Liquidity and Financial Cycles*

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PRELIMINARY

Abstract

In a financial system where balance sheets are continuously marked to market, asset price changes show up immediately in changes in net worth, and elicit responses from financial intermediaries who adjust the size of their balance sheets. We document evidence that marked-to-market leverage is strongly procyclical. Such behavior has aggregate consequences. Changes in aggregate balance sheets for intermediaries forecast changes in risk appetite in financial markets, as measured by the innovations in the VIX index. Aggregate liquidity can be seen as the rate of change of the aggregate balance sheet of the financial intermediaries.

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1. Introduction

In a financial system where balance sheets are continuously marked to market, changes in asset prices show up immediately on the balance sheet, and so have an immediate impact on the net worth of all constituents of the financial system. The net worth of leveraged financial intermediaries are especially sensitive to fluctuations in asset prices given the highly leveraged nature of such intermediaries' balance sheets.

Our focus in this paper is on the reactions of the financial intermediaries to changes in their net worth, and the market-wide consequences of such reactions. If the financial intermediaries were passive and do not adjust their balance sheets to changes in net worth, then leverage would fall when total assets rise. Change in leverage and change in balance sheet size would then be negatively related.

However, as we will see below, the evidence points to a strongly *positive* relationship between changes in leverage and changes in balance sheet size. Far from being passive, the evidence points to financial intermediaries adjusting their balance sheets actively, and doing so in such a way that leverage is high during booms and low during busts.

Procyclical leverage can be seen as a consequence of the active management of balance sheets by financial intermediaries who respond to changes in prices and measured risk. For financial intermediaries, their models of risk and economic capital dictate active management of their overall value at risk (VaR) through adjustments of their balance sheets. Credit ratings are a key determinant of their cost of funding, and they will attempt to manage key financial ratios so as to hit their credit rating targets.

From the point of view of each financial intermediary, decision rules that result in procyclical leverage are readily understandable. However, there are aggregate consequences of such behavior for the financial system as a whole that are not taken into consideration by an individual financial intermediary. We exhibit evidence that such behavior has aggregate consequences on overall financial conditions, risk appetite and the amplification of financial cycles.

Our paper has three objectives. Our first objective is to document evidence on the relationship between balance sheet size and leverage for a group of financial intermediaries - the major Wall Street investment banks - for whom the ideal of balance sheets that are continuously marked to market is a good approximation of reality. We show that leverage is strongly procyclical for these banks, and that the margin of adjustment on the balance sheet is through repos and reverse repos (and other collateralized borrowing and lending).

Our second objective is to outline the aggregate consequences of procyclical leverage, and document evidence that expansions and contractions of balance sheets have important asset pricing consequences through shifts in market-wide risk appetite. In particular, we show that changes in aggregate intermediary balance sheet size can forecast innovations in market-wide risk premiums as measured by the difference between the VIX index and realized volatility. We see this result as being very significant. Previous work in asset pricing has shown that innovations in the VIX index capture key components of asset pricing that conventional empirical models have been unable to address fully. By being able to forecast shifts in risk appetite, we hope to inject a new element in thinking about risk appetite and asset prices. The shift in risk appetite is closely related to other notions of market and funding liquidity, as used by Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2005b). One of our contributions is to explain the origins of funding liquidity in terms of financial intermediary behavior.

Our third objective is to shed light on the concept of "liquidity" as used in common discourse about financial market conditions. In the financial press and other market commentary, asset price booms are sometimes attributed to "excess liquidity" in the financial system. Financial commentators are fond of using the associated metaphors, such as the financial markets being "awash with liquidity", or liquidity "sloshing around". However, the precise sense in which "liquidity" is being used in such contexts is often unclear.

We propose an economic counterpart to the notion of the market being "awash with liquidity". Aggregate liquidity can be understood as the rate of growth of aggregate balance sheets. When financial intermediaries' balance sheets are generally strong, their leverage is too low. The financial intermediaries hold surplus capital, and they will attempt to find ways in which they can employ their surplus capital. In a loose analogy with manufacturing firms, we may see the financial system as having "surplus capacity". For such surplus capacity to be utilized, the intermediaries must expand their balance sheets. On the liabilities side, they take on more short-term debt. On the asset side, they search for potential borrowers that they can lend to. Aggregate liquidity is intimately tied to how hard the financial intermediaries search for borrowers.

The outline of our paper is as follows. We begin with a review of some very basic balance sheet arithmetic on the relationship between leverage and total assets. The purpose of this initial exercise is to motivate our empirical investigation of the balance sheet changes of financial intermediaries in section 3. Having outlined the facts, in section 5, we show that changes in aggregate repo positions of the major financial intermediaries can forecast innovations in the volatility risk-premium, where the volatility risk premium is defined as the difference between the VIX index and realized volability. We conclude with discussions of the implications of our findings for financial cycles.

2. Some Basic Balance Sheet Arithmetic

What is the relationship between *leverage* and *balance sheet size*? This question raises important issues, both conceptually and empirically. We begin with some very elementary balance sheet arithmetic, so as to focus ideas.

Before looking at the evidence for financial intermediaries, let us think about the relationship between balance sheet size and leverage for a household. The household owns a house financed with a mortgage. The balance sheet looks like this.

Assets	Liabilities
House	Equity Mortgage

For concreteness, suppose the house is worth 100, the mortgage value is 90, and so the household has net worth (equity) of 10.

Assets	Liabilities
100	10 90

Leverage is defined as the ratio of total assets to equity, and is given by $100/10 = 10$. What happens to leverage as total assets fluctuate? Denote by A the market value of total assets and E is the market value of equity. We make the simplifying assumption that the market value of debt stays roughly constant at 90 for small shifts in the value of total assets. Total leverage is then

$$L = \frac{A}{A - 90}$$

Leverage is inversely related to total assets. This is just saying that when the price of my house goes up, my net worth increases, and so my leverage goes down. Figure 2.1 illustrates the negative relationship between total assets and leverage.

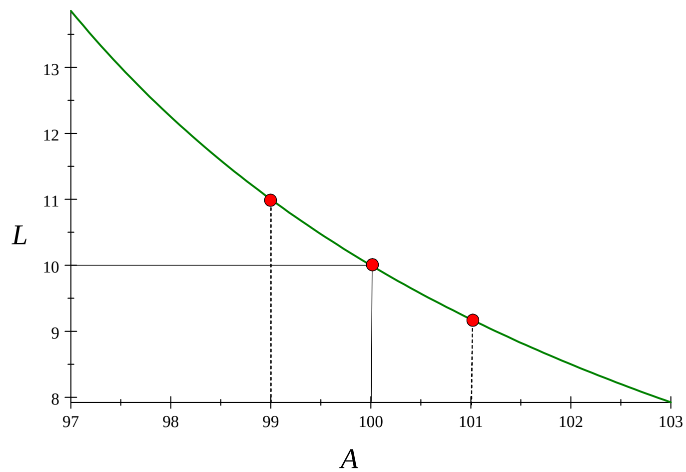

Figure 2.1: Leverage for passive investor

Indeed, for households, the negative relationship between total assets and leverage is clearly borne out in the aggegate data. Figure 2.2 plots the quarterly changes in total assets to quarterly changes in leverage as given in the Flow of Funds account for the United States. The data are from 1963 to 2006. The scatter chart shows a strongly negative relationship, as suggested by figure 2.1.

We can ask the same question for firms, and we will address this question for three different types of firms.

- Non-financial firms
- Commercial banks
- Security dealers and brokers (including investment banks).

If a firm were passive in the face of fluctuating asset prices, then leverage would vary inversely with total assets. However, the evidence points to a more active management of balance sheets.

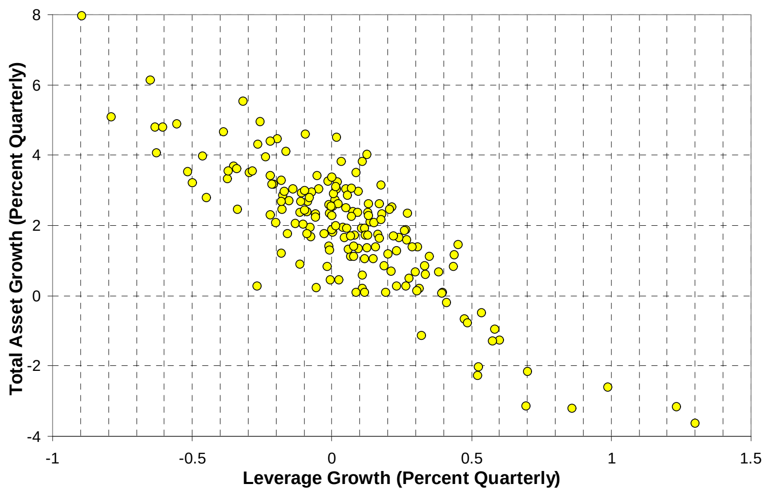

Figure 2.2: Households: Total Assets and Leverage [source: Board of Governors, Federal Reserve, Flow of Funds, 1963 Q1 - 2006 Q4.]

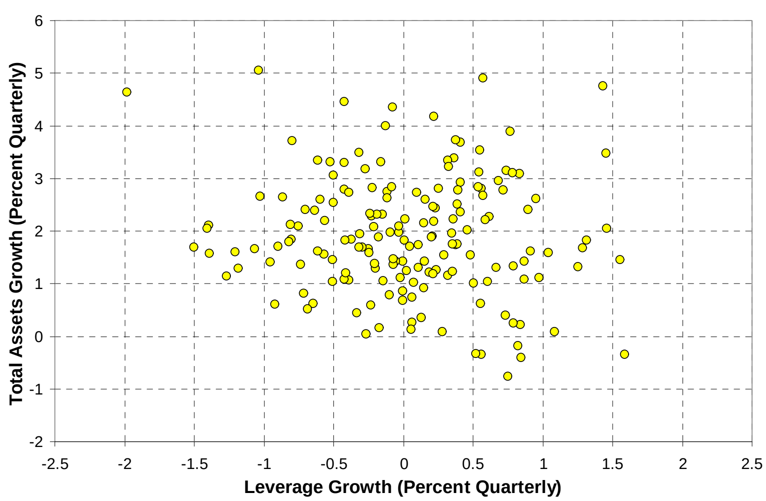

Figure 2.3: Non-financial, Non-farm Corporates: [source: Board of Governors, Federal Reserve, Flow of Funds, 1963 Q1 - 2006 Q4.]

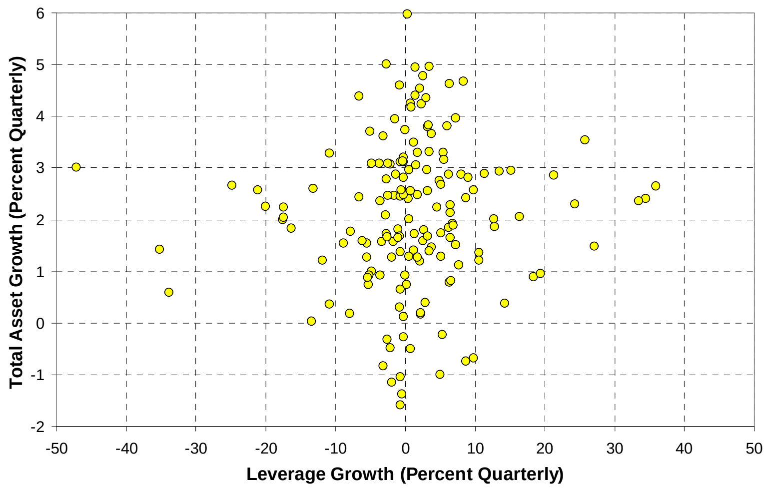

Figure 2.4: Commercial Banks: [source: Board of Governors, Federal Reserve, Flow of Funds, 1963 Q1 - 2006 Q4.]

Figure 2.3 is a scatter chart of the change in leverage and change in total assets of non-financial, non-farm corporations drawn from the U.S. flow of funds data (1963 to 2006). The scatter chart shows much less of a negative pattern, suggesting that companies react to changes in assets by shifting their stance leverage.

More striking still is the analogous chart for U.S. commercial banks, again drawn from the U.S. Flow of Funds accounts. Figure 2.4 is the scatter chart plotting changes in leverage against changes in total assets for U.S. commercial banks. A large number of the observations line up along the vertical line that passes through zero change in leverage. In other words, the data show the outward signs of commercial banks targeting a fixed leverage ratio.

Financial institutions manage their balance sheets actively for several reasons. They attempt to manage the key financial ratios so as to hit credit rating targets and the cost of capital. Their models of risk and economic capital also dictate

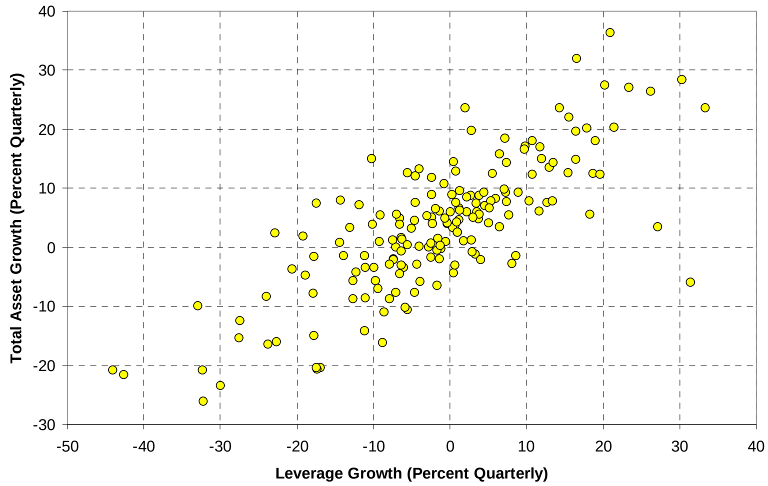

Figure 2.5: Security Dealers and Brokers: [source: Board of Governors, Federal Reserve, Flow of Funds, 1963 Q1 - 2006 Q4.]

active management of their balance sheets. Economic capital is also closely related to performance measures such as return on equity (ROE).

However, even more striking than the scatter chart for commercial banks is that for security dealers and brokers, that include the major Wall Street investment banks. Figure 2.5 is the scatter chart for U.S. security dealers and brokers, again drawn from the Flow of Funds accounts (1963 - 2006). The alignment of the observations is now the reverse of that for households. There is a strongly *positive* relationship between changes in total assets and changes in leverage. In this sense, leverage is pro-cyclical. Ayuso, Perez and Saurina (2004) exhibit similar evidence on regulatory capital over the cycle from panel data for Spanish banks.

In order to appreciate the aggregate consequences of pro-cyclical leverage, let us first consider the behavior of a financial intermediary that manages its balance sheet actively to as to maintain a *constant* leverage ratio of 10. Suppose the initial balance sheet is as follows. The financial intermediary holds 100 worth of securities, and has funded this holding with debt worth 90.

Assets	Liabilities
Securities, 100	Equity, 10
	Debt, 90

Assume that the price of debt is approximately constant for small changes in total assets. Suppose the price of securities increases by 1% to 101.

Assets	Liabilities
Securities, 101	Equity, 11
	Debt, 90

Leverage then falls to $101/11 = 9.18$. If the bank targets leverage of 10, then it must take on additional debt of D to purchase D worth of securities on the asset side so that

$$\frac{\text{assets}}{\text{equity}} = \frac{101 + D}{11} = 10$$

The solution is $D = 9$. The bank takes on additional debt worth 9, and with this money purchases securities worth 9. Thus, an increase in the price of the security of 1 leads to an increased holding worth 9. The demand curve is *upward-sloping*. After the purchase, leverage is now back up to 10.

Assets	Liabilities
Securities, 110	Equity, 11
	Debt, 99

The mechanism works in reverse, too. Suppose there is shock to the securities price so that the value of security holdings falls to 109. On the liabilities side, it is equity that bears the burden of adjustment, since the value of debt stays approximately constant.

Assets	Liabilities
Securities, 109	Equity, 10
	Debt, 99

Leverage is now too high ($109/10 = 10.9$). The bank can adjust down its leverage by selling securities worth 9, and paying down 9 worth of debt. Thus, a *fall* in the price of securities of leads to *sales* of securities. The supply curve is *downward-sloping*. The new balance sheet then looks as follows.

Assets	Liabilities
Securities, 100	Equity, 10
	Debt, 90

The balance sheet is now back to where it started before the price changes. Leverage is back down to the target level of 10.

Leverage targeting entails upward-sloping demands and downward-sloping supplies. The perverse nature of the demand and supply curves are even stronger when the leverage of the financial intermediary is pro-cyclical - that is, when leverage is high during booms and low during busts. When the securities price goes up, the upward adjustment of leverage entails purchases of securities that are even larger than that for the case of constant leverage. If, in addition, there is

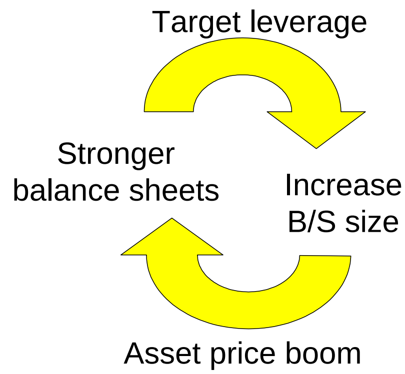

Figure 2.6: Target Leverage in Booms

the possibility of feedback, then the adjustment of leverage and price changes will reinforce each other in an amplification of the financial cycle. If we hypothesize that greater demand for the asset tends to put upward pressure on its price (a plausible hypothesis, it would seem), then there is the potential for a feedback effect in which stronger balance sheets feed greater demand for the asset, which in turn raises the asset's price and lead to stronger balance sheets. Figure 2.6 illustrates the feedback during a boom.

The mechanism works exactly in reverse in downturns. If we hypothesize that greater supply of the asset tends to put downward pressure on its price, then there is the potential for a feedback effect in which weaker balance sheets lead to greater sales of the asset, which depresses the asset's price and lead to even weaker balance sheets. Figure 2.7 illustrates the feedback during a downturn.

When the feedback between price and leverage is taken into account, the financial cycle may be amplified due to the procyclical leverage of financial intermediaries. We now turn to the empirical evidence to ascertain how the leverage of financial intermediaries vary with balance sheet size.

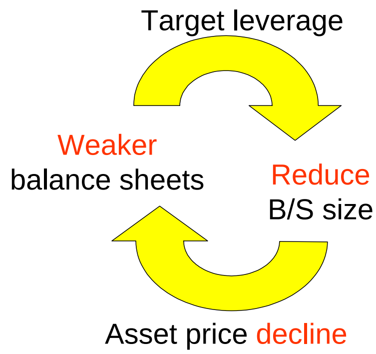

Figure 2.7: Target Leverage in Busts

3. Evidence from Investment Bank Balance Sheets

We examine the quarterly changes in the balance sheets of five large investment banks, as listed below in Table 1. The data are drawn from the Mergent database, which in turn are based on the regulatory filings with the U.S. Securities and Exchange Commission (SEC) on their 10-Q forms.

Name	Sample
Bear Stearns	1997 Q1 – 2006 Q4
Goldman Sachs	1999 Q2 – 2006 Q4
Lehman Brothers	1993 Q2 – 2006 Q4
Merrill Lynch	1991 Q1 – 2006 Q4
Morgan Stanley	1997 Q2 – 2006 Q4

Table 1: Sample of Investment Banks

Investment banks are closest to the ideal of having balance sheets that are continuously marked to market. Our choice of these five banks is motivated by our concern to examine "pure play" investment banks that are not part of a larger commercial banking group so as to focus attention on their behavior with respect to the capital markets[1]. The stylized balance sheet of an investment bank is as follows.

Assets	Liabilities
Trading assets	Short positions
Reverse repos	Repos
Other assets	Long term debt
	Shareholder equity

On the asset side, traded assets are valued at market prices or are short term collateralized loans (such as reverse repos) for which the discrepancy between face value and market value are very small due to the very short term nature of the loans. On the liabilities side, short positions are at market values, and repos are very short term borrowing. We will return to a more detailed descriptions of repos and reverse repos below. Long-term debt is typically a very small fraction of the balance sheet.[2] For these reasons, investment banks provide a good approximation of the balance sheet that is continuously marked to market, and hence provide insights into how leverage changes with balance sheet size.

The second reason for our study of investment banks lies in their significance for the financial system. Figure 3.1 plots the size of securities firms' balance sheets relative to that of commercial banks. We also plot the assets under management for hedge funds, although we should be mindful that "assets under management"

[1] Hence, we do not include Citigroup, JP Morgan Chase, Credit Suisse, Deutsche Bank, and other banking groups that have major investment banking operations.

[2] The balance sheet of Lehman Brothers as of November 2005 shows that short positions are around a quarter of total assets, and long term debt is an even smaller fraction. Shareholder equity is around 4% of total assets (implying leverage of around 25). Short-term borrowing in terms of repurchase agreements and other collateralized borrowing takes up the remainder.

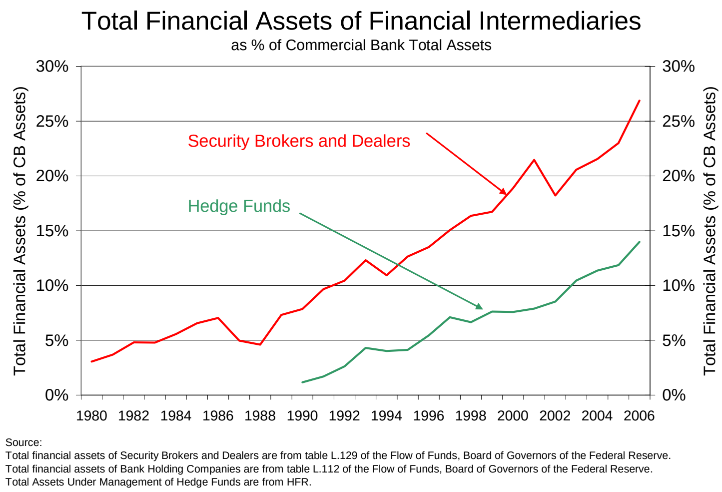

Figure 3.1: Balance sheet size as proportion of commercial banks' balance sheets

refers to total shareholder equity, rather than the size of the balance sheet. To obtain total balance sheet size, we should multiply by leverage (which is estimated at approximately 2). Figure 3.1 shows that when expressed as a proportion of commercial banks' balance sheets, securities firms have been increasing their balance sheets at a very rapid rate. Note that when hedge funds' assets under management is converted to balance sheet size by multiplying by the leverage of 2, the combined balance sheets of investment banks and hedge funds is over 50% of commercial banks balance sheets.

Size is not the only issue. When balance sheets are marked to market, the responses to price changes will entail responses that may be disproportionately large. LTCM's balance sheet was small relative to the total financial sector, but its impact would have been underestimated if only size had been taken into account. Table 2 gives the summary statistics of the investment banks over the sample period.

[Table 2 here]

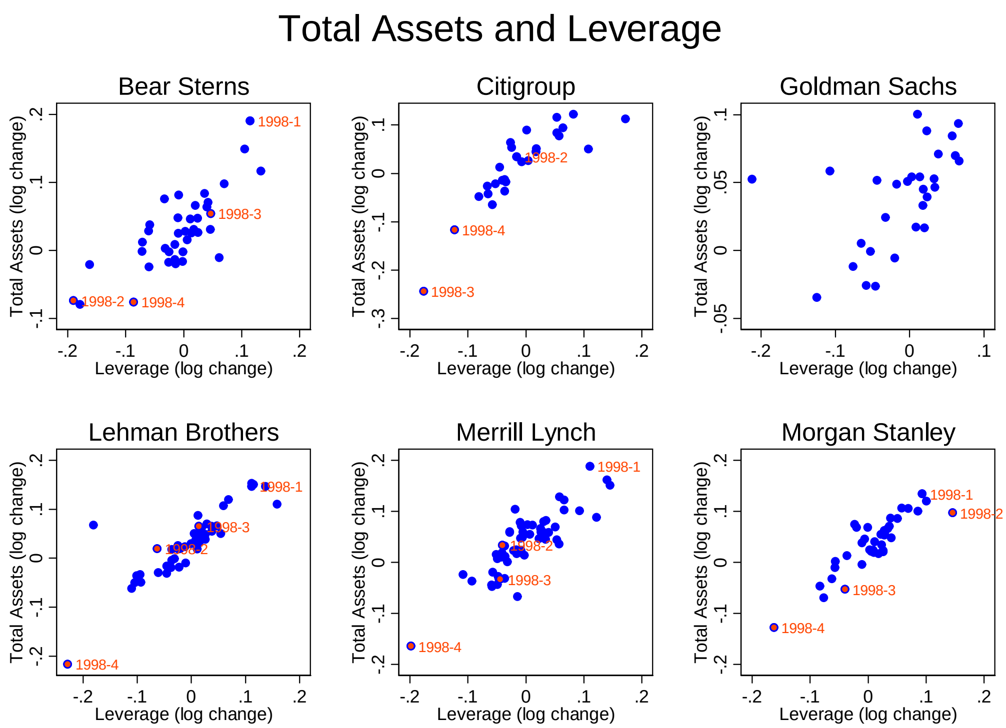

Figure 3.2: Procyclical Leverage

We begin with the key question left hanging from the previous section. What is the relationship between leverage and total assets? The answer is provided in the scatter charts in figure 3.2. Notice that we have included the scatter chart for Citigroup Global Markets (1998Q1 - 2004Q4) for comparison, although Citigroup does not figure in the panel regressions reported below. The scatter chart shows the growth in assets and leverage at a quarterly frequency. In all cases, leverage is large when total assets are large. Leverage is pro-cyclical.

There are some notable common patterns in the scatter charts, but also some notable differences. The events of 1998 are clearly evident in the scatter charts.

The early part of the year saw strong growth in total assets, with the attendant increase in leverage. However, the third and fourth quarters of 1998 shows all the hallmarks of financial distress and the attendant retrenchment in the balance sheet. For most banks, there were very large contractions in balance sheet size in 1998Q4, accompanied by large falls in leverage. These points are on the bottom left hand corners of the respective scatter charts, showing large contractions in the balance sheet and decrease in leverage. Lehman Brothers and Merrill Lynch seem especially hard hit in 1998Q4.

However, there are also some notable differences. It is notable, for instance, that for Citigroup Global Markets, the large retrenchment seems to have happened in the third quarter of 1998, rather than in the final quarter of 1998. Such a retrenchment would be consistent with the closing down of the former Salomon Brothers fixed income arbitrage desk on July 6th 1998 following the acquisition of the operation by Travelers Group (later, Citigroup). Many commentators see this event as the catalyst for the sequence of events that eventually led to the demise of Long Term Capital Management (LTCM) and the associated financial distress in the summer and early autumn of 1998.[3]

[Table 3 here]

Table 3 shows the results of a panel regression for change in leverage. The negative relationship between the change in leverage and change in total assets is confirmed in the the final column (column (v)) of Table 3. The coefficient on lagged leverage (i.e. previous quarter's leverage) is negative, suggesting that there is mean-reversion in the leverage ratio for the banks. Leverage is positively related to short-term debt, repos and collateralized borrowing. Notice, however,

[3] The official account (BIS (1999)) is given in the report of the CGFS of the Bank for International Settlements (the so-called "Johnson Report"). Popular accounts, such as Lowenstein (2000) give a description of the background and personalities.

that there is no relationship between leverage and *net* collateralized financing.

More interestingly, the regressions reveal which items on the balance sheet are adjusting when balance sheets expand and contract. In particular, the regressions show that the margin of adjustment in the expansion and contraction of balance sheets is through repos and reverse repos. In a repurchase agreement (repo), an institution sells a security while simultaneously agreeing to buy it back at a pre-agreed price on a fixed future date. Such an agreement is tantamount to a collateralized loan, with the interest on the loan being the excess of the repurchase price over the sale price. From the perspective of the funds lender – the party who buys the security with the undertaking to re-sell it later – such agreements are called reverse repos. For the buyer, the transaction is equivalent to granting a loan, secured on collateral.

Repos and reverse repos are important financing activities that provide the funds and securities needed by investment banks to take positions in financial markets. For example, a bank taking a long position by buying a security needs to deliver funds to the seller when the security is received on settlement day. If the dealer does not fully finance the security out of its own capital, then it needs to borrow funds. The purchased security is typically used as collateral for the cash borrowing. When the bank sells the security, the sale proceeds can be used to repay the lender.

Reverse repos are loans made by the investment bank against collateral. The bank's prime brokerage business vis-à-vis hedge funds will figure prominently in the reverse repo numbers. The scatter chart gives a glimpse into the way in which changes in leverage are achieved through expansions and contractions in the collateralized borrowing and lending. We saw in our illustrative section on the elementary balance sheet arithmetic that when a bank wishes to expand its balance sheet, it takes on additional debt, and with the proceeds of this borrowing

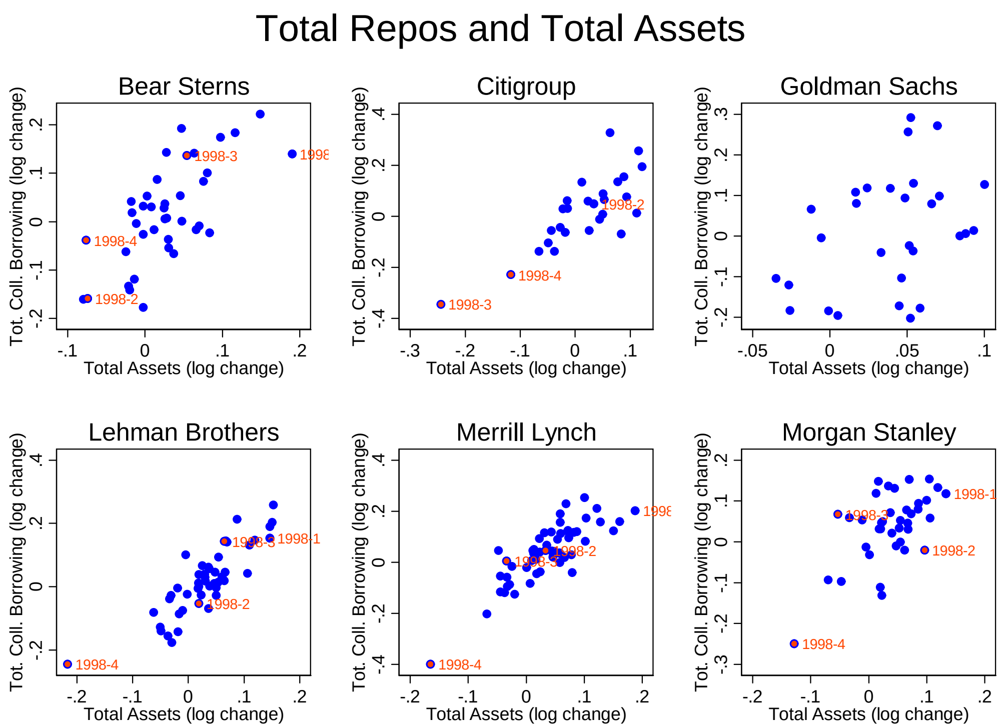

Figure 3.3: Collateralized Borrowing Growth and Asset Growth

takes on more assets.

Figure 3.3 plots the change in assets against change in collateralized borrowing. The positive relationship in the scatter plot confirms our panel regression finding that balance sheet changes are accompanied by changes in short term borrowing.

Figure 3.4 plots the change in repos against the change in reverse repos. A dealer taking a short position by selling a security it does not own needs to deliver the security to the buyer on the settlement date. This can be done by borrowing the needed security, and providing cash or other securities as collateral. When the dealer closes out the short position by buying the security, the borrowed security

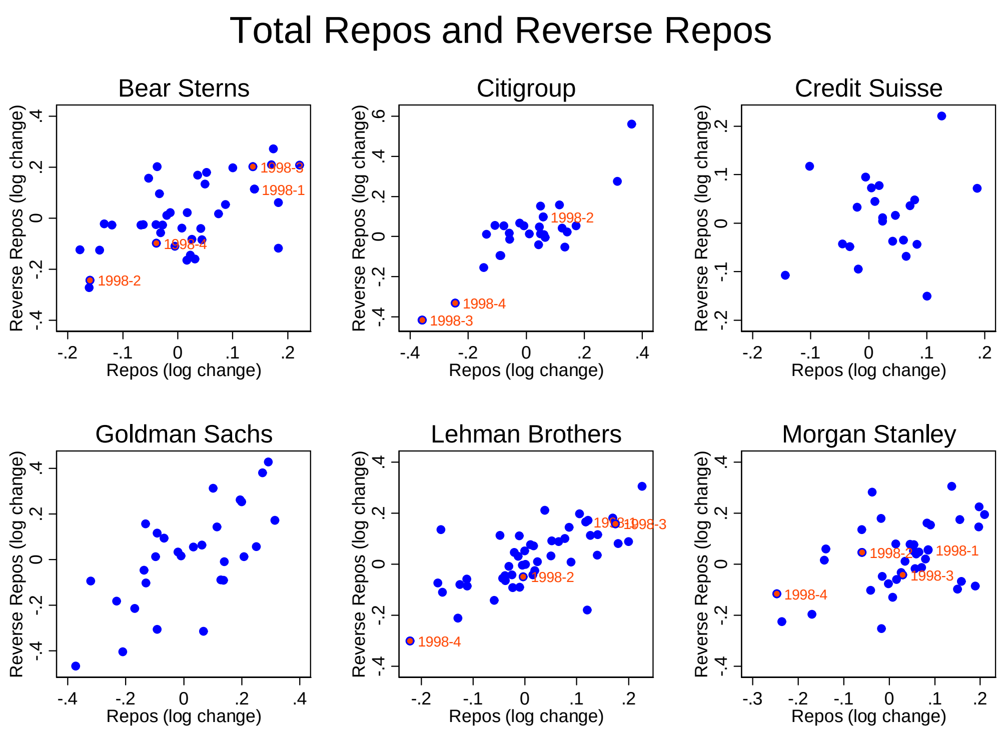

Figure 3.4: Repos and Reverse Repos

can be returned to the securities lender. The scatter plot in figure 3.4 suggests that repos and reverse repos play such a role as counterparts in the balance sheet.

4. Value at Risk

Procyclical leverage is not a term that the banks themselves are likely to use in describing what they do, although this is in fact what they are doing. To get a better handle on what motivates the banks in their actions, we explore the role of value at risk (VaR) in explaining the banks' balance sheet decisions.

For a random variable W, the *value at risk* at confidence level c relative to some base level W_0 is defined as the smallest non-negative number x such that

$$\text{Prob}\,(W < W_0 - x) \leq 1 - c$$

For instance, W could be the total marked-to-market assets of the firm at some given time horizon. Then the value at risk is the equity capital that the firm must hold in order to stay solvent with probability c. Financial intermediaries publish their value at risk numbers as part of their regulatory filings, and also regularly disclose such numbers through their annual reports. Their *economic capital* is tied to the overall value at risk of the whole firm, where the confidence level is set at a level high enough (99.98%) to target a given credit rating (typically A or AA).

If financial intermediaries adjust their balance sheets to target economic capital, then we may conjecture that their disclosed value at risk figures would be informative in reconstructing their actions. Denote by V the value at risk per dollar of assets held by a bank. If the bank maintains capital K to meet total value at risk, then we have

$$K = V \times A \tag{4.1}$$

where A is total assets. Hence, leverage L satisfies

$$L = \frac{A}{K} = \frac{1}{V}$$

Procyclical leverage then translates directly to *counter*-cyclical nature of value at risk. Measured risk is low during booms and high during busts.

We explore the way in which the ratio of total value at risk to equity varies over time. Equation (4.1) suggests that it would be informative to track the ratio of value at risk to shareholder equity over time. The naive hypothesis would be that this ratio is kept constant over time by the bank. The naive hypothesis also ties in neatly the regulatory capital requirements under the 1996 Market Risk Amendment of the Basel capital accord. Under this rule, the regulatory capital is 3 times the 10 day, 99% value at risk. If total value risk is homogenous of degree 1, then (4.1) also describes the *required* capital for the bank, also.

Table 4 presents the regressions for the quarterly change in the ratio of value at risk to equity. Value at risk numbers are those numbers that the banks themselves have reported in their 10-Q filings. For the reasons outlined already, the firm's self-assessed value at risk is closely tied to its assessment of economic capital, and we would expect behavior to be heavily influenced by changes in value at risk.

[Table 4 here]

We focus on the ratio of value at risk to equity. In the panel regressions, the lagged value at risk to equity ratio is strongly negative, with coefficients in the range of -0.5 to -0.6, suggesting rapid reversion to the mean. We take these as evidence that the banks use value at risk as a cue for how they adjust their balance sheets. However, the naive hypothesis that banks maintain a fixed ratio of value at risk to equity does not seem to be supported in the data. Column (ii) of Table 4 suggests that an increase in the value at risk to equity ratio coincides with periods when the bank increases its leverage. Value at risk to equity is procyclical, when measured relative to leverage. However, total assets have a negative sign in column (v). It appears that value at risk to equity is procyclical, but total assets adjust down some of the effects captured in leverage.

The evidence points to an additional, procyclical risk appetite component to banks' exposures that goes beyond the simple hypothesis of targeting a normalized value at risk measure. Perhaps we should not be too surprised at the positive relationship between risk appetite and leverage. For an individual bank, such behavior in the face of market movements may be an entirely natural, and rational response. However, if large swathes of the financial system behave in this way, the spillover effects will be considerable. We now turn to the asset pricing consequences of such procyclical behavior.

5. Forecasting Risk Appetite

We now turn to the asset pricing consequences of balance sheet expansion and contraction. We have already noted how the demand and supply responses to price changes can become perverse when financial intermediaries' actions result leverage that co-vary positively with the financial cycle. We exhibit empirical evidence that the waxing and waning of balance sheets have a direct impact on asset prices through the ease with which traders, hedge funds and other users of credit can obtain funding for trades.

So far, we have used quarterly data drawn either from the balance sheets of individual financial intermediaries or the aggregate balance sheet items from the Flow of Funds accounts. However, for the purpose of tracking the financial market consequences of balance sheet adjustments, data at a higher frequency is more likely to be useful. For this reason, we use the weekly data on the primary dealer repo and reverse repo positions compiled by the Federal Reserve Bank of

New York.

Primary dealers are the dealers with whom the Federal Reserve has an on-going trading relationship in the course of daily business. The Federal Reserve collects data that cover transactions, positions, financing, and settlement activities in U.S. Treasury securities, agency debt securities, mortgage-backed securities (MBS), and corporate debt securities for the primary dealers. The data are used by the Fed to monitor dealer performance and market conditions, and are also consolidated and released publicly on the Federal Reserve Bank of New York website[4]. The dealers supply market information to the Fed as one of several responsibilities to maintain their primary dealer designation and hence their trading relationship with the Fed. It is worth noting that the dealers comprise an important but limited subset of the overall market. Moreover, dealer reporting entities may not reflect all positions of the larger organizations. Nevertheless, the primary dealer data provide a valuable window on the overall market, at a frequency (every week) that is much higher than the usual quarterly reporting cycle.

Dealers gather information on each Wednesday, at the close of business, on their transactions, positions, financing, and settlement activities in the previous week. They report on U.S. Treasury securities, agency debt securities, MBS, and corporate debt securities. Data are then submitted on the following day (that is, Thursday) via the Federal Reserve System's Internet Electronic Submission System. Summary data are released publicly by the Fed each Thursday, one week after they are collected. The data are aggregated across all dealers, and are only available by asset class (that is, Treasuries, agencies, etc.). Individual issue data, and individual dealer data, are not released publicly.

Repos and reverse repos are an important subset of the security financing data. The financing is reported on a gross basis, distinguishing between "securities in"

[4] www.newyorkfed.org/markets/primarydealers.html

and “securities out” for each asset class. “Securities in” refer to securities received by a dealer in a financing arrangement (be it against other securities or cash), whereas “securities out” refer to securities delivered by a dealer in a financing arrangement (be it against securities or cash). For example, if a dealer enters into a repo, in which it borrows funds and provides securities as collateral, it would report securities out. Repos and reverse repos are reported across all sectors. The actual financing numbers reported are the funds paid or received. In the case of a repo, for example, a dealer reports the actual funds received on the settlement of the starting leg of the repo, and not the value of the pledged securities. In cases where only securities are exchanged, the market value of the pledged securities is reported.

We use the weekly repo and reverse repo data to forecast financial market conditions in the following week. Our measure of financial market conditions is the VIX index of the weighted average of the implied volatility in the S&P500 index options. The VIX index has found widespread application in empirical work as a proxy for market risk appetite. Ang, Hodrick, Xing, and Zhang (2006) show that VIX innovations are significant pricing factors for the cross section of equity returns, and Bollerslev and Zhou (2007) show that the volatility risk premium —the difference between the VIX and realized volatility of the S&P500 index — forecasts equity returns better than other commonly used forecasting variables (such as the P/E ratio or the term spread).

We use the daily VIX data from the website of the Chicago Board Options Exchange (www.cboe.com/micro/vix), and compute the S&P500 volatility from daily data over 21 trading day windows, corresponding to the maturity of the options that are used for the VIX calculation. We compute the volatility risk premium as the difference between implied volatility and current volatility. This risk premium is closely linked to the payoff to volatility swaps, which are zero investment derivatives that return the difference between realized future volatility and implied volatility over the maturity of the swap (see Carr and Wu (2004) for an analysis of variance and volatility swaps). We then compute averages of the VIX and the variance risk premium over each week (from the close of Wednesday to the close of the following Tuesday).

We are able to forecast both the *level* of the volatility risk premium, as well as the *change* in the volatility risk premium from one week to the next. We believe the latter result (the ability to forecast the innovation in the volatility risk premium) to be a very significant result.

[Table 5 here]

Our results are summarized in Table 5 and Table 6. Table 5 shows the forecast regressions for the level of the volatility risk premium at the weekly frequency. In columns (i) and (ii) of Table 5, we can see that when the level of the volatility risk premium is regressed on the growth in repos from week $t-1$ to week t, we obtain high significance, especially when the lagged level of volatility risk premium is included in the regression. Columns (iii) and (iv) of Table 5 show that the change in *reverse repos* plays a similarly informative role in forecasting the level of the volatility risk premium.

The R^2 of the forecasting regressions is low when either the repo of reverse repos are used in isolation, but reach a level of 50% when used in conjuction with the lagged value of the volatility risk premium.

[Table 6 here]

Table 6 shows the forecasting regressions for the *innovations* in the volatility risk premium. Table 6 demonstrates that the hypothesis of balance sheet expansions leading to asset pricing consquences are borne out by the data. Changes in repo and reverse repo positions are highly significant in forecasting the innovations in the volatility risk premium. In particular, when the lagged level in the volatility risk premium is included in the forecasting regression, the R^2 jumps to around 16%. Although 16% is much lower than the 50% or so for R^2 in the forecasting regression for *levels* of the volatility risk premium, we find it notable that innovations in the volatility risk premium can be forecast with such a high level of significance.

The economic rationale for the forecasting regressions presented here is that when balance sheets expand through the increased collateralized lending and borrowing by financial intermediaries, the newly released funding resources then chase available assets for purchase. More capital is deployed in increasing trading positions through the chasing of yield, and the selling of the "tails", as in the selling of out of the money puts. If the increased funding for asset purchases result in the generalized increase in prices and risk appetite in the financial system, then the expansion of balance sheets will eventually be reflected in the asset price changes in the financial system - hence, the ability of changes in repo positions to forecast future risk appetite.

6. Related Literature

The targeting of leverage seems intimately tied to the bank's attempt to target a particular credit rating. To the extent that the "passive" credit rating should fluctuate with the financial cycle, the fact that a bank's credit rating remains constant through the cycle suggests that banks manage their leverage actively, so as to shed exposures during downturns. Kashyap and Stein (2003) draw implications from such behavior for the pro-cyclical impact of the Basel II bank capital requirements.

To the extent that balance sheets play a central role in our paper, our discussion here is related to the large literature on the amplification of financial shocks. The literature has distinguished two distinct channels. The first is the increased credit that operates through the *borrower's* balance sheet, where increased lending comes from the greater creditworthiness of the borrower (Bernanke and Gertler (1989), Kiyotaki and Moore (1998, 2001)). The second is the channel that operates through the *banks'* balance sheets, either through the liquidity structure of the banks' balance sheets (Bernanke and Blinder (1988), Kashyap and Stein (2000)), or the cushioning effect of the banks' capital (Van den Heuvel (2002)). Our discussion is closer to the latter group in that we also focus on the intermediaries' balance sheets. However, the added insight from our discussions is on the way that marking to maket enhances the role of market prices, and the responses that price changes elicit from intermediaries.

Our results also related to the developing theoretical literature on the role of liquidity in asset pricing (Allen and Gale (2004), Acharya and Pedersen (2005), Brunnermeier and Pedersen (2005a, 2005b), Morris and Shin (2004), Acharya, Shin and Yorulmazer (2007)). The common thread is the relationship between funding conditions and the resulting market prices of assets. The theme of financial distress examined here is also closely related to the literature on liquidity drains that deal with events such as the stock market crash of 1987 and the LTCM crisis in the summer of 1998. Gennotte and Leland (1990) and Geanakoplos (2003) provide analyses that are based on competitive equilibrium.

The impact of remuneration schemes on the amplifications of the financial cycle have been addressed recently by Rajan (2005). The agency problems within a financial institution holds important clues on how we may explain procyclical behavior. Stein (1997) and Scharfstein and Stein (2000) present analyses of the capital budgeting problem within banks in the presence of agency problems.

The possibility that a market populated with value at risk (VaR) constrained traders may have more pronounced fluctuations has been examined by Danielsson, Shin and Zigrand (2004). Mark-to-market accounting may at first appear to be an esoteric question on measurement, but we have seen that it has potentially important implications for financial cycles. Plantin, Sapra and Shin (2005) present a microeconomic model that compares the performance of marking to market and historical cost accounting systems.

7. Concluding Remarks on Aggregate Liquidity

Aggregate liquidity can be understood as the rate of growth of aggregate balance sheets. When financial intermediaries' balance sheets are generally strong, their leverage is too low. The financial intermediaries hold surplus capital, and they will attempt to find ways in which they can employ their surplus capital. In a loose analogy with manufacturing firms, we may see the financial system as having "surplus capacity". For such surplus capacity to be utilized, the intermediaries must expand their balance sheets. On the liabilities side, they take on more short-term debt. On the asset side, they search for potential borrowers that they can lend to. Aggregate liquidity is intimately tied to how hard the financial intermediaries search for borrowers. In the sub-prime mortgage markets in the United States we have seen that when balance sheets are expanding fast enough, even borrowers that do not have the means to repay are granted credit - so intense is the urge to employ surplus capital. The seeds of the subsequent downturn in the credit cycle are thus sown. Jimenez and Saurina (2006) show from their study of Spanish banks that the loans granted during booms have higher default rates than those granted during leaner times.

In what sense is our notion of aggregate liquidity related to the traditional notion of liquidity as the money stock? In a financial system where deposit-taking banks are the only leveraged institutions, their liabilities can be identified with broad money. As such, the broad money stock would be a good indicator of the aggregate size of the balance sheets of leveraged institutions. To this extent, the growth of the money stock would play a useful role in signalling changes in the size of aggregate balance sheets.

Such a picture may have been a reasonably good description of the financial system in the first half of the 20th century, or in developing countries today. However, for market-oriented financial systems such as in the United States, we cannot so readily identify the money stock with the aggregate size of the liabilities of leveraged institutions. This is so for two reasons. First, many of the leveraged institutions (investment banks, hedge funds, and others) do not conform to the textbook ideal of the deposit-funded bank. Hence, their liabilities are not counted as "money". Even for deposit-taking banks, not all items of liabilities qualify as money.

These points seem especially important for financial systems that rely on the capital market, rather than on the banking system. Perhaps the divergent empirical results for the United States and some European countries on the role of money in financial cycles can be attributed to the fact that the capital markets play a much bigger role in the former.

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Table 2: Summary Statistics

Panel A: US$ Millions	Mean	Std Dev	Min	Median	Max	Obs
Total Assets	355881	209046	97302	302410	1120645	217
Assets (log lag)	341771	200254	93111	290311	1085215	216
Equity	14412	9381	2979	12003	39038	216
Total Collateralized Lending	108730	72746	29423	85323	417823	216
tal Collateralized Borrowing	141853	82278	34216	119362	474497	217
Repos	96196	52806	27476	89625	267566	178
Reverse Repos	66347	37252	19097	55873	210268	205
Trading VaR	50	28	11	43	159	114
Panel B: log changes	Mean	Std Dev	Min	Median	Max	Obs
Total Assets	3%	6%	-22%	4%	19%	213
Total Liabilities	3%	6%	-22%	4%	19%	211
Equity	4%	4%	-7%	3%	26%	211
Total Collateralized Lending	3%	11%	-40%	3%	29%	211
tal Collateralized Borrowing	3%	9%	-30%	3%	25%	213
Repos	2%	12%	-37%	2%	31%	174
Reverse Repos	2%	15%	-47%	2%	43%	200
Trading VaR	3%	15%	-54%	3%	56%	108

Table 3. Regressions for the Quarterly Change in Leverage

		Leverage (log change)				
		(i)	(ii)	(iii)	(iv)	(v)
Leverage (log lag)	coef	-0.086	-0.1	-0.106	-0.041	-0.042
	p-value	0.001***	0.008***	0.000***	0.026**	0.001***
Trading VaR (log change)	coef		0.068			
	p-value		0.015**			
Repos (log change)	coef			0.264		
	p-value			0.000***		
Collateralized Financing (log change)	coef				0.37	
	p-value				0.000***	
Total Assets (log change)	coef					0.904
	p-value					0.000***
Constant	coef	0.279	0.319	0.336	0.12	0.104
	p-value	0.001***	0.008***	0.000***	0.043**	0.014**
Observations		211	108	174	211	211
Number of i		5	5	5	5	5
R-squared		5%	12%	33%	43%	66%
Fixed Effects		yes	yes	yes	yes	yes

Table 4: Regressions for the Change in Value at Risk to Equity Ratio

		Trading VaR / Equity (log change)			
		(i)	(ii)	(iii)	(iv)
Trading VaR / Equity (log lag)	coef	-0.614	-0.555	-0.615	-0.542
	p-value	0.000***	0.000***	0.000***	0.000***
Leverage (log change)	coef		0.913		1.645
	p-value		0.002***		0.000***
Total Assets (log change)	coef			-0.044	-1.291
	p-value			0.9	0.009***
Constant	coef	-3.673	-3.323	-3.679	-3.204
	p-value	0.000***	0.000***	0.000***	0.000***
Observations		107	107	107	107
Number of i		5	5	5	5
R-squared		33%	39%	33%	44%
Fixed Effects		yes	yes	yes	yes

Table 5: Forecasting Volatility Risk Premium

		Volatility Risk Premium					
		(i)	(ii)	(iii)	(iv)	(v)	(vi)
Volatility Risk Premium (lag)	coef		0.704		0.703		0.700
	p-value		0.000***		0.000***		0.000***
Repos (lagged growth rate)	coef	-0.146	-0.196				
	p-value	0.009***	0.000***				
Reverse Repos (lagged growth rate)	coef			-0.091	-0.130		
	p-value			0.047**	0.000***		
Net Repos (lagged growth rate)	coef					-0.061	-0.068
	p-value					0.035**	0.001***
Constant	coef	4.788	1.428	4.778	1.422	4.782	1.437
	p-value	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Observations		862	862	862	862	862	862
R-squared		0.8%	50.0%	0.5%	49.5%	0.5%	49.2%

Table 6: Forecasting Innovations in Volatility Risk Premium

		Volatility Risk Premium (Change)					
		(i)	(ii)	(iii)	(iv)	(v)	(vi)
Volatility Risk Premium (lag)	coef		-0.296		-0.297		-0.300
	p-value		0.000***		0.000***		0.000***
Repos (lagged growth rate)	coef	-0.217	-0.196				
	p-value	0.000***	0.000***				
Reverse Repos (lagged growth rate)	coef			-0.147	-0.130		
	p-value			0.000***	0.000***		
Net Repos (lagged growth rate)	coef					-0.071	-0.068
	p-value					0.002***	0.001***
Constant	coef	0.017	1.428	0.004	1.422	0.004	1.437
	p-value	0.855	0.000***	0.964	0.000***	0.965	0.000***
Observations		862	862	862	862	862	862
R-squared		2.9%	17.3%	1.9%	16.4%	1.2%	16.0%