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Tobias Adrian
Hyun Song Shin

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Abstract

We reconsider the role of financial intermediaries in monetary economics. We explore the hypothesis that financial intermediaries drive the business cycle by way of their role in determining the price of risk. In this framework, balance sheet quantities emerge as a key indicator of risk appetite and hence of the "risk-taking channel" of monetary policy. We document evidence that the balance sheets of financial intermediaries reflect the transmission of monetary policy through capital market conditions. Our findings suggest that the traditional focus on the money stock for the conduct of monetary policy may have more modern counterparts, and we suggest the importance of tracking balance sheet quantities for the conduct of monetary policy.

Key words: financial intermediation, monetary policy, risk-taking channel

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Adrian: Federal Reserve Bank of New York (e-mail: tobias.adrian@ny.frb.org). Shin: Princeton University (e-mail: hsshin@princeton.edu). This paper is a preliminary version of a chapter prepared for the *Handbook of Monetary Economics*. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

1. Introduction

In conventional models of monetary economics commonly 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, save 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. These 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. Curdia and Woodford (2009) 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?

Banks and other financial intermediaries borrow in order to lend. Since the loans offered by banks tend to be of longer maturity than the liabilities that fund those loans, the term spread is indicative of the marginal profitability of an extra dollar of loans on intermediaries' balance sheets. The net interest margin (NIM) of the bank is the difference between the total interest income on the asset side of its balance sheet and the interest expense on the liabilities side of its balance sheet. Whereas the term spread indicates the profitability of the marginal loan that is added to the balance sheet, the net interest margin is an average concept that applies to the stock of all loans and liabilities on the balance sheet.

The net interest margin determines the profitability of bank lending and increases the present value of bank income, thereby boosting the forward-looking measures of bank capital. Such a boost in bank capital increases the capacity of the bank to increase lending in the sense that the marginal loan that was not made before the boost in bank capital now becomes feasible under the greater risk-bearing capacity of the bank. As banks expand their balance sheets, the market price of risk falls.

In this framework, financial intermediaries drive the financial cycle through their influence on the determination of the price of risk. Quantity variables - particularly the components of financial intermediary balance sheets - emerge as important economic indicators due to their role in reflecting the risk capacity of banking sector and hence on the marginal real project that receives funding. In this way, the banking sector plays a key role in determining 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 it has fallen out of favor among monetary economists.[1] The common

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

theme between our framework and the older literature is that the money stock is a balance sheet aggregate of the financial sector. Our approach suggests that broader balance sheet aggregates such as total assets and leverage are the relevant financial intermediary variables to incorporate into macroeconomic analysis.

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 marking to market their balance sheets. In this regard, fluctuations in shadow bank and broker-dealer assets are more informative than movements in commercial bank assets. However, as commercial banks 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.

Our findings have important implications for the conduct of monetary policy. According to the perspective outlined here, fluctuations in the supply of credit arise from the interactions between bank risk-taking and the market risk premium. The cost of leverage of market-based intermediaries is determined by two main variables – risk and risk-taking capacity. 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. For these reasons, short-term interest rates matter directly for monetary policy.

The effect of keeping policy rates low in the aftermath of the financial crisis of 2008 has illustrated again the potency of low policy interest rates in raising the profitability of banks and thereby recapitalizing the banking system from their dangerous low levels. When considering the debates in early 2009 about the necessity (or inevitability) of capital injections into the U.S banking system, the

fluctuations in the United States.

turnaround in the capital levels of the U.S. banking sector has been worthy of note.

Empirically, there is (for the United States) a near perfect negative one-to-one relationship between 4-quarter changes of the Fed Funds target and 4-quarter changes of the term spread defined as the 10-year/3-month term Treasury spread (Figure 1.1 uses data from 1987q1 to 2008q3). Thus, shifts in the policy rate translate directly into shifts in the slope of the yield curve. Since the term spread affects the profitability of the marginal loan and the future net interest margin (NIM) of the bank, the short rate signals future risk-taking capacity of the banking sector. In this way, variations in the target rate affect real activity because they change the risk-taking capacity of financial intermediaries, thus shifting market risk premiums and 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.

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. This "expectations channel", which is explained in Bernanke (2004), Svensson (2004), and Woodford (2003, 2005), has become an important consideration for monetary policy. In his book on central banking, Alan Blinder (1998, p.70) phrases the claim in a particularly clear way.

> "central banks generally control only the overnight interest rate,

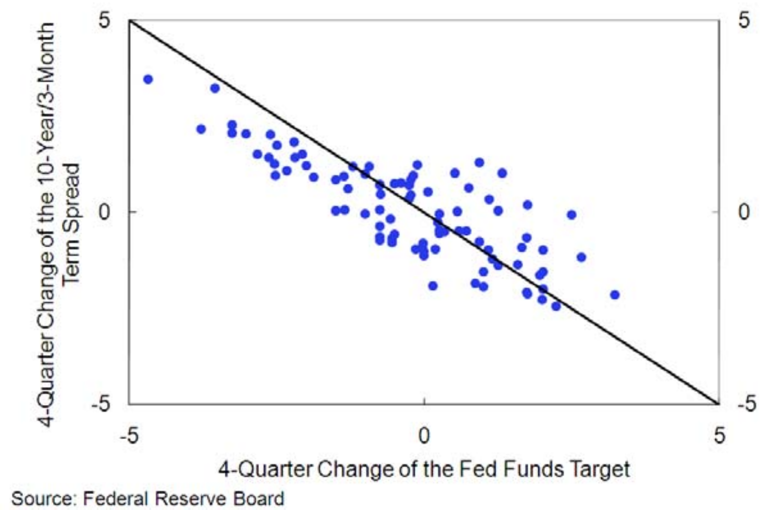

Figure 1.1: The term spread and the Federal Funds rate.

> 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. Short rates matter because they largely determine the term spread, which in turn determine the net interest margin and the forward-looking capital of the banking sector. Continued low short rates imply a steep yield curve for some time, higher net interest margin in the future, and hence higher risk-taking capacity of the banking sector. Conversely, higher short rates imply lower future net interest margin and a decline in the risk-taking capacity of the banking sector. In particular, an inverted yield curve is a sign of diminished risk-taking capacity, and by extension of lower real activity.

There is empirical support for the risk-taking channel of monetary policy. We find that the growth in shadow bank balance sheets and broker-dealer balance sheets help to explain future real activity. However, we also find that fluctuations in the balance sheet size of shadow banks and security broker-dealers appear to signal shifts in future real activity better than the fluctuations of 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 evolutions of shadow bank and broker-dealer assets have time signatures that are 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.

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: 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 equilibrium model where financial intermediaries are the main engine for the determination of the price of risk in the economy. We then present empirical results on the real impact of shadow bank and broker-dealer balance sheet changes, and on the role of short-term interest rates in the determination of balance sheet changes. We also consider the role of the central bank as the lender of last resort (LOLR) in light of our findings. We conclude by drawing some lessons for monetary policy.

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.[2] 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. 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. The model also incorporates insights from Shleifer and Vishny (1997), who demonstrate that financial constraints can lead to fluctuations of risk premia

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

even if arbitrageurs are risk neutral.[3] Adrian and Shin (2007) exhibit empirical evidence that bears on the fluctuations in the pricing of risk from the balance sheets of financial intermediaries.

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 via a chain of defaults of financial intermediaries.[4] This is not to say, of course, 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, we show that aggregate capital of the financial intermediary sector stands 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 capital, the lower is the price of risk, and the 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:

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

[3] Shleifer and Vishny (2009) present a theory of unstable banking that is closely related to our model.

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

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 i. 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:

$$W \equiv \tilde{w}y + (1+i)(e - py) \tag{2.1}$$

$$= \underbrace{(\tilde{w} - (1+i)p)}_{\text{risky excess return}} y + \underbrace{(1+i)e}_{\text{risk-free ROE}} \tag{2.2}$$

There are two groups of investors - passive investors and active investors. The passive investors can be thought of as non-leveraged investors such as households, 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 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.

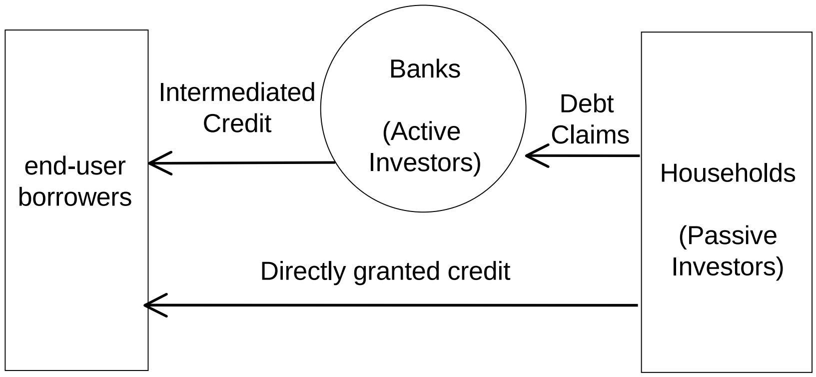

Figure 2.1: Intermediated and Directly Granted Credit

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

$$U = E(W) - \frac{1}{2\tau}\sigma_W^2 \tag{2.3}$$

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

$$U(y) = \underbrace{(q/p - (1+i))}_{\text{Expected Excess Return}} py + (1+i)e - \frac{1}{6\tau}y^2z^2 \tag{2.4}$$

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

$$(q - (1+i)p) - \frac{1}{3\tau}yz^2 = 0$$

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

$$y_P = \begin{cases} \frac{3\tau}{z^2}(q - (1+i)p) & \text{if } q > p(1+i) \\ 0 & \text{otherwise} \end{cases} \tag{2.5}$$

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.[5] 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. This is an extreme assumption which we adopt for the purpose of simplifying the model. By setting the Value-at-Risk constraint to allow no default by the bank, we can treat bank liabilities as a perfect substitute for cash. It would be possible to allow for a less stringent Value-at-Risk constraint that allows possible default by the bank, but then the modeling has to make allowance for the bank's liabilities being risky debt and being priced accordingly. However, the key qualitative features of the model would be unaffected. Thus, in what follows, we will adopt the stringent version of the VaR constraint where the bank holds enough capital to meet the worst case loss, and where the bank's liabilities are risk-free.

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 $p > q/(1+i)$ so that the price exceeds the discounted expected payoff) the investor holds no risky securities. When $p < q/(1+i)$, then $E(W)$ is strictly increasing in y, and so the Value-at-Risk

[5] A microfoundation for the VaR constraint is provided by Adrian and Shin (2008b).

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, $py - e$

For each unit of the risky security, the minimum payoff is $q - z$. Thus, the worst case loss is $(p(1+i) - (q-z))\,y$. In order for the bank to have enough equity to cover the worst case loss, we require:

$$(p(1+i) - (q-z))\,y \leq e \tag{2.7}$$

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

$$y = \frac{e}{p(1+i) - (q-z)} \tag{2.8}$$

So the demand from the bank for the risky asset depends positively on the expected excess return to the risky asset $q-(1+i)\,p$, and positively on the amount of equity that the bank is endowed with e.

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.

Replacing the constraint (2.8) in the amount of debt $py - e$ allows us to write the new balance sheet as follows:

Assets	Liabilities
securities, py	equity, e debt, $\frac{q-z}{1+i}y$

(2.9)

where the debt $\frac{q-z}{1+i}y$ was constructed by substituting $e = -\left(\left(q/p - (1+i)\right)p - z\right)y$ into $py - e$. We assume that $q > z$ so as to ensure that the payoff of the risky security is non-negative. The bank's leverage is the ratio of total assets to equity, which can be written as:

$$\text{leverage} = \frac{py}{e} = \frac{p}{p(1+i) - (q-z)} \tag{2.10}$$

Denoting by y 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

$$y + y_P = S \tag{2.11}$$

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 $q/(1+i)$. 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. For now, we simply treat the increase in q as an exogenous shock. 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

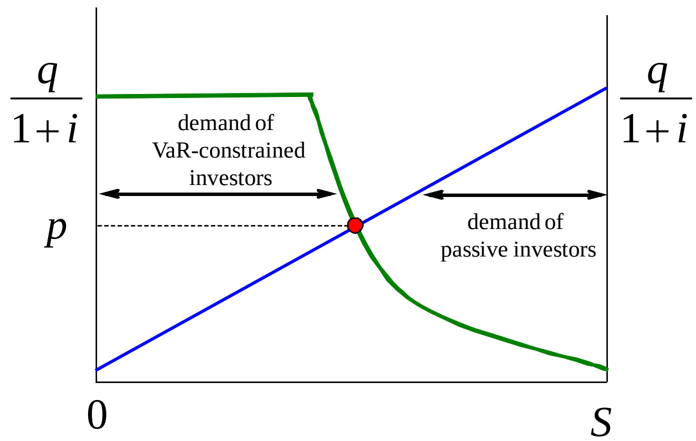

Figure 2.2: Market Clearing Price

the leveraged investors 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 $\frac{q-z}{1+i}y$. Since the new asset value is $p'y$, the new equity level e' is

$$e' = (p'(1+i) - (q-z))\,y \tag{2.12}$$

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 was already risk-free to begin with. So, the increase in asset value flows through entirely to an increase in equity. Equation (2.12) 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

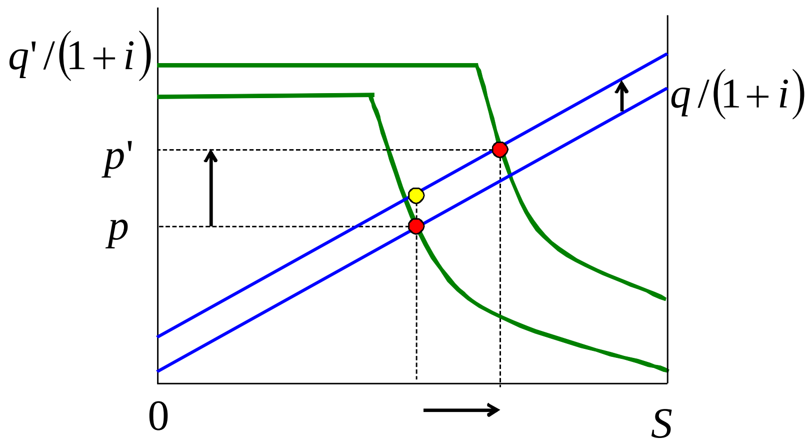

Figure 2.3: Amplified response to improvement in fundamentals q

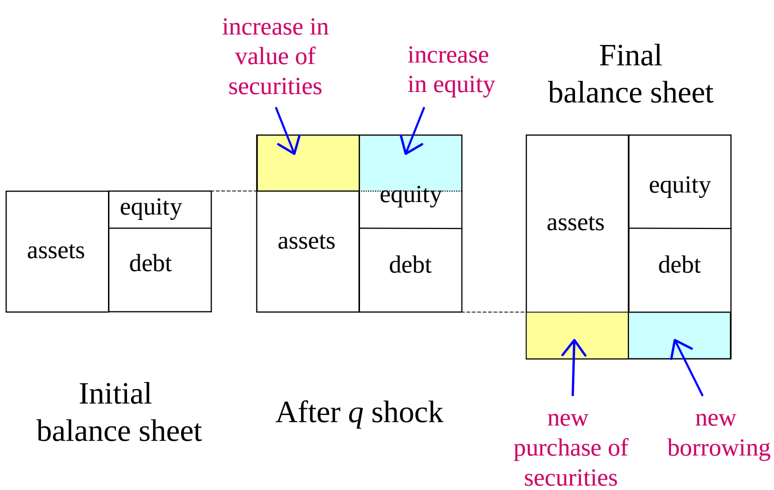

Figure 2.4: Balance sheet expansion from q shock

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,

$$e' = (p'(1+i) - (q' - z))\, y' \tag{2.13}$$

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 (2.13) 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 (2.12) and (2.13), we can write the new holding y' of the risky security as

$$y' = y \left(1 + \frac{q' - q}{p'(1+i) - q' + z} \right) \tag{2.14}$$

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

$$(1+i)\, p' - q' = \frac{z^2}{3\tau} (y' - S)$$

Substituting into (2.14),

$$y' = y \left(1 + \frac{q' - q}{\frac{z^2}{3\tau} (y' - S) + z} \right) \tag{2.15}$$

This defines a quadratic equation in y'. The solution is where the right hand side of (2.15) 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 (2.15) is positive. But this condition is guaranteed from (2.14) and the fact that $p' > \frac{q'-z}{1+i}$ (i.e. that the price of the risky security is higher than its worst possible realized discounted payoff).

Note also that the size of the amplification is increasing when fundamental risk is small, 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.

2.2. Pricing of Risk

We now explore the fluctuations in risk pricing in our model. The risk premium in our model is the excess expected return on the risky security, which can be written in terms of the ratio of the discounted expected payoff on the risky security and its price:

$$\text{Risk premium} \;=\; \frac{q}{p\,(i+1)} - 1 \tag{2.16}$$

Rather than working with the risk premium directly, it turns out to be more convenient to work with a monotonic transformation of the risk premium defined as

$$\pi \equiv 1 - \frac{p\,(1+i)}{q} \tag{2.17}$$

The "π" stands for "premium". The variable π is a monotonic transformation of the risk premium that varies from zero (when the risk premium is zero) to 1 (when the risk premium is infinite).

The market-clearing condition for the risky security is $y + y_P = S$, which can be written as

$$\frac{e}{z - q\pi} + \frac{3\tau}{z^2} q\pi = S \tag{2.18}$$

Our primary interest is in the relationship between total equity e and the risk premium π. Here, e has the interpretation of the total capital of the banking sector, and hence its risk-taking capacity. In our model, the total lending of the banking sector bears a very simple relationship to its total capital e, since the holding of the risky security by the active investors (the banks) is $e/(z - q\pi)$. We impose the restriction 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

$$q\pi < \frac{z^2}{3\tau} S \tag{2.19}$$

By defining $F(e, \pi)$ as below, we can write the market-clearing condition as:

$$F(e, \pi) \equiv e + \frac{3\tau}{z^2} q\pi (z - q\pi) - S(z - q\pi) = 0 \tag{2.20}$$

We then have

$$\frac{\partial F}{\partial \pi} = q \left(\underbrace{\frac{3\tau}{z^2}(z - q\pi)}_{A} + \underbrace{S - \frac{3\tau}{z^2} q\pi}_{B} \right) \tag{2.21}$$

Both A and B are positive. A is positive since the holding of the risky security by the active sector is $e/(z - q\pi)$, and so $z - q\pi > 0$ in order that the active investors hold positive holdings of the risky security. Another way to view this condition is to note that the market price of the risky security cannot be lower than the lowest possible realization of the payoff of the risky asset, so that

$$p > \frac{q-z}{1+i} \tag{2.22}$$

which can be written as $(1+i)\,p - (q-z) = z - q\pi > 0$. The second term (term B) inside the big brackets is positive from our condition (2.19) that the passive investors do not hold the entire supply. Since $\partial F/\partial e = 1$, we have

$$\frac{d\pi}{de} = -\frac{\partial F/\partial e}{\partial F/\partial \pi} < 0 \tag{2.23}$$

In other words, the market risk premium is decreasing in the total equity e of the banking sector. As stated above, we view e as the risk-taking capacity of the banking sector. Any shock that increases the capital buffer of the banking sector will lower the risk premium. We therefore have the following empirical hypothesis.

Empirical Hypothesis 1. Risk premiums fall when the equity of the banking system increases.

This empirical hypothesis is key to our discussion on the role of short-term interest rates on risk-taking capacity of the banking sector, through the slope of the yield curve and hence the greater profitability of bank lending. We return to this issue shortly.

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

$$\lambda = \frac{dE(W)}{de} = \frac{\partial E(W)}{\partial y}\frac{\partial y}{\partial e} = \frac{q-(1+i)p}{z-(q-(1+i)p)} \tag{2.24}$$

where we have obtained the expression for $dE(W)/dy$ from (2.1) and dy/de is obtained from (2.8), which gives the optimal portfolio decision of the leveraged investor. Using our π notation, we can re-write (2.24) as

$$\lambda = \frac{q\pi}{z-q\pi} \tag{2.25}$$

We see from (2.25) that as the risk premium π 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 risk premium π goes to zero, so does the Lagrange multiplier, implying that the return to a dollar's worth of capital goes to zero.

Furthermore, the shadow value of bank capital can be written as:

$$\lambda = \frac{z(S-y)}{3\tau - z(S-y)} \tag{2.26}$$

The shadow value of bank capital is decreasing in the size of the leveraged sector, given by y. Moreover, since there is a one-to-one relationship between λ and the risk premium π, we can also conclude that market risk premiums fall when the size of the intermediary sector increases.

Empirical Hypothesis 2. Risk premiums fall when the size of the banking sector increases.

3. Changing Nature of Financial Intermediation

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

3.1. Shadow Banking System and Security Broker-Dealers

As recently as the early 1980s, traditional banks were the dominant financial intermediaries. In subsequent years, however, they were quickly overtaken by market-based financial institutions. Figure 3.1 plots the size of different types of financial intermediaries for the United States starting in 1985. We see that market-based financial intermediaries, such as security broker dealers and ABS issuers, have become important components of the intermediary sector. The series labeled "shadow banks" aggregates ABS issuers, finance companies, and funding corporations.

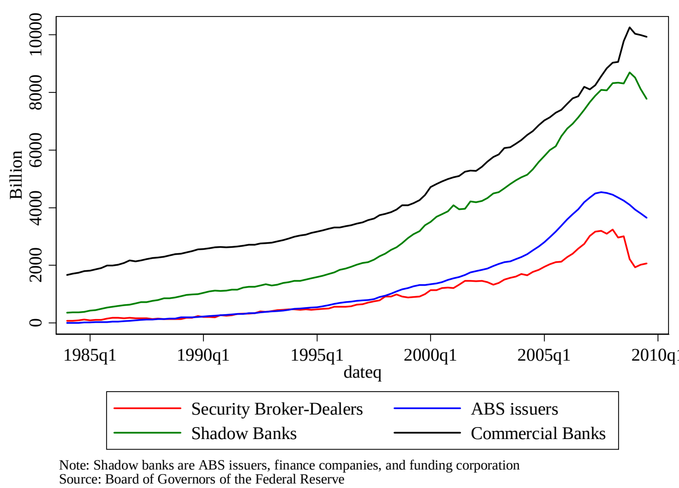

Figure 3.1: Total Assets of Commercial Banks, Shadow Banks, and Broker-Dealers.

In 1985, shadow banks were a tiny fraction of the commercial bank sector, but had 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-dealers, who 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 are smaller than total assets 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 of market-based institutions, rather than by traditional bank balance sheets. Broker-dealer balance sheets provide a timely window on this world.

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 together with the outstanding stock of repos of the primary dealers - the set of banks that bid at US Treasury security auctions, and 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 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

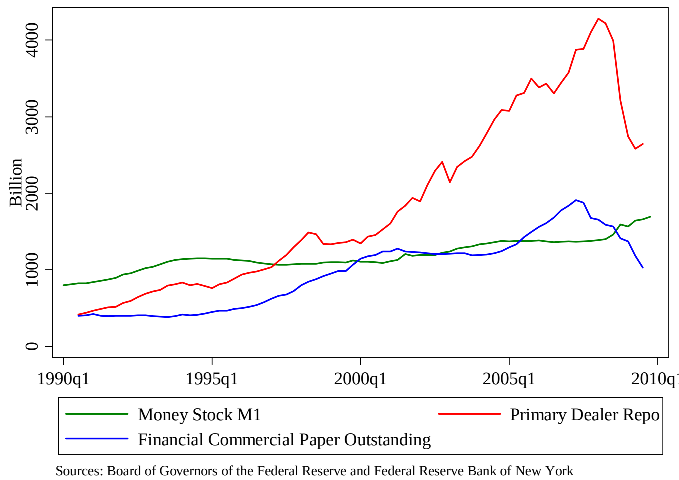

Figure 3.2: Liquid funding of financial institutions: Money (M1), Primary Dealer Repo, and Commercial Paper.

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 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 the size of their balance sheet during the crisis, the shadow banks have contracted 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. As such, looking only at aggregate commercial bank lending may give an overly rosy picture of the state of financial intermediation.

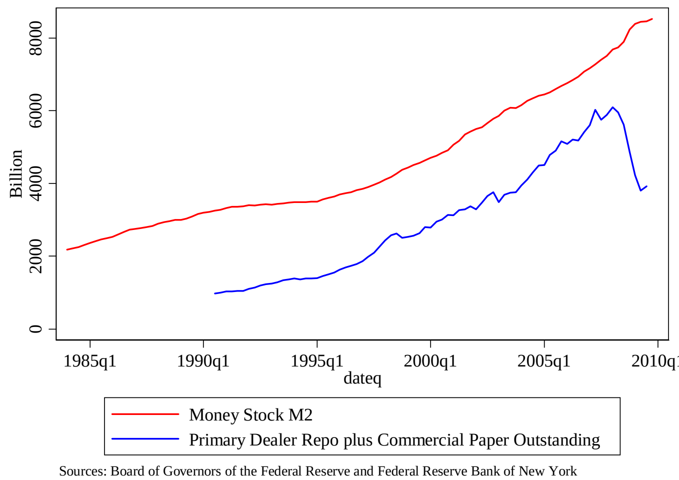

Figure 3.3: Short Term Funding: M2 versus Commercial Paper + Primary Dealer Repo.

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 is be important to bear in 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 sheets consist almost exclusively of short-term market borrowing and are not as constrained by relationship-based lending.

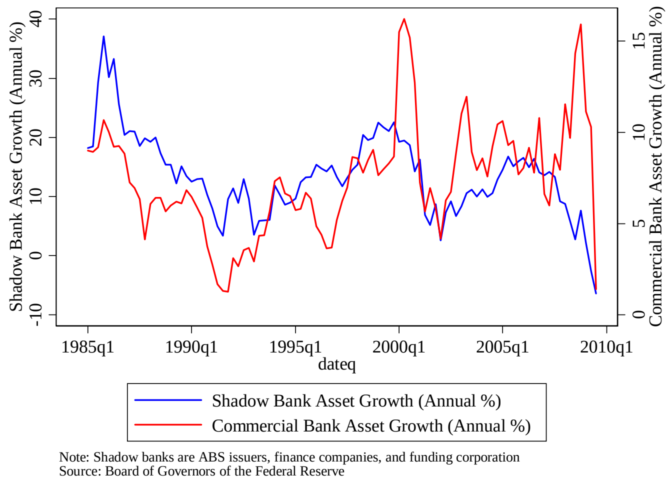

Figure 3.4: Total Asset Growth of Shadow Banks and of Commercial Banks.

3.2. Haircuts and Value at Risk

The Value at Risk constraint that is at the heart of the amplification mechanism in the model of Section 2 characterizes market-based financial intermediaries such as security broker-dealers and shadow banks. The active balance sheet management of financial institutions is documented in Adrian and Shin (2007), who show that investment banks exhibit "procyclical leverage": i.e., increases in balance sheet size are associated with increases in leverage. In contrast, the balance sheet behavior of commercial banks is consistent with leverage targeting: for commercial banks, leverage growth is uncorrelated with the growth of balance sheet size.

One useful perspective on the matter is to consider the implicit maximum leverage that is permitted in collateralized borrowing transactions such as repurchase agreements (repos). Repos are the primary source of funding for market-based financial institutions, as well as being a marginal source of funding for traditional banks. In a repurchase agreement, the borrower sells a security today for a price

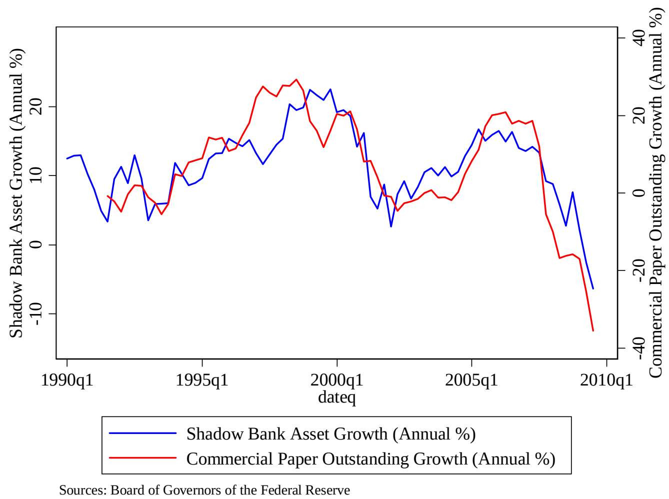

Figure 3.5: Marginal Funding of Shadow Banks is Commercial Paper.

below the current market price on the understanding that it will buy it back in the future at a pre-agreed price. The difference between the current market price of the security and the price at which it is sold is called the "haircut" in the repo, and fluctuates together with market conditions. The fluctuations in the haircut largely determine the degree of funding available to a leveraged institution. The reason is that the haircut determines the maximum permissible leverage achieved by the borrower. If the haircut is 2%, the borrower can borrow 98 dollars for 100 dollars worth of securities pledged. Then, to hold 100 dollars worth of securities, the borrower must come up with 2 dollars of equity. Thus, if the repo haircut is 2%, the maximum permissible leverage (ratio of assets to equity) is 50.

Suppose that the borrower leverages up the maximum permitted level. The borrower thus has a highly leveraged balance sheet with leverage of 50. If at this time, a shock to the financial system raises the market haircut, then the borrower faces a predicament. Suppose that the haircut rises to 4%. Then, the permitted

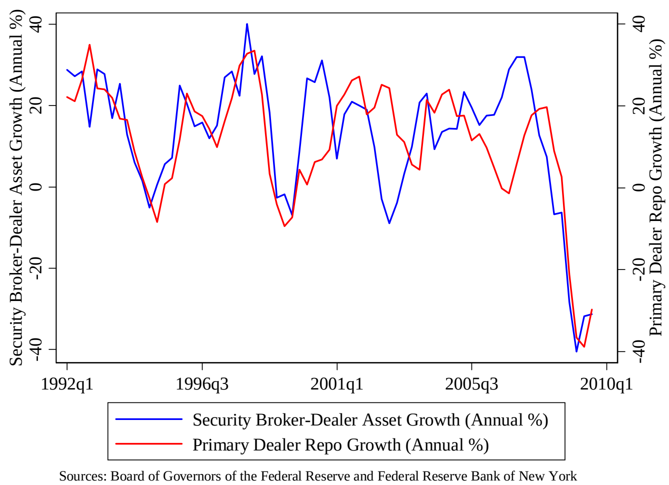

Figure 3.6: Marginal Funding of Broker-Dealers is Repo.

leverage halves to 25, from 50. The borrower then faces a hard choice. Either it must raise new equity so that its equity doubles from its previous level, or it must sell half its assets, or some combination of both. However, asset disposals have spillover effects that exacerbate the distress for others. The "margin spiral" described by Brunnermeier and Pedersen (2009) models this type of phenomenon.

Considerations of repo haircuts suggest that measured risks will play a pivotal role in the determination of leverage. Adrian and Shin (2008b) present a contracting model which yields this outcome as a central prediction, and present empirical evidence consistent with the prediction. Adrian and Shin (2008b) find that measures of Value-at-Risk (VaR) that are computed from the time series of daily equity returns explains shifts in total assets, leverage, and key components of the liabilities side of the balance sheet, such as the stock of repos.

In the benchmark case where losses are exponentially distributed, the contracting model of Adrian and Shin (2008b) yields the widely used Value-at-Risk

(VaR) rule which stipulates that exposures be adjusted continuously so that equity exactly matches total Value-at-Risk. Among other things, the Value-at-Risk rule implies that exposures are adjusted continuously so that the probability of default is kept constant - at the level given by the VaR threshold. Given the ubiquitous use of the VaR rule both by private sector financial institutions and by regulators, this microfoundation of the VaR concept gives a basis for further study.

To be sure, showing that the VaR rule is the outcome of a contracting model says little about the desirability of the widespread adoption of such practices from the point of view of economic efficiency. Indeed, there are strong arguments to suggest that risk management tools such as Value-at-Risk cause spillover effects to other financial institutions that are detrimental to overall efficiency. For instance, the prudent reduction in exposures by the creditors to Lehman Brothers is a run from the point of view of Lehman Brothers itself. The spillover effects are a natural consequence of the contracts being bilateral arrangements. They do not take account of the spillover effects across more than one step in the financial network.

3.3. 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. Before going further, we therefore note some accounting relationships that can help us to think about the extent of the double-counting.

Let a_i be the total assets of bank i, and x_i the total debt of bank i (i.e., total liabilities minus equity). 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 $\sum_{i=1}^{n} x_i$.

Define leverage λ_i as the ratio of total assets to equity of bank i:

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

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) suggests what to look for when gauging the extent of double-counting of lending to ultimate borrowers that results from the heavy use of funding raised from other financial intermediaries. The comparison is between y (the profile of lending to the ultimate borrowers in the economy) and x (the profile of debt values across all banks, which gives 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 to the extent to which banks are interwoven tightly, the norm can grow without bound. This is because as leverage becomes large, $\delta_i \to 1$ and, hence, Δ tends to the identity matrix. Moreover, as the degree of interconnectedness between banks becomes large, the norm of the matrix Π converges to 1, since 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.

Consequently, the size of the financial intermediation sector relative to the size of the economy can vary hugely over the financial cycle. We illustrate this phenomenon in 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) the household sector, (iii) the 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 1954Q1 is set equal to 1.

Over this time period, three of the four sectors had grown to roughly 80 times their 1954 size by the end of 2009. These trends, however, have been dwarfed by

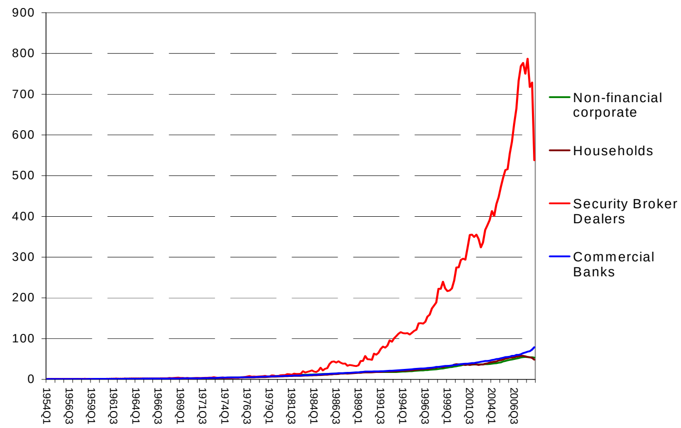

Figure 3.7: Growth of Four US Sectors (1954Q1 =1)

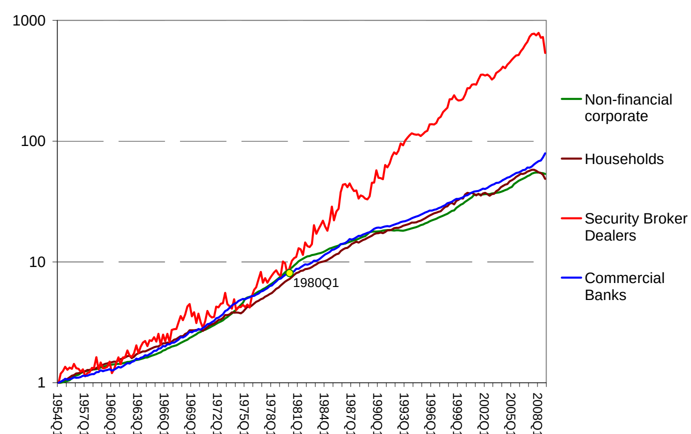

Figure 3.8: Growth of Four US Sectors (1954Q1 = 1) (in log scale)

that of the broker-dealer sector, which 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 up to about 1980, but then started a growth spurt that outstripped the other sectors. On the eve of the crisis, the size of the securities sector was roughly ten times that of the other sectors in the economy.

4. Empirical Relevance of Financial Intermediary Balance Sheets

Our discussion thus far suggests that financial intermediaries deserve independent study in models of monetary economics due to their impact on financial conditions. Asset prices are influenced by the tightness of balance sheet constraints of financial intermediaries. In this section, we examine empirically whether financial intermediaries' impact on financial conditions can feed through to affect real economic outcomes. The analysis follows Adrian and Shin (2008d) and Adrian, Moench and Shin (2009).

We label the looseness of balance sheet constraints "risk appetite" following Adrian, Moench, and Shin (2009, 2010) and Adrian, Etula, and Shin (2009). Risk appetite refers to the shadow value of capital of the (leveraged) intermediary sector in the model of section 2. This shadow value of capital indicates the additional profit that the banking sector may earn by having one dollar of extra bank capital. The looser is the capital constraint, the lower is the Lagrange multiplier, and hence the higher is the risk appetite.

The terminology of "risk appetite" is intended to highlight the apparent change in preferences of the banking sector. We say "apparent" change in preferences, since the fluctuations in risk appetite are due to the constraints faced by the banks rather than their preferences as such. However, to an outside observer, the fluctuations in risk appetite would have the outward signs of fluctuations in risk preferences of the investor.

Adrian, Moench, and Shin (2009) estimate the risk appetite of financial intermediaries for a "macro risk premium". The risk premium measures the hurdle rate of return for new projects that are financed in the economy, and hence reflects the ease of credit conditions, and correponds to the risk premium of the model in section 2. The macro risk premium is estimated from the yield spreads of fixed income securities. In particular, the macro risk premium is estimated as a linear combination of spreads that is tracking GDP growth most closely. In doing so, we allow both term spreads of the Treasury yield curve and credit spreads to enter. Both term spreads and credit spreads are measures of hurdle rates – the additional yields on longer-dated or riskier bonds that induce market investors to fund additional investment or consumption.

To estimate the macro risk premium, Adrian, Moench, and Shin (2009) contemporaneously regress GDP growth on a wide variety of Treasury and credit spreads. They then use the seven constant maturity yields published in the H.15 release of the Federal Reserve Board and compute spreads relative to the Fed Funds target, and corporate bond spreads for credit ratings AAA, AA, A, BBB, BB, and B from Standard & Poors in excess of the 10-year constant maturity Treasury yield. The analysis of Adrian, Moench, and Shin (2009) starts in the first quarter of 1985, and ends in the fourth quarter of 2009.

An estimate of the macro risk premium is obtained as the fitted value of a linear regression of GDP growth on these corporate and Treasury bond spreads. Hence, empirically, the macro risk premium is a weighted average of spreads where the weights are given by the regression coefficients. The weights can be interpreted

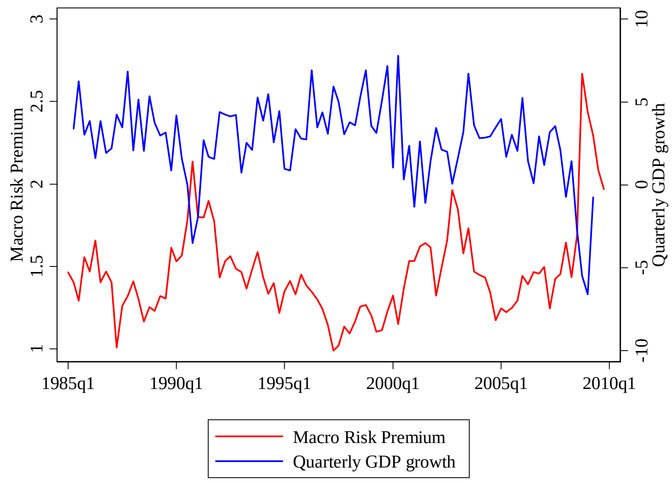

Figure 4.1: The Macro Risk Premium and GDP Growth

as portfolio weights of a portfolio that is tracking GDP growth. Conceptually, the macro risk premium represents the analogue of the risk premium term π discussed in Section 2 above. The estimated macro risk premium, together with GDP growth, are plotted in Figure 4.1. For ease of interpretation, the macro risk premium is rotated using an affine transformation so as to match the average level and the volatility of the AA credit spread. The plot shows the strong negative correlation between the macro risk premium and GDP growth.

We now turn to our measure of the looseness of financial intermediary capital constraints, which we have called "risk appetite" as shorthand. As sketched in Section 2 , the willingness of banks to lend will be positively associated with the size of intermediary balance sheets. The scenario outlined in Section 2 is that financial intermediaries manage their balance sheets actively by employing a Value-at-Risk constraint when choosing the size and composition of their portfolio.

Intuitively, the relationship between the macro risk premium, financial intermediary balance sheets, and real activity goes as follows. When financial intermediaries have ample balance sheet capacity in terms of higher capital, their balance sheet constraints are loose, risk premia are compressed, the supply of credit is plentiful, which in turn leads to lower threshold rates of return for real projects, and hence higher GDP growth. Effective risk aversion is low, and real growth is high. Conversely, when financial intermediary funding conditions worsen, their risk appetite declines, leading to lower real growth.

The macro risk premium measure can be interpreted as a portfolio of Treasury and corporate bond yields where the portfolio weights are chosen so as to maximize the contemporaneous correlation with real GDP growth. In a similar vein, we obtain a measure of intermediary risk appetite by finding the linear combination of one-year lagged balance sheet variables that best predict the (negative) one-year change of the macro risk premium. To a good approximation, the negative change reflects the return on the macro risk premium. A priori, it is not clear which institutions are the most important ones in determining risk premia for the different asset classes. We therefore build on our related work in Adrian, Moench, and Shin (2010) in which we use subset selection methods to identify the best predictors for excess returns on different asset classes among a large number of potential explanatory balance sheet proxies for various types of financial institutions. Adrian, Moench, and Shin (2010) document that annual leverage growth of security brokers and dealers is a strong predictor of excess returns on equity and corporate bond portfolios and that quarterly shadow bank asset growth is a strong forecasting variable for excess returns on corporate and Treasury bonds. Adrian, Moench, and Shin (2009) therefore restrict the set of right-hand side variables to these two types of institutions, complemented by commercial banks so as to highlight the differential impact that balance sheets of market based intermediaries have with respect to traditional banks. For each of these three types of institutions, one-year lagged asset growth and the growth of net worth are included as potential variables. Adrian, Moench, and Shin (2009) weight the growth rates of assets and net worth by the relative size of total assets of each intermediary in order to capture the trends of assets under management across different institutions.

Risk appetite is estimated by regressing the (negative) change of the macro risk premium over one year on the balance sheet measures of the security broker-dealers, the shadow banks, and the commercial banks. These negative changes capture returns to the risk premia. When the negative change of a risk premium is positive, prices today increase, leading to lower expected returns. The measure of risk appetite is constructed as the fitted value of the regressions of (the negative changes to the macro risk premium) on the intermediary balance sheet variables. The risk appetite measure is displayed together with the macro risk premium in Figure 4.2. The plot shows that risk appetite is highly negatively correlated with changes to the macro risk premium. Higher risk appetite leads to balance sheet expansions, which are associated with increases in asset prices and hence declines in spreads. Movements in risk appetite are thus strongly negatively correlated with the macro risk premium.

We can also investigate the importance of financial intermediary balance sheets for macroeconomic activity by relating intermediary balance sheets directly to GDP growth. Relative to commercial banks, broker-dealer and shadow bank balance sheets potentially hold more information related to 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 capital markets (for instance via commercial paper or repos). For commercial banks, however, their large balance sheets mask the effects operating at the margin. Broker-dealers or shadow banks, in contrast, give a purer signal of marginal

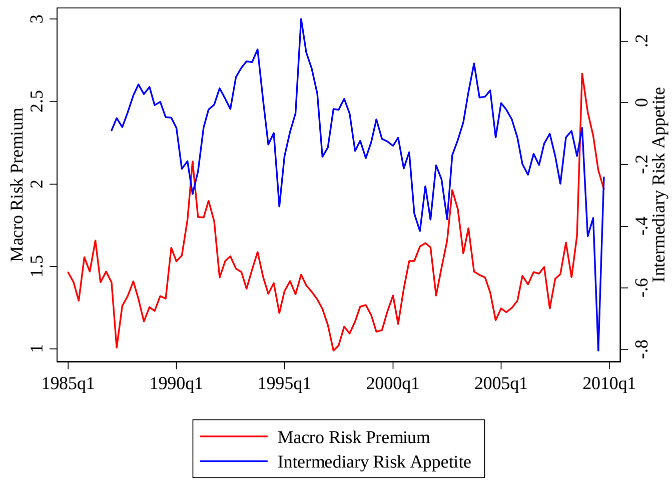

Figure 4.2: Macro Risk Premium and Intermediary Risk Appetite

funding conditions, as (i) their liabilities are short term and (ii) their balance sheets are closer to being fully marked to market.

In addition, broker-dealers originate and serve as market makers for securitized products, whose availability determines the credit supply for consumers and non-financial firms (e.g., for mortgages, car loans, student loans, etc.). Consequently, broker-dealers are important variables not only because they are the marginal suppliers of credit, but also because 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 have the potential to affect real economic variables. To examine this empirically, we estimate macroeconomic forecasting regressions. In Table 4.1, we report the results of regressions of the quarterly 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. By adding lags of additional financial variables (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, 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 done using quarterly data from 1986Q1 to 2009Q2. Variable definitions are given in the data appendix at the end of this chapter.

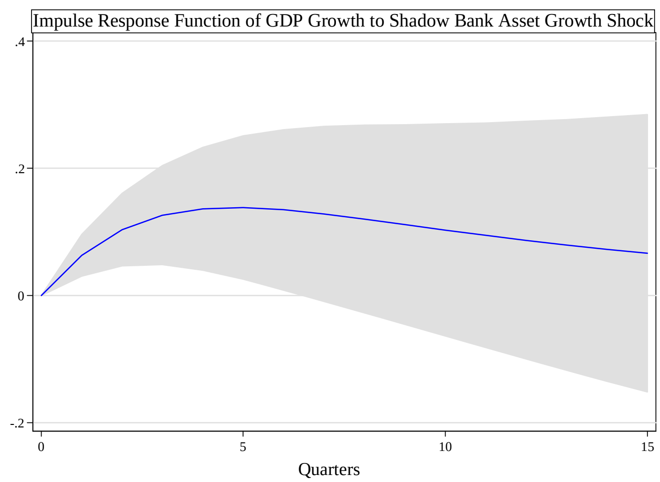

Figure 4.3: The figure plots the impulse response GDP growth from a shock to shadow bank total asset growth. The impulse response is estimated from a vector autoregression with gdp growth, pce inflation, shadow bank asset growth, credit spread, vix, the term spread, and the Federal Fund target rate as variables, and that ordering is used to produce the impulse response functions using a Cholesky decomposition. The time span is 1986Q1 to 2009Q1.

The growth rate of security broker-dealer total assets has strongest significance for the growth rate of future housing investment, and weak significance for total GDP growth (Tables 4.1 and 4.2, columns 1). Our interpretation of this finding is that the mechanisms that determine the liquidity and leverage of broker-dealers

Table 4.1: **Impact of Balance Sheets on GDP.** This table reports regressions of quarterly GDP growth on the total asset and equity 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) Quarterly GDP Growth	(2) Quarterly GDP Growth	(3) Quarterly GDP Growth
Broker-Dealer Asset Growth (lag)	0.03*		
Broker-Dealer Equity Growth (lag)	0.18		
Shadow Banks Asset Growth (lag)		0.21***	
Shadow Banks Equity Growth (lag)		0.71**	
Commercial Bank Asset Growth (lag)			0.02
Commercial Bank Equity Growth (lag)			-0.12
GDP Growth (lag)	0.03	-0.18	0.09
PCE Inflation (lag)	-1.01**	-1.00**	-1.16***
VIX (lag)	0.01	-0.03	-0.02
Credit Spread (lag)	-1.37*	-1.81**	-1.01
Term spread (lag)	0.75**	1.18***	0.75*
Fed Funds (lag)	0.40	0.19	0.49*
Constant	4.67***	4.94***	4.44**
Observations	93	93	93
R^2	0.288	0.409	0.263

affect the supply of credit, which, in turn, affect investment and consumption. The total assets and total equity of shadow banks have significant forecasting power for total GDP growth, reflecting their increased role in the total supply of credit for the US economy. Commercial banks, on the other hand, have no forecasting power for GDP, and forecast housing growth with the wrong sign. Adrian, Moench, and Shin (2010) systematically investigate the forecasting power of all financial intermediaries in the U.S. Flow of Funds, and confirm that broker-dealers and shadow banks forecast real activity.

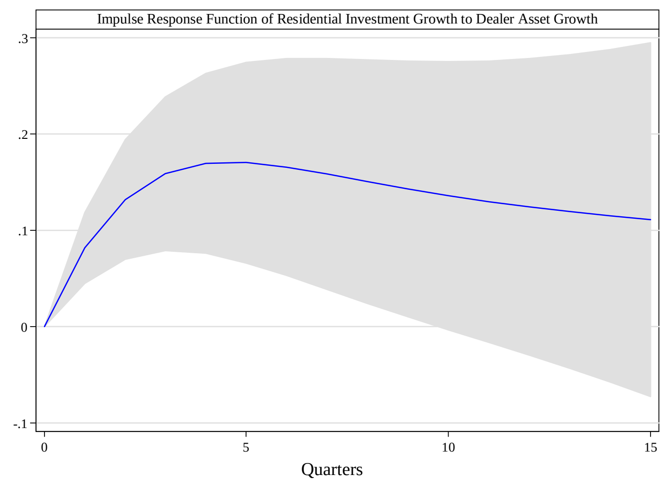

Figure 4.4: The figure plots the impulse response of residential investment growth from a shock to broker-dealer total asset growth. The impulse response is estimated from a vector autoregression with residential investment growth, pce inflation, broker-dealer asset growth, credit spread, vix, the term spread, and the Federal Fund target rate as variables, and that ordering is used to produce the impulse response functions using a Cholesky decomposition. The time span is 1986Q1 to 2009Q1.

The forecasting power of dealer assets for housing investment is graphically illustrated in Figure 4.4. The impulse response function is computed from a first

Table 4.2: **Impact of Balance Sheets on Housing Investment.** This table reports regressions of quarterly residential investment growth on the total asset and equity 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) Quarterly Housing Growth	(2) Quarterly Housing Growth	(3) Quarterly Housing Growth
Broker-Dealer Asset Growth (lag)	0.09***		
Broker-Dealer Equity Growth (lag)	0.10		
Shadow Banks Asset Growth (lag)		-0.00	
Shadow Banks Equity Growth (lag)		0.14	
Commercial Bank Asset Growth (lag)			-0.44*
Commercial Bank Equity Growth (lag)			0.23
Housing Growth (lag)	0.89***	0.94***	0.96***
PCE Inflation (lag)	-0.30	-0.11	-0.09
VIX (lag)	0.11	0.01	0.03
Credit Spread (lag)	-0.92	-0.49	0.01
Term spread (lag)	1.11**	0.60	-0.07
Fed Funds (lag)	-0.06	-0.04	-0.27
Constant	-2.53	0.13	3.76
Observations	93	93	93
R^2	0.902	0.881	0.888

order vector autoregression that includes all variables of Table 4.1, Column (1). The plot shows that the response of housing investment to a positive shock in broker-dealer assets growth is positive, large, and persistent.

The differences between the interactions of market based intermediaries and commercial banks with the macroeconomic aggregates are further highlighted in column (iii) of Table 4.1, where we see that commercial bank assets and equity do less well than shadow bank or security-broker-dealer variables as forecasting variables. 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. In addition, in Table 4.2, we find that growth in commercial bank total assets precedes declines in housing investment. This result is primarily due to the fact that commercial banks offer credit line pre-commitments that tend to be drawn in times of crisis. In fact, in Figure 3.4, we saw that commercial bank total assets grew at the onset of the recent financial crisis, as structured credit was reintermediated onto commercial bank balance sheets. 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 did 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. However, 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 (i) is more likely to reflect underlying credit supply conditions and (ii) 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. We return to a more thorough review of the literature in a later section.

5. Central Bank as Lender of Last Resort

The classical role of the central bank as the lender of last resort (LOLR) is framed 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 was not restricted to one of even a subset of institutions. Instead, entire market sectors were targeted. Figure 5.1 plots the new issuance of asset backed securities (ABS) over a three month interval preceding the measurement date, and clearly illustrates the generalized contraction of credit. If there was a run driven by a coordination failure, it was a simultaneous run from all institutions in the financial system. Albeit, the extent to which each institution suffered from the run depended on its particular vulnerability. In the model outlined in Section 2, it is the interaction between measured risks and the risk-bearing capacity of banks that determines overall lending. Financial institutions that rely on value at risk cut back lending when risk constraints become more binding (i.e., when the Lagrange multiplier

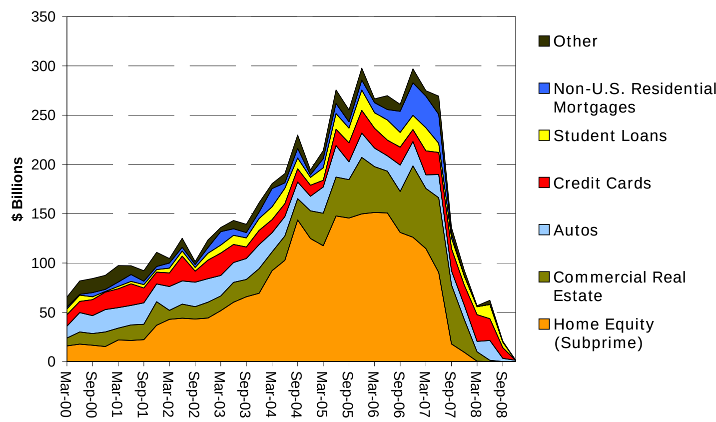

Figure 5.1: New Issuance of ABS in Previous Three Months

associated with the constraint increases). From the point of view of an individual bank, this prudent cutting of exposures by creditors will closely resemble a "run." 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 fine a distinction between the coordination view of bank runs on the one hand, and the "leverage constraints" view on the other. Coordination (or lack thereof) will clearly exacerbate the severity of any run when a bank has many creditors. The point is, rather, that an explanation of a run on the system needs to appeal to more than just coordination failures. For example, this means that explanations of the runs on Bear Stearns or Lehman Brothers, should make reference to market-wide factors, as well as to the particular characteristics of those firms and their creditors. 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.

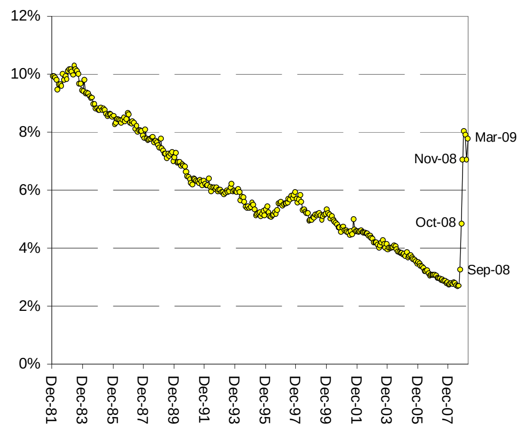

Figure 5.2: Cash as Proportion of US Commercial Bank Assets (Source: Federal Reserve, H8 database).

To the extent that the credit crunch can be seen as the consequence of a collapse of balance sheet capacity in the financial intermediary sector, we can interpret the policy response by central banks as an attempt to restore this lost capacity by lending directly into the market. The Federal Reserve has been one of the most aggressive central banks in this context, effectively interposing its own 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 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 dramatic increases in the Fed's 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 management 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 that of the Federal Funds interest rate (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 other lender of last resort programs 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 commercial paper market (CPFF and AMLF), and ABS markets (TALF). In addition, the Federal Reserve has conducted outright purchases of Treasury and agency securities, and has provided dollar liquidity in the FX futures markets (FX Swap lines). The common motivating element in these policies has been to try and alleviate the strains associated with the shrinking balance sheets of intermediaries by substituting the central bank's own balance sheet. The spirit of these policies differs from that of classic monetary policy in that they are explicitly aimed at replacing the collapse of private sector balance sheet capacity. Since the deleveraging of financial intermediary balance sheets is associated with a widening of risk premia, the effectiveness of balance sheet policies can be judged by the level of risk premia in various financial markets. In practice, the degree to which risk premia are associated with the expansions and contractions of intermediary balance sheets are important indicators for the risk appetite of the financial sector, which, in turn, affect credit supply and real activity. Adrian, Moench and Shin (2010) use this insight to decompose the risk premia of several asset classes into various components, including those associated with the risk appetite of financial intermediaries.

One instance of the Fed's liquidity facilities can be seen in Figure 5.3 (taken from Adrian, Marchioni, and Kimbrough (2010), which charts total outstanding commercial paper alongside net Federal Reserve commercial paper holdings in the "Commercial Paper Funding Facility" (CPFF).[6] 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 shaded blue area. With the creation of the CPFF in October 2008, the Fed's holdings of commercial paper in the CPFF began to increase rapidly, as shown by the green area 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. An important feature of the CPFF is that, as the facility was intended to be only a temporary liquidity backstop, it was designed to become more unattractive as market conditions begin to normalize. Accordingly, while the red line in Figure 5.3 shows that the Federal Reserve held as much as 20% of all outstanding commercial paper at the height of the crisis, CPFF holdings have since fallen steadily as market functioning has improved.

As another example, Figure 5.1 illustrated how new issuance of asset-backed securities (ABS) had collapsed by the end of 2008. In response, the Fed instituted the Term Asset-Backed Loan Facility (TALF), whereby the central bank provides secured loans to new AAA-rated ABS at a low haircut to private sector investors. TALF was designed specifically to revitalize the ABS market, and its effectiveness can be gauged by Figure 5.4, which shows the effect on new issuance of ABS before and after the introduction of TALF. The light colored bars on the right

[6] See Adrian, Marchioni, and Kimbrough (2010) for a detailed description of the CPFF.

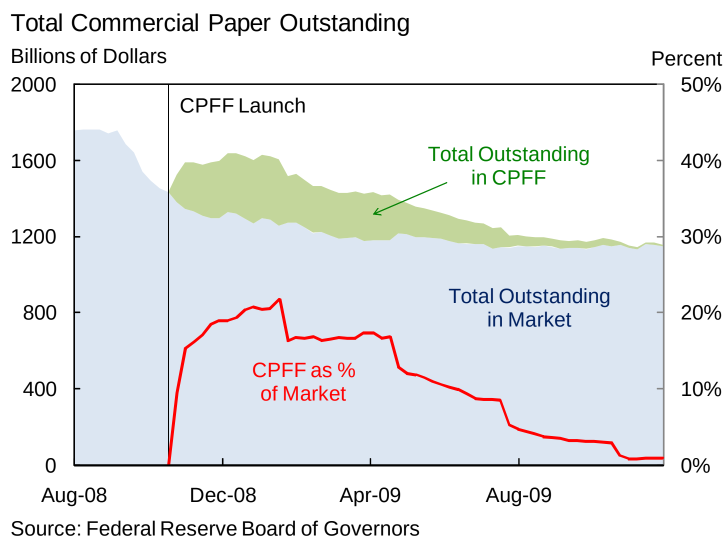

Figure 5.3: The Federal Reserve's Commercial Paper Funding Facility

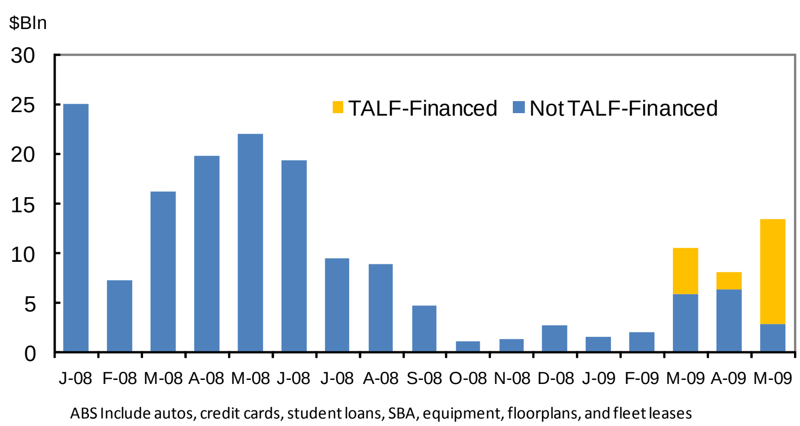

Figure 5.4: New ABS Issuance under TALF

show that much of the recent issuance of ABS has been TALF-financed, and that TALF-backed issuance dwarfs the issuance of standard issues.

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

6. Role of Short-Term Interest Rates

Having established that increases in broker-dealer and shadow bank balance sheets signal increases in real activity, we now investigate the determinants of balance sheet growth itself. 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 3.5); and the majority of commercial banks' short-term funding is through money (i.e., checking and savings 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, while another part is invested in longer-term, less liquid securities. Shadow banks, on the other hand, tend to fund holdings of ABS and MBS directly. Commercial banks primarily hold 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 are spreads—particularly term spreads—which capture the maturity transformation of financial institutions. The leverage of these 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, risk premia, and credit supply.

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

We find that 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 as well as on 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.

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 induce tighter constraints on dealer leverage (columns (1) and (2)). For M2, we find that higher VIX is associated with larger money growth, which we

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 February 3, 2010. Changes refer to 1-week changes, and lags to 1 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	Repo+CP Growth	M2 Growth
	(weekly growth)	(weekly growth)	(weekly growth)
Fed Funds (1 week change)	-0.630***	-0.355***	-0.054***
Equity Return (1 week)	-0.022*	-0.013*	0.001**
VIX (1 week change)	-0.052	-0.027	0.001
Treasury spread (1 week change)	0.703	0.291	0.151**
Credit spread (1 week change)	0.311	0.031	0.337**
Repo Growth (1 week lag)	-0.134***	-0.075***	-0.001
CP Growth (1 week lag)	0.022	0.028	-0.020
M2 Growth (1 week lag)	0.515	0.063	-0.016
Constant	0.136*	0.105**	0.050***
Observations	990	990	989
R^2	0.042	0.032	0.121

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).

Increases in the term spread are associated with higher repo growth. 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.

6.1. The 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. In constrast, 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. Our model suggests that increasing bank capital increases the risk-taking capacity of the banking system, which in turn leads to a lower equilibrium risk premium, and an increase the supply of credit by lowering the hurdle rate at which projects are financed.

Banks and other financial intermediaries borrow in order to lend. Since the loans offered by banks tend to be of longer maturity than the liabilities that fund those loans, the term spread is indicative of the marginal profitability of an extra dollar of loans on intermediaries' balance sheets. The net interest margin (NIM) of the bank is the difference between the total interest income on the asset side of its balance sheet and the interest expense on the liabilities side of its balance sheet. Whereas the term spread indicates the profitability of the marginal loan that is added to the balance sheet, the net interest margin is an average concept that applies to the stock of all loans and liabilities on the balance sheet.

The net interest margin determines the profitability of bank lending and increases the present value of bank income, thereby boosting the forward-looking measures of bank capital. Such a boost in bank capital increases the capacity of the bank to increase lending in the sense that the marginal loan that was not made before the boost in bank capital now becomes feasible under the greater risk-bearing capacity of the bank. As banks expand their balance sheets, the

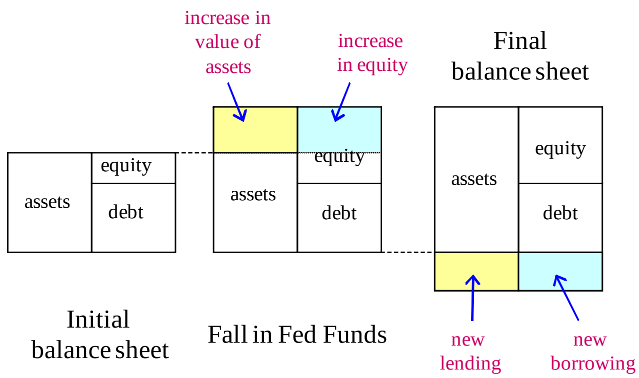

Figure 6.1: The impact of a decline in the Fed Funds rate on intermediary balance sheets.

market price of risk falls.

The logic of the argument is illustrated in Figure 6.1 for the case of monetary easing. A decline in the Fed Funds target leads to an increase in asset prices and, thus, an increase in the net worth of financial institutions. In response, levered financial institutions expand their assets by taking on additional leverage. Thus, the impact of changes in short term interest rates is amplified via the balance sheet management of financial institutions.

In order for the argument to go through a key assumption is that the term spread is determined in large part by the short-term interest rate. On this score, the evidence is supportive. Figure (1.1) in the introductory section to this chapter highlights the striking fact that there is a near perfect negative one-to-one relationship between 4-quarter changes of the Fed Funds target and 4-quarter changes of the term spread (the plot uses data from 1987q1 to 2008q3). In this way, variations in the target rate has a one-for-one relationship with the slope of the yield curve. Since the term spread leads the net interest margin (NIM), shifts in the short rate affect real activity because they change the profitability of financial intermediaries, thus shifting the supply of credit.

The connection between financial intermediary balance sheet management, the slope of the yield curve, and real economic activity in the United States was recently examined by Adrian, Estrella and Shin (2010), who conducted a vector autoregression study of the relationship between the following variables: quarterly GDP growth as a measure of real activity, the 10-year/3-month term Treasury spread, the net interest margin (NIM) of large commercial banks from their Y-9C filings, the quarterly asset growth of shadow banks, the 3-month Treasury yield as a measure of the short term interest rate, and the quarterly change in the Chicago Board Options Exchange Volatility Index (VIX) as a measure of risk. The balance sheet aggregate of the intermediary sector is taken to be the total assets of shadow banks defined as the sum of total assets of asset-backed securities issuers (ABS), finance companies, and funding corporations (each component is pulled from the Federal Reserve's Flow of Funds). The VAR includes one lag of each of the variables, as suggested by the Bayesian Information Criterion, and is estimated over the period from 1990Q3 to 2008Q3, where the starting date is determined by availability of the VIX data.

Adrian, Estrella and Shin (2010) present empirical results that are consistent with the following logic. An increase in the term spread tends to increase net interest margin. This is fairly mechanical as the term spread directly impacts net interest margin for newly originated loans funded with shorter-term liabilities. Higher net interest margin — a major source of profits for financial intermediaries — leads to an increase in total assets of financial intermediaries: as lending becomes more profitable, the supply of credit is expanded and intermediaries' balance sheets grow. Larger asset growth of intermediaries, in turn, predicts higher GDP growth, which we interpret as a shift in the supply of credit curve. Since the VAR includes only one lag of each variable, the significance levels of the coefficients may also be interpreted as a set of Granger causality tests. These tests are consistent with our hypothesis of a causal chain that runs from the term spread to net interest margin to lending volume and finally to real growth.

Adrian, Estrella and Shin (2010) also conduct impulse response studies so as to verify the main strands in the narrative. In the impulse response studies, a positive shock to the term spread leads to statistically significant increases in net interest margin over a considerable horizon. The shape of these responses is also consistent with the fact that average net interest margin tends to trail marginal changes in the term spread, as argued before. Moreover, a positive shock to net interest margin tends to increased lending by the shadow banking sector. Finally, a shock to asset growth in shadow banking has a quick and significant effect on real economic growth.

The evidence is supportive of the "risk-taking channel" of monetary policy. Variations in short term interest rates lead real economic outcomes through their impact on the slope of the yield curve. Our interpretation of this evidence is an economic mechanism that operates via the balance sheet management of financial intermediaries, who borrow short and lend long. Tighter policy leads to a compression of net interest margin and causes intermediaries to reduce lending. The flatter the term spread at the end of the tightening cycle, the greater the subsequent reduction in lending activity. This has a direct effect on the supply of credit to the real economy.

6.2. Two Case Studies

Two recent empirical papers throw further light on the channel of monetary policy that works through changes 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. In addition, they show that the hazard rate of default for *new loans* increases after the cut in short-term rates.

The fact that the riskiness of existing loans decline may be due to a fall in the interest burden of the borrower. The increased credit quality of the assets will give rise to an increase in the profitability of the lending, and lead to greater lending capacity, as outlined already. However, it is the second finding which is more telling. The fact that the riskiness of new lending increases suggests that the new loans are of lower quality, suggesting that the hurdle rate for lending has fallen. Such a combination of (i) greater lending capacity and (ii) erosion of lending standards is consistent with the risk-taking channel of monetary policy.

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. Paravisini (2008) provides estimates of the impact of bank funding constraints on the supply of bank credit using an instrumental variable approach, and Khwaja and Mian (2008) provide estimates of a bank funding shocks for an emerging market. Freixas (2009) provides an overview of the monetary transmission literature in the context of the 2007-2009 global financial crisis.

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

6.3. Related Literature

In order to highlight what we view as the specific contribution of the "risk-taking channel" of monetary policy, it is important to give an account of the points of contact between our approach and the existing literature in monetary economics and corporate finance. The discussion can be organized along a number of dimensions, but one classification that is useful is to distinguish those papers that have emphasized the *borrower's* balance sheet (and the *demand* for credit) from those emphasizing the *lender's* balance sheet (and the *supply* of credit).

Bernanke and Gertler (1989) is a classic example of the former - an explanation based on the borrower's balance sheet. Following the earlier work of Bernanke (1983) who argued for the importance of borrower balance sheet distress during the Great Depression, the Bernanke and Gertler model focuses on the agency problems entailed by the asymmetry of information between a non-financial corporate borrower and the financial market as a whole.

In the presence of asymmetric information between the borrower and lender, inefficiencies in the optimal contract manifest themselves in the form of deadweight costs and, in particular, in the spread between the cost of internal funds and that of external funds. The size of the deadweight cost is a function of the net worth of the borrower - i.e., the borrower's "skin in the game". Moreover, Bernanke and Gertler argue that the borrower's net worth is procyclical, and so the funding spread between the internal and external funds should be countercyclical.

An alternative approach that emphasizes the borrower's balance sheet is the work on credit cycles by Kiyotaki and Moore (1997, 2005)), who examine the dynamic amplification of credit constraints. In their approach, Kiyotaki and Moore assume a collateral constraint where the size of the loan that can be obtained by a borrower depends on the current market price of the collateral that can be pledged to the lender. Under such an assumption, the size of the borrower's balance sheet can depend positively on the market price of the asset - in other words, the demand reaction of the borrower can be upward-sloping. When the price of an asset increases, the borrower's funding ability increases, thereby generating larger balance sheets. When the greater demand for the asset pushes up the price of the asset, there is the possibility of amplified responses where asset price increases fuels further investment and aggregate activity, which raises prices further.

The common thread between the work of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997, 2005) is that the focus is on the *borrower's* balance sheet, and the fluctuations in the creditworthiness of the borrower. The supply of lending is determined in the market as a whole, without a separate role for the banking sector as such.

However, to the extent that the borrower in the Bernanke and Gertler (1989) model can be re-interpreted as a bank, the model can be reoriented in terms of the agency problems in the banking sector. The "double-decker" moral hazard model in Holmström and Tirole (1997) is a good illustration of such a re-interpretation where the banking sector enters the model as a borrower subject to borrowing constraints from its lenders. In the Holmström and Tirole (1997) model, there are two tiers in the agency problem. At the bottom tier, there is a moral hazard problem between a non-financial borrower who needs funding to undertake a project and a bank who supplies the funding. The moral hazard problem entails an optimal contract where the incentive constraint stipulates that the borrower has enough of a stake in the project that the good action is taken, rather than the inefficient action that yields private benefit. The importance of borrower net worth, or "skin in the game," is a theme that Holmström and Tirole (1997) shares with Bernanke and Gertler (1989). However, the innovation in Holmström and Tirole (1997) is that there is a second tier to the agency problem in which the bank (the lender) itself is subject to a moral hazard problem, so that there is a constraint on the minimum equity capital that the bank itself must hold at all times. In this respect, the minimum capital requirement of banks emerges as an endogenous feature of an agency problem where banks must raise funding from depositors and other suppliers of funds.

By re-orienting the agency problem so that the focus is on the bank (as borrower) and the financial market (as lenders), the earlier results of Bernanke and Gertler and Kiyotaki and Moore can be transferred to the context of bank distress and bank lending. The recent paper by Gertler and Kiyotaki (2009, this volume) is a good example of such a re-orientation. The agency relationship between the bank and the financial market lender is a moral hazard problem due to the possibility that the bank can steal some portion of the project outcome, so that the bank is required to keep a minimum net worth in place at all times. The bank must then keep a minimum amount of "skin in the game", which translates to a minimum capital ratio that the bank must maintain. When credit losses or a fall in the price of assets depletes the capital of the bank, the incentive constraint binds, entailing the withdrawal of lending by the bank.

Adrian and Shin (2008b) take up a similar theme of the binding incentive constraint of the bank, where the agency problem comes in the form of a risk-shifting problem where the bank may take the riskier asset when a lower risk asset may be value-enhancing for the pair as a whole. The bank's market-determined minimum capital requirement arises from the need for the bank (the borrower) to keep sufficient stake in the payoffs from the total balance sheet of the bank. Since the agency problem manifests itself as a risk-shifting problem, Adrian and Shin (2008b) can address how second-moment incentives can enter the problem, and how the value at risk (VaR) constraint can emerge as an outcome of the optimal contracting problem.

Brunnermeier and Sannikov (2009) take the moral hazard theme one step further by embedding the moral hazard problem in a dynamic, continuous time contracting environment. In this richer framework, Brunnermeier and Sannikov examine two separate incentive constraints. One is the familiar one where the borrower needs to keep sufficient "skin in the game", and results in a minimum capital ratio requirement set by the market. The second is a constraint in the spirit of a value at risk (VaR) constraint which makes the debt instantaneously risk-free. In order to accommodate a role for both types of constraints, Brunnermeier and Sannikov incorporate the innovative feature that two types of equity play an essential role. First, there is equity that carries control rights. This first type of equity is the stake of the controlling party. Second, there is equity that is loss-absorbing, but which does not carry control rights. This is the type of equity that is typified by passive investors in hedge funds whose stake can be returned by the controlling investor in the hedge fund. The interaction between these two types of equity is a distinctive feature of the Brunnermeier and Sannikov model, as well as the dynamic contracting framework, which gives the model considerable richness and complexity. The role of equity as a buffer has an affinity with the work on the effect of regulatory capital on lending as examined by Van den Heuvel (2002).

So far, we have described the set of papers that have as their starting point some type of agency problem between a borrower and a lender. However, there is another strand of the literature from monetary economics that has emphasized the institutional features surrounding the commercial banking industry, especially for the United States.

The notable example is Bernanke and Blinder (1988), which proposed a simple model of the supply of credit by banks that emphasizes the binding nature of the reserve requirement of banks. The constraint itself is not motivated with further microfoundations; instead, the institution of reserve requirements is taken as given. The reserve requirement stipulates that, for a given amount of deposit funding used by a bank, some minimum amount must be kept on deposit at the Federal Reserve as cash assets of the bank. This is a constraint that links the two sides of the balance sheet, and the assumption is that such a constraint binds all the time.

The idea that reserve requirements bind all the time has been dealt a severe blow by the experience of the aftermath of the recent financial crisis in which commercial banks in the United States held close to one trillion dollars of excess reserves on their balance sheet. Excess reserves have also been a common feature in other parts of the world after the financial crisis. Nevertheless, until recently, the assumption of binding reserve requirements has been an important feature of the academic literature in banking.

Building on the initial short paper by Bernanke and Blinder (1988), their follow-up paper (Bernanke and Blinder (1992)) is an in-depth empirical investigation of the monetary transmission mechanism. In particular, the focus is on how the Fed Funds rate works through the financial system to influence real activity. The key section (Section 4) of the paper highlights the important empirical role of the Fed Funds rate in influencing the future loan supply of banks. In particular, Bernanke and Blinder (1992) show that an increase in the Fed Funds rate leads to an eventual slow-down of bank lending at a time horizon that is similar to the impact of the Fed Funds rate on unemployment. In addition, Bernanke and

Blinder (1992) show that an initial increase in the Fed Funds rate is met with a rapid adjustment in the Bank's portfolio in which the holding of securities first falls, and then is slowly rebuilt.

Bernanke and Blinder (1992) interpret these findings as showing that the Fed Funds rate affects the supply of bank lending directly through the portfolio constraints of the bank itself. In particular, when the Fed Funds rate is raised, the deposit funding of the bank is squeezed, which puts pressure on the asset side of the bank's balance sheet to contract. Since loans are long-term contractual arrangements, bank lending is initially slow to adjust and all the short-term adjustment is made via the holding of securities. Over time, the holding of securities is built up, but the bank's loan portfolio adjusts slowly to its new (lower) optimum. In this way, a higher Fed Funds rate is seen to affect bank lending through the squeeze in the deposit funding of the bank, which eventually feeds into the decrease in bank lending.

The bank lending channel examined by Bernanke and Blinder (1992) has close affinities with the risk-taking channel of monetary policy proposed in our chapter. The common theme is that the Fed Funds rate has a direct impact on credit supply. However, the differences are also apparent. In Bernanke and Blinder (1992), the mechanism that links the Fed Funds rate with the supply of bank lending is the binding reserve requirement of the commercial banks. This poses two challenges in the context of the recent crisis. First, reserve requirements have not been binding in the aftermath of the crisis. Second, the Bernanke and Blinder (1992) account focuses on the commercial banking sector, since this is the sector for which there is a reserve requirement. However, as we have described in some detail above, the credit crunch in the recent financial crisis originated in the shadow banking system and the market-based financial intermediaries that serve it, rather than in the traditional commercial banking sector. Indeed, the commercial banking sector had seen increased balance sheets until the summer of 2009.

Nevertheless, the Bernanke and Blinder (1992) paper stands as a milestone in the literature on the relationship between monetary policy and the banking system. The conjectures that they proposed in their original paper were confirmed in a careful cross-sectional empirical study by Kashyap and Stein (2000), who used a large dataset of banks in the United States to examine portfolio changes in response to monetary policy shifts. They investigated the conjecture in Bernanke and Blinder (1992) that banks with less liquid balance sheets (i.e., with fewer securities and more loans) were subject to greater downward impact in their banking lending as a result of monetary tightening. They find strong evidence that less liquid banks are, indeed, subject to greater loan contraction due to monetary tightening. The results are driven in particular by small banks, which form the bulk of their sample.

Relative to the literature surveyed above, the risk-taking channel of monetary policy proposed in this chapter has some distinctive features. First, in contrast to Bernanke and Gertler (1989) and other approaches that emphasize the demand for credit and the non-financial borrowers' balance sheet, the risk-taking channel emphasizes the role of the *supply* of credit by the financial intermediary sector. In this respect, the risk-taking channel has greater affinity with approaches that emphasize the supply of credit and the constraints that bind on the lenders' side. However, the distinctive feature of the risk-taking channel is the role played by the price of risk and by the market-determined risk premium. The supply of credit is determined by the threshold value of the risk-premium charged by the market. In the model sketched in this chapter, the asset choice decision of the banks is determined by an underlying risk-management problem where banks are subject to a value at risk (VaR) constraint. In this chapter, we have left this constraint without a further microfoundation. However, such a search would lead naturally to a meeting point with the agency literature that emphasizes the constraint imposed on the borrowers by the market as a whole. Adrian and Shin (2008b) is an example of just such a setting.

7. Concluding Remarks

We conclude with some implications of our findings for the conduct of monetary policy. Our emphasis on the role of balance sheet aggregates of financial intermediaries leads to policy prescriptions that bear a superficial similarity to an older tradition in monetary economics that emphasized the money stock as a pivotal quantity in monetary policy. The older monetarist tradition emphasized the stock of money because of the supposed direct link between the money stock and real expenditures through the portfolio adjustment of individual consumers who rebalance their portfolios consisting of money and real goods. Monetary aggregates had fallen from favor in the conduct of monetary policy mainly as a backlash against the older monetarist line (see Friedman (1988)).

In this chapter, we have focused on balance sheet aggregates of financial intermediaries, but the rationale is quite different from the older monetarist literature. Our approach has been to emphasize the role of intermediary balance sheets as a determinant for the risk appetite ruling in the economy, and how monetary policy can affect the growth of intermediary balance sheets. Although our rationale for looking at balance sheets differs from the older monetarist literature, our discussion nevertheless suggests that there is a case for rehabilitating some role for balance sheet quantities in the conduct of monetary policy. By influencing the rate of growth of intermediary balance sheets, the monetary authorities can impact real decisions that depend on the price of risk ruling in the economy. Real decisions that are sensitive to financial conditions, such as residential investment, will be particularly susceptible to shifts in the price of risk.

To the extent that monetary policy decisions ripple through to the real economy via the financial system, our discussion also highlights the importance of tracking the institutional underpinnings of the financial system itself. The instability of money demand functions that undermines the practical use of monetary aggregates in the older monetarist-style analysis 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 United States. More useful may be measures of collateralized borrowing, such as the weekly series on repos of primary dealers. The model presented in the paper shows that balance sheet quantities of financial intermediaries are closely tied to risk premia and the supply of credit, which, in turn, makes them useful in analyzing the financial conditions that determine the supply of credit. Adrian, Moench and Shin (2010) present an empirical analysis that uses balance sheet quantities from a broad range of financial intermediaries in order to gauge financial conditions.

Finally, our results highlight the channel through which 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 were met by reductions in the target rate aimed at insulating the real economy from financial sector shocks. Our findings suggest that, in conducting monetary policy, the potential for financial sector distress should be explicitly taken into account in a forward-looking manner.

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Appendix: Data Sources

Figure 1.1. The 10-year and 3-month Treasury constant maturity yields as well as the effective Fed Funds rate are from the Federal Reserve Board's H.15 release.

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.

Figures 4.1 and 4.2. The figures are based on computations by Adrian, Moench, and Shin (2009). The macro risk premium as the predicted part of a regression of real GDP growth on constant maturity Treasury yield spreads and corporate bond spreads. The risk appetite variable is obtained by regressing (negative) changes of the macro risk premium on lagged balance sheet variables of security broker-dealers, shadow banks, and commercial banks.

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 (the VXO from 1986-1989, and the VIX from 1990 onwards). 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 February 3, 2010. Changes refer to 1-week changes, and lags to 1-week lags. Fed Funds denotes the Federal Funds Target as reported by the Federal Reserve Board. The equity return is the 1-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 1-week growth rate of total commercial paper outstanding reported by the Federal Reserve Board. Repo growth is the 1-week growth rate of primary dealer repo, from the Federal Reserve Bank of New York. M2 growth is the 1-week growth of the money measure M2 from the Federal Reserve Board.