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Financial Intermediaries and Monetary Economics*

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Abstract

We reconsider the role of financial intermediaries in monetary economics. We explore the hypothesis that the financial intermediary sector is the engine that drives the financial cycle through the fluctuations in the price of risk. In this framework, balance sheet quantities emerge as a key indicator of risk appetite and hence for the "risk-taking channel" of monetary policy. We document evidence that balance sheets of financial intermediaries provide a window on the transmission of monetary policy through capital market conditions. Short-term interest rates are found to be important in influencing the size of financial intermediary balance sheets. Our findings suggest that the traditional focus on the money stock for the conduct of monetary policy may have more modern counterparts, and suggest the importance of tracking balance sheet quantities for the conduct of monetary policy.

*This paper is a preliminary version of a chapter prepared for the *Handbook of Monetary Economics*. The views expressed in this chapter are those of the authors and do not necessarily represent those of the Federal Reserve Bank of New York or the Federal Reserve System.

Contents

1. Introduction

In conventional models of monetary economics commonly used in central banks, the banking sector has not played a prominent role. The primary friction in such models is the price stickiness of goods and services. Financial intermediaries do not play a role, except perhaps as a passive player that the central bank uses as a channel to implement monetary policy.

However, financial intermediaries have been at the center of the global financial crisis that erupted in 2007. They have borne a large share of the credit losses from securitized subprime mortgages, even though securitization was intended to parcel out and disperse credit risk to investors who were better able to absorb losses. Credit losses and the associated financial distress have figured prominently in the commentary on the downturn in real economic activity that followed. Recent events suggest that financial intermediaries may be worthy of separate study in order to ascertain their role in economic fluctuations.

The purpose of this chapter in the Handbook of Monetary Economics is to reconsider the role of financial intermediaries in monetary economics. In addressing the issue of financial factors in macroeconomics, we join a spate of recent research that has attempted to incorporate a financial sector in a New Keynesian DSGE model. Woodford and Curdia (2008) and Gertler and Karadi (2009) are recent examples. However, rather than phrasing the question as how financial "frictions" affect the real economy, we focus on the financial intermediary sector itself. We explore the hypothesis that the financial intermediary sector, far from being passive, is instead the engine that drives the boom-bust cycle. To explore this hypothesis, we propose a framework for study with a view to addressing the following pair of questions. What are the channels through which financial intermediaries exert an influence on the real economy (if at all), and what are the implications for monetary policy?

In the framework proposed to explore our hypothesis, financial intermediaries play the role of the engine of the financial cycle through their influence on the determination of the price of risk. Quantity variables - especially the components of financial intermediary balance sheet - emerge as important economic indicators in their own right due to their role in reflecting the risk capacity of banking sector balance sheets, the pricing of risk, and hence on the level of real activity. Ironically, our findings have some points of contact with the older theme in monetary economics of keeping track of the money stock at a time when the money stock has fallen out of favor among monetary economists.[1] The common theme between our framework and the older literature is that the money stock is a balance sheet aggregate of the financial sector.

Using the language of "frictions", our results suggest a second friction, in addition to sticky prices. This second friction originates in the agency relationships embedded in the organization of financial intermediaries, which are manifested in the way that financial intermediaries manage their balance sheets. This is a friction in the supply of credit. We are certainly not the first to study frictions in the supply of credit, and there has been an extensive discussion of financial frictions within monetary economics, as we will describe in more detail below. However, it would be fair to say that financial frictions have received less emphasis in recent years (at least, until the eruption of the financial crisis).

When we examine balance sheet measures that reflect the underlying funding conditions in capital markets, we find that the appropriate balance sheet quantities are of institutions that are marked to market. In this regard, broker-dealer assets are more informative than commercial bank assets. However, as commercial banks

[1]See Friedman (1988) for an overview of the role of monetary aggregates in macroeconomic fluctuations in the United States.

begin to mark more items of their balance sheets to market, commercial bank balance sheet variables are likely to become more important variables for studying the transmission mechanism.

There are implications for the conduct of monetary policy. According to the perspective outlined here, fluctuations in the supply of credit arise from how much slack there is in financial intermediary balance sheet capacity. The cost of leverage of market-based intermediaries is determined by two main variables – risk, and short term interest rates. The expected profitability of intermediaries is proxied by spreads such as the term spread and various credit spreads. Variations in the policy target determine short term interest rates, and have a direct impact on the profitability of intermediaries. Moreover, for financial intermediaries who tend to fund long-term assets with short-term liabilities, movements in the yield curve may also have valuation effects due to the fact that assets are more sensitive to discount rate changes than liabilities.

Monetary policy actions that affect the risk-taking capacity of the banks will lead to shifts in the supply of credit. Borio and Zhu (2008) have coined the term "risk-taking channel" of monetary policy to describe this set of effects working through the risk appetite of financial intermediaries. For these reasons, short term interest rates matter directly for monetary policy. This perspective on the importance of the short rate as a price variable is in contrast to current monetary thinking, where short term rates matter only to the extent that they determine long term interest rates, which are seen as being risk-adjusted expectations of future short rates. Current models of monetary economics used at central banks emphasize the importance of managing market expectations. By charting a path for future short rates and communicating this path clearly to the market, the central bank can influence long rates and thereby influence mortgage rates, corporate lending rates and other prices that affect consumption and investment.

The "expectations channel" has become an important consideration for monetary policy, especially among those that practice inflation targeting. The expectations channel is explained in Bernanke (2004), Svensson (2004) and Woodford (2003, 2005). Alan Blinder (1998, p.70) in his book on central banking phrases the claim in a particularly clear way.

> "central banks generally control only the overnight interest rate, an interest rate that is relevant to virtually no economically interesting transactions. Monetary policy has important macroeconomic effects only to the extent that it moves financial market prices that really matter - like long-term interest rates, stock market values and exchange rates."

In contrast, our results suggest that short-term rates may be important in their own right. In the run-up to the global financial crisis of 2007 to 2009, the financial system was said to "awash with liquidity", in the sense that credit was easy to obtain. In an earlier study[2], we showed how liquidity in this sense is closely related to the growth of financial intermediary balance sheets. Our theoretical framework is designed to capture the notion of liquidity in the sense of the ease of credit conditions. When asset prices rise, financial intermediaries' balance sheets generally become stronger, and—without adjusting asset holdings—their leverage becomes eroded. The financial intermediaries then hold surplus capital, and they will attempt to find ways in which they can employ their surplus capital. In analogy with manufacturing firms, we may see the financial system as having "surplus capacity". For such surplus capacity to be utilized, the intermediaries must expand their balance sheets. On the liability side, they take on more debt. On the asset side, they search for potential borrowers. When the set of

[2] Adrian and Shin (2007)

potential borrowers is fixed, the greater willingness to lend leads to an erosion in risk premium from lending, and spreads become compressed.

There is some empirical support for the risk-taking channel of monetary policy. We find that the growth in broker-dealer balance sheets helps to explain future real activity, especially for components of GDP that are sensitive to the supply of credit. However, we also find that fluctuations in the balance sheet size of security broker-dealers appear to signal shifts in future real activity better than the larger commercial banking sector. Thus, one lesson from our empirical analysis is that there are important distinctions between different categories of financial intermediaries. In fact, the evolution of broker-dealer assets has a time signature that is markedly different from those of commercial banks. Our results point to key differences between banking as traditionally conceived and the market-based banking system that has become increasingly influential in charting the course of economic events.

Broker-dealers have traditionally played market-making and underwriting roles in securities markets. However, their importance in the supply of credit has increased dramatically in recent years with the growth of securitization and the changing nature of the financial system toward one based on the capital market, rather than one based on the traditional role of the bank as intermediating between depositors and borrowers. Although total assets of the broker-dealer sector is smaller than total asset of the commercial banking sector, our results suggest that broker-dealers provide a better barometer of the funding conditions in the economy, capturing overall capital market conditions. Perhaps the most important development in this regard has been the changing nature of housing finance in the US. The stock of home mortgages in the US is now dominated by the holdings in market-based institutions, rather than traditional bank balance sheets. Broker-dealer balance sheets provide a timely window on this world.

Having established the importance of financial intermediary balance sheets in signaling future real activity, we go on to examine the determinants of balance sheet growth. We find that short-term interest rates are important. Indeed, the level of the Fed Funds target is a key variable. We find that a lowering of short-term rates are conducive to expanding balance sheets. In addition, a steeper yield curve, larger credit spreads, and lower measures of financial market volatility are conducive to expanding balance sheets. In particular, an inverted yield curve is a harbinger of a slowdown in balance sheet growth, shedding light on the empirical feature that an inverted yield curve forecasts recessions. The Fed funds target determines other relevant short term interest rates, such as repo rates and interbank lending rates through arbitrage in the money market. As such, we may expect the Fed funds rate to be pivotal in setting short-term interest rates more generally.

These findings reflect the economics of financial intermediation, since the business of banking is to borrow short and lend long. For an off-balance sheet vehicle such as a conduit or SIV (structured investment vehicle) that finances holdings of mortgage assets by issuing commercial paper, a difference of a quarter or half percent in the funding cost may make all the difference between a profitable venture and a loss-making one. This is because the conduit or SIV, like most financial intermediaries, is simultaneously both a creditor and a debtor – it borrows in order to lend.

The outline of this chapter is as follows. We begin with a simple general equilibrium model where financial intermediaries as the main engine for the determination of the price of risk in the economy. We then present our empirical results on the real impact of broker-dealer balance sheet changes, the determinants of balance sheet changes. We consider the role of the central bank as the lender of last resort (LOLR) in the light of our findings. We conclude by drawing some lessons for monetary policy in the light of our findings.

2. Financial Intermediaries and the Price of Risk

To motivate the study of financial intermediaries and how they determine the price of risk, we begin with a stylized model set in a one period asset market.[3] The general equilibrium model below is deliberately stark. It has two features that deserve emphasis.

First, there is no default in the model. The debt that appears in the model is risk-free. However, as we will see, the amplification of the financial cycle is present. John Geanakoplos (2009) has highlighted how risk-free debt may still give rise to powerful spillover effects through fluctuations in leverage and the pricing of risk. Adrian and Shin (2007) exhibit empirical evidence that bears on the fluctuations in the pricing of risk from the balance sheets of financial intermediaries. Shleifer and Vishny (1997) demonstrated how financial constraints can lead to fluctuations of risk premia even if arbitrageurs are risk neutral; and Shleifer and Vishny (2009) present a theory of unstable banking.

Second, in the example, there is no lending and borrowing between financial intermediaries themselves. So, any effect we see in the model cannot be attributed to what we may call the "domino model" of systemic risk where systemic risk propagates through the financial system through the chain of defaults of financial intermediaries[4]. This is not to deny that interlocking claims do not matter. However, the benchmark case serves the purpose of showing that chains of default are not necessary for fluctuations in the price of risk.

To anticipate the punchline from the simple model, it is that the aggregate

[3] A similar model appeared in Shin (2009).

[4] See Adrian and Shin (2008c) for an argument for why the "domino model" is inappropriate for understanding the crisis of 2007 -9.

balance sheet quantities of financial intermediaries stand in a one-to-one relation with the price of risk and the availability of funding that flows to real projects. The larger is the aggregate intermediary sector balance sheet, the lower is the price of risk, and easier is credit.

2.1. Model

Today is date 0. A risky security is traded today in anticipation of its realized payoff in the next period (date 1). The payoff of the risky security is known at date 1. When viewed from date 0, the risky security's payoff is a random variable $\tilde{w}$, with expected value $q > 0$. The uncertainty surrounding the risky security's payoff takes a particularly simple form. The random variable $\tilde{w}$ is uniformly distributed over the interval:

$$[q - z, q + z]$$

where $z > 0$ is a known constant. The mean and variance of $\tilde{w}$ is given by

$$\begin{aligned} E(\tilde{w}) &= q \\ \sigma^2 &= \frac{z^2}{3} \end{aligned}$$

There is also a risk-free security, which we call "cash", that pays an interest rate of zero. Let p denote the price of the risky security. For an investor with equity e who holds y units of the risky security, the payoff of the portfolio is the random variable:

$$W \equiv \tilde{w}y + (e - py) \tag{2.1}$$

There are two groups of investors - passive investors and active investors. The passive investors can be thought of as non-leveraged investors such as pension funds and mutual funds, while the active investors can be interpreted as leveraged institutions such as banks and securities firms who manage their balance sheets

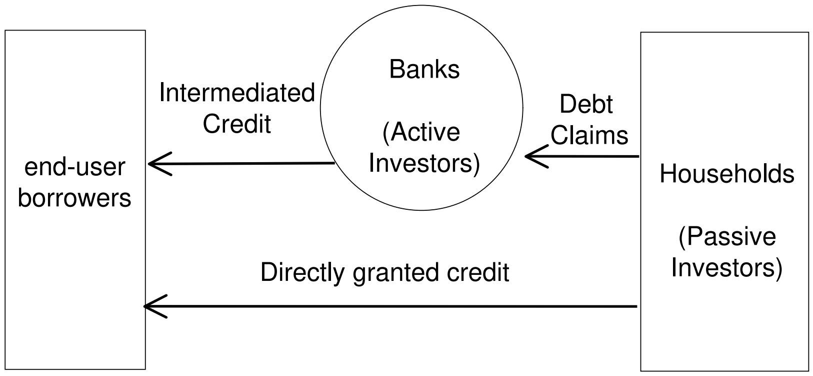

Figure 2.1: Intermediated and Directly Granted Credit

actively. The risky securities can be interpreted as loans granted to ultimate borrowers or securities issued by the borrowers, but where there is a risk that the borrowers do not fully repay the loan. Figure 2.1 depicts the relationships. Under this interpretation, the market value of the risky securities can be thought of as the marked-to-market value of the loans granted to the ultimate borrowers. The passive investors' holding of the risky security can then be interpreted as the credit that is granted *directly* by the household sector (through the holding of corporate bonds, for example), while the holding of the risky securities by the active investors can be given the interpretation of *intermediated finance* where the active investors are banks that borrow from the households in order to lend to the ultimate borrowers.

We assume that the passive investors have mean-variance preferences over the payoff from the portfolio. They aim to maximize

$$U = E(W) - \frac{1}{2\tau}\sigma_W^2 \tag{2.2}$$

where $\tau > 0$ is a constant called the investor's "risk tolerance" and σ_W^2 is the variance of W. In terms of the decision variable y, the passive investor's objective function can be written as

$$U(y) = qy + (e - py) - \frac{1}{6\tau} y^2 z^2 \tag{2.3}$$

The optimal holding of the risky security satisfies the first order condition:

$$q - p - \frac{1}{3\tau} z^2 y = 0 \tag{2.4}$$

The price must be below the expected payoff for the risk-averse investor to hold any of the risky security. The optimal risky security holding of the passive investor (denoted by y_P) is given by

$$y_P = \begin{cases} \frac{3\tau}{z^2}(q - p) & \text{if } q > p \\ \\ 0 & \text{otherwise} \end{cases} \tag{2.5}$$

These linear demands can be summed to give the aggregate demand. If τ_i is the risk tolerance of the ith investor and $\tau = \sum_i \tau_i$, then (2.5) gives the aggregate demand of the passive investor sector as a whole.

Now turn to the portfolio decision of the active (leveraged) investors. These active investors are risk-neutral but face a Value-at-Risk (VaR) constraint, as is commonly the case for banks and other leveraged institutions. The general VaR constraint is that the capital cushion be large enough that the default probability is kept below some benchmark level. Consider the special case where that benchmark level is zero.

Denote by VaR the Value-at-Risk of the leveraged investor. The constraint is that the investor's capital (equity) e be large enough to cover this Value-at-Risk. The optimization problem for an active investor is:

$$\max_y E(W) \quad \text{subject to VaR} \leq e \tag{2.6}$$

If the price is too high (i.e. when $p > q$) the investor holds no risky securities. When $p < q$, then $E(W)$ is strictly increasing in y, and so the Value-at-Risk constraint binds. The optimal holding of the risky security can be obtained by solving VaR $= e$. To solve this equation, write out the balance sheet of the leveraged investor as

Assets	Liabilities
securities, py	equity, e debt, $py - e$

The Value-at-Risk constraint stipulates that the equity of the bank (the active investor) be large enough to cover the worst case loss. For each unit of the security, the minimum payoff is $q - z$. Thus, the worst case loss is $py - (q - z)\,y$. In order for the bank to have enough equity to cover the worst case loss, we require:

$$py - (q - z)\,y \leq e \tag{2.7}$$

This inequality also holds in the aggregate. The left hand side of (2.7) is the Value-at-Risk (the worst possible loss) relative to today's market value of assets, which must be met by equity e. Since the constraint binds, the optimal holding of the risky securities for the leveraged investor is

$$y = \frac{e}{z - (q - p)} \tag{2.8}$$

and the balance sheet is

Assets	Liabilities
securities, py	equity, e debt, $(q - z)\,y$

(2.9)

Since (2.8) is linear in e, the aggregate demand of the leveraged sector has the same form as (2.8) when e is the *aggregate capital* of the leveraged sector as a whole.

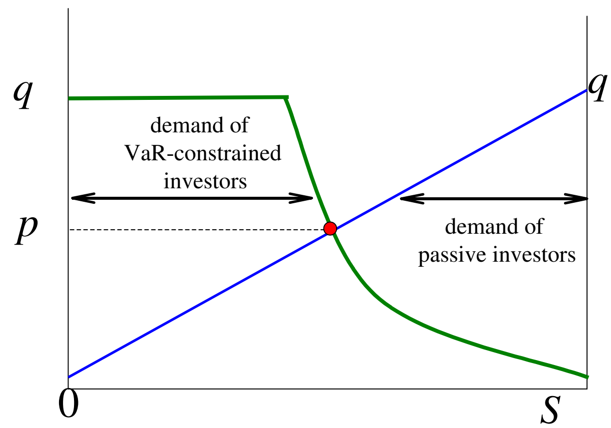

Figure 2.2: Market Clearing Price

Denoting by y_A the holding of the risky securities by the active investors and by y_P the holding by the passive investors, the market clearing condition is

$$y_A + y_P = S \tag{2.10}$$

where S is the total endowment of the risky securities. Figure 2.2 illustrates the equilibrium for a fixed value of aggregate capital e. For the passive investors, their demand is linear, with the intercept at q. The demand of the leveraged sector can be read off from (2.8). The solution is fully determined as a function of e. In a dynamic model, e can be treated as the state variable (see Danielsson, et al. (2009)).

Now consider a possible scenario involving an improvement in the fundamentals of the risky security where the expected payoff of the risky securities rises from q to q'. In our banking interpretation of the model, an improvement in the expected payoff should be seen as an increase in the marked-to-market value of bank assets. In a later section, we explore the role of monetary policy in affecting q. For now we simply treat the increase in q as an exogenous shock.

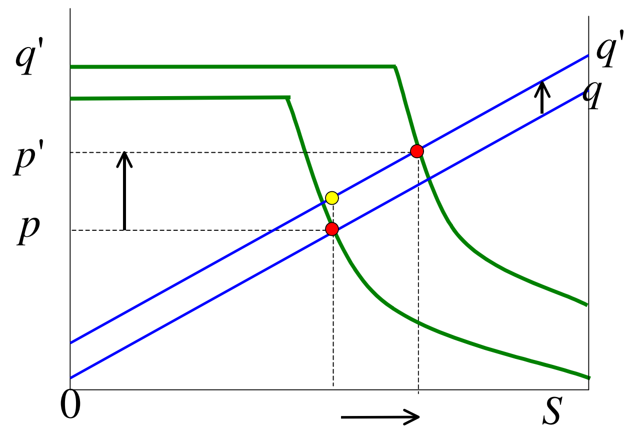

Figure 2.3: Amplified response to improvement in fundamentals q

Figure 2.3 illustrates the scenario. The improvement in the fundamentals of the risky security pushes up the demand curves for both the passive and active investors, as illustrated in Figure 2.3. However, there is an amplified response from the leveraged institutions as a result of marked-to-market gains on their balance sheets.

From (2.9), denote by e' the new equity level of the leveraged investors that incorporates the capital gain when the price rises to p'. The initial amount of debt was $(q-z)\,y$. Since the new asset value is $p'y$, the new equity level e' is

$$\begin{aligned} e' &= p'y - (q-z)\,y \\ &= (z+p'-q)\,y \end{aligned} \tag{2.11}$$

Figure 2.4 breaks out the steps in the balance sheet expansion. The initial balance sheet is on the left, where the total asset value is py. The middle balance sheet shows the effect of an improvement in fundamentals that comes from an increase in q, but before any adjustment in the risky security holding. There is an increase in the value of the securities without any change in the debt value, since the debt

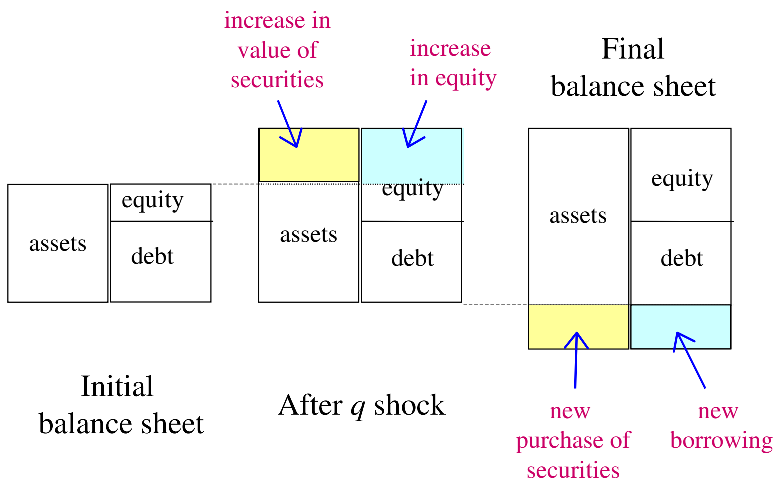

Figure 2.4: Balance sheet expansion from q shock

was already risk-free to begin with. So, the increase in asset value flows through entirely to an increase in equity. Equation (2.11) expresses the new value of equity e' in the middle balance sheet in Figure 2.4.

The increase in equity relaxes the Value-at-Risk constraint, and the leveraged sector can increase its holding of risky securities. The new holding y' is larger, and is enough to make the VaR constraint bind at the higher equity level, with a higher fundamental value q'. That is,

$$\begin{aligned} e' &= p'y' - (q' - z)\, y' \\ &= (z + p' - q')\, y' \end{aligned} \tag{2.12}$$

After the q shock, the investor's balance sheet has strengthened, in that capital has increased without any change in debt value. There has been an erosion of leverage, leading to spare capacity on the balance sheet in the sense that equity is now larger than is necessary to meet the Value-at-Risk. In order to utilize the slack in balance sheet capacity, the investor takes on additional debt to purchase additional risky securities. The demand response is upward-sloping. The new holding of securities is now y', and the total asset value is $p'y'$. Equation (2.12) expresses the new value of equity e' in terms of the new higher holding y' in the right hand side balance sheet in Figure 2.4. From (2.11) and (2.12), we can write the new holding y' of the risky security as

$$y' = y\left(1 + \frac{q' - q}{z + p' - q'}\right) \tag{2.13}$$

From the demand of passive investors (2.5) and market clearing,

$$p' - q' = \frac{z^2}{3\tau}\left(y' - S\right)$$

Substituting into (2.13),

$$y' = y\left(1 + \frac{q' - q}{z + \frac{z^2}{3\tau}\left(y' - S\right)}\right) \tag{2.14}$$

This defines a quadratic equation in y'. The solution is where the right hand side of (2.14) cuts the 45 degree line. The leveraged sector amplifies booms and busts if $y' - y$ has the same sign as $q' - q$. Then, any shift in fundamentals gets amplified by the portfolio decisions of the leveraged sector. The condition for amplification is that the denominator in the second term of (2.14) is positive. But this condition is guaranteed from (2.13) and the fact that $p' > q' - z$ (i.e. that the price of the risky security is higher than its worst possible realized payoff).

Note also that the size of the amplification is increasing in leverage, seen from the fact that $y' - y$ is large when z is small. Recall that z is the fundamental risk. When z is small, the associated Value-at-Risk is also small, allowing the leveraged sector to maintain high leverage. The higher is the leverage, the greater is the marked-to-market capital gains and losses. Amplification is large when the leveraged sector itself is large relative to the total economy. Finally, note that the amplification is more likely when the passive sector's risk tolerance τ is high.

The price gap, $q - p$ is the difference between the expected payoff from the risky security and its price. It is one measure of the price of risk in the economy. The market clearing condition and the demand of the passive sector (2.5) give an empirical counterpart to the price gap given by the size of the leveraged sector. Recall that y_A is the holding of the risky security by the leveraged sector. We have

$$q - p = \tfrac{z^2}{3\tau} (S - y_A) \tag{2.15}$$

which gives our first empirical hypothesis.

Empirical Hypothesis. Risk premiums are low when the size of the leveraged sector is large relative to the non-leveraged sector.

We will explore alternative notions of risk premiums below. The amplifying mechanism works exactly in reverse on the way down. A negative shock to the fundamentals of the risky security drives down its price, which erodes the marked-to-market capital of the leveraged sector. The erosion of capital induces the sector to shed assets so as to reduce leverage down to a level that is consistent with the VaR constraint. Risk premium increases when the leveraged sector suffers losses, since $q - p$ increases.

2.2. Pricing of Risk

We now explore the fluctuations in risk pricing in our model more systematically. For now, let us treat S (the total endowment of the risky security) as being exogenous. Once we solve for the model fully, we can make S endogenous and address the issue of credit supply with shifts in economic fundamentals.

Begin with the market-clearing condition for the risky security, $y_A + y_P = S$. Substituting in the expressions for the demands of the active and passive sectors, we can write the market clearing condition as

$$\frac{e}{z-(q-p)}+\frac{3\tau}{z^2}(q-p)=S \tag{2.16}$$

We also impose a restriction on the parameters from the requirement that the active investors have a strictly positive total holding of the risky security, or equivalently that the passive sector's holding is strictly smaller than the total endowment S. From (2.5) this restriction can be written as

$$\frac{3\tau}{z^2}(q-p)<S \tag{2.17}$$

Our discussion so far of the amplification of shocks resulting from the leveraged investors' balance sheet management suggests that a reasonable hypothesis is that the risk premium to holding the risky security is falling as the fundamental payoff of the risky security improves. This is indeed the case. We have:

Proposition 1. *The expected return on the risky security is strictly decreasing in* q*.*

The expected return to the risky security is $(q/p)-1$. It is convenient to work with a monotonic transformation of the expected return given by

$$\pi \equiv 1-\frac{p}{q} \tag{2.18}$$

We see that π lies between zero and one. When $\pi = 0$, the price of the risky security is equal to its expected payoff, so that there is no risk premium in holding the risky security over cash. As π increases, the greater is the expected return to holding the risky security. Using the π notation, the market-clearing condition (2.16) can be written as follows.

$$F \equiv e+\frac{3\tau}{z^2}q\pi(z-q\pi)-S(z-q\pi)=0 \tag{2.19}$$

We need to show that π is decreasing in q. From the implicit function theorem,

$$\frac{d\pi}{dq} = -\frac{\partial F/\partial q}{\partial F/\partial \pi} \tag{2.20}$$

and

$$\frac{\partial F}{\partial q} = \pi \left(\frac{3\tau}{z} \left(1 - \frac{2\pi q}{z} \right) + S \right)$$

Dividing this expression by $3\tau\pi/z^2 > 0$, we see that $\partial F/\partial q$ has the same sign as

$$\begin{aligned} & (z - \pi q) + \left(\frac{z^2}{3\tau} S - \pi q \right) \\ = \quad & (z - (q-p)) + \left(\frac{z^2}{3\tau} S - (q-p) \right) \end{aligned} \tag{2.21}$$

The left hand term in (2.21) is positive since price p is above the minimum payoff $q - z$. The right hand term is positive from our parameter restriction (2.17) that ensures that the risky security holding by the leveraged sector is strictly positive. Hence, $\partial F/\partial q > 0$. Similarly, it can be shown that $\partial F/\partial \pi > 0$. Therefore, $d\pi/dq < 0$. This concludes the proof of Proposition 1.

The expected return on the risky security is falling as the fundamentals improve. We could rephrase this finding as saying that the risk premium in the economy is declining during booms, or whatever causes the increase in q. In a later section, we explore the role of monetary policy in raising q by raising the marked-to-market value of bank assets.

Although the somewhat mechanical proof we have given for Proposition 1 is not so illuminating concerning the economic mechanism, the heuristic argument in the previous section involving the three balance sheets in Figure 2.4 captures the spirit of the argument more directly.

When fundamentals improve, the leveraged investors (the banks) experience mark-to-market gains on their balance sheets, leading to higher equity capital. The higher mark-to-market capital generates additional balance sheet capacity for the banks that must be put to use. In our model, the excess balance sheet capacity is put to use by increasing lending (purchasing more risky securities) with money borrowed from the passive investors.

2.3. Shadow Value of Bank Capital

Another window on the risk premium in the economy is through the Lagrange multiplier associated with the constrained optimization problem of the banks, which is to maximize the expected payoff from the portfolio $E(W)$ subject to the Value-at-Risk constraint. The Lagrange multiplier is the rate of increase of the objective function with respect to a relaxation of the constraint, and hence can be interpreted as the shadow value of bank capital. Denoting by λ the Lagrange multiplier, we have

$$\begin{aligned}\lambda &= \frac{dE(W)}{de} \\ &= \frac{dE(W)}{dy}\frac{dy}{de} \\ &= (q-p)\cdot\frac{1}{z-(q-p)} \end{aligned} \tag{2.22}$$

where we have obtained the expression for $dE(W)/dy$ from (2.2) and dy/de is obtained from (2.8), which gives the optimal portfolio decision of the leveraged investor. We see from (2.22) that as the price gap $q-p$ becomes compressed, the Lagrange multiplier λ declines. The implication is that the marginal increase of a dollar's worth of new capital for the leveraged investor is generating less expected payoff. As the price gap $q-p$ goes to zero, so does the Lagrange multiplier, implying that the return to a dollar's worth of capital goes to zero.

Furthermore, we have from (2.15) that the price gap $q-p$ is decreasing as the size of the leveraged sector increases relative to the whole economy. The shadow value of bank capital can be written as:

$$\begin{aligned}\lambda &= (q-p)\cdot\frac{1}{z-(q-p)} \\ &= \frac{z(S-y_A)}{3\tau+z(y_A-S)}\end{aligned} \tag{2.23}$$

We have the following proposition.

Proposition 2. *The shadow value of bank capital is decreasing in the size of the leveraged sector.*

The *leverage* of the active investor is defined as the ratio of total assets to equity. Leverage is given by

$$\begin{aligned}\frac{py}{e} &= \frac{p}{e}\times\frac{e}{z-(q-p)} \\ &= \frac{p}{z-(q-p)}\end{aligned} \tag{2.24}$$

As q increases, the numerator $p(q)$ increases without bound. Since the price gap is bounded below by zero, overall leverage eventually increases in q. Thus, leverage is high when total assets are large. In the terminology of Adrian and Shin (2007), the leveraged investors exhibit *procyclical leverage*.

Proposition 3. *For values of q above some threshold $\bar{q}$, leverage is procyclical.*

2.4. Supply of Credit

Up to now, we have treated the total endowment of the risky securities S as being fixed. However, as the risk spread on lending becomes compressed, the leveraged investors (the banks) will be tempted to search for new borrowers they can lend to. In terms of our model, if we allow S to be endogenously determined, we can expect credit supply to be increasing when the risk premium falls. Through this window, we could gain a glimpse into the way that *credit supply* responds to overall economic conditions.

To explore this idea further, we modify our model in the following way. Suppose there is a large pool of potential borrowers who wish to borrow to fund a project, from either the active investors (the banks) or the passive investors (the households). They will borrow from whomever is willing to lend.

Assume that the potential borrowers are identical, and each have identical projects to those which are already being financed by the banks and households. In other words, the potential projects that are waiting to be financed are perfect substitutes with the projects already being funded. Denote the risk premium associated with the pool of potential projects by the constant π_0. If the market risk premium were ever to fall below π_0, the investors in the existing projects would be better off selling the existing projects to fund the projects that are sitting on the sidelines. Therefore, the market premium cannot fall below π_0, so that in any equilibrium with endogenous credit supply, we have

$$\pi \geq \pi_0 \tag{2.25}$$

Define the *supply of credit function* $S(q)$ as the function that maps q to the total lending S. When $\pi(q) \geq \pi_0$, there is no effect of a small change in q on the supply of credit. Define q^* as the threshold value of q defined as $q^* = \pi^{-1}(\pi_0)$. When $q > q^*$, then the equilibrium stock of lending S is determined by the market clearing condition (2.19) where $\pi = \pi_0$. Hence, S satisfies

$$F \equiv e + \frac{3\tau}{z^2} q\pi_0 (z - q\pi_0) - S(z - q\pi_0) = 0$$

The slope of the supply of credit function is given by

$$\frac{dS}{dq} = -\frac{\partial F/\partial q}{\partial F/\partial S} \tag{2.26}$$

We know from (2.21) that the numerator of (2.26) is positive, while $\partial F/\partial S = -(z - q\pi_0) = q - p - z < 0$. Therefore $dS/dq > 0$, so that credit supply is increasing in q. We can summarize the result as follows.

Proposition 4. *The supply of credit S is strictly increasing in q when $q > q^*$.*

The assumption that the pool of potential borrowers have projects that are perfect substitutes for the existing projects being funded is a strong assumption, and unlikely to hold in practice. Instead, it would be reasonable to suppose that the project quality varies within the pool of potential borrowers, and that the good projects are funded first. For instance, the pool of borrowers would consist of households that do not yet own a house, but would like to buy a house with a mortgage. Among the potential borrowers would be good borrowers with secure and verifiable income.

However, as the good borrowers obtain funding and leave the pool of potential borrowers, the remaining potential borrowers will be less good credits. If the banks' balance sheets show substantial slack, they will search for borrowers to lend to. As balance sheets continue to expand, more borrowers will receive funding. When all the good borrowers already have a mortgage, then the banks must lower their lending standards in order to generate the assets they can put on their balance sheets. In the sub-prime mortgage market in the United States in the years running up to the financial crisis of 2007, we saw that when balance sheets are expanding fast enough, even borrowers that do not have the means to repay are granted credit—so intense is the urge to employ surplus capital. The seeds of the subsequent downturn in the credit cycle are thus sown.

3. Changing Nature of Financial Intermediation

In preparation for our empirical investigations, we review briefly the structure of financial intermediation in the United States, in particular the increasing importance of market-based financial intermediaries and the shadow banking system.

3.1. Shadow Banking System

As recently as the early 1980s, traditional banks were the dominant holders of home mortgages, but bank-based holdings have been quickly overtaken by market-based holders of mortgages. Figure 3.1 plots the size of different types of financial intermediaries for the United States from the 1985. We see that market-based financial intermediaries, such as security broker dealers, ABS issuers have become important components of the intermediary sector. The series marked “shadow banks” aggregates ABS issuers, finance companies and funding corporations.

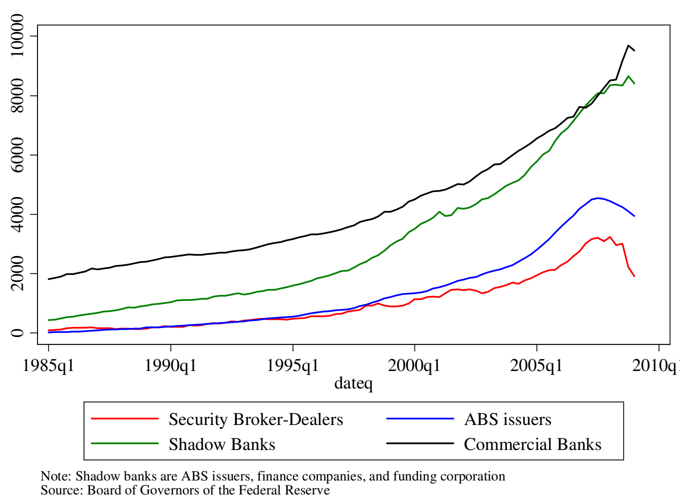

Figure 3.1: Total Assets of Commercial Banks, Shadow Banks, and Broker-Dealers.

In 1985, shadow banks were a tiny fraction of the commercial bank sector, but caught up with the commercial bank sector by the eve of the crisis. The increased importance of the market-based banking system has been mirrored by the growth of the broker-dealer sector of the economy. Broker-dealers have traditionally played market-making and underwriting roles in securities markets. However, their importance in the supply of credit has increased in step with securitization. Thus, although the size of total broker-dealer assets is small by comparison to the commercial banking sector (it was around one third of the commercial bank sector on the eve of the crisis) it had seen rapid growth in recent decades and is arguably a better barometer of overall funding conditions in a market-based financial system.

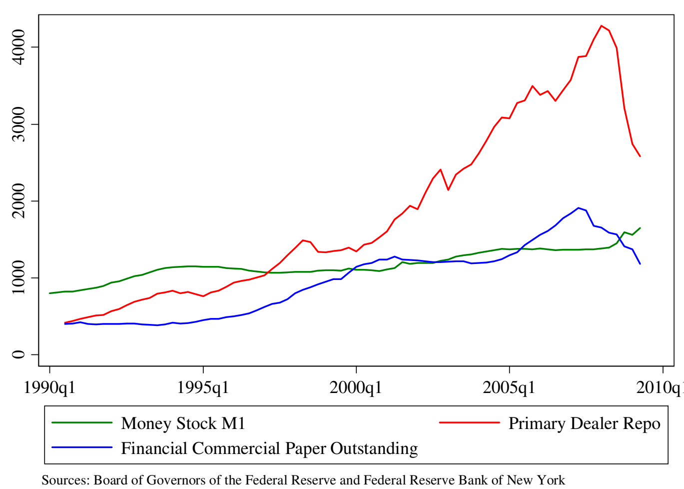

Figure 3.2: Liquid funding of financial institutions: Money (M1), Primary Dealer Repo, and Commercial Paper.

The growth of market-based financial intermediaries is also reflected in the aggregates on the liabilities side of the balance sheet. Figure 3.2 shows the relative size of the M1 money stock relative to the outstanding stock of repos of the primary dealers - the set of banks that bid at US Treasury security auctions, and hence for whom data are readily available due to their reporting obligations to the Federal Reserve. We also note the rapid growth of financial commercial paper as a funding vehicle for financial intermediaries.

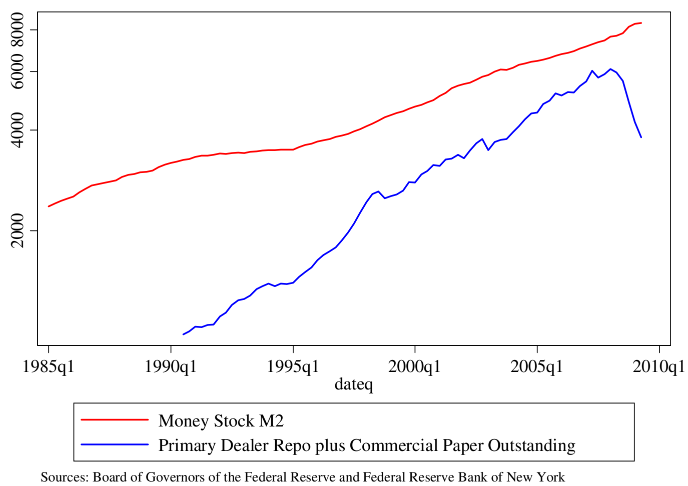

Figure 3.3: Short Term Funding: M2 versus Commercial Paper + Primary Dealer Repo.

Figure 3.3 charts the relative size of M2 (bank deposits plus money market fund balances) compared to the sum of primary dealer repos and financial commercial paper outstanding. As recently as the 1990s, the M2 stock was many times larger than the stock of repos and commercial paper. However, by the eve of the crisis, the gap had narrowed considerably, and M2 was only some 25% larger than the stock of repos and financial commercial paper. However, with the eruption of the crisis, the gap has opened up again.

Not only have the market-based intermediaries seen the most rapid growth

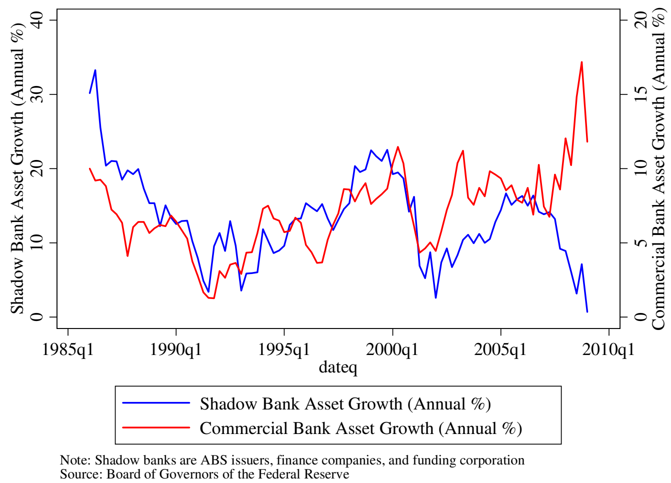

Figure 3.4: Total Asset Growth of Shadow Banks and of Commercial Banks.

in the run-up to the financial crisis, they were also the institutions that saw the sharpest pull-back in the crisis itself. Figure 3.4 shows the comparative growth rate of the total assets of commercial banks (in red) and the shadow banks (in blue), while Figure 3.5 shows the growth of commercial paper relative to shadow bank asset growth. We see that whereas the commercial banks have increased lending during the crisis, the shadow banks have contracted their lending substantially. Traditionally, banks have played the role of a buffer against fluctuations in capital market conditions, and we see that they have continued their role through the current crisis. Thus, just looking at aggregate commercial bank lending may give an overly rosy picture of the state of financial intermediation.

Figure 3.6 shows that the broker-dealer sector of the economy has contracted in step with the contraction in primary dealer repos, suggesting the sensitivity of the broker-dealer sector to overall capital market conditions. Therefore, in empirical studies of financial intermediary behavior, it would be important to bear in

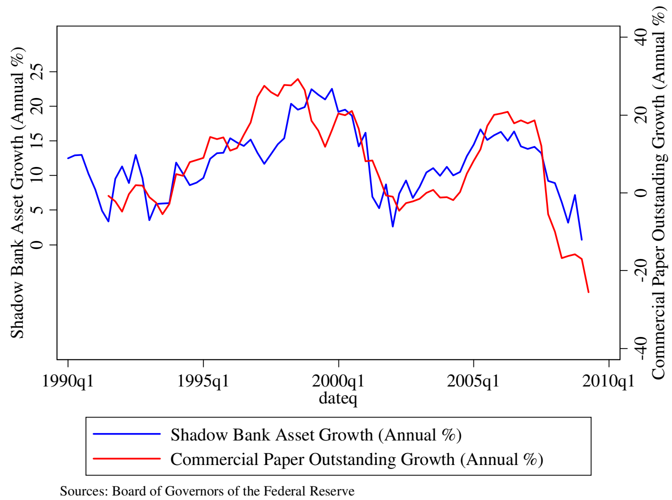

Figure 3.5: Marginal Funding of Shadow Banks is Commercial Paper.

mind the distinctions between commercial banks and market-based intermediaries such as broker dealers. Market-based intermediaries who fund themselves through short term borrowing such as commercial paper or repurchase agreements will be sensitively affected by capital market conditions. But for a commercial bank, its large balance sheet masks the effects operating at the margin. Also, commercial banks provide relationship-based lending through credit lines. Broker-dealers, in contrast, give a much purer signal of marginal funding conditions, as their balance sheet consists almost exclusively of short-term market borrowing and are not bound as much by relationship-based lending.

3.2. Relative Size of the Financial Sector

The rapid growth of the market-based intermediaries masks the double-counting involved when adding up balance sheet quantities across individual institutions. So, before going further, we note some accounting relationships that helps us to

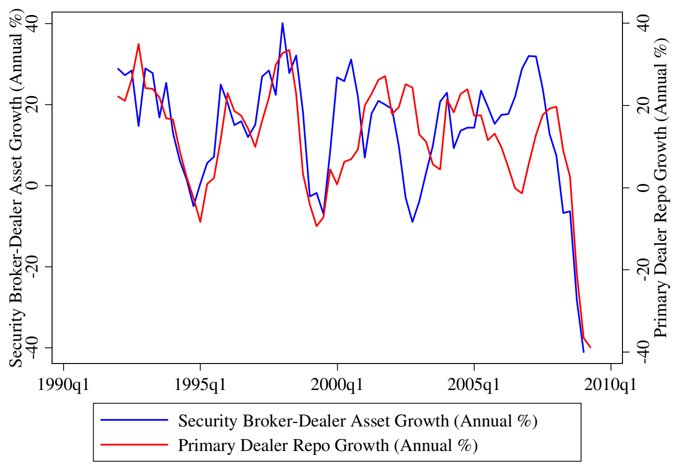

Figure 3.6: Marginal Funding of Broker-Dealers is Repo.

think about the extent of the double-counting.

Let a_i be total assets of bank i and x_i be the total debt of bank i, where x_i measures the total liabilities minus the equity of bank i. The total size of the banking sector in gross terms can be written as the sum of all bank assets, given by $\sum_{i=1}^{n} a_i$. A closely related measure would be the aggregate value of all bank debt, given by $\sum_{i=1}^{n} x_i$. However, since aggregate balance sheet statistics incorporate double-counting.

Define leverage λ_i as the ratio of total assets to equity of bank i. Leverage is given by

$$\lambda_i = \frac{a_i}{a_i - x_i} \tag{3.1}$$

Then, solving for x_i and using the notation $\delta_i = 1 - \frac{1}{\lambda_i}$, we have

$$\begin{aligned} x_i &= \delta_i \left(y_i + \sum_j x_j \pi_{ji} \right) \\ &= \delta_i y_i + \begin{bmatrix} x_1 & \cdots & x_n \end{bmatrix} \begin{bmatrix} \delta_i \pi_{1i} \\ \vdots \\ \delta_i \pi_{ni} \end{bmatrix} \end{aligned} \tag{3.2}$$

Let $x = \begin{bmatrix} x_1 & \cdots & x_n \end{bmatrix}$, $y = \begin{bmatrix} y_1 & \cdots & y_n \end{bmatrix}$, and define the diagonal matrix Δ as follows.

$$\Delta = \begin{bmatrix} \delta_1 & & \\ & \ddots & \\ & & \delta_n \end{bmatrix} \tag{3.3}$$

Then we can write (3.2) in vector form as:

$$x = y\Delta + x\Pi\Delta$$

Solving for x,

$$\begin{aligned} x &= y\Delta \left(I - \Pi\Delta \right)^{-1} \\ &= y\Delta \left(I + \Pi\Delta + (\Pi\Delta)^2 + (\Pi\Delta)^3 + \cdots \right) \end{aligned} \tag{3.4}$$

The matrix $\Pi\Delta$ is given by

$$\Pi\Delta = \begin{bmatrix} 0 & \delta_2\pi_{12} & \cdots & \delta_n\pi_{1n} \\ \delta_1\pi_{21} & 0 & & \delta_n\pi_{2n} \\ \vdots & & \ddots & \vdots \\ \delta_1\pi_{n1} & \delta_2\pi_{n2} & \cdots & 0 \end{bmatrix} \tag{3.5}$$

The infinite series in (3.4) converges since the rows of $\Pi\Delta$ sum to a number strictly less than 1, so that the inverse $(I - \Pi\Delta)^{-1}$ is well-defined.

Equation (3.4) gives us a clue as to what to look for when gauging the extent of the double-counting of lending to ultimate borrowers that result from heavy use of funding raised from other financial intermediaries. The comparison is between y which is the profile of lending to the ultimate borrowers in the economy and x, which is the profile of debt values across all banks which give a gross measure of balance sheet size. The factor that relates the two is the matrix:

$$\Delta\left(I + \Pi\Delta + (\Pi\Delta)^2 + (\Pi\Delta)^3 + \cdots\right)$$

This matrix has a finite norm, since the infinite series $I+\Pi\Delta+(\Pi\Delta)^2+(\Pi\Delta)^3+\cdots$ converges to $(I - \Pi\Delta)^{-1}$. However, for a financial system where leverage is high and the extent to which banks are interwoven tightly, the norm can grow without bound. This is because as leverage becomes large, $\delta_i \to 1$, so that Δ tends to the identity matrix. Moreover, as the extent of interconnections between banks become large, the norm of the matrix Π converges to 1, since then each row of Π will sum to a number that converges to 1. In the limit as $\Delta \to I$ and $\|\Pi\| \to 1$, the norm of the matrix $\Delta\left(I + \Pi\Delta + (\Pi\Delta)^2 + (\Pi\Delta)^3 + \cdots\right)$ grows without bound.

The consequence of this result is that size of the financial intermediation sector relative to the size of the economy as a whole can vary hugely over the financial cycle. We can illustrate this phenomenon with Figures 3.7 and 3.8, which show the growth of four sectors in the United States from 1954. The four sectors are (i) the non-financial corporate sector, (ii) household sector, (iii) commercial banking sector and (iv) the security broker-dealer sector. The data are taken from the Federal Reserve's Flow of Funds accounts. The series are normalized so that the size in Q1 1954 is set equal to 1.

Three of the four sectors grew to roughly 80 times their 1954 size, but the broker dealer sector had grown to around 800 times its 1954 level at the height of the boom, before collapsing in the recent crisis. Figure 3.8 is the same chart, but in log scale. The greater detail afforded by the chart in log scale reveals that the securities sector kept pace with the rest of the economy until around 1980,

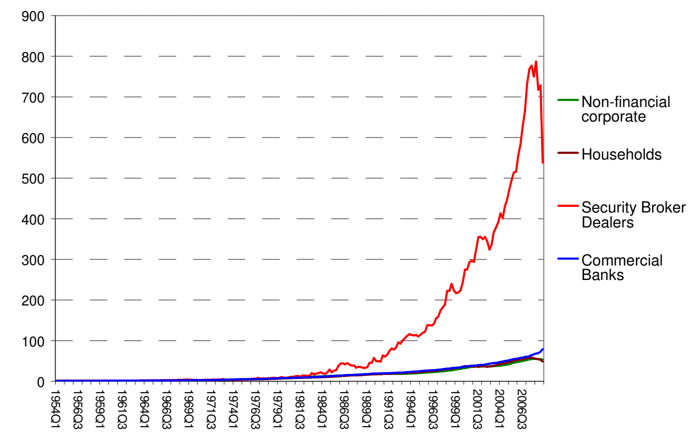

Figure 3.7: Growth of Four US Sectors (1954Q1 =1)

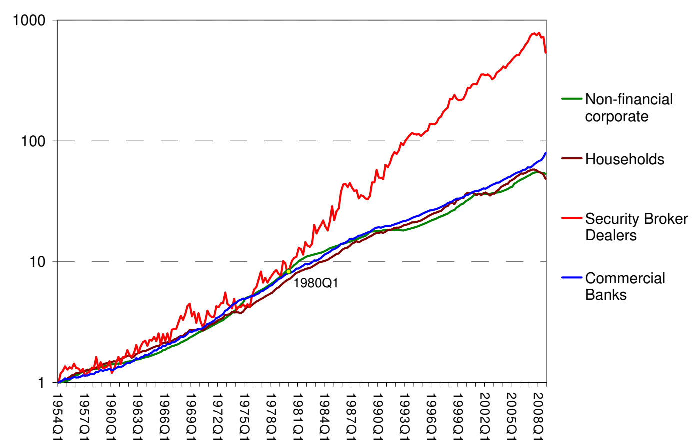

Figure 3.8: Growth of Four US Sectors (1954Q1 = 1) (in log scale)

but then started a growth spurt that outstripped the other sectors. On the eve of the crisis, the securities sector had grown to around ten times its size relative to the other sectors in the economy.

4. Empirical Relevance of Financial Intermediary Balance Sheets

In models of monetary economics that are commonly used at central banks, the role of financial intermediaries is largely incidental; financial intermediaries whether they be commercial banks, shadow banks, and broker-dealers are passive players that the central bank uses to implement monetary policy. In contrast, our discussion thus far suggests that they deserve independent study because of their impact on financial conditions and hence on real economic outcomes. In this section, we examine empirically whether financial intermediaries' impact on financial conditions feed through to affect real economic outcomes, in particular, on components of GDP. We find that it does, especially on those components of GDP that are sensitive to credit supply, such as housing investment and durable goods consumption.

Broker-dealer and shadow bank balance sheets hold potentially more information on underlying financial conditions, as they are a signal of the marginal availability of credit. At the margin, all financial intermediaries (including commercial banks) have to borrow in markets (for instance via commercial paper or repos). For a commercial bank, even though only a small fraction of its total liabilities are market based, at the margin, it has to tap the capital markets. But for commercial banks, their large balance sheets mask the effects operating at the margin. Broker-dealers or shadow banks, in contrast, give a purer signal of marginal funding conditions, as their liabilities are short term, and their balance sheets are closer to being fully marked to market.

In addition, broker-dealers originate and make markets for securitized products, whose availability determines the credit supply for consumers and non-financial firms (e.g. for mortgages, car loans, student loans, etc.). So broker-dealers are important variables for two reasons. First, they are the marginal suppliers of credit. Second, their balance sheets reflect the financing constraints of the market-based financial system.

To the extent that balance sheet dynamics affect the supply of credit, they would have the potential to affect real economic variables. To examine whether there are indeed real effects of the balance sheet behavior of intermediaries, we estimate macroeconomic forecasting regressions. In Table 4.1, we report the results of regressions of the annual growth rate of GDP components on lagged macroeconomic and financial variables. In addition, we add the lagged growth rate of total assets and market equity of security broker-dealers on the right hand side. By adding lags of additional financial variables on the right hand side (equity market return, equity market volatility, term spread, credit spread), we offset balance sheet movements that are purely due to a price effect. By adding the lagged macroeconomic variables on the right hand side, we control for balance sheet movements due to past macroeconomic conditions. In Table 4.1, (and all subsequent tables), * denotes statistical significance at the 10%, ** significance at the 5% level, and *** at the 1% level. All our empirical analysis is using quarterly data from 1986Q1 to 2009Q2. Variable definitions are given in the data appendix at the end of this chapter.

The growth rate of security broker-dealer total assets has strongest significance for the growth rate of future housing investment and for durable good consumption (Table 4.1, column 1). Our interpretation of this finding is that the mechanisms that determine the liquidity and leverage of broker-dealers affect the supply of credit, which in turn affect investment and consumption. The finding

Table 4.1: **Impact of Balance Sheets on GDP.** This table reports regressions of GDP growth on the total asset growth of broker-dealers, shadow banks, and commercial banks for 1986Q1 to 2009Q2. *** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level. Significance is computed from robust standard errors.

	(1) GDP Growth	(2) GDP Growth	(3) GDP Growth
Broker-Dealer Asset Growth (lag)	0.01*		
Shadow Banks Asset Growth (lag)		0.06***	
Commercial Bank Asset Growth (lag)			-0.05
GDP Growth (lag)	0.85***	0.69***	0.89***
PCE Inflation (lag)	-0.18	-0.25*	-0.15
VIX (lag)	0.03	0.02	0.02
Credit Spread (lag)	-0.63***	-0.83***	-0.50**
Term spread (lag)	0.25**	0.31***	0.13
Fed Funds (lag)	0.02	-0.02	-0.02
Constant	1.06*	1.68***	1.66***
Observations	92	93	93
R^2	0.865	0.878	0.862

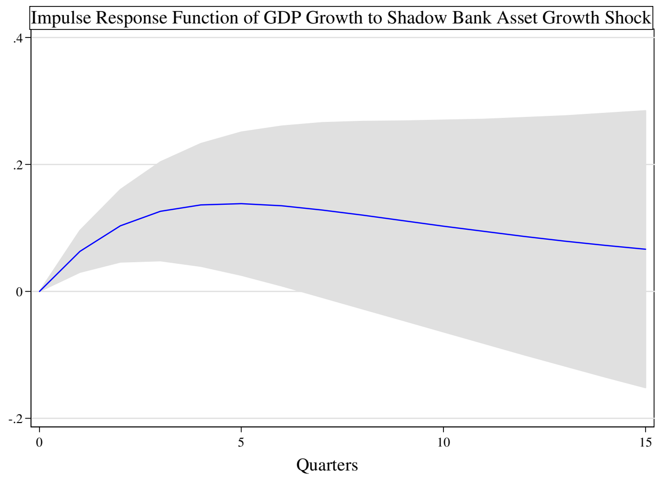

Figure 4.1: The figure plots the impulse response GDP growth from a shock to shadow bank total asset growth. The impulse response is estimated from a vector autoregression with gdp growth, pce inflation, shadow bank asset growth, credit spread, vix, the term spread, and the Federal Fund target rate as variables. The time span is 1986Q1 to 2009Q1.

that dealer total assets significantly forecast durable but not total consumption, and that they forecast housing investment but not total investment, lends support to this interpretation, as durable consumption and housing investment could be seen as being particularly sensitive to the supply of credit. The market value of security broker-dealer equity also has predictive power for housing investment, but additionally forecasts total consumption, total investment, and GDP.

In Table 4.1, equity is market equity, rather than book equity. To the extent that shifts in market equity are good indicators of the shifts in the marked-to-market value of book equity, we can interpret the empirical finding that equity growth has real impact through the amplification mechanism discussed in Section 2. When balance sheets become strong, equity increases rapidly, eroding leverage.

Table 4.2: **Impact of Balance Sheets on Housing Investment.** This table reports regressions of residential investment growth on the total asset growth of broker-dealers, shadow banks, and commercial banks for 1986Q1 to 2009Q2. *** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level. Significance is computed from robust standard errors.

	(1) Housing Growth	(2) Housing Growth	(3) Housing Growth
Broker-Dealer Asset Growth (lag)	0.08***		
Shadow Banks Asset Growth (lag)		0.00	
Commercial Bank Asset Growth (lag)			-0.44**
Housing Growth (lag)	0.90***	0.94***	0.95***
PCE Inflation (lag)	-0.30	-0.11	-0.07
VIX (lag)	0.11	0.02	0.02
Credit Spread (lag)	-1.03	-0.64	0.13
Term spread (lag)	1.09**	0.57	-0.07
Fed Funds (lag)	-0.07	-0.07	-0.28
Constant	-2.23	0.33	3.67
Observations	93	93	93
R^2	0.911	0.891	0.898

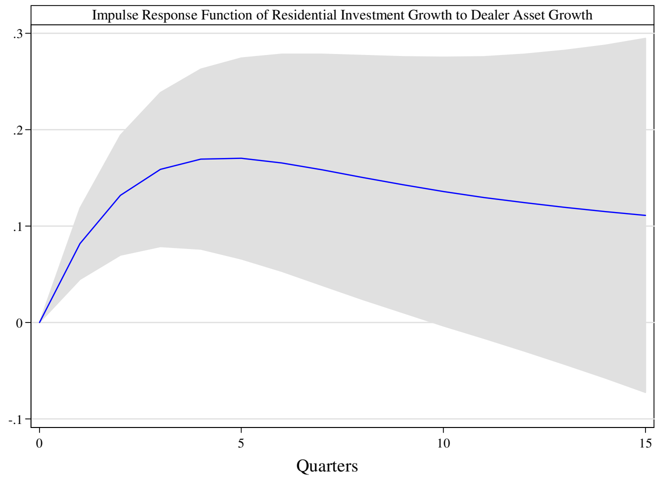

Figure 4.2: The figure plots the impulse response of residential investment growth from a shock to broker-dealer total asset growth. The impulse response is estimated from a vector autoregression with gdp growth, pce inflation, broker-dealer asset growth, credit spread, vix, the term spread, and the Federal Fund target rate as variables. The time span is 1986Q1 to 2009Q1.

Financial intermediaries then attempt to expand their balance sheets to restore leverage. Since our data are quarterly, but balance sheets adjust quickly, the one quarter lagged assets may not fully capture this effect. However growth in market equity may be a good signal of growth of spare balance sheet capacity.

The forecasting power of dealer assets for housing investment is graphically illustrated in Figure 4.2. The impulse response function is computed from a first order vector autoregression that includes all variables of Table 4.1, Column (iv). The plot shows a response of housing investment to broker-dealer assets growth that is positive, large, and persistent.

To further understand differences between the security broker-dealer and commercial bank balance sheet interactions with the macroeconomic aggregates, we can see from column (iii) of Table 4.1 that commercial bank assets do less well than security-broker-dealer variables as forecast variables. In separate regressions (not reported) we do find that commercial bank (market) equity is significant in explaining real economic activity, but commercial bank total assets are not. Our interpretation of these findings is that commercial bank balance sheets are less informative than broker-dealer balance sheets as they (largely) did not mark their balance sheets to market, over the time span in our regressions. However, market equity is a better gauge of underlying balance sheet constraints, and so better reflects the marginal increases in balance sheet capacity. So, whereas growth in total assets do not signal future changes in activity, growth in market equity does.

The finding that commercial bank assets do not predict future real growth is also consistent with Bernanke and Lown (1991) who use a cross sectional approach to show that credit losses in the late 80's and early 90's do not have a significant impact on real economic growth across states. See Kashyap and Stein (1994) for an overview of the debate on whether there was a "credit crunch" in the recession in the early 1990s.

In the same vein, Ashcraft (2006) finds small effects of variations in commercial bank loans on real activity when using accounting based loan data, but Ashcraft (2005) finds large and persistent effects of commercial bank closures on real output (using FDIC induced failures as instruments). Morgan and Lown (2006) show that the senior loan officer survey provides significant explanatory power for real activity – again a variable that is more likely to reflect underlying credit supply conditions, and is not based on accounting data.

The credit supply channel sketched so far differs from the financial amplification mechanisms of Bernanke and Gertler (1989), and Kiyotaki and Moore (1997, 2005). These papers focus on amplification due to financing frictions in the borrowing sector, while we focus on amplification due to financing frictions in the lending sector. Our approach raises the question of whether the failure of the Modigliani-Miller theorem may be more severe in the lending rather than the borrowing sector of the economy. The interaction of financial constraints in the lending and the borrowing sector is likely to give additional kick to financial frictions in the macro context that mutually reinforce each other. These interactions would be fertile ground for new research.

We should also reiterate the caveats that underpin the results in Table 4.1. Inference for macroeconomic aggregates is difficult as all variables are endogenous. In analyzing the data, we started with the prior that balance sheets of financial intermediaries should matter for real economic growth. This prior has guided our empirical strategy. Researchers who look at the data with a different prior will certainly be able to minimize the predictive power of the broker-dealer balance sheet variable. However, analyzing the data with the prior that financial intermediary frictions are unimportant has the potential cost of overlooking the friction. Further searching examinations of the data will help us uncover the extent to which financial variables matter. In addition, we have not analyzed the importance of the balance sheets of other institutions of the market based financial system, such as the GSEs, hedge funds, etc.

5. Central Bank as Lender of Last Resort

The classical role of the central bank as the lender of last resort (LOLR) is in terms of meeting panics that affect solvent but illiquid banks. In the simplest case, bank runs arise when depositors fail to achieve coordination in a situation with multiple equilibria. For example, in Bryant (1980) and Diamond and Dybvig (1983), an individual depositor runs for fear that others will run, leaving no assets in place for those who do not run.

However, in the financial crisis of 2007 -2009, the withdrawal of credit hit the

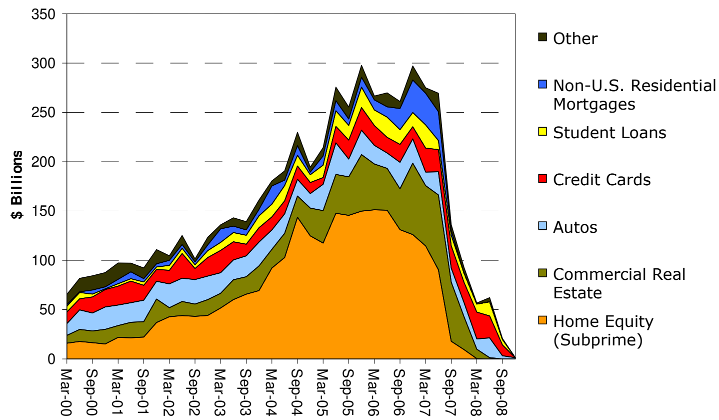

Figure 5.1: New Issuance of ABS in Previous Three Months

whole market, not simply one or even a subset of the institutions. Figure 5.1 plots the new issuance of asset backed securities (ABSs) over a three month interval preceding the measurement date. We see the generalized contracting of credit, hitting not just a particular institution but the whole economy. If there was a run driven by a coordination failure, then it was a run from all the institutions in the financial system simultaneously, although the extent to which they suffered from the run depended on their vulnerability. In the model outlined in Section 2, it is the interaction between measured risks and the risk bearing capacity of banks that determines the overall lending. For financial institutions that rely on Value-at-Risk, they cut back lending when risk constraints bind. The prudent cutting of exposures by the creditors to a bank will look like a "run" from the point of view of that bank itself. In this sense, the runs on Northern Rock, Bear Stearns and Lehman Brothers may be better seen as the tightening of constraints on the creditors of these banks, rather than as a coordination failure among them.

Of course, we should not draw too hard and fast a distinction between the coordination view of bank runs and the "leverage constraints" view of bank runs. Coordination (or lack thereof) will clearly exacerbate the severity of any run when a bank has many creditors. The point is rather that the run on the system needs to appeal to more than just coordination failure. In practice, this means that an explanation of the run on, for instance Bear Stearns or Lehman Brothers, should make reference to market-wide factors, as well as the characteristics of these particular firms and their creditors viewed in isolation. This is one more instance of the general maxim that in a modern market-based financial system, banking and capital market conditions cannot be viewed in isolation.

To the extent that the credit crunch is the consequence of a collapse of balance sheet capacity in the financial intermediary sector, the lender of last resort policy response by central banks can be seen as an attempt to restore the lost balance sheet capacity by lending directly into the market. The Federal Reserve has been one of the most aggressive central banks in this context. The Federal Reserve's response has been to make up for the lost balance sheet capacity by interposing the Fed's balance sheet between the banking sector and the ultimate borrowers. The Fed has taken in deposits from the banking sector (through increased reserves) and then lent out the proceeds to the ultimate borrowers through the holding of securities (Treasuries, mortgage backed securities, commercial paper and other private sector liabilities), as well as through currency swap lines to foreign central banks. One indication of the increased Fed balance sheet can be seen in the sharp increase in the holding of cash by US commercial banks, as seen from Figure 5.2. The increased cash holdings reflect the sharp increase in reserves held at the Fed – a liability of the Fed to the commercial banks.

In this way, central bank liquidity facilities have countered the shrinking of intermediary balance sheets and have become a key plank of policy, especially after short-term interest rates were pushed close to their zero bound. The man-

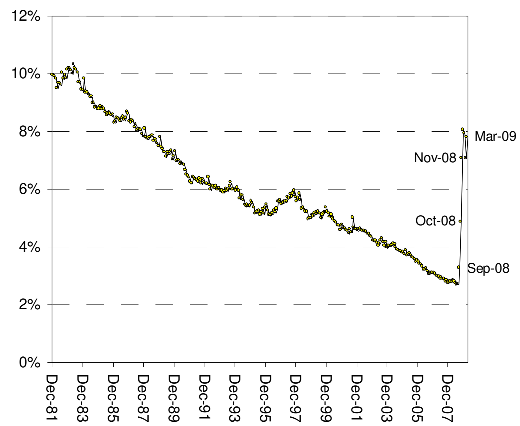

Figure 5.2: Cash as Proportion of US Commercial Bank Assets (Source: Federal Reserve, H8 database).

agement of the increased Federal Reserve balance sheet has been facilitated by the introduction of interest on reserves on October 1, 2008, which effectively separates the management of balance sheet size from the Federal Funds interest rate management (see Keister and McAndrews (2009) for a discussion of the interest on reserve payment on the Federal Reserve's balance sheet management).

The Federal Reserve has also put in place various lender of last resort programs under section 13(3) of the Federal Reserve act in order to cushion the strains on balance sheets and to thereby target the unusually wide spreads in a variety of credit markets. Liquidity facilities have been aimed at the repo market (TSLF and PDCF), the CP market (CPFF and AMLF), the FX futures markets (FX Swap lines), and ABS markets (TALF). In addition, the Federal Reserve has conducted outright purchases of Treasury and agency securities. The common element in these liquidity facilities has been to alleviate the strains associated with the shrinking balance sheets of intermediaries. While classic monetary policy targets a price (e.g. the Fed Funds rate), the liquidity facilities affect balance sheet quantities.

One instance of the Fed's liquidity facilities can be seen in Figure 5.3, which charts the total outstanding commercial paper as well as net Federal Reserve commercial paper holdings. Following the Lehman Brothers bankruptcy in September 2008, the outstanding amount of commercial paper began to fall precipitously, as can be seen by the sharp downward shift in the red line in Figure 5.3. With the creation of the CPFF in October 2008, the Fed's net holdings of commercial paper began to increase rapidly, as shown by the blue line in Figure 5.3. The Fed's holdings can be seen to replace virtually dollar-for-dollar the decline in the outstanding amount of commercial paper. In this respect, the Fed's balance sheet was being used to directly replace the decline in balance sheet capacity of the financial intermediary sector. The introduction of the Federal Deposit Insurance Corporation's (FDIC) Temporary Liquidity Guarantee Program (TLGP) in December 2008 led to a lengthening of debt issuance of financial intermediaries and a subsequent decline in both the CPFF usage and total outstanding commercial paper. Adrian, Marchioni, and Kimbrough (2009) give more detail about the functioning and the effects of the CPFF.

We had encountered earlier in Figure 5.1 how the new issuance of asset-backed securities (ABSs) had collapsed by the end of 2008. The Federal Reserve's Term Asset-Backed Loan Facility (TALF) is a facility whereby the Federal Reserve provides secured loans to new AAA-rated ABSs at a low haircut to private sector investors. TALF was designed specifically with the revitalization of the ABS market in mind. Figure 5.4 shows the effect on new issuance of ABSs before and after the introduction of TALF. The light colored bars on the right show that much of the issuance of ABSs owes to TALF, and that TALF-backed issuance dwarfs the issuance of standard issues.

The balance sheet expansion of the Federal Reserve in response to the finan-

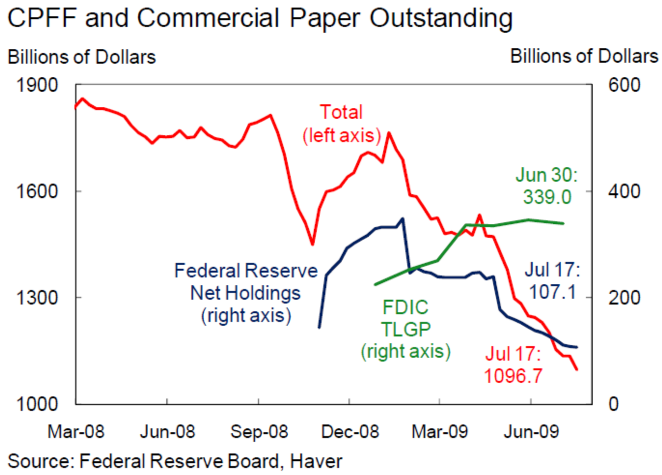

Figure 5.3: Commercial Paper Funding Facility, Federal Reserve

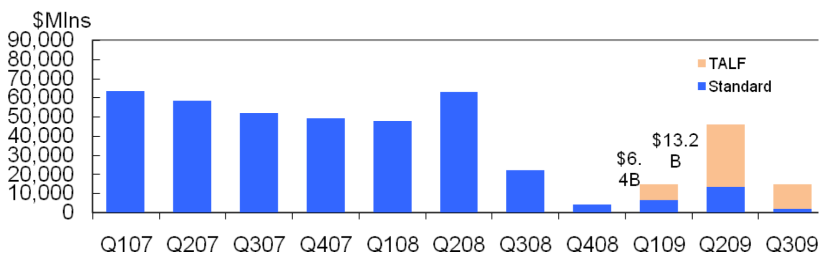

Figure 5.4: New ABS Issuance under TALF

cial crisis of 2007-2009 has refocused the monetary policy debate on the role of quantities in the monetary policy transmission mechanism. The financial crisis forcefully demonstrated that the collapse of balance sheet capacity of the financial sector can have powerful adverse affects on the real economy. The traditional role of the central bank as the lender of last resort has undergone some far-reaching innovations in the crisis.

6. Role of Short Term Interest Rates

Having established that increases in broker-dealer and shadow bank balance sheets precede increases in real activity, we investigate the determinants of balance sheet growth. Broker-dealers, shadow banks, and commercial banks fund themselves with short term debt. Broker-dealers are primarily funded in the repo market (see Figure 3.6); shadow banks are primarily funded in the commercial paper market (see Figure 2.23); and the majority of commercial banks' short term funding is through money (i.e. deposits). In the case of broker-dealers, part of the repo funding is directly passed on to other leveraged institutions such as hedge funds in the form of reverse repos. Another part is invested in longer term, less liquid securities. Shadow banks tend to fund holdings of ABS and MBS directly. Commercial banks are primarily holding non-tradable loans.

Because the majority of the liability side of financial institutions comes from short term borrowing arrangements, their cost of borrowing is tightly linked to short term interest rates, such as the Federal funds target rate. As broker-dealers and shadow banks hold longer term assets, proxies for their expected returns of are spreads, particularly the term spreads, which captures the maturity transformation of financial institutions. The leverage of the intermediaries is constrained by risk; in more volatile markets, leverage is more risky, margins and haircuts are higher, and credit supply tends to be more constrained. We saw in Section 2 how

Value-at-Risk determined balance sheet size.

Much of the balance sheet adjustments occur at high frequencies. The total assets used in the previous regressions are only available at a quarterly frequency. However, on the liability side of the balance sheet, outstanding repo data, outstanding commercial paper, and total money is available at a weekly frequency. We use repo data that is collected for the primary dealer universe by the Federal Reserve Bank of New York. Outstanding commercial paper is collected by the depository trust corporation, and is published at a weekly frequency by the Federal Reserve Board. The broad money measure M2 is also available from the Federal Reserve Board.

Increases in the Fed funds target rate are generally associated with a slower growth rate of short term liabilities. In Table 6.1, we show regressions of growth rates of repo, repo + commercial paper, and M2 on changes of the Fed Funds' target, the lagged Fed Funds target, as well as other asset prices (and lags of the left hand side variables). The three types of regressions correspond to the funding of the three main financial institutions: broker-dealers, shadow banks, and commercial banks. In each case, increases in the Fed Funds target are associated with declines in the short term funding liabilities. We use 13-week changes and lags in the regression, in order to pick up correlations that occur at the same frequency as the quarterly data.

Financial market volatility, as measured by the VIX index of implied equity volatility, relates negatively to security repo growth and repo+cp growth, as higher volatility is associated with higher haircuts and tighter capital constraints, both inducing tighter constraints on dealer leverage (columns (1) and (2)). For M2, we find that higher VIX is associated with larger money growth, which we interpret as flight to quality: in times of crisis, households and non-financial corporations tend to reallocate short term savings to commercial banks (see Gatev, Schuermann, and Strahan, 2009). Credit spread changes are negatively related to repo growth and repo+cp growth, but positively to M2 growth. Changes of credit spreads are picking up variation in the profitability of financial intermediaries (the asset side), as well as the cost of longer term funding (the liability side of the balance sheet). In columns (1) and (2), the increase in the funding cost due to higher credit spreads appears to dominate the increase in profitability due to higher spreads, leading to a negative sign.

Increases in the term spread are associated with higher repo growth (see column 2). This finding is consistent with the notion that financial intermediaries fund themselves with short term debt, but lend out longer term, so that a higher term spread increases the carry between assets and liabilities and is associated with larger balance sheets. Equity returns enter positively into the repo and repo+cp regressions, again proxying for higher profitability of lending and better investment opportunities when equity returns are high.

6.1. Risk-Taking Channel of Monetary Policy

Current models in monetary economics emphasize the importance of managing market expectations. By charting a path for future short rates and communicating this path clearly to the market, the central bank can influence long rates and thereby influence mortgage rates, corporate lending rates and other prices that affect consumption and investment. Instead, our findings point to the short-term interest rate as an important price variable in its own right. Empirically, we have seen that the Fed Funds rate is an important explanatory variable for the growth of balance sheet aggregates. In turn, we have seen earlier in Section 2 that the growth of intermediary balance sheets conveys information on the risk appetite of the financial intermediary sector and hence on the hurdle rate of return on projects that are financed by the banking sector.

Table 6.1: **Determinants of Balance Sheet Growth.** This table reports regressions of repo growth, repo + commercial paper growth, and M2 growth on their own lags, and asset price variables. The data frequency is weekly from October 3, 1990 to August 12, 2009. Changes refer to 13-week changes, and lags to 13 week lags. *** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level. Significance is computed from robust standard errors.

	(1)	(2)	(3)
	Repo Growth	Repo+CP Growth	M2 Growth
Fed Funds (change)	-0.048***	-0.024**	-0.013***
Fed Funds (lag)	0.054***	0.023***	-0.010***
Equity Return	0.002***	0.001***	-0.000
Equity Index (lag)	0.025***	0.015***	-0.001*
VIX (change)	-0.001	-0.001	0.001***
VIX (lag)	-0.010***	-0.003*	0.002***
Term spread (change)	0.059***	0.019	-0.003
Term spread (lag)	0.124***	0.060***	-0.021***
Credit Spread (change)	-0.084**	-0.078***	0.013***
Credit Spread (lag)	-0.075***	-0.137***	-0.002
Repo Growth (lag)	-0.141***	-0.079***	0.017***
CP Growth (lag)	0.014	-0.033	0.016**
M2 Growth (lag)	1.246***	0.685***	-0.160***
Constant	-0.241**	0.072	0.089***
Observations	972	972	965
R^2	0.250	0.360	0.637

Here, we mention two possible channels for how the short interest rate affects the banking sector balance sheet, and hence affect the risk-taking channel of monetary policy. Borio and Zhu (2008) contains a wide-ranging discussion of the risk-taking channel.

First, the short term interest rate affects the quality of outstanding loans through cashflow implications. Take a simple case where the bank borrows short-term at $r\%$ interest, and lends out at the same short-term horizon at the rate of $(r + \mu)\,\%$ for constant $\mu > 0$. In other words, the bank charges a constant mark-up of μ percent for the floating short-term rate loan. For the borrower, the notional interest burden is falling when r falls, so that for any given cashflow, the borrower becomes less likely to default. Thus, a lowering of the Fed Funds rate would lower r, and the lower r is associated with an increase in the expected value of the repayment flows associated with the loan. The expected value of the asset is the discounted present value of the cashflow from the loan minus the funding costs. As r declines, there is a simultaneous reduction in the notional funding cost and he notional interest charged to the borrower. However, because the loan becomes less risky, the market value of the loan increases. In section 2, our main comparative statics exercise was with respect to the expected value of the risky asset, given by q. We see that a lowering of the short rate will tend to raise q when the borrower is borrowing at the short-rate.

So far, we have assumed that the bank is lending short-term to the borrower at the same maturity as the funding obtained by the bank. However, if the bank lending is at a longer maturity to the bank's own funding, then the impact of monetary policy on the yield curve as a whole will determine the overall impact on the bank's balance sheet. Consider the case where the bank's assets have a longer maturity than the bank's liabilities. Among other things, the duration of assets will then be longer than the duration of liabilities, so that the asset side of the bank's balance sheet will fluctuate more sensitively to shifts in discount rates compared to the liabilities side of the balance sheet. When the short-term interest rate falls, the relative change in the value of assets and liabilities will depend crucially on the duration mismatch of assets and liabilities, and the extent to which long-term rates fall when short rates come down. If the decline in short rates leads to substantial falls in long rates also, and the duration mismatch between assets and liabilities is large, then there will be a large increase in the marked-to-market value of assets compared to liabilities. As asset values rise more than liabilities, marked-to-market equity will increase, thereby kicking off the feedback process that leads to increased risk appetite of the banking system and greater loan supply.

In summary, there are two channels whereby a cut in short rates may impact the value of bank's marked-to-market equity, and hence to increased lending capacity. First, there are cashflow implications whereby the quality of existing loans improve. Second, there are valuation effects that follow from duration mismatch. For both these reasons, monetary policy that shifts the short term interest rate can be expected to affect the risk-taking capacity of the banking system directly through the balance sheet valuation effects of the banking sector as a whole.

Two recent empirical papers throw light on this channel of monetary policy that works through the change in the market value of existing loans. Jimenez, Ongena, Peydro and Saurina (2008) examine a large database of European loans through the detailed information contained in the loan register and show that a lower short-term interest rate lowers the hazard rate of default on *existing* loans. This effect is consistent with the valuation channel and the increase in q mentioned already. In addition, they show that the hazard rate of default for *new loans* increases after the cut in short-term rates. This finding is consistent with the model outlined in section 2, where an increase in q resulting from a lowering of short-term interest rates leads to increased balance sheet capacity and the hence the taking on of lower quality projects that previously did not meet the standards of the bank before the interest rate cut.

The same combination of (i) a lowering of a hazard rate of default on *existing* loans and (ii) an increase in the hazard rate of default on *new* loans is also observed in Ioannidou, Ongena and Peydro (2009). In this study, the authors examine the effect of shifts of the US Fed Funds rate on the quality of bank loans in Bolivia, which had a banking system which was close to being dollarized. To the extent that the US Fed Funds rate is determined independently of the events in Bolivia, the authors regard the effect of short-term interest rate changes as being a quasi-natural experiment of the effect of short-term interest rate movements on bank asset quality. As with the paper by Jimenez et al. (2008), the Bolivian study reveals the same combination whereby a cut in the US Fed Funds rate leads to an improvement in the quality of existing assets, but new assets are of a lower quality.

This combination of results on existing and new loans suggest that the risk-taking channel is a potentially fruitful avenue to explore further. The model in section 2 provides some of the conceptual background that may be necessary to understand the results.

7. Concluding Remarks

We conclude with some implications of our findings for the conduct of monetary policy. One has to do with forward-looking guidance on future policy rates or the publication of the central bank's own projections of its policy rate. Such communication not only has implications for market participants' expectations of the future path of short rates, but also for the uncertainty around that path. If central bank communication compresses the uncertainty around the path of future short rates, the risk of taking on long-lived assets financed by short-term debt is compressed. If the compression increases the potential for a disorderly unwinding later in the expansion phase of the cycle, then such compression of volatility may not be desirable for stabilization of real activity. In this sense, there is the possibility that forward-looking communication can be counterproductive.

Secondly, there is a case for rehabilitating some role for balance sheet quantities for the conduct of monetary policy. Ironically, our call comes even as monetary aggregates have fallen from favor in the conduct of monetary policy (see Friedman (1988)). The instability of money demand functions that makes the practical use of monetary aggregates challenging is closely related to the emergence of the market-based financial system. As a result of those structural changes, not all balance sheet quantities will be equally useful. The money stock is a measure of the liabilities of deposit-taking banks, and so may have been useful before the advent of the market-based financial system. However, the money stock will be of less use in a financial system such as that in the US. More useful may be measures of collateralized borrowing, such as the weekly series on repos of primary dealers.

Third, our results highlight the way that monetary policy and policies toward financial stability are linked. When the financial system as a whole holds long-term, illiquid assets financed by short-term liabilities, any tensions resulting from a sharp pullback in leverage will show up somewhere in the system. Even if some institutions can adjust down their balance sheets flexibly, there will be some who cannot. These pinch points will be those institutions that are highly leveraged, but who hold long-term illiquid assets financed with short-term debt. When the short-term funding runs away, they will face a liquidity crisis. The traditional lender of last resort tools (such as the discount window), as well as the recent liquidity provision innovations are tools that mitigate the severity of the tightening of balance sheet constraints. However, experience has shown time and again that the most potent tool in relieving aggregate financing constraints is a lower target rate. Past periods of financial stress such as the 1998 crisis was met by reduction in the target rate, aimed at insulating the real economy from financial sector shocks. In conducting monetary policy, our findings suggest that the potential for financial sector distress should be explicitly taken into account in a forward looking manner.

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Appendix: Data Sources

Figures 3.1–3.6. Figures 3.1, 3.4, 3.5, 3.6 use total assets of security broker-dealers, ABS issuers, shadow banks (the sum of ABS issuers, finance companies, funding corporations), and nationally chartered commercial banks from the Flow of Funds published by the Federal Reserve Board. In Figures 3.2 and 3.3, the money stock measure M1 and M2. Total outstanding and financial commercial paper used in Figures 3.2, 3.3, and 3.5 are from the Federal Reserve Board. Primary dealer repo in Figures 3.2, 3.3, and 3.6 is from the Federal Reserve Bank of New York.

Figures 3.7 and 3.8. The figures use total financial assets from the Federal Reserve Board's Flow of Funds.

Tables 4.1 and 4.2: Impact of Balance Sheets on GDP and Residential Investment. The tables report regressions of GDP and residential investment growth on the total asset growth of broker-dealers, shadow banks, and commercial banks for 1986Q1 to 2009Q2. Lags are one quarter lags; growth rates are annual. Total assets are from the Federal Reserve Board's Flow of Funds. Shadow banks include ABS issuers, funding corporations, and finance companies. Gross domestic product (GDP) and residential investment is from the Bureau of Economic Analysis (BEA). PCE inflation is the personal consumption expenditures deflator excluding food and energy as reported by BEA. The equity return is the one quarter return of Standard & Poor's S&P500 index. The VIX is CBOE's implied volatility index for the S&P500. The term spread is the difference between the 10-year constant maturity Treasury yield and the 3-month Treasury bill rate, both are from the Federal Reserve Board. The credit spread is the difference between Moody's Baa spread and the 10-year Treasury rate, both are from the Federal Reserve Board.

Table 6.1: Determinants of Balance Sheet Growth The table reports regressions of repo growth, repo + commercial paper growth, and M2 growth on their own lags, and asset price variables. The data frequency is weekly from October 3, 1990 to August 12, 2009. Changes refer to 13-week changes, and lags to 13

week lags. Fed Funds denotes the Federal Funds Target as reported by the Federal Reserve Board. The equity return is the 13-week return of Standard & Poor's S&P500. The VIX is CBOE's implied volatility index for the S&P500. The term spread is the difference between the 10-year constant maturity Treasury yield and the 3-month Treasury bill rate, both from the Federal Reserve Board. The credit spread is the difference between Moody's Baa spread and the 10-year Treasury rate. Commercial paper growth is the 13-week growth rate of total commercial paper outstanding reported by the Federal Reserve Board. Repo growth is the 13-week growth rate of primary dealer repo, from the Federal Reserve Bank of New York. M2 growth is the 13-week growth of the money measure M2 from the Federal Reserve Board.