymmetry of results found by Oliner and Rudebusch (1996) for periods of tight money versus easy money is consistent with the theoretical work describing the balance sheet channel (see, for example, Gertler and Hubbard (1988), Bernanke and Gertler (1989), and

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[30] Gertler and Gilchrest (1993).
[31] Oliner and Rudebusch (1996).

Stiglitz (1992)). As these works indicate, firms' and households' balance sheets will affect their ability to borrow primarily when their net worth is low. When firms or households seek external finance for an investment at other times, balance sheet considerations will become secondary. This theoretical argument does, however, indicate that the balance sheet channel may play a significant role during some periods of expansionary policy – if balance sheets are particularly weak. Thus, the balance sheet channel may have functioned throughout the episode of the Subprime crisis – in which the strength of balance sheets generally declined and monetary policy was expansionary.[32]

Cumulatively, the balance sheet channel implies an expected relationship between M0 and the money multiplier. If monetary policy is negatively related to the EFP – as predicted by this view – then an expansion of M0 will lead to a decline in the EFP, a rise in both the demand for loans and M1, and ultimately to a *static* money multiplier.

B.iii The bank lending channel

Monetary policy may also be linked to the external finance premium via a "bank lending channel." This view holds that, because monetary policy will either increase or decrease bank reserves, monetary shocks will shift the supply of bank loans.[33] Because "bank dependent" borrowers will not be *literally* shut off from other forms of credit, movement in the supply of bank loans will have an impact on the EFP. In the case of a contractionary shock which disrupts the supply of loans, for example, borrowers face high costs in locating a new lender. In fact, the information that banks have about their customers may be critical to the borrower's ability to

[32] Bernanke (2009).
[33] Boivin et al. (2010).

obtain loans. If a bank is unable to lend to a firm as a result of a monetary shock, other lenders – who do not possess the same information – must charge that firm a higher rate of interest. In extreme cases, firms which are unable to borrow from long term partner banks may be unable to find any new source of financing.[34] This indicates that contractionary monetary innovations will cause the EFP to rise.

In the case of an expansionary policy, the story is symmetrical. Because the expansionary policy will increase bank reserves, the quantity of bank loans available will shift outwards. Banks will issue more loans to borrowers with whom they have established a relationship, leading to a fall in the aggregate EFP. In turn, borrowing will increase – causing aggregate investment, consumer spending, and national output to rise. This implies that, as in the case of the balance sheet channel, bank dependent firms will be disproportionately impacted by a change in monetary policy.

It is important to note that the bank lending channel is intrinsically linked to the balance sheet channel. For example, if a Federal Reserve policy affects an increase in bank lending, that policy will in turn impact firms' and households' balance sheets. This will occur because the value of a firm's assets is determined, at least in part, by the liquidity of industry peers.[35] This implies, in turn, that with an injection of liquidity, the average value of firms' asset will rise to allow for greater collateralization of loans and even greater availability of credit. To see this, consider the value of capital which can be used only in the context of a single given industry. Because that capital cannot be efficiently employed elsewhere, if firms within that industry face a period of reduced liquidity, the value of that asset will decline and the firm which owns it will

[34] Romer and Romer (1990).
[35] Benmelech and Bergman (2009).

have reduced access to credit owing to collateral considerations. If, however, liquidity is reintroduced into the market – in this case the group of firms which constitute our hypothetical industry – then both the value of that asset and the availability of credit will rise.

Because the bank lending and balance sheet channels are complimentary, the relationship between M0 and the multiplier which is implied by the lending channel also must be negative. Thus, if the credit view holds *in general*, an expansion of M0 will lead to a decline in the EFP, a rise in both the demand for and supply of loans followed by an expansion in M1, and finally to a static money multiplier. However, and as has been previously mentioned, even should evidence for the existence of a neutral relationship between M0 and the multiplier be found, this will not *prove* that the credit channel exists. The same relationship may be found if movement in M0 coincides with changes in lending for purely coincidental reasons, or if both variables are predicted by a third.

B.iv Building blocks of the lending channel

In order for the lending channel to operate, certain conditions must hold. Cumulatively, these can be described as the building blocks of the lending channel.[36] The most obvious of these is that prices be sticky in the short run. After all, if prices were to adjust to a monetary shock without a lag, any increase in the level of investment resulting from that shock would exist purely in nominal terms. The rigidity of short term prices is a theory which has been met with widespread acceptance within the economic community, and as such, has been the subject of relatively little empirical investigation. One study which *does* seek to explore this issue is

[36] A description borrowed from Kashyap and Stein (1994), which provides an in depth analysis of the various preconditions which must be met in order for a lending channel to operate.

Kashyap (1995), which examines the frequency of changes in nominal prices. This study finds that, for a wide range of goods which are sold at relatively high volumes, prices change relatively infrequently – which is consistent with short term price rigidity. Other conditions which are necessary for the existence of a credit channel are more subtle, and more controversial in nature.

One such requirement is that, for at least some firms, security issuance and bank loans must not be viewed as perfect substitutes as sources of funding. This assumption, which has developed a significant literature in its own right, may be more intuitive than it at first appears to be. [37] Small businesses, for example, may depend on banks for funding as a result of their higher costs of monitoring – and because, for firms of this nature, the costs of accessing public credit markets will be prohibitively expensive. A company need not be small, however, in order to depend on banks for financing. If a company's business model is such that its details cannot be publicly disclosed, the cost of monitoring that firm will be much greater for individual investors than for a single intermediary. If all firms had equal access to both bank loans and public credit markets – or if the EFP did not exist, in other words – there could be no difference in cost between public and private debt. Firms seeking to attract external funds would always choose the cheapest source of financing – be it public debt, private, or otherwise – which would have the effect of arbitraging away any price difference between the various sources of funding. As such, the availability of credit would not depend on monetary policy; rather, in this case the level of aggregate investment will be influenced by monetary shocks only through the market level of interest rates, and as a result of the impact of wealth creation.

Diamond (1984) provides some evidence that this is not the case, developing a theoretical framework in which financial intermediaries represent efficient vehicles for

[37] Peek and Rosengren (1995).

minimizing the costs of monitoring certain types of borrowers – a finding which implies that, for those borrowers, public debt will be an imperfect substitute for bank loans.[38] In addition to theoretical work, a number of empirical studies support the notion that bank loans are somehow "special." Among these, Fama (1985) and James (1987) show that the cost of reserve requirements initially borne by banks are ultimately passed on to borrower. This finding indicates that, since borrowers are willing to bear these costs, bank loans perform some service for borrowers which other sources of funding do not.[39]

A final condition for the lending channel to function is that, as a whole, the intermediary sector must not be able to completely insulate its lending activities from the effects of a monetary shock to reserves. That is, in the event of a contractionary shock, banks must be unable to offset the change in transaction deposits by either switching from deposits to less reserve-intensive sources of financing, or by paring their net holdings of bonds.[40] For an expansionary shock, the story is symmetrical. Thus, and if this is true, adjustment to banks' balance sheets following a monetary shock will occur at least in part via a change in loans. In aggregate, this will constitute a shift in the aggregate supply of loans, and will have important real consequences on both investment and on output.

This condition may also be couched in terms of banks' portfolio preferences. As Kashyap and Stein (1994) discusses, at any given point a bank faces the possibility of random depositor withdrawals. Because liquidating loans on short notice in order to meet depositor demand can be very costly, banks tend to hold a portion of their assets in easily marketable securities – such as

[38] Kashyap and Stein (1994).
[39] Kashyap and Stein (1994).
[40] Kashyap and Stein (1994).

T-bills.[41] What this implies in turn is that banks are not indifferent between asset compositions – or in other words, that each bank has an ideal portfolio composition which dictates its asset allocation, and which depends on that bank's circumstances. If this is the case, and in the event of a monetary shock which either reduces or expands a bank's reservable deposits, we would expect that bank to adhere to its preferred portfolio compositions as best as it is able – and to the extent that those preferences remain constant. It then follows that monetary policy will have an impact on the availability of loans.[42]

While each precondition for the existence of a lending channel may be challenged in its own right, the overall academic landscape – consisting of both theoretical and empirical findings – seems to support their cumulative plausibility. Further empirical evidence for and against the existence of the credit channel is discussed more extensively below.

B.v Previous research

As previously mentioned, one implication of the credit channel is a disproportionate effect of monetary policy on smaller firm – thus, a large number of cross-sectional studies have been conducted in order to test for such a trend. Gertler and Gilchrist (1994) is typical of these, and employs quarterly time series of inventory, sales, and short-term debt data available for manufacturing firms to find that a differential impact to monetary policy is in fact felt between small and large manufacturers. Oliner and Rudebusch (1992) and Iacoviello & Minetti (2007) employ a similar methodology, examining manufacturing data and data from housing markets within the EMU respectively. Both find a significant role for the credit channel**.** Kashyap et al.

[41] Kashyap and Stein (1994).
[42] Kashyap and Stein (1994).

(1992) comes to a similar conclusion – using firm-level inventory data for firms which do and do not have bond ratings, and finding that inventory movements for firms which do not have bond ratings are much more dependent on credit conditions than are those for larger firms'.

Kashyap and Stein (1995) further pursues a cross sectional approach to the investigation of the credit channel by disaggregating data on bank balance sheets between small and large banks. The premise of the study is that, because smaller banks are more likely to have difficulty substituting from reservable deposits to non-deposit sources of funding, monetary shocks should have a differential impact on the lending behavior of large versus smaller banks. Kashyap and Stein (1995) finds evidence that this is the case – within their study, smaller banks were less able to insulate their lending activities from the impact of a monetary shock.

So too have VAR frameworks frequently been applied to the investigation of the credit channel. One such study is Bernanke and Blinder (1992), which finds via a VAR framework that loans decline (with a lag) following a tightening of monetary policy – supporting the existence of a credit channel. Similarly, Bayoumi and Darius (2011) finds that direct measures of credit conditions anticipate future movement in asset prices, indicating that credit supply drives other financial variables (rather than responding to them) and supporting the potential importance of the lending channel. Despite the apparent strength of these conclusions, and as is noted by critics of the credit view, these approaches fail to disentangle the reduction in loan demand from a reduction in loan supply – and thus may be viewed as only weak evidence for the existence of the lending channel.[43]

Evidence which explicitly *conflicts* with the existence of a lending channel can be found in Romer and Romer (1990), which examines changes in the money supply and bank lending during the Volcker disinflation. In this case, Romer and Romer find that data from this period do

[43] Peek and Rosengren (1995).

not support a causal relationship between financial variables and real output. They argue that this may be due to a breakdown in the conditions necessary for the existence of a lending channel – or, more specifically, that "because reserve requirements on certificates of deposit are low, banks can obtain [non-deposit] funds with little cost in terms of reserve holdings." In turn, this argument is challenged by Kashyap and Stein (1993, 1994), which asserts that federal subsidies to deposit financing (via federal deposit insurance) make CDs and other forms of less-reserve intensive funding inferior substitutes to deposits. Another study of note is Carpenter and Demiralp (2010), which investigates the lending channel specifically in terms of the money multiplier. As Carpenter and Demiralp find, the level of reserve balances (defined as balances deposited by commercial banks with the Federal Reserve) cannot be causally linked to change in the level of deposits. This is inconsistent with the money multiplier story, and is taken as evidence against the existence of a credit channel. However, this study may be flawed in that banks' deposits with the Federal Reserve are taken as an indicator of bank reserves in general – which need not be the case.

Findings regarding the balance sheet channel have been much less controversial. Bernanke and Gertler (1995) typifies work investigating the balance sheet channel, and demonstrates that its existence can help resolve a number of inconsistencies between the neoclassical explanation of monetary transmission and the data.

Because empirical research tends to support the existence of both the balance sheet and lending channels, this investigation operates under the assumption that both may play a significant role in the transmission of monetary policy. That said, it is important to note that, though the credit channel of monetary transmission may exist, so too could it at times become impaired – or even break down entirely. In the event that evidence against the operation of the credit channel is brought to bear, it is then pertinent to explore the potential reasons why, within this study's particular data set, that channel may not have functioned.

V. Theories of Credit Channel Impairment

As has been a general theme of this paper, if either banks' lending behavior or the creditworthiness of potential borrowers is affected by an exogenous event, this may lead to important real consequences for aggregate investment and the economy. The question which this section explores is: if a separate event has such an impact and precedes a monetary shock, will the transmission of that shock be significantly altered relative to other or "normal" times? I argue that a financial crisis constitutes such an event, and that as a result, it is reasonable to expect that the transmission of monetary policy throughout the recent financial crisis differed significantly from the period which preceded it. The theory that financial crisis will impact the functionality of credit markets is largely intuitive or even obvious; however, because credit markets are complex, the attempts to restate this theory in more rigorous terms have been prolific. The most important or widely known of these are explored in detail below. Though these theories differ significantly in their formulation, they do not necessarily compete.

A. "Capital crunches" – deleveraging and the threat of depositor discipline:

One theory for the impairment of credit markets stems from the history of the Great Depression – and is based in the costs imposed by principal agent problems between bankers and their creditors. Because of issues of asymmetric information, (as formalized by Diamond, 1984, and discussed earlier within this paper), banks face strong incentives to offer extremely short term (typically demandable) low risk debt.[44] More specifically, banks will tend to segment their risk such that it is highly concentrated in the equity and debt holdings of insiders. When adopted, this segmentation serves to insulate depositors from the risk of loans whose quality they will be unable to evaluate without enduring significant costs. In effect, banks must offer low-risk debt because such debt protects depositors from inappropriate bank behavior. [45]

As a result of this finding, the principal agent problem between banks and depositors holds strong implications for the ways in which banks are likely to respond to shocks. For example, if a bank experiences unexpected loan losses, the riskiness of bank debt will consequently rise. Depositors who were previously content with the expected return/risk (or Sharpe) ratio of their deposits will then react in one of two ways: A) by demanding a higher return to their deposits, or B) by withdrawing their deposits and placing them into other banks which they perceive to be more safe.[46] In this scenario, banks will face strong incentives to lower depositor risk; however, the only practical means of accomplishing this will be either through the issuance of new equity in order to raise capital, or by liquidating some portion of the bank's portfolio of risky assets.[47]

Of course, in the context of an economic downturn, both of these options are potentially very costly. The issuance of new equity may entail significant costs as a result of the problem of adverse selection (lemons problem) inherent to the issuance of equity – costs which will be grossly exaggerated during a period in which the relative extent of bank loan losses is largely an unknown factor. In other words, potential investors will face high costs in distinguishing good

[44] Calomiris and Wilson (1998).
[45] Calomiris and Wilson (1998).
[46] A potential criticism of this argument is that depositors will be unable to observe their banks' portfolios. However, as discussed within Calomiris and Wilson (1998), "even if depositors cannot observe the precise characteristics of [their] bank's portfolio, they can observe economic downturns and make projections about the consequent average loan losses experienced by banks."
[47] Calomiris and Wilson (1998).

from bad bank loan portfolios, and will pass those costs along when purchasing the new equity of banks which choose to issue.[48] Further, Kashyap and Stein (1995) shows that smaller banks have a marginally poorer ability to attract marginal sources of funding. Thus, the costs of issuing equity will be disproportionately higher for small banks. Significantly, small banks are those which primarily broker in loans to smaller businesses.

So too will the sale of risky assets entail significant costs. If many banks simultaneously liquidate loans, the effect may be to flood the market for risky assets and lead to fire-sale prices. In addition, such a reaction have the potential effect of placing borrowers into financial distress. Both effects, if realized, will diminish the value of unsold bank assets and further deplete bank capital. Finally, and because banks build valuable customer relationships over time,[49] the severance of ties with a loan customer implies the loss of assets which earn quasi-rents for banks.[50] The question which then arises is this: which of these two potentially costly options will constitute the least cost response to unanticipated capital losses?

As Calomiris and Wilson (1998) find, in the context of the Great Depression "reductions in bank lending were the least-cost response, given the desirability of avoiding both depositor 'discipline' and the adverse selection costs of raising new equity." This finding, that the *supply* of bank loans diminished following the Depression rather than *demand*, holds strong implications for the functionality of the credit channel during periods of financial crisis. During the Great Depression, for example, it seems unlikely that a large scale expansion of the monetary base (enacted through the purchase of government debt) would have translated into a rise in the availability of loans. Banks at that time bore significantly more risk than was desirable given the need to limit risk for depositors. The risk of standing loans had been upwardly reassessed, and as

[48] Calomiris and Wilson (1998).
[49] See Calomiris (1995) for empirical evidence.
[50] Calomiris and Wilson (1998).

Calomiris and Wilson (1998) finds, a shift occurred in banks' ideal portfolio allocations towards riskless assets. This trend can be seen in the plot of the deposit-reserve ratio depicted in Figure 6 and, significantly, a similar trend is depicted in Figure 7 using data from the recent crisis. In the case of the Great Depression, Calomiris and Wilson argue that this development led to the widespread unavailability of bank loans. Thus – even had the balance sheets of potential borrowers improved, or had the level of transaction deposits increased – banks would almost certainly not have issued new loans.

The example of the Great Depression may then potentially be generalized into a theory of "capital crunches." An implication of such a theory is that, during a period in which the riskiness of bank assets has been upwardly reassessed (or a period in which loan losses exceed expectations), expansionary monetary policy will fail to translate into an increased availability of loans. This view is echoed within Meh and Moran (2009), an investigation of the role of bank capital in propagating the subprime crisis shock. Meh and Moran (2009) develops a DSGE model which allows for the endogenous determination of bank capital, and finds that a bank's capital position may affects its ability to attract loanable funds. As they find, a theoretical channel exists through which bank capital may potentially influence the business cycle.[51]

This theory, however, may fail to explain the lending behavior of commercial banks over the course of recent years.[52] First, a precondition for the onset of a capital crunch is that banks face difficulty in seeking to reduce their leverage via the sale of risky assets. Because one aspect of the Federal Reserve's response to the crisis was a program of targeted asset purchases – in

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[51] Meh and Moran (2009).

[52] The role played by and effect upon *investment* banks during the Great Recession may merit an entirely separate investigation. In any case, investment banks are less relevant to the credit channel than are commercial banks, since the latter are generally the originating source of bank loans. Of course, as a result of securitization, the general health investment banks is also pertinent to an investigation of the credit channel. However, this is true only insofar as *overall* bank lending is subject to securitization - and regardless of whether certain, specialized types of bank loans are commonly securitized (unless these loan classes constitute a significant fraction of overall bank loans).

which mortgage backed securities (MBS') and other assets whose risk had been upwardly reassessed were removed from bank balance sheets – this condition may not have held.[53] Even more damaging to this view is the fact that, as a result of the introduction of Federal Deposit Insurance following the Great Depression, banks may no longer face the threat of depositor discipline. This point is emphasized by Calomiris (2009), which provides a survey of financial crises and banking regulation within the United States, and argues that – even in the event of significant capital losses – banks will have no incentive to deleverage and limit depositor risk.

Finally, there is a certain amount of evidence which, through the lens of casual empiricism, would seem to indicate that a capital crunch story cannot fully explain the lending behavior of banks throughout the Subprime crisis. Most strikingly, from the onset of the crisis until September, 2008, western banks were able to raise some $400 bn in capital from a variety of sources.[54] Nonetheless, though large, this sum may have proved insufficient in helping banks to delever. Further, banks' ability to raise capital may not have been uniformly distributed. As a result, the possibility of a capital crunch is not excluded from this investigation, and a proxy for banks' capital levels is included within the model.

B. "Credit traps" - the role of collateral values and liquidity:

The credit channel may also become impaired in the event that a "credit trap" arises. In this case, the flow of loanable funds from banks to potential borrowers will be severed if circumstances conspire such that banks are encouraged to hoard liquidity. This theory focuses on a feedback loop between the strength of firms' balance sheets, the liquidity of those firms' assets, and the dual role played by assets as collateral for bank lending. As opposed to the problem of a

[53] Bernanke (2009).
[54] Croft (2008).

"capital crunch" – which stems from principal agent problems between banks and their *creditors* – a "credit trap" may arise as a result of the asymmetric distribution of information between banks and *potential borrowers*. Benmelech and Bergman (2009) describes the feedback loop which may lead, in certain circumstances, to the onset of a credit trap. According to this description:

> "Increases in collateral values allow greater lending due to the attendant reductions in financial frictions; Greater lending, in turn, increases liquidity in the corporate sector; Finally, increases incorporate liquidity serve to increase collateral values, as these are determined in part by the ability of industry peers to purchase firm assets."[55]

Benmelech and Bergman (2009) explores this feedback loop via a general equilibrium model in which collateral values are endogenously determined. Within this framework, the authors find three mutually exclusive types of potential equilibria. The first of these – which the authors describe as the 'conventional equilibrium' – occurs when collateral values are high, and allows monetary policy to successfully influence aggregate lending activity.[56]

The second type of equilibrium identified by Benmelech and Bergman is that of a "credit trap." In this equilibrium, lending is constrained by prohibitively low collateral values, which are therefore unable to mitigate the principal agent problem which occurs between banks and potential borrowers. In order for collateral values to rise, banks will need to inject liquidity into the corporate sector so as to increase firms' abilities to purchase the assets of other industry participants. However, in this case, the marginal increase in collateral values which such an injection would produce, and the associated increase in the affected firms' debt capacity, is not sufficiently large to induce banks to lend. As a result, banks may rationally choose to hoard

[55] Benmelech and Bergman (2009).
[56] Benmelech and Bergman (2009).

liquidity throughout the course of a monetary expansion, and regardless of the amount of liquidity injected into credit markets by the central bank.[57]

Benmelech and Bergman (2009) also identify a third type of equilibrium, which they dub the 'jumpstart' equilibrium. In this case, monetary policy can be effective, but only when the central bank injects liquidity with sufficient force. If only a moderate amount of reserves are distributed to banks, they will understand that making new loans will produce too small of a rise in collateral values to justify the disbursement of funds. However, if monetary policy is eased sufficiently, rational expectations will dictate a high lending, high collateral value outcome.[58] Interestingly, this finding may provide a justification for the Federal Reserve's recent program of quantitative easing.

Because this model implies a large role for collateral asset values, a proxy for general asset values is included within the model. If it can be shown that asset values played a significant role in determining bank lending throughout the Subprime crisis, this will constitute evidence for the presence of a credit trap.

D. Regulation - binding capital-to-asset ratios:

Another theory regarding the impairment of the credit channel stems from the role of regulation, and the changes in bank lending which capital-to-asset ratio requirements may impose. As Peek and Rosengren (1995) describes, "a bank facing a binding capital-to-asset ratio will be unable to expand its assets in response to an easing of monetary policy, even if loan demand increases with the ease in policy, since it is a shortage of capital, not reserves, that is preventing the bank from increasing its lending." Much like the theory of "capital crunches,"

[57] Benmelech and Bergman (2009).
[58] Benmelech and Bergman (2009).

then, this view emphasizes the depletion of bank capital as a potential source of impairment to the credit channel. As opposed to a "capital crunch," however, capital ratio requirements will not dynamically interfere with the credit channel. Rather, the relationship between capital ratio requirements and the credit channel will be binary in nature – either having no impact, or else totally removing banks from credit markets as providers of new loans.

Peek and Rosengren (1995) investigates the role of capital constraints on banks' differential reactions to monetary shocks and, in accordance with this argument, finds that capital constrained banks are unable to contribute to the transmission of monetary policy through a lending channel. Thus, as Peek and Rosengren argue, investigations of the impact of monetary policy that do not allow a role for bank capital can potentially produce misleading results.[59] Further, if the period in question includes a change to capital ratio requirements, that change must somehow be taken into account.

As a result, this study allows a role for bank capital – as proxied through returns to the BKX banking index. Though the Basel II accord has stipulated changes to capital requirements since its original publication in 2004, those changes have yet to be properly implemented. As such, no changes to capital ratio requirements occurred over the period investigated by this study.

[59] Peek and Rosengren (1995).

IV. The Subprime Crisis, 2007-2009

The Subprime Crisis – otherwise known as the "Great Recession" – has featured a disruption of financial intermediation on a scale which has not been seen since the Great Depression.[60] The crisis began in the U.S. housing market – first with a decline in housing values, and followed by an unexpected rise in delinquency rates for subprime mortgages. Because the boom in subprime lending was only a part of a larger credit boom – fueled by the global savings glut and low short term interest rates, amongst other factors – the crisis soon spread to other forms of credit. A broad range of asset markets, such as those for securitized loans, became impaired to the point that financial institutions depending on those markets suffered large losses on their investments. This, in turn, lead to a widespread reduction in the availability of credit. The crisis peaked in September, 2008, when the failure (or near failure) of many financial firms shook investor confidence and resulted in a total freeze of national financial markets.[61]

In responding to the crisis, the Federal Reserve has utilized a wide array of tools. Some of these, such as the federal funds rate, are traditional mechanisms which are relatively well understood. Others, such as the program of Large Scale Asset Purchases (LSAPs) or "quantitative easing," have been used in the United States for the first time. LSAPs in particular have greatly increased the size of the Federal Reserve's balance sheet – and the assets which were acquired through this program may remain there for many years to come.[62]

Of course, the Federal Reserve took many important steps in order to combat the effects of the financial crisis. As the onset of the crisis became clear, the Fed moved to lower the federal

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[60] Gertler (2010).
[61] Sarkar (2009), Bernanke (2009).
[62] Gagnon et al. (2010).

funds rate – adopting an expansionary monetary policy as early as September, 2007.[63] However, by December, 2008, the Federal Reserve's Open Market Committee (OMC) had lowered the federal funds rate to a target range of 0 to 25 basis points – effectively reaching the zero lower bound. Financial markets continued to flounder, and with its traditional policy tool exhausted, the Fed was forced to consider other ways to ease its monetary policy.[64]

One such tool was that of communication. More specifically, and so that the reduction to short term rates might influence the overall term structure of interest rates, the Fed issued numerous statements indicating its long-term commitment to keeping interest rates low.[65] Other policies consisted of specially designed facilities which provided short-term liquidity assistance to targeted institutions and markets – both financial and otherwise.[66] Finally, the Federal Reserve moved to expand its portfolio through the purchase of longer-term securities. This, the expansion of the Federal Reserve's balance sheet through asset purchases, is the primary shock which is of interest to this investigation.

According to a speech delivered by Ben Bernanke in 2009, the goal of the Federal Reserve's policy response to the financial crisis was to, "stimulate aggregate demand in the [crisis] environment, ... to reduce [credit] spreads and [to improve] the functioning of private credit markets more generally." Since no consensus has ever emerged in regard to the mechanisms by which monetary policy is transmitted, it is unsurprising that interest in this area has waxed following the large scale and unprecedented expansion of the monetary base.

An interesting question which arises is this: will credit market imperfections inhibit the transmission of monetary policy in the event that traditional mitigators of credit market

[63] Bernanke (2009).
[64] Bernanke (2009).
[65] Bernanke (2009).
[66] Gagnon et al. (2010).

information asymmetries – high collateral values and low-risk deposits – become significantly impaired? Was the credit channel operational during the recent financial crisis, and if not, what prevented it from functioning? The answers to these questions may shed light on both the role played by credit market imperfections in the greater economy and, in turn, on how effective monetary policy can be expected to be when the mitigators of those imperfections no longer remain effective.

V. Data

This study examines the behavior of the Money Multiplier in relation to changes in the monetary base – controlling for those variables which might endogenously determine both shifts in monetary policy and prevailing credit conditions. Measurements of the money multiplier are provided by the St. Louis branch of the Federal Reserve on a bi-weekly basis, and were collected through the online database "FRED." I restrict the sample to measurements taken between 2001 and 2010, owing to the limited availability of data for other pertinent variables, and in order to control for changes to banking regulation which may have caused a shift in the rules of the game over a longer period of time. The sample contains 236 observations which are subsequently divided into two subsamples ranging from December, 2001 to August, 2007 and from August, 2007 to December, 2010. The date break used in order to subdivide the primary sample is based on the onset of widespread instability within U.S. financial markets.[67]

Records from the online database "FRED" provide measurements of both the St. Louis Adjusted Monetary Base (M0), and M1 on a weekly basis ending Wednesday – in both

[67] See the discussion of spikes in the LIBOR-OIS spread which can be found in Section IX.

seasonally adjusted and unadjusted forms. The series relating seasonally adjusted data for M0 is used as a measurement of monetary policy and, following treatment described in section VIII, serves as this study's independent variable. Data for the federal funds rate (FF), reported on a weekly basis ending Wednesday, was also found via FRED.

The Consumer Price Index (CPI), is used as a proxy for inflation, and data for this series was drawn from the United States Department of Labor Bureau of Labor Statistics. This series is reported on a monthly basis, for each month cumulatively and therefore at month's end. Because biweekly data was not available, straight-line interpolation was used to generate intermediate data points such that the series is compatible with the frequency of the dependent variable in a time-series framework. The use of interpolation introduces a potential source of error into my methodology, particularly in terms of the volatility of the CPI series. Data for the unemployment rate was also drawn from the Bureau of Labor Statistics, as reported on a monthly basis. This series was given a similar treatment to that of the CPI.

Expected inflation was interpreted from daily data for the yields of Treasury Inflation Protected Securities (TIPS) and from Treasury debt of corresponding maturities. TIPS yields were taken from Bloomberg, and data for 10-year constant maturity rate treasuries was reported by the online database of the Board of Governors of the Federal Reserve System. The spread between these yields is taken as an indicator of inflation expectations. Week-end data was used (ending Wednesday) rather than a moving average – avoiding the introduction of short term noise into a series which is based in movement over the long term. This data may still be limited by short term fluctuations which arise as a result of market forces but which are unrelated to inflation expectations.

The BKX banking index – a market cap weighted average of the largest 24 banks in the United States – is taken as a measure of asset values within the financial sector, and is used in order to investigate the possible role of bank capital in propagating a financial shock to the greater economy. Historical data for the level of this index is widely available, and was drawn in this case from *finance.Yahoo.com*. A 15-day calculation of the volatility of the BKX index is also examined in order to investigate the potential relationship between asset value uncertainty and aggregate trends in lending. This series was located and collected via Bloomberg. Because each series pertaining to bank asset values is available only on days in which stock exchanges are open, interpolation was also used in order to match the frequency of these variables with that of the money multiplier. More specifically, and because data was not available for holidays, straight line interpolation was used in order to calculate level values for a number of data points within each of these series. It may also have been appropriate to include a market-cap weighted average of bid ask spreads for the equities within this basket as a measure of bank asset liquidity. Unfortunately, owing to time constraints, these calculations were not conducted and the model, as it stands, lacks any measure of bank asset liquidity.

The Wilshire 5000, an index which seeks to track the values of all commonly traded equities within the United States, is used as a proxy for common asset values within the U.S. – assets which may be used in turn as collateral for bank lending. As in the case of the BKX index, a 15-day calculation of the volatility of the Wilshire 5000 is also briefly examined.

The spread between LIBOR and the overnight index swap (OIS) rate (or the LIBOR-OIS spread) is included within the model as a barometer of the general health of the financial sector. Data for this series was collected from Bloomberg, originally at a daily frequency. This variable dictates the lower bound of the period investigated, because data for the variable is only available beginning December 12th, 2001.

US corporate BBB option-adjusted spreads – calculated as the difference between a computed index of all bonds in the BBB rating category and a spot treasury curve – is included within the model as a proxy for the average external finance premium (EFP) charged to BBB rated companies. Data for this series was obtained at a bi-weekly frequency, ending Wednesday, and was found through the FRED database as a publication of Bank of America Merrill Lynch.

Ideally, including a greater number of variables in the VAR model would lead to a more detailed picture of credit market functionality over the period in question. However, given the exponential nature of growth in the number of coefficients which must be estimated should an additional variable be included, this is not the case. The primary limitation of the data is its low degrees of freedom – even independent of the statistical model employed. Only 236 observations are divided into two smaller periods, which means that the VAR estimated for each will include even fewer degrees of freedom than if calculated using the already limited cumulative data set. Because of this, variables were included within each VARs assessed only when absolutely necessary.

VI. Methodology

Boivin and Giannoni (2002) applies a VAR framework to model the relationships between economic variables and monetary policy, and in order to assess whether there was a change in the transmission of monetary policy over the course of the 20th century. My study adopts a similar methodology in order to investigate a potential change in the transmission mechanism during the recent period of financial crisis. Within their study, Boivin and Giannoni employ a data set spanning from 1960 to 2001, and which includes only four variables: detrended output, the inflation rate, commodity price inflation, and the federal funds rate. First, an initial VAR is calculated using the entire data set in order to test for parameter instability. In this case, evidence for parameter instability is found. Next, VARs are estimated for two smaller samples – such that more specific details of the change in monetary transmission can be extracted from the data. Four lags were included in each of the VARs estimated, and data transformations were performed (first differences, high pass filter, lags) in order to correct for various issues.

The test of stability which Boivin and Giannoni employ is the Quandt-Andrews test for an unknown date break, or the 'Wald version' of the Quandt (1960) likelihood-ratio test. Though the Quandt-Andrews test successfully isolates a number of potential date-breaks for use in their study, Boivin and Giannoni use that output only as evidence for general parameter instability – and instead elect to base the break-date for their benchmark comparison on anecdotal evidence. This, they argue, a more consistent picture of the timing of observed instability.

Following many papers in the literature, Boivin and Giannoni choose to adhere to the "recursiveness" assumption – or that the policy variable affects non policy variables only with a lag of one period (in this case one quarter). The policy variable, however, is allowed to respond contemporaneously to all other variables. Once estimated, the variance decompositions and impulse responses for each VAR were compared in order to assess the nature of the shift in the transmission mechanism.

My hypothesis is that, similar to the changes identified in Boivin and Giannoni (2002), the transmission mechanism of monetary policy has undergone a significant shift between the pre-crisis and crisis periods. Much like Boivin and Giannoni, parameter instability tests are conducted in the context of a VAR estimated using data from both periods cumulatively. The recursiveness assumption is retained, and three lags are included within each VAR. Data transformations (first differences, lags) are used in order to address issues of stationarity. In its final form, each series satisfies an Augmented Dickey-Fuller test for stationarity with a rejection of the null hypothesis at the 99.5% significance level or higher. Once estimated, variance decompositions and impulse responses are analyzed in order to address questions regarding the operation of the credit channel.

Because VAR models estimated using this data set are limited by lost degrees of freedom, normal time series regressions were also conducted. While these fail to render the dynamic response of the money multiplier to innovations in various economic variables, the use of a crisis dummy variable allows for the investigation of a change in relationship over the pre-crisis and crisis periods between the multiplier and a given variable.

My analysis of the transmission mechanism uses two sample periods: from December, 2001 to August, 2007 and from August, 2007 to December, 2010. As are discussed later, the results from a Quandt-Andrews unknown date break test and two Chow *known* date break tests can be found in Tables 4 and 5 of the appendix, respectively.

Monetary policy innovations were isolated via autoregression of the M0 series against three lags. Residuals were taken from this regression, and are employed as a measure of monetary shocks.

Because movement in the Wilshire 5000 (W5000) reflects returns to the BKX banking index, a similar approach was applied to adjust data for this series. More specifically, movement in the Wilshire 5000 was regressed against returns to the BKX banking index – such that the residuals from this regression measure movement in the W5000 holding returns to the BKX index static. These values were then used in the estimation of both VAR and time series models.

VII. Results

A. Vector Autoregression Analysis

A.i Parameter instability

In order to test for parameter instability between the crisis and pre-crisis periods, I first estimate a reduced-form recursive VAR for the overall data set – including only changes in the money multiplier (MM), the federal funds rate (Ffrate), returns to the BKX banking index (rBKX), and the change in the monetary base (M0) as variables. Using the equation in which MM is the dependent variable, I then perform a Quandt-Andrews unknown breakpoint test. The result of this test can be found in Table 4 of the appendix, and shows that, based on the maximization of the Wald F-test for all potential date breaks considered, January 30th, 2008 is statistically the most probable location for a breakpoint within the time frame in question (F-statistic 110.4939, $P<0.01$). However, while this finding indicates that January 30th, 2008 is a potentially valid break date, it is also taken as evidence for general parameter instability, and the majority of the testing conducted within this investigation is based on a date break of August 1, 2007.

The decision to use this date break in place of Sept. 10, 2008 is made based on a significant increase in the LIBOR-OIS spread which occurred during throughout the month of August, 2007. More specifically, the LIBOR-OIS rose a dramatic 53.2% between July 18th and August 1st, and 383.6% between August 1st and August 15th. This rise in the LIBOR-OIS spread implies that a breakdown of interbank lending occurred at that time – one of the first real symptoms of the interruption of financial intermediation which occurred in the United States over the course of the Great Recession.

Given this information, Chow tests for a known breakpoint were conducted for both January 30, 2008 and August 1, 2007, using the equation for MM referenced above. The Chow test for the August 1, 2007 fails to reject the null hypothesis of parameter continuity (P> 0.65). The results of both tests can be seen in Table 5 of the appendix. Nonetheless, an argument for using August 1, 2007 can still be made. The shifts which occurred in the LIBOR-OIS spread during the month of August 2007 marked the first symptoms of the coming financial crisis. Thus, the time period following this date, but before January 30, 2008 should not be viewed as part of the "pre-crisis period." Of course, tests might be conducted using *three* periods; however, owing to the limited size of the data set, this approach would be impractical. As such, for the subsequent testing described within this paper, April 1, 2007 is assumed to mark the onset of financial crisis within both the VAR model and time series regressions estimated.

A.ii Granger causality tests

In addition to Quandt-Andrews and Chow tests for parameter instability, a comparison of Granger causality tests conducted for the crisis and pre-crisis periods may also serve to demonstrate a shift in the relationship between each of the variables in question. Results for pairwise Granger causality tests pairing each variable with the money multiplier can be found in Table 6 of the appendix. Whereas the federal funds rate, CPI, expected inflation, the LIBOR-OIS spread, the external finance premium, returns to the BKX banking index, the 15 day volatility for the W5000 and changes in M0 are collectively *not* found to Granger cause movement in the money multiplier during the period preceding the crisis, each is found to Granger cause movement in the multiplier during the crisis at the 90% probability level or above. Together, these findings may indicate that a shift in the transmission mechanism of monetary policy occurred between the crisis and pre-crisis periods. In addition to this collective implication, each of these findings is individually significant.

Though pairwise Granger causality tests do not yield a sign for the relationship between variables, that the federal funds rate, CPI and expected inflation are all better predictors of MM during the crisis implies that the interest rate channel operated more strongly during this period. Of these, only the federal funds rate might have had an impact on the denominator of the multiplier (via the open market operations through which target rates are achieved). Otherwise, the effect of each of these variables on the money multiplier must have been felt through the multiplier's numerator – in other words through aggregate lending. Because the federal funds rate, the CPI and expected inflation all have an impact on the real level of interest rates – as well as on the term structure of real interest rates – it may be reasonable to infer that the impact of these variables on the multiplier is felt through neoclassical channels. In order to confirm this conclusion, however, further investigation is necessary regarding the nature of the relationships between each of these variables and the multiplier.

A separate finding relates to the relationship between movement in the monetary base and change in the multiplier. While M0 did not Granger cause movement in the multiplier during the period preceding the crisis, M0 *was* found to Granger cause movement in MM within the crisis period. This is consistent with the expected relationship between M0 and the multiplier which is suggested by the credit view, in which an expansion of M0 will lead to a reduction in the external finance premium, an outward shift in the supply of loans, and a rise in both lending and in output. Because the money multiplier is defined as the ration between M1 and M0, M0 will only have a neutral impact on the multiplier in the event that movement in M0 is matched by movement in M1. Within the sample period, movement in the latter variable is driven largely by bank lending behavior (since the currency ratio is fairly static). This finding indicates then that movement in M0 led to a shift in lending during the period preceding the crisis, but did not during the crisis itself. Of course, Granger causality tests do not control for the movement in other variables, and as such the change in interest rates which movement in M0 precipitates could be responsible for the pre-crisis period result. Similarly, lending may be impacted by a wide range of other economic variables. As such, while suggestive of a credit channel, this finding may only be viewed as very limited evidence.

Similarly, that M0 predicts movement in MM *during* the crisis is consistent with but does not demonstrate that the operation of credit channel was in some way changed. This could have occurred in only one of two ways – either M0 became positively or negatively correlated with movement in MM. If movement in M0 was found to have related *positively* to movement in MM, this would suggest that the operation of the credit channel had become enhanced. If M0 is *negatively* related to MM, however, this suggests that the credit channel became impaired. Alternatively, of course, change in a third, omitted variable which causes movement in both M0 and the multiplier may have led to the appearance of either a negative or positive correlation, but which implies nothing about the credit channel. This criticism may be refitted for any interpretation of Granger causality tests in general. Nonetheless, and though Granger causality tests do not indicate the nature of a given relationship, this finding *does* indicate that a change of some kind occurred. The nature of that change will be taken up later, in light of further evidence.

The finding that returns to the BKX banking index (rBKX) Granger caused movements in the multiplier during, but not preceding the crisis also holds implications. More specifically, this suggests that bank capital played a larger role in determining lending behavior during the crisis than before it – though, in the context of Granger causality tests, (in which no sign is rendered), the nature of that role ultimately remains ambiguous. In light of the finding that M0 Granger causes the multiplier during the crisis, it may be tempting to see the similarly enhanced role for rBKX during the crisis as evidence for a capital crunch. However, as is discussed later, results from time series regressions cast doubt on this interpretation.

Finally, it is interesting to note that returns to the W5000 index were found to Granger cause movement in the multiplier both during and preceding the crisis. This implies a significant role for collateral values in determining lending behavior throughout the period investigated – which is in turn consistent with the balance sheet channel of monetary transmission. It is also important to note that, if returns to the W5000 index were *not* found to Granger cause movement in MM during the crisis, this result would constitute compelling evidence against the existence of a credit trap. Because this was not found, the hypothesis that a credit trap occurred cannot be rejected without further investigation.

Granger causality tests were also conducted using the date break of January 30, 2008, in order to test for a large difference in results. If a large difference were found, a strong argument could be made for conducting further tests using both date breaks as well – and in fact, given an unlimited amount of time, this would be desirable regardless. As can be seen in Table 6, however, the results using this date break are largely consistent with those derived from the date break of August 1st, 2007. As opposed to those results, the second Granger estimations show that MM causes rw5000resid in Panel 2, MM does *not* cause CPI in Panel 1, MM causes Expin in Panel 1, and rw5000resid does *not* cause MM in Panel 2. Findings for every other test remained the same. Of these differences, the last is the most interesting. As opposed to the results generated using the August 1st date break, this result more strongly supports a differential role played by collateral values in determining lending between the non-crisis and crisis periods.

A.iii Impulse response and variance decomposition

As previously discussed, one limitation of VAR analysis in the context of this data set is the limited degrees of freedom which may be retained as additional variables are included. Observations for the data set are collected at a bi-weekly frequency, and within a time frame which spans less than a decade. As a result, the estimated VARs are limited to the inclusion of a maximum of five variables. The exclusion of other series – which are known from economic theory to relate to lending behavior and therefore the money multiplier – implies that the VAR systems estimated will necessarily present a limited picture of the determinants of the multiplier.

Two VARs were estimated, using different sets of variables. The first, VAR(1), includes the Money Multiplier (MM), the federal funds rate (Ffrate), the LIBOR-OIS spread (LiborOisSpread), returns to the BKX banking index (rBKX), and changes in the monetary base (M0). The variance decompositions for VAR(1) Panel 1 and VAR(1) Panel 2 can be found in the appendix, in Table 7 and Table 8, respectively. The Impulse responses generated for VAR(1) Panel 1 and VAR(1) Panel 2 can also be found in the appendix, in Figure 10 and Figure 11.

Unfortunately, the majority of the impulse responses generated for VAR(1) yield few significant results – primarily owing to the width of error bands. One significant result, however, is found in the impulse response of M0 to an innovation in MM, as drawn from VAR(1) Panel 1. As the graph of this impulse response shows, a one percentage point innovation in MM leads to a

2 percent fall in M0 which persists for a period of two weeks. Inversely, then, a fall in the multiplier can be said to lead to a rise in M0. This may imply that the Federal Reserve has adopted what might be described as a "fire fighting" approach over the course of the recent decade. In other words, and if the Fed did follow such an approach, as lending fell as a result of movement in real economic variables, the Fed would then expand the monetary base in order to stimulate lending and as a measure to combat that trend. That the impulse response of M0 to a rise in MM is even stronger within Panel 2 (the crisis period) may also support this view. Similarly, and as can be seen in Table 6, it was found that (as opposed to change in M0 Granger causing movement in EFP) change in the EFP Granger caused changes in M0.

The next VAR which was estimated, VAR(2), includes the Money Multiplier, the federal funds rate, returns to the BKX banking index, returns to the W5000 index (rw5000resid), and changes in the monetary base. The variance decompositions for VAR(2) Panel 1 and VAR(2) Panel 2 can be found in the appendix, in Table 9 and Table 10, respectively. The Impulse responses generated for VAR(2) Panel 1 and VAR(2) Panel 2 can also be found in the appendix, in Figure 11 and Figure 12.

The impulse responses which VAR(2) generate are of a similar mint – again, findings are largely limited by the small number of variables which may be included, and by wide standard error bands resulting from limited data. Unlike VAR(1), however, the impulse responses for VAR(2) do indicate a marginally significant role for rBKX and rw5000resid in determining movement in MM. In Panel 1, an innovation in rBKX leads to a rise in MM following a lag of 3 weeks, but which quickly returns to zero. This finding is consistent with the view that bank capital, in part, determines the lending behavior of banks. Next, an innovation in rw5000resid leads to a similar response – a rise in MM following a lag of 3 weeks. This indicates that, as for bank capital, collateral values may play a role in determining lending behavior. In Panel 2, the impulse response of rBKX shifts. MM reacts negatively to an innovation in this series, but only following a lag of 7 weeks and which returns to zero by week 8. The short lived and lagged nature of this response may indicate that this finding is merely a statistical blip. Unlike rBKX, the impulse response of MM to an innovation in rw5000resid in Panel 2 is largely similar to that in Panel 1. MM responds positively to an innovation in rw5000resid following a lag of 3 weeks, returning to zero by week four. Findings for the relationship between rw5000resid and MM are larger and more significant than those for rBKX. Thus, while the short lived and marginally significant findings for rBKX are likely spurious, a stronger argument can be made for change in the value of collateral as a determinant of bank lending.

Another interesting finding which may be drawn from VAR(2) pertains to the impulse responses of MM to an innovation in M0 – as compared between Panels 1 and 2. In Panel 1, an innovation in M0 leads to a small, marginally significant negative reaction in MM following a lag of three weeks. By week four, this response has fallen to zero. In Panel 2, the same innovation leads to no significant response in the multiplier at all. Interestingly, and in contradiction to other evidence found within this investigation, this finding indicates that the credit channel did not function during the period preceding the crisis, but *did* function during the crisis itself. However, because the response of MM to an innovation in M0 within Panel 1 (the non-crisis period) is both small and short lived, it is plausible that this result is merely an artifact of the VAR's order and specification.

Overall, while a VAR framework may be appropriate for investigation of the credit channel over a longer period or with data of a higher frequency, it may ultimately be poorly suited to an examination of the given data set. Because the results produced through the estimation of VARs are largely insignificant, traditional time series regressions were also employed in addition to these models.

B. Time Series Analysis

The time series regressions estimated within this investigation each employ the money multiplier (MM) as the dependent variable. Varying by regression, a combination of the federal funds rate, the LIBOR-OIS spread, returns to the BKX banking index, returns to the W5000 index, changes in the monetary base, a crisis dummy variable, and interactions between the crisis dummy and other series are included on the RHS.

The specification of regressions two and three of Table 3 within the appendix was conducted in two steps. [68] First, each variable was tested for an optimum number of lags based on minimization of the Akaike and Bayesian Information Criteria (AIC and BIC, respectively). When the marginal inclusion of a lag produced a lower AIC value but a higher value for the BIC, a comparison of values for either regression's adjusted R^2 was used as the final deciding factor. The result of this process can be found in regression two of Table 3, which includes three lags for the federal funds rate, five lags for returns to the BKX banking index, and one lag for returns to the W5000 index. This methodology was not applied in determining the number of lags included for autoregression of the money multiplier, or for changes in the monetary base.[69] In these cases, the *insignificance* of the coefficients estimated for lagged values of these variables is also highly illustrative – and as a result, three lags are used for both. Because this model was not

[68] Because coefficients relating the LIBOR-OIS spread to movement in the Money Multiplier were insignificant in every variation of the regression, this variable was not included within regressions two or three of Table 3 within the appendix.
[69] While this methodology was not used to determine the number of lags included, tests for an "ideal" number of lags were nevertheless conducted. Based on that process, a model optimized for the purpose of forecasting movement in the money multiplier should include only one lagged value for changes in M0, and no lagged values of the multiplier.

intended for use in forecasting – but rather to test for the existence of and change in relationships over time – a reduction in the model's accuracy stemming from the inclusion of these lags is largely an irrelevant phenomenon.

Once the optimum number of lags for each variable was identified, a series of interactions between those variable and the crisis dummy were conducted in order to test for a change in the relationship between a given variable and the multiplier during the crisis period. Interactions were conducted individually, such that no two variables were interacted with the crisis dummy within a single regression. Further, for any given test the original lagged terms of the variable were retained within the regression in their original form – *copies* of those terms were added for the purpose of interaction. Thus, the test for a change in relationship between rBKX and the multiplier includes the original five lagged terms for the variable (as determined during lag specification) and a copy of those terms interacted with the dummy variable.

The results from these tests indicate that returns to both the BKX banking and W5000 indices can more significantly explain variation in the money multiplier in the context of the crisis period. When either variable was interacted with the crisis dummy, it was found that the coefficients for the interacted terms were significant, while the coefficients estimated either variable's *original* terms no longer explained MM. Regressions were then estimated including the interacted terms in the absence of the originals – and AIC and BIC values from these regressions were compared to those of the base specification. In both cases, this comparison indicates that the interacted variables contribute more significantly to explaining movement in the multiplier.

That lagged values of rBKX can better explain movement in the multiplier when interacted with the crisis dummy has important implications – though multiple valid interpretations of this finding may exist. First, and because larger movements occurs in the rBKX series during the crisis period than in the period preceding it, this result may indicate a non-linear relationship between rBKX and the multiplier.[70] Alternatively, this finding may indicate that, as this investigation has hypothesized, the relationship between rBKX and change in the money multiplier shifted with the onset of the crisis. Ultimately, and without further investigation, it is impossible to definitively state whether one or both of these interpretations is valid.

Regardless of which of these is true, this finding holds further notable implications. Because returns to the BKX index serve as a proxy for changes in the level of bank capital, this result suggests that bank capital played a more significant role in determining lending behavior during the crisis than it did in the period preceding it.[71] This finding is consistent with the literature regarding a "capital crunch," which implies that bank capital will affect lending to a higher degree when capital has become depleted – and as was the case during the crisis period.[72] However, upsetting this interpretation, the cumulative sign of the five lags for rBKX which are included in the model is estimated to be negative. As can be seen from the results reported for regression three, (found in Table 3), a positive shift in returns to the BKX banking index predicts an overall fall in change to the money multiplier over time – contradicting the view that reduced bank capital led to a capital crunch during the recent financial crisis.

The finding that returns to the W5000 index better predict movement in the multiplier when interacted with the crisis dummy also holds important implications – some of which echo those regarding returns to the BKX index. First, as for rBKX, this finding implies either a shift in

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[70] This could be investigated through a more exhaustive specification search. No such search is conducted here owing to time limitations.

[71] This is true whether rBKX is non-linearly related to movement in MM, (in which case the larger movement in rBKX would lead to a disproportionately larger impact on the multiplier), or if a change in the relationship between these variables occurred with the onset of the crisis.

[72] Calomiris and Wilson (1998).

the relationship between these variables, or that returns to the W5000 are nonlinearly related to movement in the money multiplier. As before, it is impossible to identify the correct interpretation of this finding without further investigation.

Regardless, that returns to the W5000 more significantly explain movement in MM when interacted with the crisis dummy implies that collateral values played a *larger* role in determining lending behavior during the crisis period. Importantly, the sign found for this relationship is positive – which provides evidence for the existence of a balance sheet channel of monetary transmission during the recent financial crisis. So too is this evidence consistent with the view that a "credit trap" may have occurred, resulting in liquidity hoarding and the interruption of financial intermediation. However, while such interpretations are compelling, so too must they be viewed with a certain degree of skepticism. It may be the case that movement in economic variables not included within this model caused changes in both returns to the W5000 index and to aggregate lending behavior simultaneously.

A final conclusion which may be drawn from these regressions relates to the relationship between M0 and movement in the multiplier. As can be seen in Table 3, M0 was only found to significantly predict movement in the money multiplier only in regression 3, when interacted with the crisis dummy. That movement in M0 significantly predicts a negative movement in MM during the crisis but is insignificant during the period preceding is consistent with the hypothesis that operation of the credit channel was relatively impaired throughout the crisis.

VIII. Conclusion

The results show mixed evidence regarding the relationship between movement in the monetary base and change in the money multiplier over time. Granger causality tests indicate that movement in M0 does not explain change in the multiplier for the period preceding the crisis, but does explain movement in MM *during* the crisis. Conversely, VAR impulse responses for a one percentage point innovation in M0 are found to have a weakly significant (negative) impact on movement of the multiplier during the non crisis period, and no impact during the crisis itself. Finally, time series regressions show that M0 only becomes significantly related to movement in MM when interacted with a crisis dummy. Cumulatively, and because findings from the VAR may represent an artifact of the VAR's specification, these results are consistent with the hypothesis that the credit channel was relatively impaired during the recent financial crisis as compared to the period which preceded it.

So too is the relationship between returns to the W5000 index and movement in the multiplier consistent with this interpretation. Based on the theory of the balance sheet channel, we would predict that this relationship would grow stronger during the financial crisis – during which, balance sheets became significantly weakened. This is, in fact, what is found. While Granger causality tests indicate that this variable significantly explains movement in MM both during the crisis and preceding it – as is also indicated by VAR impulse responses – results from time series regressions imply a greater role for this variable in explaining movement in MM *during* the crisis period. This notion is further supported by the fact that when Granger causality tests are conducted using the date break of January 30, 2008 – as suggested by the results of a Quandt-Andrews unknown date break test – returns to the W5000 index are found to Granger cause movement in the multiplier *only* during the crisis period.

In turn, these finding supports the notion that a "credit trap" may have led to the interruption of financial intermediation throughout the course of the Great Recession. Corroborating this view, results from the time series regression of returns to the BKX banking index against changes in the multiplier indicate that the theory of a "capital crunch" provides a *poor* explanation for the widespread reduction in lending. Because the introduction of Federal Deposit Insurance in the wake of the Great Depression removed the threat of depositor discipline formerly faced by banks, this result is unsurprising.

Evidence is found for the operation of a credit channel during the non-crisis period, and for impairment of that channel during the recent financial crisis. Together, these findings indicate that credit market imperfections play a significant role in determining the impact of monetary policy on the economy. Further, this study implies that when collateral values are low, they may fail to mitigate problems of asymmetric information which occur between borrowers and banks. As a result, an expansionary monetary policy can be expected to have a reduced impact on bank lending when asset values are low.

Though the findings of this study are largely consistent with the theoretical literature, so too must their limitations be acknowledged. Since the linkages between economic variables are complex and interrelated, results from the estimated time series regressions suffer both from a likely omitted variable bias and from a failure to recognize the dynamic responses of macroeconomic variables to monetary policy innovations. Many important economic variables were not included within this model, and unlike results taken from VAR analysis, basic time series regressions do not imply a dynamic impulse response. Further, returns to the W5000 and BKX banking indices may serve as only noisy indicators of the variables for which they are intended to proxy – bank capital and the value of collateral assets. So too are the VAR models developed here limited by these issues – as well as by the sample size employed and the exponential nature of estimations which must be conducted as additional variables are included.

Though beyond the scope of this investigation, the use of recently developed econometric techniques may allow for these issues to be addressed. Bernanke, et al. (2005) describes the Factor Augmented Vector Autoregression model, or FAVAR, which allows for the inclusion of a wider set of economic variables without the loss of significance which occurs within a traditional VAR. Further research into the issues addressed within this investigation might employ this newly developed approach, rendering more accurate results for the dynamic responses of movement in the money multiplier to innovations in economic variables.

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Appendix

Table 1: Summary Statistics

Series	Median	Mean	Minimum	Maximum	Standard Deviation
ΔMM	0.06	-0.31	-18.84	11.94	2.62
M0	-0.06	0.05	-13.76	10.83	2.12
ΔFF rate	0.00	-2.50	-226.67	47.37	23.22
Δ10yr T	-0.45	-0.29	-26.59	17.34	4.97
ΔCPI	0.10	0.09	-0.92	0.68	0.17
ΔE(π)	-0.06	1.19	-50.82	218.84	17.60
ΔUnem.	0.00	0.24	-2.17	5.10	1.30
ΔLIBOR-OIS spread	0.00	4.09	-82.65	383.56	39.22
R[BKX]	0.05	-0.38	-39.19	22.23	6.02
ΔBKX σ(15D)	-3.11	4.96	-52.42	186.03	36.37
R[W5000]	0.25	0.03	-8.03	8.09	2.09
ΔW5000 σ(15D)	14.82	18.28	5.44	86.23	12.43
ΔEFP	-0.43	0.13	-19.51	27.12	6.13

Table 2: Correlation Matrices

TOTAL DATA	n=236		**BOLD**= significant at the 5% level			Critical value = 0.195							
	ΔMM	*ΔM0*	*ΔFF rate*	*Δ10yr T*	*ΔCPI*	*ΔE(π)*	*ΔUnem.*	*ΔLIBOR-OIS spread*	*R[BKX]*	*ΔBKX σ(15D)*	*R[W5000]*	*ΔW5000 σ(15D)*	*ΔEFP*
ΔMM	1												
ΔM0	**-0.828**	1											
ΔFF rate	**0.351**	**-0.318**	1										
Δ10yr T	0.098	-0.063	0.150	1									
ΔCPI	**0.367**	**-0.286**	**0.349**	**0.227**	1								
ΔE(π)	0.046	**-0.207**	**0.204**	**0.217**	**0.202**	1							
ΔUnem.	-0.160	0.069	**-0.234**	0.026	-0.082	0.110	1						
ΔLIBOR-OIS spreac	0.000	0.056	0.013	0.001	-0.046	-0.063	-0.061	1					
R[BKX]	0.187	-0.187	-0.042	0.092	0.107	-0.048	-0.135	-0.031	1				
ΔBKX σ(15D)	-0.072	0.105	0.109	-0.023	0.107	0.046	0.015	0.175	-0.081	1			
R[W5000]	0.104	**-0.205**	0.005	0.138	0.028	**0.263**	0.163	-0.154	-0.031	-0.156	1		
ΔW5000 σ(15D)	**-0.417**	**0.315**	**-0.437**	**-0.224**	**-0.443**	-0.004	**0.397**	0.066	-0.186	0.173	-0.048	1	
ΔEFP	**-0.239**	**0.285**	-0.139	**-0.300**	-0.185	**-0.196**	0.000	0.189	**-0.304**	**0.297**	**-0.381**	**0.353**	1

2007-2008	n=53		**BOLD**= significant at the 5% level			Critical value = 0.273							
	ΔMM	*M0*	*ΔFFrate*	*ΔTenYrT*	*ΔCPI*	*ΔExpin*	*ΔUnem*	*ΔLiborOisSpread*	*rBKX*	*ΔBKX σ(15d)*	*rW5000*	*W5000 σ(15d)*	*ΔEFP*
ΔMM	1												
M0	**-0.895**	1											
ΔFFrate	**0.388**	**-0.337**	1										
ΔTenYrT	0.152	0.056	0.167	1									
ΔCPI	**0.675**	**-0.564**	**0.467**	**0.316**	1								
ΔExpin	**0.526**	**-0.568**	**0.389**	0.171	**0.558**	1							
ΔUnem	-0.258	0.152	**-0.280**	-0.079	-0.211	-0.201	1						
ΔLiborOisSpread	0.026	0.046	0.107	0.011	-0.021	-0.023	-0.201	1					
rBKX	**0.469**	**-0.441**	-0.169	0.122	**0.294**	**0.441**	-0.067	-0.041	1				
ΔBKX σ(15d)	0.042	0.034	0.158	-0.120	0.182	0.122	-0.172	0.223	-0.063	1			
rW5000	0.233	**-0.417**	-0.045	-0.080	0.041	0.027	0.104	**-0.301**	-0.097	-0.256	1		
W5000 σ(15d)	**-0.655**	**0.544**	**-0.547**	**-0.521**	**-0.746**	**-0.403**	0.257	0.045	-0.170	0.090	-0.164	1	
ΔEFP	**-0.346**	**0.426**	-0.123	**-0.340**	**-0.307**	-0.112	-0.015	0.231	**-0.278**	0.257	**-0.518**	**0.537**	1

PANEL 1 n=146 **BOLD**= significant at the 5% level Critical value = 0.195

	ΔMM	*ΔM0*	*ΔFF rate*	*Δ10yr T*	*ΔCPI*	*ΔE(π)*	*ΔUnem.*	*ΔLIBOR-OIS spread*	*R[BKX]*	*ΔBKX σ(15D)*	*R[W5000]*	*ΔW5000 σ(15D)*	*ΔEFP*
ΔMM	1												
ΔM0	**-0.429**	1											
ΔFF rate	0.004	0.063	1										
Δ10yr T	-0.022	-0.070	-0.076	1									
ΔCPI	-0.058	0.032	0.044	0.122	1								
ΔE(π)	-0.052	0.024	0.046	**0.591**	**0.215**	1							
ΔUnem.	0.014	-0.095	-0.151	-0.004	0.021	0.020	1						
ΔLIBOR-OIS spreac	-0.013	0.108	**-0.199**	0.058	-0.032	0.054	0.094	1					
R[BKX]	-0.082	-0.152	0.052	0.135	-0.099	**0.208**	0.134	0.040	1				
ΔBKX σ(15D)	**-0.203**	**0.216**	0.110	-0.074	0.095	-0.043	0.101	0.046	-0.159	1			
R[W5000]	0.045	-0.087	-0.110	**0.207**	-0.030	0.141	0.036	0.050	**0.428**	**-0.237**	1		
ΔW5000 σ(15D)	-0.051	0.049	-0.121	-0.071	-0.035	0.057	0.108	0.069	-0.011	**0.231**	-0.172	1	
ΔEFP	-0.089	0.044	0.188	-0.128	0.004	-0.124	-0.031	0.021	**-0.394**	**0.307**	**-0.323**	0.173	1

PANEL 2 n=90 **BOLD**= significant at the 5% level Critical value = 0.205

	ΔMM	*ΔM0*	*ΔFF rate*	*Δ10yr T*	*ΔCPI*	*ΔE(π)*	*ΔUnem.*	*ΔLIBOR-OIS spread*	*R[BKX]*	*ΔBKX σ(15D)*	*R[W5000]*	*ΔW5000 σ(15D)*	*ΔEFP*
ΔMM	1												
ΔM0	**-0.853**	1											
ΔFF rate	**0.360**	**-0.327**	1										
Δ10yr T	0.127	-0.064	0.201	1									
ΔCPI	**0.492**	**-0.373**	**0.435**	**0.287**	1								
ΔE(π)	0.059	**-0.224**	**0.225**	0.193	**0.241**	1							
ΔUnem.	-0.178	0.073	**-0.227**	0.083	-0.086	0.125	1						
ΔLIBOR-OIS spreac	0.009	0.052	0.064	-0.036	-0.050	-0.098	-0.202	1					
R[BKX]	**0.210**	-0.186	-0.075	0.073	0.168	-0.065	-0.195	-0.056	1				
ΔBKX σ(15D)	-0.043	0.098	0.141	0.019	0.126	0.069	-0.076	**0.279**	-0.050	1			
R[W5000]	0.132	**-0.247**	0.037	0.110	0.073	**0.300**	**0.214**	**-0.281**	-0.156	-0.114	1		
ΔW5000 σ(15D)	**-0.486**	**0.361**	**-0.472**	**-0.295**	**-0.633**	-0.043	**0.391**	0.054	-0.191	0.146	-0.051	1	
ΔEFP	**-0.300**	**0.374**	**-0.210**	**-0.416**	**-0.306**	**-0.253**	-0.032	**0.316**	**-0.280**	**0.286**	**-0.433**	**0.454**	1

Table 3: ADL Time Series Regressions

Dependent Variable = Growth in the money multiplier (MM)

	(1)	(2)	(3)
MM (-2)	0.0778	0.0021	-0.0094
	(0.268)	(0.008)	(-0.044)
MM (-4)	0.1465	0.2251	0.2112
	(0.690)	(1.131)	(-1.404)
MM (-6)	-0.0420	-0.1002	-0.0857
	(-0.253)	(-0.701)	(-0.666)
Ffrate (-2)	-0.0091	-0.0111	-0.0136
	(-0.600)	(-0.885)	(-1.188)
Ffrate (-4)	0.0003	0.0044	0.0084
	(0.020)	(0.321)	(0.626)
Ffrate (-6)	0.0157**	0.0284***	0.0358***
	(1.977)	(2.848)	(3.163)
LiborOisSpread (-2)	-0.0015		
	(-0.267)		
LiborOisSpread (-4)	-0.0029		
	(-1.137)		
LiborOisSpread (-6)	-0.0014		
	(-0.775)		
rBKX (-2)	-0.0711**	-0.0827**	
	(-2.056)	(-2.405)	
rBKX (-4)	-0.0074	-0.0159	
	(-0.208)	(-0.435)	
rBKX (-6)	-0.0633	-0.0643	
	(-1.391)	(-1.519)	
rBKX (-8)		-0.0770*	
		(-1.914)	
rBKX (-10)		0.0734*	
		(1.769)	
rBKX (-2) * Crisis			-0.0895**
			(-2.393)
rBKX (-4) * Crisis			-0.0146

			(-0.341)
rBKX (-6) * Crisis			-0.0718
			(-1.382)
rBKX (-8) * Crisis			-0.1065**
			(-2.148)
rBKX (-10) * Crisis			0.0978**
			(2.061)
rw5000resid (-2)	0.3342**	0.3455***	
	(2.808)	(3.348)	
rw5000resid (-4)	-0.0605		
	(-0.611)		
rw5000resid (-6)	0.0291		
	(0.324)		
rw5000resid (-2) x Crisis			0.4390***
			(3.286)
M0 (-2)	-0.4627	-0.5327	
	(-1.305)	(-1.546)	
M0 (-4)	-0.1315	-0.1296	
	(-0.603)	(-0.679)	
M0 (-6)	0.0756	0.0838	
	(0.370)	(0.493)	
M0 (-2) * Crisis			-0.5692*
			(-1.733)
M0 (-4) * Crisis			-0.1634
			(-0.877)
M0 (-6) * Crisis			0.1310
			(0.762)
Crisis dummy variable	-0.5573	-0.5146	-0.4992
	(-1.552)	(-1.594)	(-1.526)
Intercept	-0.0364	-0.0689	-0.0677
	(-0.330)	(-0.603)	(-0.826)

Notes: T-stat is in parentheses; Heterosketastic Robust Standard Errors used; *denotes significance at the 90% level; ** denotes significance at the 95% level; *** denotes significance at the 99% level.

Table 4: Quandt-Andrews Unknown Breakpoint Test

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data

Equation Sample: 7 236
Test Sample: 42 202
Number of breaks compared: 161

Statistic	Value	Prob.
Maximum LR F-statistic (Obs. 191)	6.391405	1
Maximum Wald F-statistic (Obs. 182)	110.4939	0
Exp LR F-statistic	0.964199	1
Exp Wald F-statistic	50.16553	0
Ave LR F-statistic	1.130197	1
Ave Wald F-statistic	22.43634	0.0104

Table 5: Chow Breakpoint Tests

April 1, 2007:

Chow Breakpoint Test: 147
Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 7 236

F-statistic	0.762728	Prob. F(13	0.6988
Log likelihood ratio	10.91601	Prob. Chi-	0.6179
Wald Statistic	23.50082	Prob. Chi-	0.036

January 30, 2008

Chow Breakpoint Test: 161
Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 7 236

F-statistic	0.873145	Prob. F(13	0.5823
Log likelihood ratio	12.45421	Prob. Chi-	0.4908
Wald Statistic	19.90107	Prob. Chi-	0.0977

Table 6: Pairwise Granger Causality Tests

August 1st, 2007 date break

	PANEL 1			PANEL 2		
Null Hypothesis:	Obs	F-Statistic	Prob.	Obs	F-Statistic	Prob.
FFRATE does not Granger Cause MM	369	0.81661	0.5575	84	3.45458	0.0047
MM does not Granger Cause FFRATE		0.98643	0.4342		6.76747	1.00E-05
TENYRT does not Granger Cause MM	369	1.09393	0.3655	84	0.89564	0.503
MM does not Granger Cause TENYRT		0.4057	0.8752		2.14511	0.0586
CPI does not Granger Cause MM	369	0.36423	0.9013	84	4.86976	0.0003
MM does not Granger Cause CPI		2.45478	0.0244		0.53039	0.7834
EXPIN does not Granger Cause MM	266	0.64996	0.6901	84	2.04374	0.0709
MM does not Granger Cause EXPIN		0.763	0.5997		8.53637	5.00E-07
UNEM does not Granger Cause MM	369	0.737	0.6201	84	0.49105	0.813
MM does not Granger Cause UNEM		0.70329	0.6471		0.53965	0.7763
LIBOROISSPREAD does not Granger Cause MM	140	1.57353	0.1601	84	2.11198	0.0624
MM does not Granger Cause LIBOROISSPREAD		1.01642	0.4177		0.70646	0.6454
EFP does not Granger Cause MM	268	1.96623	0.0709	84	2.48858	0.0305
MM does not Granger Cause EFP		1.32252	0.2474		1.54653	0.1757
RBKX does not Granger Cause MM	369	1.1217	0.349	84	2.77892	0.0174
MM does not Granger Cause RBKX		0.81858	0.556		2.13865	0.0593
BKX15D does not Granger Cause MM	369	0.0982	0.9965	84	0.85387	0.5331
MM does not Granger Cause BKX15D		0.54842	0.7712		0.18494	0.9801
RW5000RESID does not Granger Cause MM	369	3.83673	0.001	84	5.44454	0.0001
MM does not Granger Cause RW5000RESID		0.74008	0.6177		1.73786	0.1248
W500015D does not Granger Cause MM	361	0.77639	0.5889	84	3.39496	0.0053
MM does not Granger Cause W500015D		1.12434	0.3475		0.17905	0.9817
M0 does not Granger Cause MM	369	1.30731	0.253	84	3.17757	0.0081
MM does not Granger Cause M0		1.17419	0.3194		3.15995	0.0084
M0 does not Granger Cause EFP	268	0.34936	0.91	84	1.24464	0.2942
EFP does not Granger Cause M0		0.72011	0.6337		2.33338	0.041

Table 6 (Continued): Granger Causality Tests

January 30th, 2008 date break

	PANEL 1			PANEL 2		
Null Hypothesis:	Obs	F-Statistic	Prob.	Obs	F-Statistic	Prob.
FFRATE does not Granger Cause MM	153	1.42456	0.2093	71	2.98943	0.013
MM does not Granger Cause FFRATE		0.88929	0.5046		6.48997	3.00E-05
TENYRT does not Granger Cause MM	153	0.87331	0.5163	71	0.83063	0.5511
MM does not Granger Cause TENYRT		1.27123	0.2744		2.21876	0.0539
CPI does not Granger Cause MM	153	0.94968	0.4618	71	5.0247	0.0003
MM does not Granger Cause CPI		1.34322	0.242		0.35874	0.9019
EXPIN does not Granger Cause MM	153	0.61042	0.7217	71	1.75596	0.1244
MM does not Granger Cause EXPIN		2.24804	0.0421		7.40026	7.00E-06
UNEM does not Granger Cause MM	153	0.88373	0.5087	71	0.41493	0.8662
MM does not Granger Cause UNEM		0.34979	0.909		0.36793	0.8963
LIBOROISSPREAD does not Granger Ca	153	1.52728	0.1735	71	3.02957	0.012
MM does not Granger Cause LIBOROISSPREAD		0.52114	0.7915		1.01491	0.4247
EFP does not Granger Cause MM	153	1.84562	0.0945	71	3.01716	0.0123
MM does not Granger Cause EFP		1.14923	0.3372		1.72805	0.1307
RBKX does not Granger Cause MM	153	1.25946	0.2801	71	2.43431	0.0362
MM does not Granger Cause RBKX		0.97593	0.4439		2.1872	0.0571
BKX15D does not Granger Cause MM	153	0.40345	0.8758	71	1.09711	0.3751
MM does not Granger Cause BKX15D		0.6515	0.6888		0.13025	0.992
RW5000RESID does not Granger Cause	153	1.05653	0.3917	71	6.00824	6.00E-05
MM does not Granger Cause RW5000RESID		0.75545	0.6061		1.91363	0.0938
W500015D does not Granger Cause MI	153	0.95676	0.4569	71	3.03614	0.0119
MM does not Granger Cause W500015D		0.90463	0.4935		0.11658	0.9941
M0 does not Granger Cause MM	153	0.9271	0.4776	71	2.63967	0.0248
MM does not Granger Cause M0		1.77235	0.109		2.77825	0.0192

Table 7: Variance decompositions VAR(1) Panel 1

Variance Decomposition of MM:

Period	S.E.	MM	FFRATE	)ROISSPREAD	RBKX	M0
1	0.84	100	0	0	0	0
2	0.84	100	0	0	0	0
3	0.88	92.95	0.68	5.11	1.00	0.26
4	0.88	92.95	0.68	5.11	1.00	0.26
5	0.92	89.74	0.80	6.72	1.16	1.59
6	0.92	89.74	0.80	6.72	1.16	1.59
7	0.94	86.69	1.93	7.06	1.56	2.76
8	0.94	86.69	1.93	7.06	1.56	2.76
9	0.94	86.44	1.93	7.09	1.69	2.86
10	0.94	86.44	1.93	7.09	1.69	2.86

Variance Decomposition of FFRATE:

Period	S.E.	MM	FFRATE	)ROISSPREAD	RBKX	M0
1	5.93	0.05	99.95	0	0	0
2	5.93	0.05	99.95	0	0	0
3	6.12	1.49	94.26	0.95	2.07	1.24
4	6.12	1.49	94.26	0.95	2.07	1.24
5	6.45	1.40	88.87	1.89	2.13	5.72
6	6.45	1.40	88.87	1.89	2.13	5.72
7	6.60	1.62	85.59	2.03	5.00	5.76
8	6.60	1.62	85.59	2.03	5.00	5.76
9	6.63	1.67	84.82	2.01	4.96	6.54
10	6.63	1.67	84.82	2.01	4.96	6.54

Variance Decomposition of LIBOROISSPREAD:

Period	S.E.	MM	FFRATE	)ROISSPREAD	RBKX	M0
1	33.67	0.00	5.03	94.97	0	0
2	33.67	0.00	5.03	94.97	0	0
3	34.31	0.17	4.98	91.67	2.95	0.22
4	34.31	0.17	4.98	91.67	2.95	0.22
5	34.73	0.50	5.06	89.83	3.66	0.96
6	34.73	0.50	5.06	89.83	3.66	0.96
7	34.88	1.22	5.03	89.16	3.64	0.95
8	34.88	1.22	5.03	89.16	3.64	0.95
9	34.94	1.25	5.09	88.91	3.68	1.07
10	34.94	1.25	5.09	88.91	3.68	1.07

Variance Decomposition of RBKX:

Period	S.E.	MM	FFRATE	LIBOROISSPR	RBKX	M0
1	2.88	0.81	0.46	2.21	96.52	0
2	2.88	0.81	0.46	2.21	96.52	0
3	2.96	4.83	1.02	2.10	92.03	0.02
4	2.96	4.83	1.02	2.10	92.03	0.02
5	2.98	5.14	1.09	2.32	91.38	0.08
6	2.98	5.14	1.09	2.32	91.38	0.08
7	3.03	4.94	2.36	4.30	87.93	0.47
8	3.03	4.94	2.36	4.30	87.93	0.47
9	3.04	4.98	2.40	4.29	87.76	0.57
10	3.04	4.98	2.40	4.29	87.76	0.57

Variance Decomposition of M0:

Period	S.E.	MM	FFRATE	LIBOROISSPR	RBKX	M0
1	0.53	16.48	1.32	0.24	5.37	76.59
2	0.53	16.48	1.32	0.24	5.37	76.59
3	0.56	22.57	1.54	1.65	4.93	69.31
4	0.56	22.57	1.54	1.65	4.93	69.31
5	0.59	20.51	1.41	1.58	4.49	72.01
6	0.59	20.51	1.41	1.58	4.49	72.01
7	0.61	21.31	4.64	2.14	4.48	67.44
8	0.61	21.31	4.64	2.14	4.48	67.44
9	0.61	21.64	4.67	2.32	4.50	66.87
10	0.61	21.64	4.67	2.32	4.50	66.87

Table 8: Variance decompositions VAR(1) Panel 2

Variance Decomposition of MM:

Period	S.E.	MM	FFRATE	RBKX	LIBOROISSPREAD	M0
1	3.55	100	0	0	0	0
2	3.55	100	0	0	0	0
3	4.19	89.45	0.00	3.28	6.93	0.33
4	4.19	89.45	0.00	3.28	6.93	0.33
5	4.37	86.91	0.07	3.86	8.87	0.31
6	4.37	86.91	0.07	3.86	8.87	0.31
7	4.50	82.03	0.40	8.19	8.88	0.50
8	4.50	82.03	0.40	8.19	8.88	0.50
9	4.54	81.40	0.59	8.43	8.74	0.83
10	4.54	81.40	0.59	8.43	8.74	0.83

Variance Decomposition of FFRATE:

Period	S.E.	MM	FFRATE	RBKX	LIBOROISSPREAD	M0
1	25.64	8.13	91.87	0	0	0
2	25.64	8.13	91.87	0	0	0
3	35.73	17.00	53.41	8.86	19.62	1.11
4	35.73	17.00	53.41	8.86	19.62	1.11
5	37.94	17.36	49.30	9.00	18.89	5.46
6	37.94	17.36	49.30	9.00	18.89	5.46
7	40.46	18.08	43.55	8.54	22.32	7.51
8	40.46	18.08	43.55	8.54	22.32	7.51
9	40.70	18.15	43.17	8.85	22.06	7.77
10	40.70	18.15	43.17	8.85	22.06	7.77

Variance Decomposition of RBKX:

Period	S.E.	MM	FFRATE	RBKX	LIBOROISSPREAD	M0
1	8.67	6.98	4.50	88.52	0	0
2	8.67	6.98	4.50	88.52	0	0
3	9.13	6.36	6.34	80.41	1.13	5.75
4	9.13	6.36	6.34	80.41	1.13	5.75
5	9.31	6.32	6.79	77.36	1.65	7.88
6	9.31	6.32	6.79	77.36	1.65	7.88
7	9.60	9.81	7.02	72.82	2.51	7.84
8	9.60	9.81	7.02	72.82	2.51	7.84
9	9.87	13.71	6.68	69.17	3.01	7.44
10	9.87	13.71	6.68	69.17	3.01	7.44

Variance Decomposition of LIBOROISSPREAD:

Period	S.E.	MM	FFRATE	RBKX	LIBOROISSPREAD	M0
1	26.09	0.58	0.38	0.61	98.43	0
2	26.09	0.58	0.38	0.61	98.43	0
3	26.73	2.54	1.25	0.72	93.79	1.70
4	26.73	2.54	1.25	0.72	93.79	1.70
5	27.51	5.73	1.89	1.60	88.59	2.19
6	27.51	5.73	1.89	1.60	88.59	2.19
7	27.87	5.74	1.89	1.81	87.52	3.04
8	27.87	5.74	1.89	1.81	87.52	3.04
9	27.89	5.77	1.92	1.81	87.45	3.04
10	27.89	5.77	1.92	1.81	87.45	3.04

Variance Decomposition of M0:

Period	S.E.	MM	FFRATE	RBKX	LIBOROISSPREAD	M0
1	3.43	93.05	0.79	0.13	0.38	5.65
2	3.43	93.05	0.79	0.13	0.38	5.65
3	3.61	84.71	1.75	1.03	6.14	6.36
4	3.61	84.71	1.75	1.03	6.14	6.36
5	3.63	83.79	1.96	1.85	6.07	6.33
6	3.63	83.79	1.96	1.85	6.07	6.33
7	3.76	80.63	2.53	4.90	5.88	6.06
8	3.76	80.63	2.53	4.90	5.88	6.06
9	3.78	80.39	2.69	4.93	6.01	5.99
10	3.78	80.39	2.69	4.93	6.01	5.99

Table 9: Variance decompositions VAR(2) Panel 1

Variance Decomposition of MM:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	0.77	100	0	0	0	0
2	0.77	100	0	0	0	0
3	0.80	94.40	0.19	0.67	2.90	1.84
4	0.80	94.40	0.19	0.67	2.90	1.84
5	0.82	94.24	0.46	0.65	2.89	1.76
6	0.82	94.24	0.46	0.65	2.89	1.76
7	0.82	93.48	0.58	0.99	3.14	1.81
8	0.82	93.48	0.58	0.99	3.14	1.81
9	0.82	93.44	0.60	1.00	3.15	1.81
10	0.82	93.44	0.60	1.00	3.15	1.81

Variance Decomposition of FFRATE:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	5.38	0.18	99.82	0	0	0
2	5.38	0.18	99.82	0	0	0
3	5.49	1.38	98.24	0.35	0.00	0.02
4	5.49	1.38	98.24	0.35	0.00	0.02
5	5.66	2.00	97.42	0.42	0.00	0.16
6	5.66	2.00	97.42	0.42	0.00	0.16
7	5.72	1.96	96.21	0.50	0.12	1.21
8	5.72	1.96	96.21	0.50	0.12	1.21
9	5.73	1.96	96.18	0.51	0.13	1.22
10	5.73	1.96	96.18	0.51	0.13	1.22

Variance Decomposition of RBKX:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	4.29	0.08	0.17	99.75	0	0
2	4.29	0.08	0.17	99.75	0	0
3	4.30	0.22	0.17	99.37	0.06	0.18
4	4.30	0.22	0.17	99.37	0.06	0.18
5	4.36	0.27	0.50	98.00	0.52	0.71
6	4.36	0.27	0.50	98.00	0.52	0.71
7	4.40	0.83	0.60	96.44	0.83	1.30
8	4.40	0.83	0.60	96.44	0.83	1.30
9	4.40	0.83	0.61	96.42	0.84	1.31
10	4.40	0.83	0.61	96.42	0.84	1.31

Variance Decomposition of RW5000RESID:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	1.76	0.07	0.16	1.86	97.91	0
2	1.76	0.07	0.16	1.86	97.91	0
3	1.77	0.18	0.18	2.13	97.49	0.02
4	1.77	0.18	0.18	2.13	97.49	0.02
5	1.78	0.18	0.32	3.20	96.12	0.16
6	1.78	0.18	0.32	3.20	96.12	0.16
7	1.80	0.38	1.04	3.17	95.15	0.25
8	1.80	0.38	1.04	3.17	95.15	0.25
9	1.80	0.41	1.08	3.17	95.09	0.25
10	1.80	0.41	1.08	3.17	95.09	0.25

Variance Decomposition of M0:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	0.64	22.32	1.90	2.25	0.98	72.55
2	0.64	22.32	1.90	2.25	0.98	72.55
3	0.68	22.68	2.54	2.85	2.13	69.80
4	0.68	22.68	2.54	2.85	2.13	69.80
5	0.68	22.54	2.92	2.91	2.13	69.51
6	0.68	22.54	2.92	2.91	2.13	69.51
7	0.69	22.71	3.54	2.86	2.36	68.54
8	0.69	22.71	3.54	2.86	2.36	68.54
9	0.69	22.70	3.55	2.86	2.37	68.53
10	0.69	22.70	3.55	2.86	2.37	68.53

Table 10: Variance decompositions VAR(2) Panel 2

Variance Decomposition of MM:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	3.40	100	0	0	0	0
2	3.40	100	0	0	0	0
3	4.25	86.22	0.03	2.64	10.91	0.21
4	4.25	86.22	0.03	2.64	10.91	0.21
5	4.37	85.46	0.10	3.25	10.91	0.27
6	4.37	85.46	0.10	3.25	10.91	0.27
7	4.50	80.64	0.15	7.64	11.13	0.44
8	4.50	80.64	0.15	7.64	11.13	0.44
9	4.55	79.63	0.66	7.73	11.26	0.73
10	4.55	79.63	0.66	7.73	11.26	0.73

Variance Decomposition of FFRATE:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	26.17	14.01	85.99	0	0	0
2	26.17	14.01	85.99	0	0	0
3	32.83	13.12	71.23	5.65	4.19	5.81
4	32.83	13.12	71.23	5.65	4.19	5.81
5	38.27	13.79	54.66	5.50	12.33	13.72
6	38.27	13.79	54.66	5.50	12.33	13.72
7	40.23	13.70	50.18	6.12	13.57	16.43
8	40.23	13.70	50.18	6.12	13.57	16.43
9	40.58	13.50	49.34	6.16	14.08	16.92
10	40.58	13.50	49.34	6.16	14.08	16.92

Variance Decomposition of RBKX:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	8.53	4.02	1.78	94.20	0	0
2	8.53	4.02	1.78	94.20	0	0
3	9.10	4.16	2.78	83.74	3.41	5.90
4	9.10	4.16	2.78	83.74	3.41	5.90
5	9.28	4.01	3.45	80.50	3.30	8.74
6	9.28	4.01	3.45	80.50	3.30	8.74
7	9.56	7.84	3.35	76.10	4.20	8.51
8	9.56	7.84	3.35	76.10	4.20	8.51
9	9.78	10.81	3.54	73.07	4.46	8.13
10	9.78	10.81	3.54	73.07	4.46	8.13

Variance Decomposition of RW5000RESID:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	2.93	6.74	0.32	3.64	89.31	0
2	2.93	6.74	0.32	3.64	89.31	0
3	3.01	9.45	1.06	4.28	85.18	0.04
4	3.01	9.45	1.06	4.28	85.18	0.04
5	3.05	9.23	1.67	4.52	84.04	0.55
6	3.05	9.23	1.67	4.52	84.04	0.55
7	3.12	9.96	3.15	4.34	82.02	0.53
8	3.12	9.96	3.15	4.34	82.02	0.53
9	3.14	9.95	3.63	4.27	81.63	0.52
10	3.14	9.95	3.63	4.27	81.63	0.52

Variance Decomposition of M0:

Period	S.E.	MM	FFRATE	RBKX	RW5000RESID	M0
1	3.28	92.46	0.58	0.12	0.38	6.46
2	3.28	92.46	0.58	0.12	0.38	6.46
3	3.57	79.93	2.47	0.90	9.95	6.75
4	3.57	79.93	2.47	0.90	9.95	6.75
5	3.59	79.07	2.48	1.82	9.90	6.73
6	3.59	79.07	2.48	1.82	9.90	6.73
7	3.69	75.92	2.64	4.74	10.18	6.51
8	3.69	75.92	2.64	4.74	10.18	6.51
9	3.79	73.31	3.01	4.62	12.87	6.19
10	3.79	73.31	3.01	4.62	12.87	6.19

Figure 9: Growth Rate of the Deposit-Currency Ratio (1919-1941)

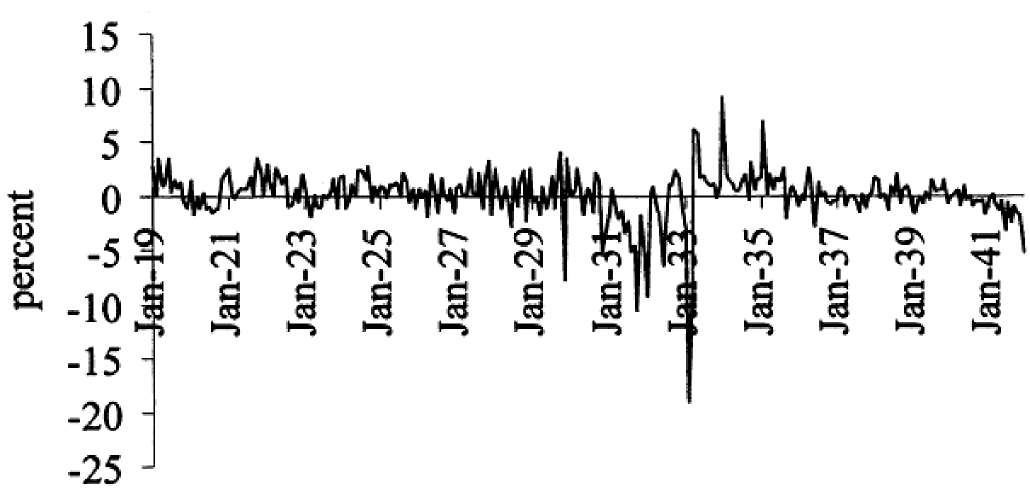

Figure 10: Impulse responses for VAR(1) Panel 1

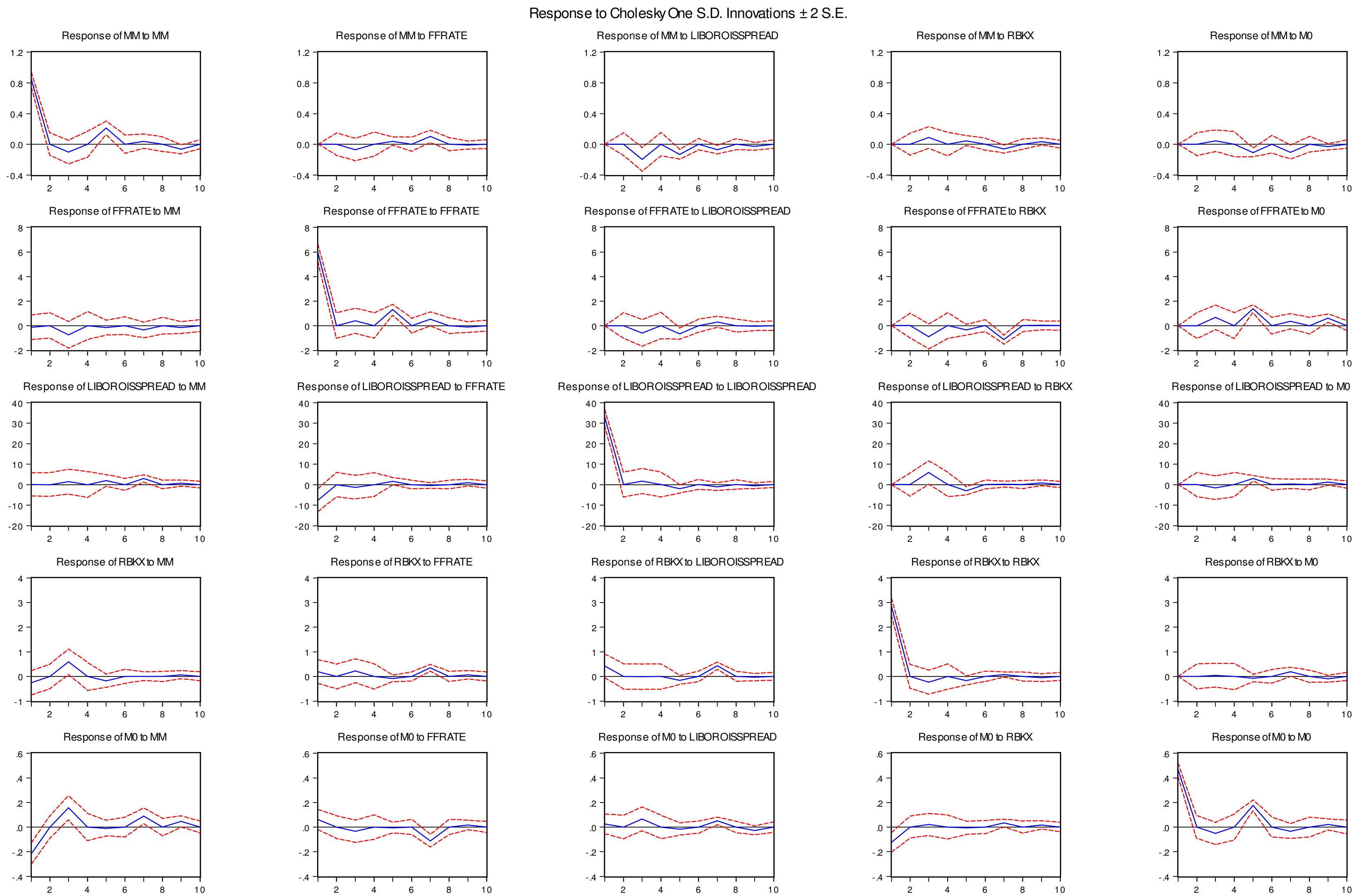

Figure 11: Impulse responses for VAR(1) Panel 2

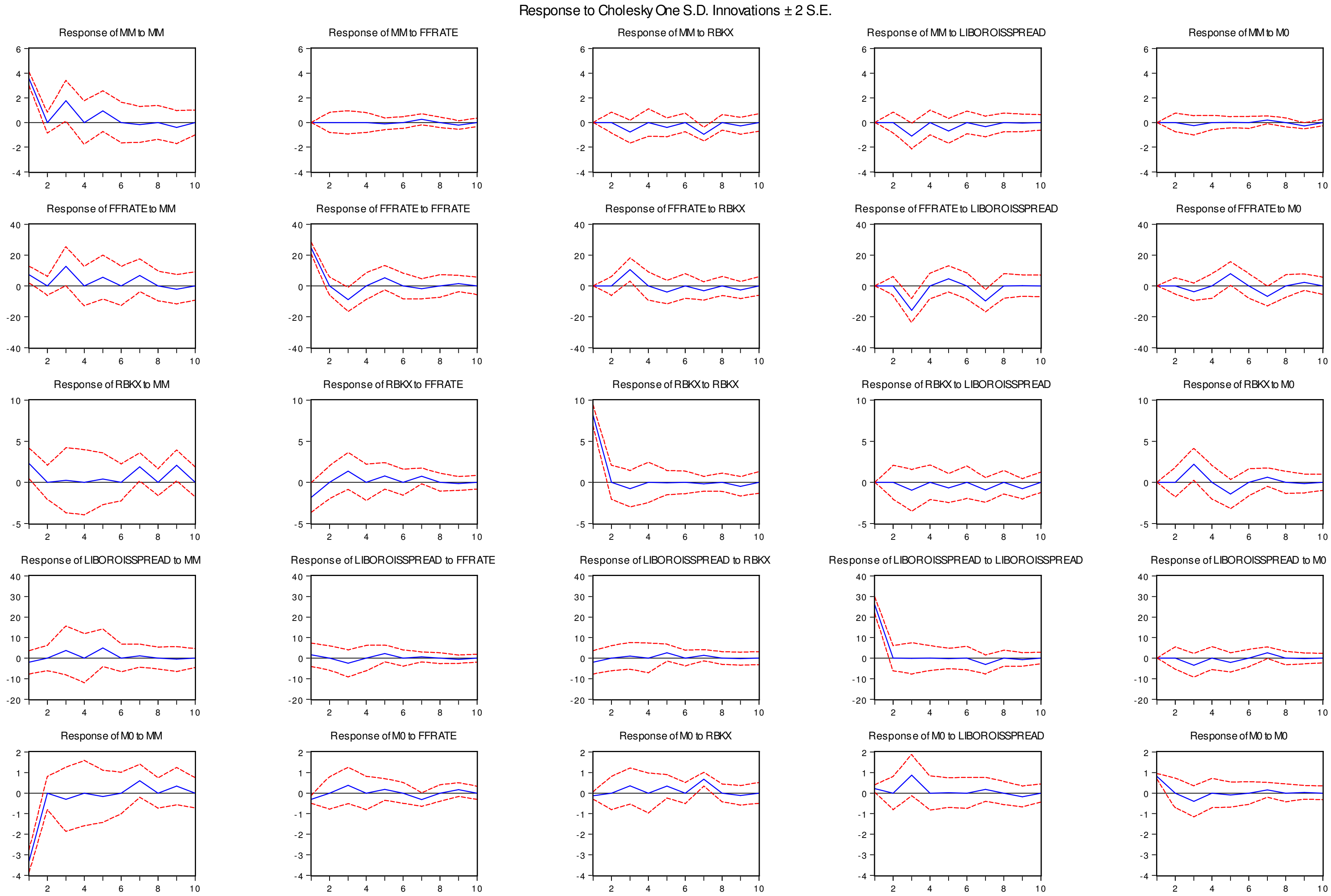

Figure 12: Impulse responses for VAR(2) Panel 1

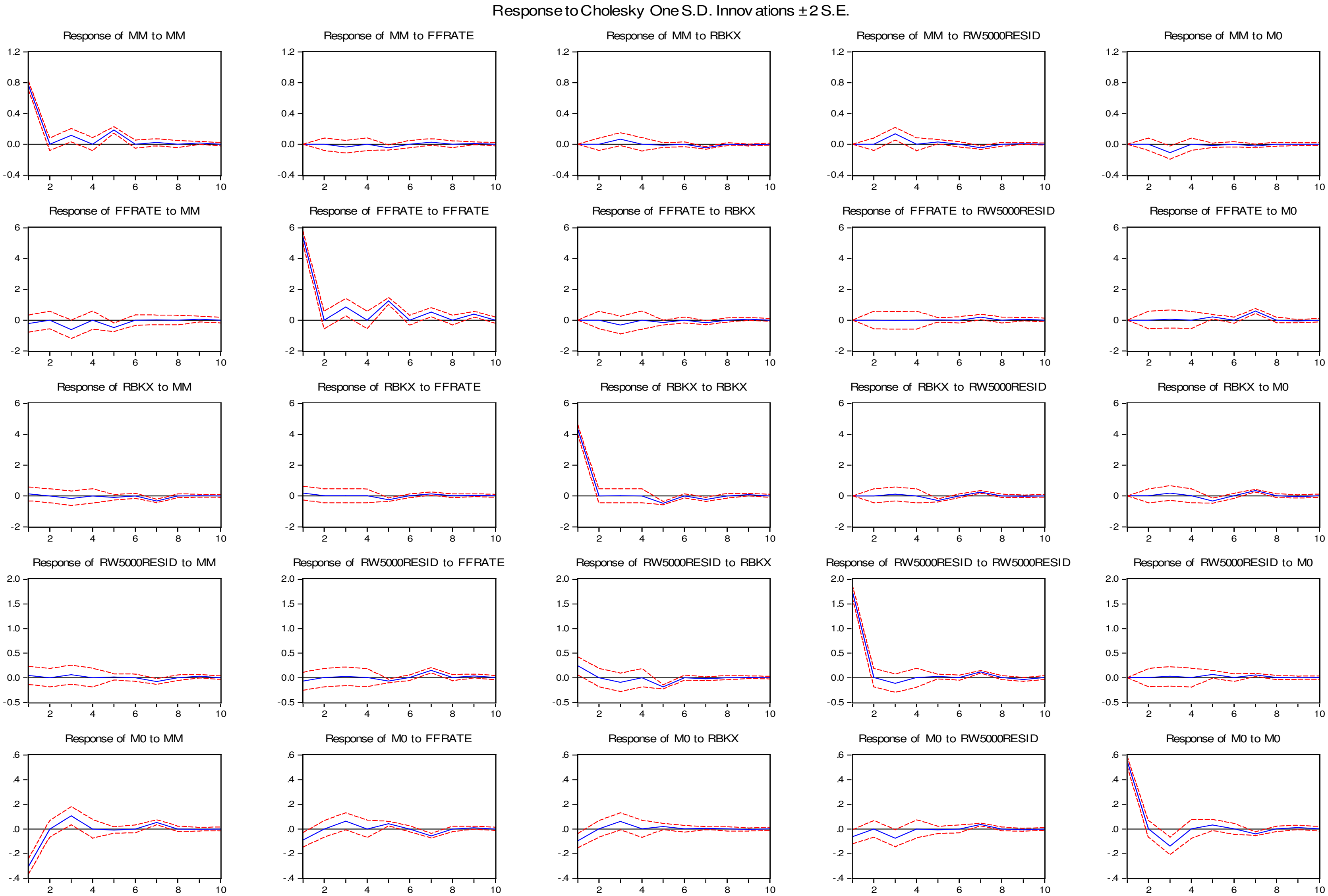

Figure 13: Impulse responses for VAR(2) Panel