Financial Dampening

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Abstract

We document a systematic change in the behavior of financial sector leverage and credit growth, which declined more strongly and persistently in post-1990 recessions and recoveries compared to pre-1990 recessions and recoveries, and provide evidence that this has reduced the efficacy of monetary policy in engineering a rapid recovery. In our model of financial intermediation, where banks have leverage targets and asymmetric portfolio adjustment costs, deleveraging banks will have a lower pass-through from reductions in policy rates to credit supply. We call this novel mechanism financial dampening. We find strong support for financial dampening in micro-data on U.S. regulated financial intermediaries. In response to a 1% monetary policy shock, a bank at the 10^{th} percentile of the deleveraging distribution increases its loan growth by 1.7% more than a bank at the 90^{th} percentile according to our baseline specification. Using these estimates we illustrate that financial dampening was likely an important contributor to slow post-1990 recoveries by attenuating the effectiveness of monetary policy.

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1 Introduction

Postwar U.S. recoveries after 1990 have been much slower than recoveries before 1990: whereas pre-1990 the U.S. economy regained its pre-recession GDP level after 1.75 quarters on average, post-1990 it took on average 4 quarters to catch up. The reasons for this slowdown are less well understood. But the relatively modest output gains in U.S. GDP following the end of the Great Recession, seemed to support the hypothesis that in the aftermath of financial crises, recoveries are typically sluggish. If indeed "not all recessions are alike" and the nature of recoveries after financial crises is different from recoveries after other shocks, this potentially has important implications for the conduct of monetary and fiscal policy. The basis of this "financial crises recoveries are different" hypothesis, is typically cross-country empirical evidence as in Reinhart and Rogoff [2008] and Cerra and Saxena [2008]. Yet, we currently lack a clear conceptual or empirical understanding of the mechanisms that might render recoveries after financial shocks different from other recoveries.

This paper contributes to this debate in three ways. First, using flow-of-funds data we show that the cyclical behavior of the financial sector changed markedly from pre-1990 recession to post-1990 recessions. Financial sector leverage declines more strongly and more persistently after post-1990 recessions whereas after pre-1990 recessions it remains high and steady. This deleveraging is driven primarily by a decline in the growth of credit quantities (e.g., loans) in post-1990 recessions, which is absent in pre-1990 recessions.

Second, we propose a novel mechanism of how this change in financial behavior can affect the speed of economic recoveries. Through the lens of our model, the decline in credit growth represents a desire by financial intermediaries to meet lower leverage targets. This deleveraging reduces the pass-through from interest rate reductions to loan supply in the model, and thus attenuates the effectiveness of monetary policy. We call this mechanism "financial dampening."

Third, we test and find strong support for the implications of our model using microdata on financial intermediation: in response to a 1% monetary policy shock, a bank at the 10^{th} percentile of the deleveraging distribution increases its loan growth by 1.7% more than a bank at the 90^{th} percentile according to our baseline specification. These estimates suggest that had the financial sector not deleveraged in post-1990 recessions, then the average monetary stimulus in post-1990 recessions would have raised loan growth and additional 0.62% per year. A back-of-the envelope calculation using existing estimates from Amiti and Weinstein [2013] on the investment effects of loan supply then implies that, solely based on the investment margin, output would have been 0.93 percent higher two years after the end of a recession. To the extent that the central bank does not (or cannot) compensate for this financial dampening with additional interest rate reductions, the monetary stimulus to GDP will be smaller and recovery slower relative to an economy that is not deleveraging. This suggests that financial dampening is likely a quantitatively important factor in slow recoveries from post-1990 recessions.

In section 2 we focus on the cyclical behavior of the financial sector. We follow Hall [2007] and distinguish between pre-1990 and "modern" post-1990 recessions. Using flow-of-funds data from 1960q1 to 2013q4, we show that both leverage and credit quantities behave very different economically and statistically in modern recessions. Specifically, post-1990 leverage is high at the onset of a recession and then declines strongly and persistently towards its end and during the recovery. By contrast, pre-1990 leverage rises during the recession and remains high during the recovery. We document that this difference is driven primarily by a change in the of cyclicality credit quantities: The post-1990 deleveraging is driven by a persistent drop in four-quarter asset growth from 10% to 4%. This contrasts with pre-1990 asset growth which hovers around 7-9% throughout pre-1990 recessions and recoveries. On the other hand, the growth of financial sector capital does not exhibit a notable economic or statistical change in post-1990 recessions and therefore cannot explain these changing patterns.

In section 3 we argue that the change in the cyclicality of leverage and credit quantities is connected to of slow recoveries from post-1990 recessions. We construct a model of financial intermediation that allows us to interpret the aggregate findings from the flow-of-funds and their relevance for macroeconomic policy. This model combines three key ingredients. First, financial intermediaries are assumed to have leverage targets as in Adrian and Shin [2010] or Landier, Sraer, and Thesmar [2013]. Second, banks face asymmetric adjustment costs on their portfolio. This introduces a key trade-off: banks cannot costlessly attain their leverage target by adjusting their portfolio. Third, a failure of the Modigliani-Miller Theorem implies that downward adjustments towards the leverage targets are typically not achieved by capital injections but by reducing the size of assets in the financial intermediaries' balance sheet. Through the lens of this model, the evolution of leverage and credit growth in post-1990 recessions reflects a desire to lower leverage, undertaken gradually because portfolio adjustments are costly and equity cannot be easily raised.

Next we derive the key prediction from this model: that credit growth responds less to an interest rate reduction when banks deleverage. It derives from the key condition that banks obey in equilibrium: the marginal portfolio adjustment cost must be equal to the marginal cost of deviating from the leverage target. This trade-off is shown in figure 1. The ellipses denote the indifference sets of deviating from the leverage target and asset growth. When both are zero, the bliss point is attained. Non-zero asset growth is costly because of the adjustment costs. When adjustment costs are symmetric (figure 1(a)), then the ellipses are symmetric around the y-axis. When selling assets is more costly (figure 1(b)), then the ellipses to the left of the y-axis are bunched closer together.

The off-diagonal lines depict the feasible choices of leverage deviations and asset growth given the current level of leverage at the bank. In particular, a 1% reduction in asset growth will also reduce leverage by 1% and thus the log deviation of leverage from target by 1 percentage point. Given initial conditions, a bank will optimally operate at a tangency point of the indifference sets and the choice sets, such as points A and A'. The diagonal dashed line connects all these tangency points. When adjustment costs are symmetric, then the tangency points form a straight line. Thus, the same rise in equity from a reduction in interest rates, from A to B and A' to B', triggers the same increase in asset growth — irrespective of whether a bank is located in the bottom left deleveraging quadrant or the top right levering-up quadrant.

However, when selling assets is more costly, then the tangency line is steeper in the bottom left quadrant than in the top right quadrant. A deleveraging bank will then choose to increase asset growth less in response to the same rise in equity from an interest-rate reduction. This is simply the flip-side of asymmetric adjustment costs mitigating the decline in asset growth when equity falls. Thus, the interest rate elasticity of credit supply is lower when banks deleverage, because fewer assets are purchased and less credit is extended relative to the case where banks lever up. We call this effect "financial dampening."

To the best of our knowledge, this is the first paper to propose and test for this mechanism. Typical "Financial Accelerator Models", such as Bernanke, Gertler, and Gilchrist [1999] or Gertler and Karadi [2011] emphasize the role of net worth and leverage in the propagation of shocks. For example, a negative monetary policy shock (decline in interest rates) raises asset prices and net worth of financial intermediaries, which allows them to increase loan supply and reinforces the real effects of monetary policy. The strength of this financial accelerator is governed by financial sector leverage: The higher leverage the greater the increase in intermediaries net wealth and larger the increase in loan supply. This theory then suggests that monetary policy should be more effective in modern recessions, which occur when leverage is relatively high. However, as we argue in this paper, the strength of the financial accelerator depends not only on the size of leverage, but also on the direction that the financial sector desires to change leverage.

This financial dampening effect is not only a plausible explanation for the aggregate facts on post-1990 recessions, but, as we show in section 5, it is also strongly supported by micro-data from call reports of regulated financial institutions in the U.S. To directly test the importance of financial dampening, we derive an econometric specification from our model and estimate the response of loan growth to Romer and Romer [2004] monetary policy shocks from 1980q1 to 2007q4. In accordance with our theory, we find the response of loan growth to monetary policy shocks is weaker at deleveraging financial institutions. We also provide evidence that this relationship is driven by loan supply and not by loan demand, and show that the effect is robust to a range of specifications and sub-samples.

In section 6 we turn to the aggregate implications of the financial dampening mechanism. Applying our micro-level estimates to the interest rate path in the average post-1990 recession suggests that total loan supply would have been 1.86% higher two years after the end of the recession had the financial sector not deleveraged. Thus, financial dampening reduced annual loan growth by 0.62 percentage points over three years starting in the first year of the recession. Using estimates from Amiti and Weinstein [2013] on the effect of loan supply on investment suggests that this would have translated into an additional 0.22 percentage points of GDP growth over these three years. Output would thus have been 0.93% higher two years after the end of an average post-1990 recession based solely on the investment margin. Since we abstract from many other possible effects of reduced loan supply, these estimates imply that financial dampening is likely an important determinant of the central bank's ability to stimulate the economy in a modern recession.

This paper relates to at least five strands of literature. First, it emphasizes the role of financial intermediation in the propagation of monetary shocks, as in Kashyap and Stein [1995, 2000], Campello [2002] and Landier et al. [2013] among others. Relative to the existing literature we propose a novel mechanism – financial dampening – that effects the strength of this "credit channel." Second, our banking model builds on work of Adrian and Shin [2010, 2014] in stressing bank leverage targets and our use of asymmetric adjustment costs appeals to a long literature emphasizing asymmetric information in asset markets (e.g., Coval and Stafford [2007]). Third, it has implications for macroeconomic modeling of financial frictions in the macroeconomy. In particular, our evidence in favor of asymmetric adjustment costs and financial dampening suggests that these may be important ingredients for financial accelerator models in the tradition of Bernanke et al. [1999] and Gertler and Karadi [2011]. Fourth, our results imply that the effectiveness of monetary policy is state-contingent on the state of the financial sector, whereas existing work in this area stresses differential effectiveness in recessions and expansions (e.g., Tenreyro and Thwaites [2013]) or based on uncertainty (Vavra [2013]). Finally, our results suggest that monetary policy is less effective in post-1990 recessions in particular, which may be one contributing factor to their relatively slow and jobless recoveries (e.g., Galí, Smets, and Wouters [2012]).

2 Aggregate facts on post-1990 recessions

We begin by providing an overview of the aggregate stylized facts that motivate our theory and detailed micro-level empirical analysis. To produce a comprehensive picture of the cyclical patterns of leverage, we draw on publicly accessible U.S. flow of funds data. We first compile summary statistics based on raw data, before we turn to formal statistical analysis.

Figure 2 illustrates the time-series pattern for overall leverage of the financial sector, defined as the sum of total assets relative to capital. This paper focuses on the cyclical pattern of leverage around U.S. recessions. We base the timing of recessions on official dates from the NBER business cycle dating committee. In table 1 we document a first cut of these patterns, comparing leverage at the business cycle peak with leverage eight quarters after the ensuing recession. In in pre-1990 recessions leverage rises by an average of 3.9% over this horizon, with only the 1960-1961 recession displaying a modest 1.2% decline. By contrast, leverage declines the post-1990 recessions by between 5.9% to 9.4%. We reject that the average change in log leverage is the same over the two sub-periods with a p-value of 0.002. The economic importance of this change derives from the economically significant changes in credit quantities that we document below. However, before we turn to these variables, we first provide further evidence that financial sector leverage patterns have changed in post-1990 recessions.

Figure 3 displays the average pattern of financial sector leverage in recessions across the two sub-periods. We calculate averages across recessions based on the distance to a business cycle trough. Thus, zero on the x-axis denotes the end of a recession. The y-axis shows leverage relative to trend. All data are HP-filtered to focus on the cyclical properties of leverage. We use a relatively large smoothing parameter, $\lambda = 14400$, to ensure that we only remove long-run trends rather than cyclical features.[1] A notable feature of figure 3 is that for pre-1990 recessions, overall leverage slightly increases during the recession and remains high. This is shown by the blue line. Contrast this with the pattern of financial sector leverage in modern recessions, shown in the red line. Post-1990, financial sector leverage is high during a recession and then strongly and persistently declines towards its end and during the recovery.

A disadvantage of the calculation in figure 3 is that we cannot control for the different length of recessions. For instance, four quarters before the 2001 recession ended ($t = -4$) the U.S. economy was not in a recession, whereas four quarters before the 2007-9 recession ended it was. We can address this issue in statistical analysis, which also allows us to test whether leverage behaves statistically different in post-1990 recessions and recoveries. Let $y_{i,t}$ be a measure of leverage in a symmetric 25-quarter window ($t \in [-12, 12]$) around the end-date of recession i. Our baseline specification is

$$y_{i,t} = \alpha_i + \beta_1(I(t \geq \text{recession start}) \times I(i \geq 1990)) + \beta_2 I(t \geq \text{recession start}) + \varepsilon_{i,t} \qquad (1)$$

where α_i is a recession fixed effect and $I(\bullet)$ is an indicator variable. The indicator $I(t \geq \text{recession start})$ captures if leverage is different after a recession begins for the remainder of the 25-quarter window. Our coefficient of interest is β_1, which tells us if the de-leveraging patterns during recessions and recoveries are statistically different after 1990.

In table 2 we document the regression results where y_{i+t} is either the log level of leverage, the HP-filtered log leverage with smoothing-parameters $\lambda \in \{14400, 1600\}$, or the four-

[1]By contrast, the conventional smoothing parameter for quarterly data is $\lambda = 1600$.

quarter growth rate of leverage. The first column confirms the baseline results from table 1: whereas in pre-1990 recessions and recoveries leverage tends to rise by approximately 4.7%, post-1990 it declines by -5.14% on average. In column 2 we control for lagged leverage. This attenuates the coefficient β_1 but this should now be interpreted as a short-run response. The long-run relative decline in leverage is of similar magnitude than our baseline estimate. It is given by $\frac{\beta_1}{1-\rho}$, where ρ is the autoregressive coefficient.

Columns 3 through 6 conduct the same set of exercises using HP-filtered log leverage. With this specification we can guard against interpreting secular changes as cyclical patterns, by removing slow-moving trends from the data. Of course, some persistent cyclical changes may be soaked up by the secular trend. Not surprisingly then, the coefficient β_1 is smaller than in our baseline specification, though still statistically significant. With HP-filtered data it is also important to control for lagged variables since it induces mean-reversion in persistent cyclical components. Intuitively, the HP filter may eliminate much of the persistent effect 2-3 years after the recession, but cannot soak up much of the short-run effect on leverage. Thus, the HP-filtered and baseline short-run responses are more similar than the respective long-run estimates.

As another alternative, we use the recession fixed-effects to capture low-frequency movements in four-quarter growth rate of leverage. We run this specification in the last two columns of table 2. The coefficient β_1 is again significant and the magnitudes consistent with table 1. Since the average post-1990 recession lasted approximately four quarters, the difference in leverage in table 1 occurs over approximately three years. Multiplying the coefficient β_1 by three, we also obtain approximately a 10 percentage point (relative) reduction in leverage in post-1990 recessions and recoveries.

In short, the results in tables 1 and 2 document a systematic and significant change in the behavior of financial sector leverage in post-1990 recessions and recoveries. Further, this difference appears to be strongly linked to the business cycle and not merely a reflection of secular trends.

Underlying this changing behavior of leverage, we find economically important changes in credit quantities, such as asset and loan growth. In figure 4(a) we display the four quarter growth in financial sector assets by sub-period, and again center the graph at the end of a recession. There is a substantial change in the cyclicality of this asset growth for pre- vs. post-1990 recessions. Asset growth following the end of a recession used to be around 9% on average one year after the end of a recession. By contrast, post 1990, the same financial sector asset growth typically was around 4% and only slowly recovered from this level.

We find a much more limited role for valuation effects in explaining these changing patterns. Figure 4(b) shows the cyclical behavior of bank capital growth around the end of recessions. Not surprisingly the value of bank capital typically first falls at the beginning of the recession. Valuation effects are therefore important to understand the rise in leverage at the onset of recessions. Bank capital growth also quickly recovers after the end of a recession, unlike asset growth. Note however, that this pattern is basically the same for pre- and post-1990 recessions and therefore cannot explain the change in the strength of de-leveraging during recessions.

Two further facts provide supporting evidence that banks deliberately choose a reduced rate of asset growth. First we consider the liability side of the financial sector. Typically financial intermediaries finance their asset purchases with short-term debt or deposits, whereas the assets bought tend to be longer maturity and/or more risky. Thus, if the observed changes in asset growth simply reflect valuations, we would not expect any changes in the behavior of liabilities (excluding net worth). Yet figure 5(a) demonstrates that the same slow-down of asset growth is mirrored in liabilities.

Second, we determine if the changes in asset growth of the financial sector are mirrored by relatively less liquid assets such as loans, whose valuations are likely to change only gradually. In figures 5(b) we display four-quarter loan growth of the financial sector over the course of a recession and recovery. Again it emerges that loan growth drops much more rapidly and persistently in post-1990 recessions and recoveries. Furthermore, charge-offs of bad loans contribute only marginally to the post-1990 decline. This suggests that the deceleration in loan growth is driven by a reduction of credit quantities and not by a re-valuation of existing credit lines. We interpret this evidence as a clear indication that the structure of financial intermediation in post-1990 recoveries has changed at the aggregate level.

We again confirm the statistical significance of these changes using our baseline specification (1) in table 3. Columns 1 and 2 confirm that total assets grow less in post-1990 recessions and recoveries than in pre-1990 recessions and recoveries. The behavior of liabilities in columns 3 and 4 replicates that pattern. However, columns 5 and 6 show that there neither no statistically nor economically significant difference in the behavior of capital growth in recessions and recoveries over the two sub-periods.

We conclude that valuation effects are important at the beginning of recessions when leverage rises, but they cannot explain why post-1990 recessions exhibit strong de-leveraging movements. A more promising explanation for this pattern is the slow growth rate of assets in financial intermediary balance sheets, which suggestive of qualitatively different conduct of financial intermediation in modern recessions.

As a final check, we determine if the broad-based change from pre-1990 recoveries to post-1990 recoveries reflects a composition effect. Adrian and Shin (2010) document that from 1964 to 2010 leverage at commercial banks was mostly acyclical while leverage at dealer-broker firms was strongly procyclical. If dealer-brokers are responsible for a higher share of the financial sector post-1990, then this might explain the change in cyclicality of financial sector leverage without any obvious implications for financial intermediation. To address these concerns, we separately calculate financial asset growth for depository institutions in figure 6(a). We note that qualitative and quantitative patterns of changes in asset growth after the end of a recession are similar to before.

3 Bank de-leveraging and the response to monetary policy: linking micro to macro

These facts are clearly relevant to the extent that financial sector deleveraging exhibits contractionary effects on the macroeconomy. This has been the focus of numerous previous papers, including Jermann and Quadrini [2012], Eggertsson and Krugman [2012], Midrigan and Philippon [2011], and Iacoviello [2013]. However, it is not obvious why such deleveraging should necessarily result in slower recoveries relative to recessions induced by other shocks.

We propose such a mechanism in this paper: that deleveraging also reduces the effectiveness of monetary policy. That is, a given decline in the federal funds rate will generate a smaller increase in loan supply, and thus a smaller increase in output, when the financial sector is deleveraging. To the extent that the central bank does not (or cannot) compensate the dampened effects with additional interest rate reductions, the monetary stimulus to GDP will be smaller and recovery slower relative to an economy that is not deleveraging.

In the following subsection we develop a simple model that allow us to characterize necessary conditions for this mechanism to work. Beyond clarifying its microfoundations, and thus allowing the reader to judge its plausibility, this exercise has additional advantages. First, the model gives some interpretation to the aggregate facts in section 2. Second, it allows us to determine the correct measure of deleveraging at the intermediary level. And third, we use the model to derive a structural equation to guide our estimation with bank-level microdata.

3.1 A baseline model Time is indexed by t. The model is inhabited by N banks indexed by i. Banks can hold a assets a_{it}, which are traded at a nominal price Q_t. Purchases can be financed through one-period debt/deposits d_{it} and net worth n_{it}.[2] A bank's balance sheet is

[2]Clearly our model captures the logic of traditional depository institutions such as commercial banks. Other leveraged financial intermediaries that might hold securitized loans on their asset side might exhibit a similar logic to the model we outline here.

thus

$$\underbrace{Q_t a_{it}}_{Assets} \equiv \underbrace{n_{it} + d_{it}}_{Liabilities}.$$

The value of assets on the financial intermediary's balance sheet can be thought of as the value of credits extended. To simplify the exposition we think of bank i extending loan volume a_{it} to a representative corporate sector. As a result of no-arbitrage, all debt to the corporate sector has the same price Q_t. Its leverage, ϕ_{it}, is in turn defined as

$$\phi_{it} \equiv \frac{Q_t a_{it}}{n_{it}}. \tag{2}$$

Banks accumulate net worth through capital gains on assets and issuance of new equity $e_{it} \equiv j_{it} n_{it-1}$ but also have to meet interest payments to debtors and depositors

$$n_{it} = (Q_t + y_t) a_{i,t-1} - r_{t-1} d_{i,t-1} + j_{it} n_{i,t-1}.$$

where r_{t-1} is the gross nominal interest rate paid on deposits. Defining ER_t^Q as the excess return of assets over debt, we can derive the effect of monetary policy shocks (changes in r_t) on net worth,

$$\frac{\mathrm{d}\frac{n_{it}}{n_{i,t-1}}}{\mathrm{d}r_t} = \phi_{i,t-1} \frac{\mathrm{d}ER_t^Q}{\mathrm{d}r_t} + \frac{\mathrm{d}j_{it}}{\mathrm{d}r_t}. \tag{3}$$

The first term of the right-hand-side (RHS) captures the effect of monetary policy on asset prices. When a decline in nominal rates raises asset prices then the bank's asset holdings increase in value and net worth rises. Leverage amplifies this effect. The second term on the RHS captures the extent to which banks raise additional equity after a monetary policy shock. Also note that the monetary policy shocks do not affect the nominal value of debt repayment, $r_{t-1} d_{i,t-1}$, since the gross nominal interest rate, r_{t-1}, was determined last period.

We measure the strength of the financial accelerator as the response of nominal asset values to a monetary policy shock,

$$\frac{\mathrm{d}\ln\frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}}}{\mathrm{d}r_t} = \frac{\mathrm{d}\ln\frac{n_{it}}{n_{i,t-1}}}{\mathrm{d}r_t} + \frac{\mathrm{d}\ln\frac{\phi_{it}}{\phi_{i,t-1}}}{\mathrm{d}r_t}$$
$$= \frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}j_{it}}{\mathrm{d}r_t} + \frac{\mathrm{d}\ln\frac{\phi_{it}}{\phi_{i,t-1}}}{\mathrm{d}r_t} \tag{4}$$

The first line uses the definition of leverage. The second line substitutes equation (3) using the approximation $\frac{\mathrm{d}\frac{n_{it}}{n_{i,t-1}}}{\mathrm{d}r_t} = \frac{\mathrm{d}(\frac{n_{it}}{n_{i,t-1}}-1)}{\mathrm{d}r_t} \approx \frac{\mathrm{d}\ln\frac{n_{it}}{n_{i,t-1}}}{\mathrm{d}r_t}$.

The first term of equation (4) shows that the financial accelerator is amplified at banks with higher past leverage holding current leverage fixed. This occurs because their net worth is more sensitive to asset prices and thus monetary policy shocks (equation (3)). Similarly, banks that raise additional equity will accumulate more assets for a given level of leverage. The third term captures the response of the financial intermediary's leverage to a monetary policy shock. If a decline in interest rates also leads to a decline in leverage, then total asset accumulation, and thus total credit supply, will be less than if leverage had remained constant.

While standard models emphasize the importance of leverage operating through the first term, our focus is on how banks leverage choices respond to monetary shocks, i.e., the third term. Given our empirical results in section 5.2, we focus on the case where deleveraging banks reduce their leverage relatively more than banks that lever up. This renders monetary policy less effective in a deleveraging environment because banks will purchase fewer assets and give out fewer loans for a given reduction in interest rates. It is this mechanism that we call "financial dampening." In order to determine under what conditions financial dampening may be important, we need to solve for the optimal leverage choice.

3.2 Optimization We assume that banks have a (potentially time-varying) leverage target ϕ_{it}^T that is exogenous with respect to the monetary shock. Adrian and Shin [2010] among others have documented evidence that supports this assumption. One can think of this leverage target as resulting from an optimal contracting problem that keeps the bank equity value-at-risk constant over the business cycle as in Adrian and Shin [2014]. Our main focus is to understand how such leverage targets shape the credit supply response of financial intermediaries to monetary policy. We assume that log deviations of leverage from the target have quadratic costs, $\tilde{c}(\phi_{it}, \phi_{it}^{T}) = \frac{1}{2}(\ln \phi_{it} - \ln \phi_{it}^{T})^2$.

Given a leverage target, there exist in principle two margins that can be adjusted to meet this target. The first margin are bank capital injections or reductions or j_{it}. As much of the corporate finance literature following Myers and Majluf [1984], we assume that asymmetric information problems render capital injections very costly, especially in recessionary times. Specifically, as in Kashyap and Stein [1995] and Landier et al. [2013] we assume that capital injections typically cannot be used to shield leverage against aggregate shocks, at least not in the short run. Thus we set $j_{it} = 0$ for the remainder of this section.

The second margin of adjustment are bank assets a_{it}. This will be our main focus. Here we assume that restructuring the bank's portfolio is subject to smooth and possibly asymmetric adjustment costs $c()$. It is important that we allow for this possible asymmetry in loan adjustment costs, since this is a plausible feature of the data. Specifically, distressed selling of bank assets such as loans is likely to be more costly than an expansion of loan supply. For instance, distressed selling of loans can give rise to asymmetric information problems that reduce the returns on these sales. Further, markets for securitized loans might be thin due to these information problems, so that it is easier to buy up securitized loans than to sell them. Consistent with this view, Coval and Stafford [2007] document that asset sales are particularly costly during times of financial distress. There are also possible asymmetries in direct costs of adjusting loan portfolios. For instance, if a bank wants to expand the volume of loans it could easily do so by hiring more sales people or more traders that buy securitized loans from other banks without signaling anything about the financial situation of the bank itself. By contrast, fire sales of loans might signal that the bank is in financial distress. The bank may therefore have to invest significant effort to hide the fire sales by using multiple brokers and other non-transparent operations, which increases the sales cost of loans.

These assumptions on adjustment costs in capital injections and bank loan restructuring give rise to realistic patterns of leverage in recessions. In post-1990 data, we typically see a rapid rise in bank leverage at the onset of a recession as bank equity values drop. This rise is then followed by a gradual but persistent decline in leverage towards what appears to be a lower leverage target. Further, this adjustment occurs primarily through reduced asset accumulation rather than additional equity injections. Indeed, the up-and-down movement in leverage suggests that banks either cannot or choose not to smooth leverage using equity injections or asset sales during recent recessions.

To sum up, we rule out equity issuance and allow for portfolio adjustment costs $\bar{c}(a_{it}, a_{i,t-1}) = C(\ln a_{it} - \ln a_{i,t-1})$. We model adjustment costs as utility costs to avoid having to model a fully securitized loan market in general equilibrium. Note however, that an asymmetric loan adjustment cost function $C(.)$ can also be seen as a reduced form of the bank health signaling problem described above. If the bank wants to expand its loan portfolio it can do by hiring more bank sales people who seek out lenders. If on the other hand the bank wants to systematically sell assets, adjustment costs can be higher, since the bank wants to avoid signaling its financial distress to markets. In this case the bank would incur additional costs to hide its asset sales operations.

To make the mechanism as transparent as possible we model the banks portfolio decision as a one-shot static optimization problem,

$$\max_{a_{it}} \; U_t = -\frac{1}{2}(\ln \phi_{it} - \ln \phi_{it}^T)^2 - C(\ln a_{it} - \ln a_{i,t-1})$$

$$\text{s.t. } \; \ln \phi_{it} = \ln Q_t + \ln a_{it} - \ln n_{it}$$

$$Q_t, n_{it}, a_{i,t-1} \text{ given.}$$

The first order condition for asset purchases satisfies,

$$\begin{aligned} & -(\ln\phi_{it} - \ln\phi_{it}^T) = C'(\ln a_{it} - \ln a_{i,t-1}) \\ \Leftrightarrow\ & -(\ln\phi_{it} - \ln\phi_{it}^T) = C'(\ln\phi_{it} - \ln\phi_{it}^C), \end{aligned} \tag{5}$$

where $\phi_{it}^C = \frac{Q_t a_{i,t-1}}{n_{it}}$ is the "counterfactual" leverage today if there is no change in asset holdings from the previous period. Equation (5) characterizes the trade-off between achieving the leverage target, $\ln\phi_{it}^T$, and minimizing portfolio adjustment costs. In equilibrium, the marginal benefit of getting leverage closer to target, $|(\ln\phi_{it} - \ln\phi_{it}^T)|$ must equal the marginal adjustment cost of asset purchases/sales $|C'(\ln a_{it} - \ln a_{i,t-1})|$. The second line follows by definition of counterfactual leverage ϕ_{it}^C. If the bank accumulates more assets, $a_{it} > a_{i,t-1}$, then actual leverage will exceed the counterfactual (no-action) leverage, $\phi_{it} > \phi_{it}^C$.

The optimal leverage choice is shown graphically in figures 1. The ellipses are the indifference curves generated by the preferences U_t — with symmetric adjustment costs in panel 1(a) and asymmetric adjustment costs in panel 1(b). The off-diagonal lines describe are leverage definition $\ln\phi_{it} = \ln Q_t + \ln a_{it} - \ln n_{it}$, which characterizes the feasible choices of a_{it} and ϕ_{it} given asset prices Q_t and net worth n_{it}. The slope of this "budget line" is -1. It is clear that the optimal choice is a tangency of the "budget line" with the indifference curves. Formally, this implies that the marginal rate of substitution, $MRS = \frac{\mathrm{d}U_t/\mathrm{d}\ln\phi_{it}}{\mathrm{d}U_t/\mathrm{d}\ln a_{it}}$, equals -1, which is just another restatement of (5). Since

The first order condition allows us characterize the financial dampening effect in equation (4). Since (5) holds in equilibrium, we differentiate with respect to the monetary policy shock r_t,

$$\begin{aligned} \frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} &= -C''(\ln\phi_{it} - \ln\phi_{it}^C)\left(\frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} - \frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t}\right) \\ &= \frac{C''}{1+C''}\frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t}, \end{aligned} \tag{6}$$

where we use the assumption that the leverage target is exogenous to the shock. This equation describes the movement along the set of tangency points in figure 1 (the dashed green line). To build intuition for equation (6), suppose the bank is initially at target leverage, $\phi_{i,t-1} = \phi_i^T$, and that a decline in nominal rates raises asset values and thus lowers bank leverage if it took no action, $\phi_{it}^C < \phi_i^T$. In particular, the decline in counterfactual leverage is given by,

$$\frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t} = -\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}. \tag{7}$$

Consider two extreme cases: First, if $C'' = 0$ then there are no adjustment costs and $\frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} = 0$. Intuitively, in this case it is costless for the bank to increase its asset holdings a_{it} to raise leverage back to target, $\phi_{i,t} = \phi_i^T$. In that case, the set of tangency points in figure 1 lies flat on the x-axis ($\ln\phi_{it} = \ln\phi_{it}^T$), and any rightward shift in the budget line from a reduction in interest rates will simply raise asset growth.

Second, if $C'' \to \infty$ then adjustment costs are prohibitive and $a_{it} = a_{i,t-1}$. Now the set of tangency points in figure 1 is a vertical line on the y-axis ($\Delta\ln a_{it} = 0$), and any rightward shift in the budget line from a reduction in interest rates will simply lower leverage. Thus, leverage will fall to $\phi_{i,t} = \phi_{i,t}^C < \phi_i^T$, so that $\frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} = \frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t} > 0$.

With positive but finite adjustment costs, the set of tangency points in figure 1 is an upward-sloping line. Thus, relative to the case were no adjustment costs are present ($C'' = 0$), the impact of monetary shocks on asset growth is dampened. In panel 1(a) we consider first the case of symmetric, finite adjustment costs, $c(x) = \frac{\xi}{2}x^2$. We note that the dampening effect is constant and equal to $\frac{\xi}{1+\xi}$. In particular, an increase in equity (rightward-shift of the budget line) has the same effect on asset growth, irrespective of whether a bank is deleveraging (point A') or not (point A).

That monetary policy has weaker effects on asset growth at deleveraging banks will therefore rely on the asymmetry of the adjustment cost function. We parameterize it with the linex function,[3]

$$c(x) = \xi \frac{\exp(-\psi x) + \psi x - 1}{\psi^2}.$$

The two parameters ξ and ψ govern the size and asymmetry of the cost function. When $\psi = 0$ it reduces to quadratic costs, $c(x) = \frac{\xi}{2}x^2$. When $\psi > 0$ then negative changes, $x < 0$, are more costly than positive changes, $x > 0$. Substituting this function into (6) yields,

$$\frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} = \left[\frac{\xi e^{-\psi(\ln\phi_{it} - \ln\phi_{it}^C)}}{1 + \xi e^{-\psi(\ln\phi_{it} - \ln\phi_{it}^C)}}\right] \frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t}. \tag{8}$$

Thus, $\psi > 0$ implies that the marginal costs of adjusting assets rises particularly quickly when banks de-lever, $a_t < a_{t-1} \iff \phi_{it} < \phi_{it}^C$, than if they lever up, $a_t > a_{t-1} \iff \phi_{it} > \phi_{it}^C$. This case is shown in panel 1(b). For instance, take the deleveraging case and suppose that a decline in interest rates raises bank equity and thus lowers counterfactual leverage $\frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t} > 0$. Then the bank will absorb most of that increase in equity and let leverage fall, corresponding to the movement from point A' to point A in 1(b). The increase in asset growth for a deleveraging bank is then smaller for a deleveraging bank than for a bank that levers up (point A to B) given the same increase in equity. This implies that expansionary monetary shocks will cause a greater reduction in leverage when banks deleverage, which weakens the financial accelerator. Similarly, after a contractionary shock banks let leverage rise more rather than selling off a lot of assets (from B' to A'). Thus, both expansionary and contractionary shocks have smaller effects in de-leveraging states because the financial accelerator is dampened. This is the "financial dampening" effect that we propose and test for in this paper.

3.3 Estimation To allow for standard estimation techniques, we take a first order approximation of the square bracket term in (8), and substitute $(\ln\phi_{it} - \ln\phi_{it}^C) \approx \frac{1}{(1+\xi)}(\ln\phi_{it}^T - \ln\phi_{it}^C)$

[3] This function has previously been employed by Kim and Ruge-Murcia [2009] in the context of asymmetric nominal wage rigidity.

from equation (5),

$$\frac{\mathrm{d}\ln\phi_{it}}{\mathrm{d}r_t} \approx \left[\frac{\xi}{1+\xi} - \frac{\psi\xi}{(1+\xi)^3}(\ln\phi_{it}^T - \ln\phi_{it}^C)\right]\frac{\mathrm{d}\ln\phi_{it}^C}{\mathrm{d}r_t}. \tag{9}$$

Note that equation (9) embeds a complicated non-linear structure. The counterfactual leverage $\ln\phi_{it}^C$ is affected by r_t, through asset prices and leverage. Thus, the larger r_t, the greater its effect on $\ln\phi_{it}^C$, which will introduce non-linearities in the response of leverage to interest rates.

To circumvent these non-linearities, we assume that banks close some fraction of the gap each period allowing for correlated and uncorrelated noise,

$$\ln\phi_{it}^T - \ln\phi_{it}^C = \mu(\ln\phi_{i,t-1}^T - \ln\phi_{i,t-1}^C) + \nu_t + \varepsilon_{it}. \tag{10}$$

This allows us to measure the de-leveraging state using lagged asset growth:

$$\ln\phi_{it}^T - \ln\phi_{it}^C = \mu(1+\xi)(\ln a_{i,t-1} - \ln a_{i,t-2}) + \nu_t + \varepsilon_{it}. \tag{11}$$

Since the lagged state is predetermined, this eliminates the non-linear structure in equation (9) and more closely aligns our specification with the existing literature (e.g., Kashyap and Stein [2000] and Landier et al. [2013]) that also conditions on lagged variables of interest. We further assume that the errors are independent of lagged asset growth, $\mathbb{E}(\nu_t | \ln a_{i,t-1} - \ln a_{i,t-2}) = \mathbb{E}(\varepsilon_{it} | \ln a_{i,t-1} - \ln a_{i,t-2}) = 0$.

Next, we substitute equations (11) and (7) into (9), and the result into equation (4). Further we group terms and make two more manipulations: First, since we cannot measure physical assets (a_t) directly, we derive the deleveraging in terms of asset values $Q_t a_t$. Second, we specify the equation in terms deviations of bank-level asset growth from aggregate asset growth. As we show in appendix A, this yields the following specification,

$$
\begin{aligned}
\frac{\mathrm{d}\left(\ln \frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}} - \ln \frac{Q_t a_t}{Q_{t-1}a_{t-1}}\right)}{\mathrm{d}r_t} = & \underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]\ln\frac{Q_{t-1}a_{t-1}}{Q_{t-2}a_{t-2}}}_{\text{Aggregate effect}} \\
& + \underbrace{\left[\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\psi\xi\mu}{(1+\xi)^2}\left(-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right)\left(\ln\frac{Q_{t-1}}{Q_{t-2}}\right)\right]}_{\text{Cross-sectional effect: Leverage}}\ln\frac{\phi_{i,t-1}}{\phi_{t-1}} \\
& - \underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{De-leveraging}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \qquad (12) \\
& - \underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right]}_{\text{Interaction}}\ln\frac{\phi_{i,t-1}}{\phi_{t-1}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \\
& \underbrace{-\frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1}\right]\nu_t - \frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]\varepsilon_{it}}_{\text{Noise}},
\end{aligned}
$$

where any variables not indexed by i refer to aggregate quantities or prices. Treating aggregate leverage as constant we get the following regression model:

$$
\frac{\mathrm{d}\ln\frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}} - \ln\frac{Q_t a_t}{Q_{t-1}a_{t-1}}}{\mathrm{d}r_t} = \alpha_t + \beta_1\ln\frac{\phi_{i,t-1}}{\phi_{t-1}} + \beta_2\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} + \beta_3\left(\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}}\right) + \upsilon_{it} \qquad (13)
$$

The coefficient β_1 captures how bank-level leverage affects asset growth. A decline in interest rates raises bank equity more at highly levered banks, so that they will increase their lending and asset purchases more (all else equal). Thus, we expect that this coefficient is negative, $\beta_1 < 0$. The next term captures the importance of deleveraging. When deleveraging is more costly than levering up ($\psi > 0$), we expect that deleveraging banks will respond less to monetary shocks, $\beta_2 < 0$, because they largely absorb the increase in equity to get closer to their leverage target. Note that $\beta_2\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} - \alpha_t$ essentially captures the deviation of deleveraging from the aggregate. For our purposes it is not important whether we group this term because the α_t term will be absorbed by a time-fixed effect. The final term captures the interaction of leverage with deleveraging. A highly levered but deleveraging bank will use most of the increase in equity to get closer to target. Thus, this term mutes the leverage effect and $\beta_3 < 0$. Intuitively, when banks try very hard to reduce their leverage, the increase in asset holdings will be small no matter what their initial leverage is.

4 Data construction

4.1 Bank level data We use the Report of Condition and Income data available on the Federal Reserve Bank of Chicago and WRDS. It captures all commercial banks regulated by the Federal Reserve System, the Federal Deposit Insurance Corporation and the Comptroller of the Currency. The data are at a quarterly frequency from 1976:1 to 2010:4. This dataset has been previously used by Kashyap and Stein [2000] and Campello [2002] among others. An advantage of this dataset is its historical length, which allows us to analyze bank level responses to the large monetary shocks in the early 1980s. By contrast, the Bank Holding Company (BHC) consolidated statement, which are used by Landier et al. [2013], are only available since 1986.

We restrict our analysis to banks whose head office is insured by either the FDIC, the National Credit Union Savings Insurance Fund, and/or its resident state. This removes U.S. branches of foreign banks as well as domestic national trusts. Further, whenever a bank merger occurs then we treat the resulting entity as a new bank. We mark mergers using the bank and BHC merger files available from the Federal Reserve Bank of Chicago website. We are left with 26,195 unique banks and a total of 1.65 million bank-date observations.

Table 4 tabulates cross-sectional summary statistics for our key variables of interest. In our sample the average bank-date observation has \$450 million in assets and \$264 million in loans. As is apparent from the large standard deviations, the distribution of asset and loans is very skewed towards the top. The average leverage ratio in our sample is 11, in line with existing studies, and the average cash-to-asset ratio is 7.3%. Most banks are small relative to the market: the median market share over a bank's lifetime is on average 0.0075%.

For the growth rates of assets, liabilities and loans we follow Kashyap and Stein [2000] and remove all observations that are five standard deviations above and below the mean. Nevertheless, large cross-sectional variation remains: the mean growth rate rates range from 8.6% (assets) to 9.5% (loans) but their respective standard deviations are 13.1% and 17.9%. It is these differences in bank-level de-leveraging that we exploit in our empirical exercise.

4.2 Relation of bank level data and Flow of Funds One concern with using the bank-level microdata is to what extent it can informative the patterns that we highlight in section 2. We make two distinctions here: (1) is the bank-level microdata representative of depository institutions in flow of funds and (2) do depository institutions exhibit similar patterns as the financial sector?

To answer (1) we aggregate bank-level assets and loans in the microdata and divide them by the flow of funds aggregates for private depository institutions. This gives us the coverage of total private depository assets and loans that we capture in the microdata. One caveat is that the flow of funds only report total financial assets rather than total assets as our microdata. These are plotted in figure 7(a). The cover ratios tend to be high; on average 96% for assets and 77% for loans. This suggests that our dataset indeed captures much of the asset positions of private depository institutions. A more stringent test is whether the microdata also matches the time series pattern in the flow of funds. In figures 7(b) and 7(c) we plot the four-quarter growth rates of assets and loans in the aggregated microdata and for private depository institutions in the flow of funds. In general, the microdata tracks the movement of depository institutions relatively well: the correlations are 0.63 for assets and 0.77 for loans. When we exclude the spikes in the late 1970s microdata the correlation further increase to 0.73 and 0.95 respectively. To avoid the measurement errors associated with these spikes we restrict our sample to start in 1980.

Next, we compare depository institutions to the financial sector. According to the flow of funds depository institutions now account for approximately 20% of all assets. This is down from the 40% market share they had from 1960-1980. Nevertheless, as shown in figures 7(b) and 7(c) their cyclical behavior is quite similar. In particular, before 1980 the quarterly asset and loan growth rates in both sectors are nearly identical. After 1980, the growth rates are lower at depository institutions reflecting the downward trend but peaks and troughs do coincide. Thus, for the sample when microdata are available, the correlation between the sectors is 0.56 for asset growth and 0.89 for loan growth.

In short, the microdata appears to capture the behavior of private depository institutions, which in turn exhibit similar cyclical pattern as the financial sector. This suggests that these data can indeed be informative about the cyclical patterns that we documented in section 2.

4.3 Monetary Policy Shocks We use the Romer and Romer [2004] monetary policy shock series ("Romer-shocks"). These are residuals from a regression of the federal funds rate on lagged values and the Federal Reserve's information set. As argued by Romer and Romer [2004] these are plausibly exogenous with respect to the evolution of economic activity. The Romer-shocks are available at monthly frequency from 1969:1 to 2007:4.[4] We sum the shocks to a quarterly frequency and merge them with the bank data.

The advantages of using a monetary shock relative to a time-series of nominal interest rates are twofold. First, a negative monetary policy shock more plausibly reduces equity at banks. By contrast, nominal interest rates will endogenously rise as economic conditions improve, which has ambiguous effects on bank equity. Second, since monetary policy shocks are unanticipated, we do not have to worry about banks strategically adjusting their portfolio in anticipation of these shocks.

[4]The original data have been extended by Coibion [2012] and Coibion, Gorodnichenko, Kueng, and Silvia [2012]. We are grateful to Lorenz Kueng for providing us with these data.

5 Estimation

Before testing directly for financial dampening we first examine two unconditional predictions from our modeling assumptions. First, equation (11) implies that asset growth is positively serially correlated,

$$\ln Q_t a_{it} - \ln Q_{t-1} a_{i,t-1} = \mu(\ln Q_{t-1} a_{i,t-1} - \ln Q_{t-2} a_{i,t-2}) + \frac{1}{1+\xi}\tilde{\nu}_t + \frac{1}{1+\xi}\varepsilon_{it}. \tag{14}$$

Second, since counterfactual leverage is equal to $\phi_{it}^C = \phi_{i,t-1} - (\ln n_{it} - \ln n_{i,t-1}) + (\ln Q_t - \ln Q_{t-1})$, we can also use lagged asset growth to predict future leverage growth,

$$\ln \phi_{it} - \ln \phi_{i,t-1} = \mu(\ln Q_{t-1} a_{i,t-1} - \ln Q_{t-2} a_{i,t-2}) - (\ln n_{it} - \ln n_{i,t-1}) + \frac{1}{1+\xi}\hat{\nu}_t + \frac{1}{1+\xi}\varepsilon_{it}. \tag{15}$$

Intuitively, a bank with relatively high lagged asset growth is likely to be below its leverage target, so we would expect future leverage to be higher.

If lagged asset growth and current net worth growth $(\ln n_{it} - \ln n_{i,t-1})$ are uncorrelated, then regressing current asset growth and current leverage growth on lagged asset growth should yield the same coefficient μ. By contrast, if that correlation is positive (negative) then regressing leverage growth on lagged asset growth will yield a coefficient less than (greater than) μ. Our maintained hypothesis is that it is not easy for deleveraging banks to raise equity. We would therefore (if anything) expect a positive correlation between lagged asset growth and current leverage growth, and thus a smaller coefficient on a regression of leverage growth on asset growth.

In table 5 we document evidence in line with these predictions. The first two columns show that lagged asset growth is a significant positive predictor of future asset growth. Notably, the addition of time fixed-effects in the second column barely affects this result. Columns 3 and 4 also show that lagged asset growth positively predicts future leverage growth. The coefficient is roughly two-thirds of that in the first two columns. This implies that the correlation between asset growth and current net worth growth is negative, consistent with our assumption that it is difficult for deleveraging banks to raise equity. In short, the evidence in table 5 confirms the basic (unconditional) predictions of our model. We therefore proceed with testing for financial dampening conditional on monetary policy shocks.

5.1 Specification Our baseline specification integrates equation (13) with respect to the monetary policy shock, while also allowing for lagged effects as in Kashyap and Stein [1995] and Landier et al. [2013],[5]

$$\begin{aligned} y_{it} - y_{i,t-1} =& \alpha_i + \eta_t + \sum_{j=0}^{8} \beta_{1,j} r_{i,t-j} \ln\left(\frac{\phi_{i,t-1-j}}{\phi_{t-1-j}}\right) + \sum_{j=0}^{8} \beta_{2,j} r_{t-j} \ln\left(\frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}\right) \\ &+ \sum_{j=0}^{8} \beta_{3,j} r_{t-j} \ln\left(\frac{\phi_{i,t-1-j}}{\phi_{t-1-j}}\right) \ln\left(\frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}\right) + \sum_{j=0}^{8} \theta_{1j} \ln\left(\frac{\phi_{i,t-1-j}}{\phi_{t-1-j}}\right) \\ &+ \sum_{j=0}^{8} \theta_{2j} \ln\left(\frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}\right) + \sum_{j=0}^{8} \theta_{3j} \ln\left(\frac{\phi_{i,t-1-j}}{\phi_{t-1-j}}\right) \ln\left(\frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}\right) \\ &+ \sum_{j=1}^{8} \gamma_{1,j} (y_{i,t-j} - y_{i,t-1-j}) + \delta \times \text{controls} + \zeta_{it}. \end{aligned} \tag{16}$$

The LHS is the growth rate of our variable of interest. In our case, total asset growth and total loan growth at bank i. We allow for bank-level fixed effects α_i to account for bank-level heterogeneity in growth rates, as well as time dummies η_t to soak up (potentially time-varying) responses to monetary shocks at the aggregate level. The next three terms derive from the structural equation (13): the interaction of the monetary shocks with lagged leverage, with lagged asset growth, and with the interaction of lagged leverage and lagged asset growth. We date each of these variables at one lag relative to the monetary policy shock and determine the impact of monetary policy conditional on that state.

The following three terms (with θ coefficients) control for bank-level heterogeneity in our variables of interest and the final terms (with γ coefficients) for bank-level dynamics in the

[5] See Hamilton [2008] for an economic justification of the lag structure.

dependent variable. In our robustness checks also include additional controls to ensure that our deleveraging variable does not capture other bank-specific heterogeneity such as liquidity or size [Kashyap and Stein, 2000]. The error term ζ_{it} contains, among other elements, the error $\varepsilon_{it} r_t$. (The other error, $\eta_t r_t$, is absorbed by the time fixed effect.) Given our assumption that these errors are uncorrelated with deleveraging, $\mathbb{E}(\varepsilon_{it} | \ln a_{i,t-1} - \ln a_{i,t-2})$, an application of the law of iterated expectations shows that this will not bias our estimates.

5.2 Main Results Table 6 presents our baseline estimates. The dependent variable in the first two columns is total asset growth of bank i at time t minus median asset growth at time t.[6] Due to space constraints we only report the coefficients on the interaction of the Romer-shock with the deleveraging variable, $\{\beta_{2,j}\}_{j=0}^{8}$. The coefficients of all interactions with the monetary shock are instead tabulated in appendix table 12. We do however report the sum of coefficients on these other interactions at the bottom of table 6 along with the p-value of a χ^2-test that the sum is zero. All standard errors are robust and clustered at the bank level.

The first column presents estimates based on equation (16) without any controls. As expected, the coefficients on the interaction of monetary shocks with de-leveraging are consistently negative and typically significant. The sum of coefficients is -4.50. This implies that a one percentage point reduction in interest rates will raise total asset growth by 0.45 percentage points more at a bank who's four-quarter asset growth is at the aggregate trend, relative to a bank that who's four-quarter balance sheet growth is 10 percentage points below the mean. We discuss the economic importance of these estimates in the cross-section and time-series dimensions at the end of this sub-section.

The second column illustrates that our results are not driven by other variables that have been shown to affect loan growth. In particular, we control for bank liquidity through the cash-to-asset ratio and for size using a bank's median market share over its lifetime. As

[6] We subtract median asset growth rather than mean asset growth because it does not feature the latter's spikes (figure 7(b)) but similarly captures the declining growth of assets at commercial banks.

in Kashyap and Stein [2000] we find that larger banks and banks with more liquid assets respond less to monetary policy shocks. However, while these controls are significant, they barely affect our coefficient of interest.

Next we use total loan growth of bank i at time t minus median loan growth at time t as our dependent variable. This is naturally of interest since many studies have shown a link between bank loan supply and real economic outcomes (Peek and Rosengren [2000], Chodorow-Reich [2014] and Amiti and Weinstein [2013]). As column 3 shows, the deleveraging effects are even stronger for loan growth. The sum of coefficients on the deleveraging interaction is -7.00. Thus, banks who's balance sheet grow 10% slower will expand their loan growth by -0.7 percentage points less than the average bank.

In column 4 we include the same controls as in column 2. Again we find that these controls enter with the expected sign although only the liquidity interaction is significant at conventional levels. In any case, they have very little impact on the de-leveraging coefficient.

Our last dependent variables are commercial and industrial (C&I) loans. These make up 19.3% of all loans in our sample. We find that the response of C&I loans is again weaker at deleveraging banks and this effect is of very similar magnitude to that of total loans. This suggests that such banks reduce their loan supply to firms in similar manner as they reduce aggregate lending. Again, both size and liquidity controls leave this coefficient effectively unchanged.

In analyzing the economic importance of our results we follow the existing literature and focus on loan growth. Our estimates imply that a bank at the 90^{th} percentile of the deleveraging distribution (the 10^{th} percentile of four-quarter asset growth) will increase its loan growth by 1.67% less in response to a 1% interest rate reduction than a bank at the 10^{th} percentile of the deleveraging distribution. This is comparable to other effects that have been highlighted in the existing literature. For instance, Kashyap and Stein [1995] show that small banks loan growth rises by 0.3% more following a 1% reduction in interest rates than large bank loan growth (their figure 2). Kashyap and Stein [2000] argue that differential liquidity between the 10^{th} and 90^{th} generates a $0.8-5.3\%$ difference in loan growth after two years to the same monetary policy shock. Finally, Landier et al. [2013] show that the income gap difference between 25^{th} and 75^{th} percentile cause a 1.6% difference in loan growth after 4 quarters.

In addition to being important in the cross-section, financial dampening may also be an important factor in determining the strength of the aggregate credit channel. This is because there is also significant time-variation in our deleveraging variable — four-quarter asset growth. Kashyap and Stein [1995] show that aggregate loan growth ranges from 0.8% to 1.1% after two years following a 1% reduction in interest rates (their figure 2). At the aggregate level four-quarter asset growth ranges from 2% to 10% in recent recession implying a spread in loan growth of 0.56% at these different points in time given our (partial-equilibrium) estimates. If the Kashyap-Stein measure captures the credit channel in normal times, then this calculation implies that its strength could be cut in half in modern recessions. This suggests that financial dampening is likely a key factor in state-dependent strength of the credit channel and monetary policy in general. In section 6 we further elaborate on these aggregate effects below and their likely impact on GDP.

5.3 Robustness Next, we conduct a series of robustness exercises. First, we de-median the deleveraging variable by bank. That is, if a bank typically grows its balance sheet by 6% per year, then we subtract that value and only estimate the deleveraging effect based on deviations from trend. This should eliminate any endogeneity concerns that involve fixed bank-level characteristics. Note however, that this is a very conservative calculation. If we observe that bank growing its balance sheet by 8% rather than its typical 6% growth, then we treat it the same way as a bank that grows by 2% but exhibits no trend growth. Thus, from the perspective of the baseline model, we introduce measurement error in our de-leveraging variable and a bias towards zero.[7] Nevertheless, as we show in table 7 we still

[7] This holds true even though we include bank fixed-effects: the de-levering variable is interacted with the monetary policy shock, which renders that interaction approximately mean zero for every bank.

find significantly negative and economically important effects in this specification. The sum of coefficients on the de-leveraging variable in the loan regression (column 3) is now -3.84 and still highly significant. The effects range from 55%-85% of our baseline specification, but as we argued are likely biased down. Thus they represent likely a lower bound on the plausible effect of the financial dampening channel we emphasize. Indeed, that we still find such effects even in this conservative specification, in our view, strongly supports the theory.

Second, we consider potential endogeneity in the dynamics of our deleveraging variable. Suppose that our effect is driven by firm or consumer demand: that those who have reduced their loan demand in the past are also less responsive to monetary shocks. We note that this is simply an application of financial dampening to loan demand rather than loan supply. Thus, to the extent that both the flow-of-funds and our cross-sectional results are driven by loan demand, our finding that financial dampening renders monetary policy less effective still applies.

However, we also provide evidence that the cross-sectional results are driven by loan supply. In particular, we now use assets net of C&I loans as our deleveraging variable and use it to predict the growth in C&I loans. Thus, our independent variable can no longer pick up demand by C&I borrowers. As we document in table 8, C&I loan growth responds in an essentially identically manner to this deleveraging variable. This suggests that our deleveraging variables are indeed picking up loan supply effects.[8]

Our baseline results span the sample from 1980 onwards, yet banking underwent significant changes in the 1980s. Could it be that we pick up effects of regulation that make it difficult for banks to raise equity? And that these are disproportionally reflected in our estimates because of the large monetary shocks in the early 1980s? To illustrate that this is not the case, we re-run our baseline specification on the sub-sample from 1987 onwards.

[8]One could also conceive of using assets net of loans to predict loan growth. However, this would likely conflate deleveraging with risk-adjustment since non-loan assets have a very different risk profile than loans. Thus it is not clear that assets net of loans would primarily measure a deleveraging effect. By contrast, since C&I loans are only a small proportion of the bank portfolio (10% versus 56% for total loans) we are much less likely to be subject to this bias.

As shown in table 9, we find that the financial dampening channel in this sub-sample is of similar strength. For total assets the sum of coefficients is now -4.88 compared to -4.5 in the baseline estimation and for loans it is -6.99 versus -7.00 in the baseline. This suggests that our mechanism is quantitatively as important post-1987 as over the whole sample.

Kashyap and Stein [2000] document that monetary policy shocks affect large banks much less than small banks. They argue that large banks have an easier time raising equity or other funds when the central bank withdraws reserves from the system. To check if our proposed mechanism is also sensitive to firm size, we estimate our baseline equation using only banks who's lifetime median market share is in the top 5% of the sample. These are shown in table 10. The financial dampening effect is stronger than in our baseline but more imprecisely estimated. This suggest that our proposed mechanism operates at banks across the size spectrum.

In short, we document robust evidence in support of our theory emphasizing asymmetric adjustment costs and financial dampening: banks that shrink their balance sheet are much less responsive to monetary policy shocks than banks that grow their balance sheet. The strength of this channel at the micro-level is economically significant, suggesting that it could also has important effects in the aggregate. We turn to this next.

6 Implications for Investment and Output

How much does financial dampening matter for real activity during the recovery? In the previous section we outlined a illustrative calculation based on our estimates that showed that the same expansionary monetary policy action can have a substantially weaker impact on credit supply under de-leveraging. In this section we formalize that calculation for post-1990 recessions and use estimates from the literature to benchmark the real effects of this channel. Throughout, we focus on the post-1990 recessions and create two simple counterfactual scenarios.

In our first scenario, we compare the effectiveness of monetary policy in recessions to the effectiveness of monetary policy before the recession. We measure relative deleveraging as the difference between asset growth during post-1990 recession minus peak asset growth before the recession (10.6%). We then use our baseline coefficients from table 6 to compute the implied differential loan growth given the actual path of the federal funds rate in post-1990 recessions. This path is plotted in figure 8. Note that this calculation is conservative in the sense that we miss any stimulative effects from non-standard monetary policy.

We initialize this calculation when we observe the first large decline in the federal funds rate coinciding with a significant decline in asset growth. This occurs three quarters before an average post-1990 recession ends. The calculation implies that loan levels two years after the end of the recession would have been 1.86% higher as a result of (standard) monetary policy alone had the economy not been deleveraging. Thus, on average, financial dampening reduced yearly aggregate loan growth by 0.62 percentage points over the course of 3 years.

In our second scenario, we compare the effectiveness of monetary policy in post-1990 recessions to pre-1990 recessions. We measure relative deleveraging as the difference in the total asset growth path pre- and post-1990. Combined with the same interest rate path and our baseline coefficients, this calculation implies that loan levels three years later would have been 1.13% higher as a result of monetary policy alone had the economy not been deleveraging.

To gauge the impact of this credit supply effect on real activity we focus on firm investment, since it is a plausible channel through which lower credit supply growth can affect the economy. Since we do not focus on other margins, such as consumer credit, our estimates should therefore be thought of as a lower bound on the attenuation of monetary policy effectiveness by financial dampening.

To quantify the impact of our estimated credit supply effects on investment, one would need an estimate of the elasticity of investment with respect bank credit supply. Obtaining this elasticity is notoriously difficult since firms can potentially substitute loans as one form of financing with either internal financing through reinvestment of profits or in the case of very large firms through the issuance of bonds or equity. Addressing the issue of whether bank loan supply is easily substitutable is beyond the scope of this study.

However, recent empirical work by Amiti and Weinstein [2013] enables us to provide some back-of-the-envelope calculations on the investment impact of our estimates. Using a unique Japanese dataset that matches firms and their loan volumes to banks, Amiti and Weinstein [2013] are able to estimate the impact of credit supply shocks to firm investment, controlling for loan demand shocks to firms. Even more important, they include the interaction between firm-specific loan-to-asset ratios and their loan supply shock. This allows them to quantify to what degree the investment effects of credit supply differ depending on how large the loan-to-asset ratio of a firm is. The intuition is that firms with high loan-to-asset ratios are more likely to depend on bank credit as an important source of financing and are therefore less likely to be able to substitute to other financing sources. On the other hand, firms with low loan-to-asset ratios such as large U.S. corporations are likely to be able to issue bonds to substitute for bank loans as Adrian, Colla, and Shin [2012] argue. For this section, we follow Amiti and Weinsteins' logic and apply their estimates to our credit supply effects. Thus, our estimates on the impact of restricted loan growth on investment will explicitly take account of the fact that firms can substitute out of loans into other forms of financing. The baseline estimation result in Amiti and Weinstein [2013] imply that

$$\Delta\left(\frac{I_t}{K_t}\right) = [-0.11 + 0.809 \cdot \phi^{L/A}] \times \Delta \ln\left(\frac{L_t^S}{L_{t-1}^S}\right)$$

where the measure $\phi^{L/A}$ is the loan to asset ratio. To apply these estimates to the US data, we use a loan to asset ratio of 0.285. Loan to asset ratios typically differ by firm size. Sufi [2009] reports a loan-to-asset ratio of 0.16 for a random sample of Compustat firms, while data from the Survey of small business finances shows that small firms have average loan-to-asset ratios of about 0.41. Our calibration is a compromise between those two extremes.

As discussed before our first scenario implies a counterfactual loan growth in response to expansionary monetary policy of $\Delta \ln \left(\frac{L_t^S}{L_{t-1}^S}\right)_1 = 0.0186$ if banks would not have been actively deleveraging during post-1990 recessions. As table 11 shows, this implies a cumulative effect on the investment-capital ratio of 0.00223 or 0.223% over three years ($0.00223 = [-0.11 + 0.809 \times 0.285] \times 0.0186$). Using the capital-output ratio of 4.166[9], this implies a cumulative output effect of 0.93 percent over 3 years and an annual output loss of 0.31% through financial dampening.

Thus, four-quarter growth at the end of an average post-1990 recession would have been approximately -1.30% rather than -1.61%, and four-quarter output growth during the first two recovery years would have been approximately 2.26% rather than 1.95%. We get somewhat weaker effects for scenario 2, in which we compare pre- vs. post 1990 recessions. For this case, the cumulative output effect is 0.56% after 3 years or an annual output loss of 0.18%. It is worth emphasizing again that these effects are based solely on the investment margin and abstract from other loan supply effects that are also likely to be quantitatively important.

Beyond gauging whether our credit supply effects imply important aggregate effects, our back-of-the envelope calculations also allow us to characterize important heterogeneities in the real effects as table 11 shows. In particular, output effects at small firms are likely larger since loans are more important source of financing for small firms than for large firms. For large Compustat firms around 70% of debt is financed through bond issuance rather than credit lines as shown by Sufi [2009]. By contrast, small firms rarely issue bonds but instead cover their credit demand mostly through loans from banks. This difference is reflected in different loan-to-asset ratios in table 11. As discussed before, the higher this loan-to-asset ratio, the less substitutable are bank loans and the higher will be the impact of restricted credit supply on investment. Table 11 shows that the same credit supply effect therefore has dramatically different output effects at small compared to large firms in our calculations. Specifically, the cumulative output effect at large firms is very small with output 0.15%

[9] We arrive at this capital-output ratio by assuming Cobb-Douglas production, so that $MPK = \alpha \frac{Y}{K}$. Using $\alpha = 1/3$ and $MPK = 0.08$ from Caselli and Feyrer (2007), we then solve for $\frac{K}{Y}$.

higher two years after the end of a typical post-1990 recession. By contrast, our cumulative output effects at small firms are a much larger 1.71%.

Note that these back-of-the-envelope calculations on the real effects of financial dampening are likely to be conservative due to at least four factors. First, in line with our micro-estimates we focused on bank loans, which as we noted are potentially easily substitutable as a form of financing at large firms. Our results showed however that financial asset growth at banks in general are subject to financial dampening. This would include equity and bonds as a form of financing, which in turn implies that our baseline calibrations overestimate the degree to which firms can substitute out of restricted supply of financing.

Second, we concentrated on banks as the primary financial intermediaries. However, the baseline logic of leverage targeting and therefore financial dampening easily also applies to a much wider range of leveraged financial intermediaries such as hedge funds and dealer-brokers. In fact, Adrian and Shin [2010] and Adrian and Shin [2014] developed their theory of leverage targets with dealer-brokers in mind. If applied to this broad notion of financial intermediaries, the asset side of these intermediaries will include a broad range of assets such as securitized mortgage loans, junk bonds etc and will therefore again be much harder to substitute as a source of financing, rendering financial dampening effects more powerful.

Third, there are likely to be strong reallocation effects induced by financial dampening. Even with a representative bank the misallocation of credit between large and small firms might be worsened since large firms can easily substitute out of bank loans while small firms cannot. This can lower aggregate TFP and therefore have additional aggregate output effects. In addition, our main results in section 5.1 suggest that there is considerable heterogeneity in bank deleveraging. This heterogeneity means that strongly deleveraging banks have a weaker response of loan supply growth in response monetary policy rate reductions. As a consequence, credit rationing of firms that borrow from these banks is stricter than for firms that borrow from banks that do not deleverage much. If firm-bank lending-relationships are important, as for instance argued by Sharpe [1990] Holmstrom and Tirole [1997] or

Williamson [1987], these credit supply effects translate into further misallocation of capital.

Fourth, there are likely to be important general-equilibrium effects that enforce the direct financial dampening effects we modeled and estimated here. For instance, restricted credit growth at banks will likely trigger deleveraging effects at households as modeled by Eggertsson and Krugman [2012] or Guerrieri and Lorenzoni [2012] and therefore reduce aggregate demand. Alternatively, deleveraging at banks and the associated limited credit supply is likely to reduce firms' profits and therefore the net value of their capital which might further reduce their ability to raise loans as in classical financial accelerator models.

7 Conclusion

We document new evidence suggesting that the way the financial sector responds to recessions significantly changed in the last 20 years. Prior to 1990, financial sector leverage remain high after the end of a recession, while in the years since 1990 this leverage strongly and persistently declined. Our stylized facts are valid not only for dealer-brokers as analyzed by Adrian and Shin [2010], but also depository institutions and are not mechanically driven by equity capital at financial intermediaries. We argue that lower financial asset growth at financial intermediaries is the key to understand these new leverage patterns.

To understand the macroeconomic implications of this change in financial sector behavior, we build a new model of financial intermediation centered on leverage targets and asymmetric portfolio adjustment costs. In this theory, banks restrict asset growth to move closer to their leverage target in the aftermath of a financial shock. Because deleveraging is relatively costly, banks will absorb much of the increase in equity from a monetary stimulus to move closer to the leverage target. This reduces the amount of credit supply, and thus dampens the real effects of monetary policy in a deleveraging economy. We call this novel mechanism financial dampening.

We test our baseline theory with micro-data on financial intermediation and found strong and robust support for financial dampening. We also provided illustrative calculations of the magnitude of the direct effect of financial dampening on output growth during recoveries. These suggests that the same monetary policy path could have increased output growth by an additional 0.31 percentage points over three years if banks had not been deleveraging. Thus, financial dampening resulted in a cumulative output loss of 0.93% two years after the end of an average post-1990 recession. This has important implications for monetary policy, as it suggest that policy rate cuts in deleveraging economies are less powerful than standard estimates suggests. Given financial dampening the Fed would need lower policy rates or conduct non-standard monetary policy more aggressively to achieve the same output effect.

There are several promising avenues for further research. First, extending our empirical analysis of financial dampening to a broader class of financial intermediaries than banks would help to clarify the full scope of application of our theory. Second, a quantitative general equilibrium model with our financial dampening mechanism at its heart would be useful for a broader quantitative analysis. Specifically, such a model could be used to structurally estimate the parameters of our asymmetric adjustment cost parameters by matching impulse-responses of post-1990 financial leverage and credit growth in response to monetary policy shocks. We hope that our preliminary results on financial dampening inspire a more extensive analysis.

References

Adrian, T., P. Colla, and H.S. Shin, "Which Financial Frictions? Parsing the Evidence the Financial Crisis 2007-2009," *NBER Macroeconomics Annual 2012*, 2012.

Adrian, Tobias and Hyun Song Shin, "Liquidity and leverage," *Journal of financial intermediation*, 2010, *19* (3), 418–437.

_ and _ , "Procyclical leverage and value-at-risk," *Review of Financial Studies*, 2014, *27* (2), 373–403.

Amiti, Mary and David E Weinstein, “How much do bank shocks affect investment? Evidence from matched bank-firm loan data,” Technical Report, National Bureau of Economic Research 2013.

Bernanke, Ben S, Mark Gertler, and Simon Gilchrist, “The financial accelerator in a quantitative business cycle framework,” *Handbook of macroeconomics*, 1999, *1*, 1341–1393.

Campello, Murillo, “Internal capital markets in financial conglomerates: Evidence from small bank responses to monetary policy,” *The Journal of Finance*, 2002, *57* (6), 2773–2805.

Cerra, Valerie and Sweta Chaman Saxena, “Growth dynamics: the myth of economic recovery,” *The American Economic Review*, 2008, *98* (1), 439–457.

Chodorow-Reich, Gabriel, “The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008–9 Financial Crisis,” *The Quarterly Journal of Economics*, 2014, *129* (1), 1–59.

Coibion, Olivier, “Are the Effects of Monetary Policy Shocks Big or Small?,” *American Economic Journal: Macroeconomics*, 2012, *4* (2), 1–32.

_ , Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia, “Innocent bystanders? Monetary policy and inequality in the US,” Technical Report, National Bureau of Economic Research 2012.

Coval, Joshua and Erik Stafford, “Asset fire sales (and purchases) in equity markets,” *Journal of Financial Economics*, 2007, *86* (2), 479–512.

Eggertsson, Gauti B and Paul Krugman, “Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach*,” *The Quarterly Journal of Economics*, 2012, *127* (3), 1469–1513.

Galí, Jordi, Frank Smets, and Rafael Wouters, “Slow recoveries: A structural interpretation,” *Journal of Money, Credit and Banking*, 2012, *44* (s2), 9–30.

Gertler, Mark and Peter Karadi, “A model of unconventional monetary policy,” *Journal of Monetary Economics*, 2011, *58* (1), 17–34.

Guerrieri, V. and G Lorenzoni, “Credit Crises, Precautionary Savings, and the Liquidity Trap,” *Working Paper, University of Chicago - Booth*, 2012.

Hall, Robert Ernest, “How much do we understand about the modern recession?,” *Brookings Papers on Economic Activity*, 2007, *2007* (2), 13–28.

Hamilton, James D, “Daily monetary policy shocks and new home sales,” *Journal of Monetary Economics*, 2008, *55* (7), 1171–1190.

Holmstrom, B. and J. Tirole, “Financial Intermediation, Loanable Funds and the Real Sector,” *Quarterly Journal of Economics*, 1997.

Iacoviello, Matteo, “Financial Business Cycles,” 2013.

Jermann, Urban and Vincenzo Quadrini, “Macroeconomic Effects of Financial Shocks,” *American Economic Review*, 2012, *102* (1), 238–71.

Kashyap, Anil K and Jeremy C Stein, “The impact of monetary policy on bank balance sheets,” in “Carnegie-Rochester Conference Series on Public Policy,” Vol. 42 Elsevier 1995, pp. 151–195.

_ and _ , “What do a million observations on banks say about the transmission of monetary policy?,” *American Economic Review*, 2000, pp. 407–428.

Kim, Jinill and Francisco J Ruge-Murcia, “How much inflation is necessary to grease the wheels?,” *Journal of Monetary Economics*, 2009, *56* (3), 365–377.

Landier, Augustin, David Sraer, and David Thesmar, “Banks’ Exposure to Interest Rate Risk and The Transmission of Monetary Policy,” Technical Report, National Bureau of Economic Research 2013.

Midrigan, Virgiliu and Thomas Philippon, "Household leverage and the recession," 2011.

Myers, Stewart C and Nicholas S Majluf, "Corporate financing and investment decisions when firms have information that investors do not have," *Journal of financial economics*, 1984, *13* (2), 187–221.

Peek, Joe and Eric S Rosengren, "Collateral damage: Effects of the Japanese bank crisis on real activity in the United States," *American Economic Review*, 2000, pp. 30–45.

Reinhart, Carmen M and Kenneth S Rogoff, "This time is different: A panoramic view of eight centuries of financial crises," Technical Report, National Bureau of Economic Research 2008.

Romer, Christina D and David H Romer, "A New Measure of Monetary Shocks: Derivation and Implications," *The American Economic Review*, 2004, *94* (4), 1055–1084.

Sharpe, S., "Assymetric information, bank lending and implicit contracts: a stylized model of customer relationships," *Journal of Finance*, 1990.

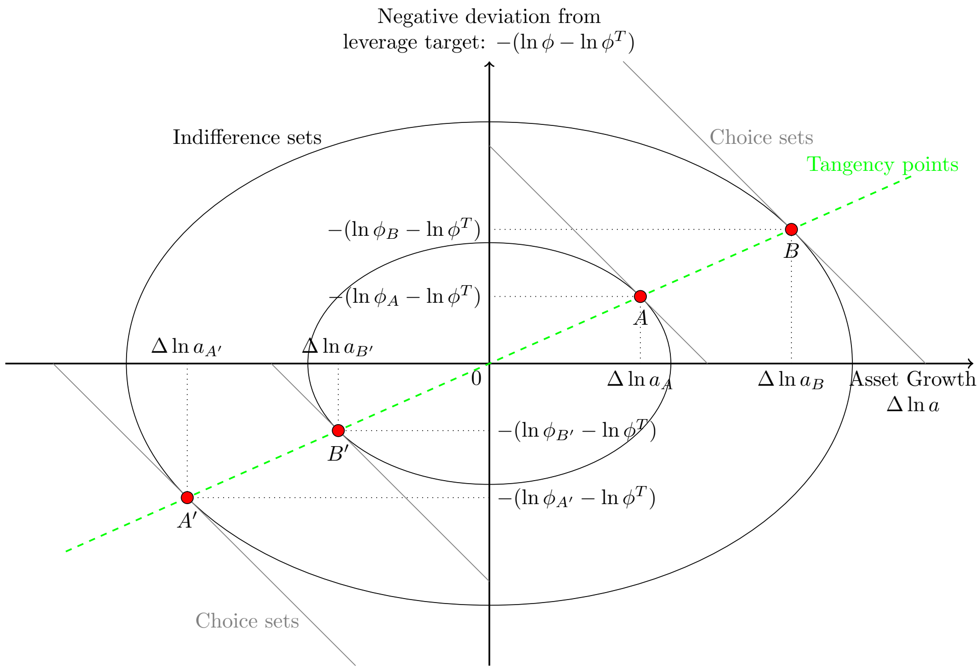
Sufi, A., "Bank Lines of Credit in Corporate Finance: An Empirical Analysis," *Review of Financial Studies*, 2009.

Tenreyro, Silvana and Gregory Thwaites, "Pushing on a string: US monetary policy is less powerful in recessions," 2013.

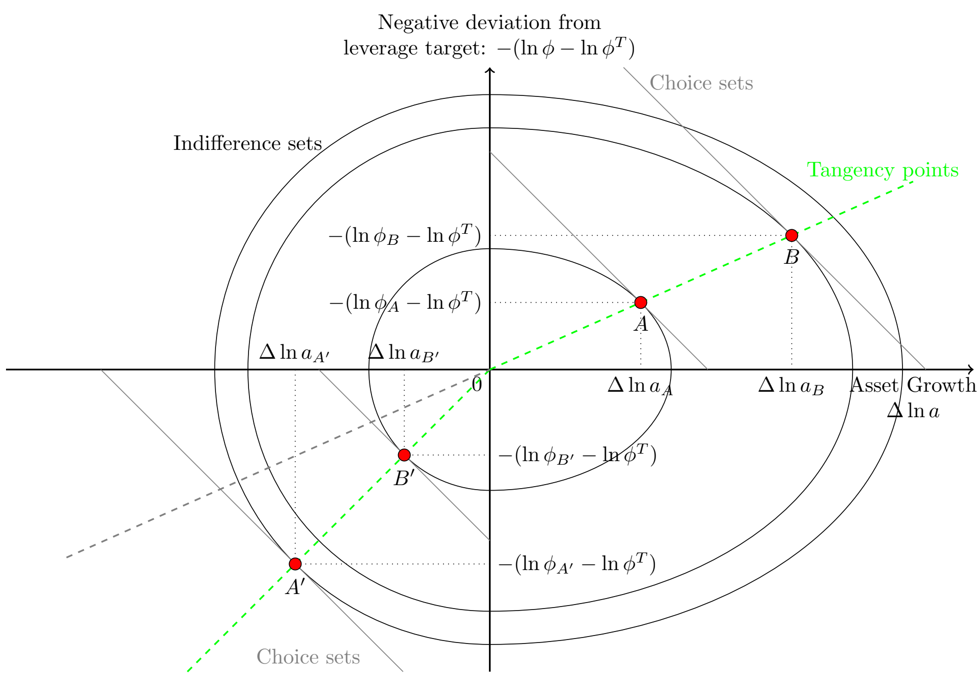
Vavra, Joseph, "Inflation dynamics and time-varying uncertainty: New evidence and an ss interpretation," *The Quarterly Journal of Economics, forthcoming*, 2013.

Williamson, S., "Costly Monitoring, Loan Contracts and Equilibrium Credit Rationing," *Quarterly Journal of Economics*, 1987.

8 Figures & Tables



(a) Symmetric adjustment costs



(b) Asymmetric adjustment costs: more costly to sell assets

Figure 1: Financial dampening. Ellipses denote indifferent sets of asset growth and deviations from the leverage targets. The off-diagonal lines denote feasible choices of asset growth and deviations from the leverage target given the current leverage and asset holdings of the bank. With symmetric adjustment costs, the indifference curves are symmetric around the y-axis. When selling assets is more costly, then the indifference curves are bunched closer together to the left of the y-axis. Consequently, the same increase in equity (and thus reduction in leverage) from a monetary policy shock will result in a smaller rise in asset growth when banks lever down (A' to B') than when banks lever up (A to B).

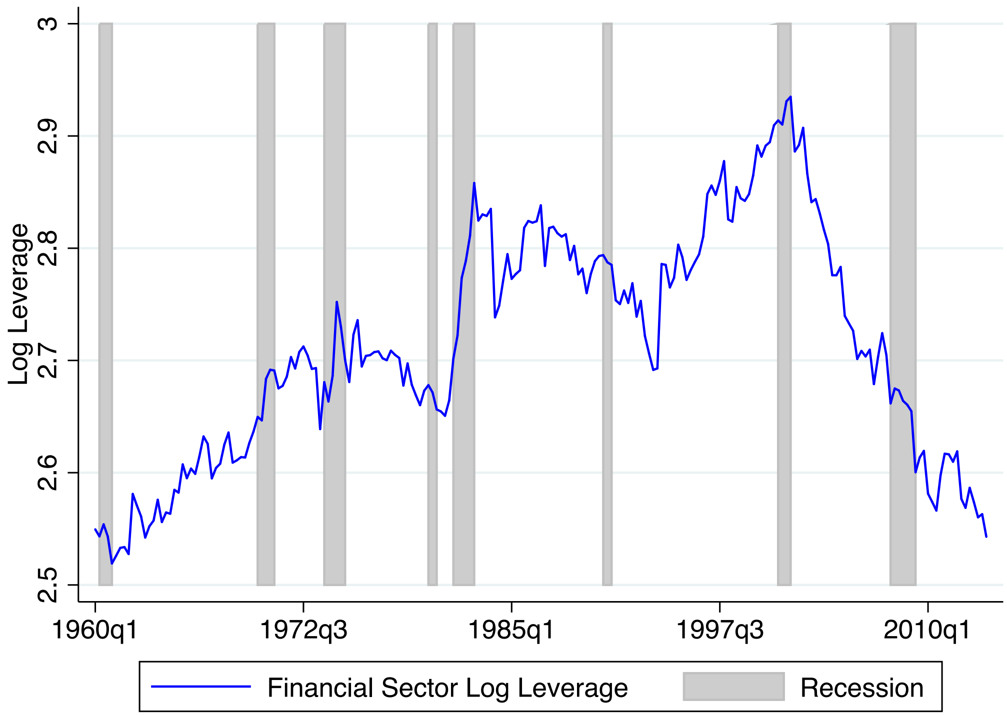


Figure 2: Leverage of the U.S. financial sector. Units are in natural logarithm. Source: U.S. Flow of Funds.

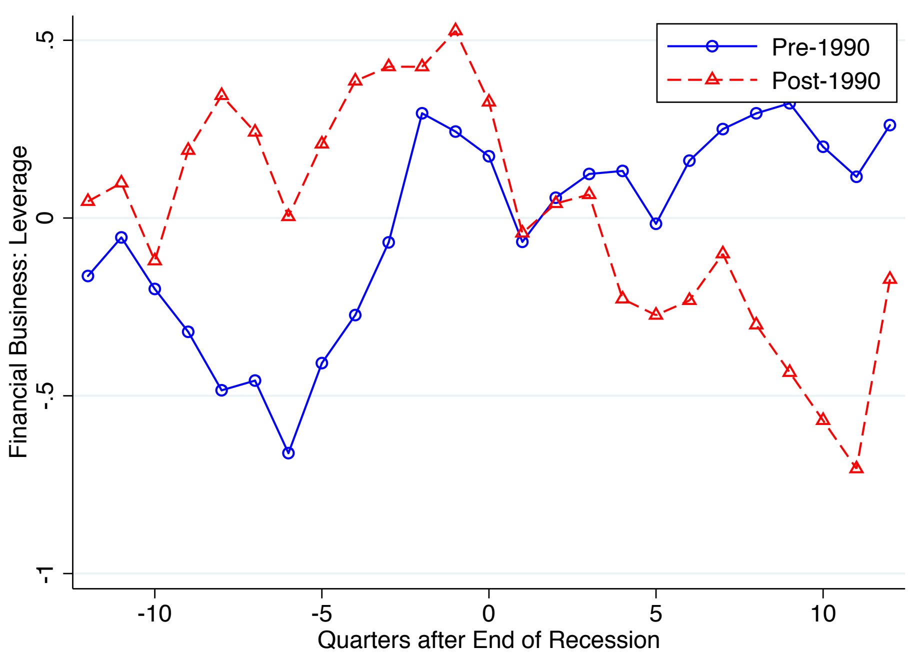
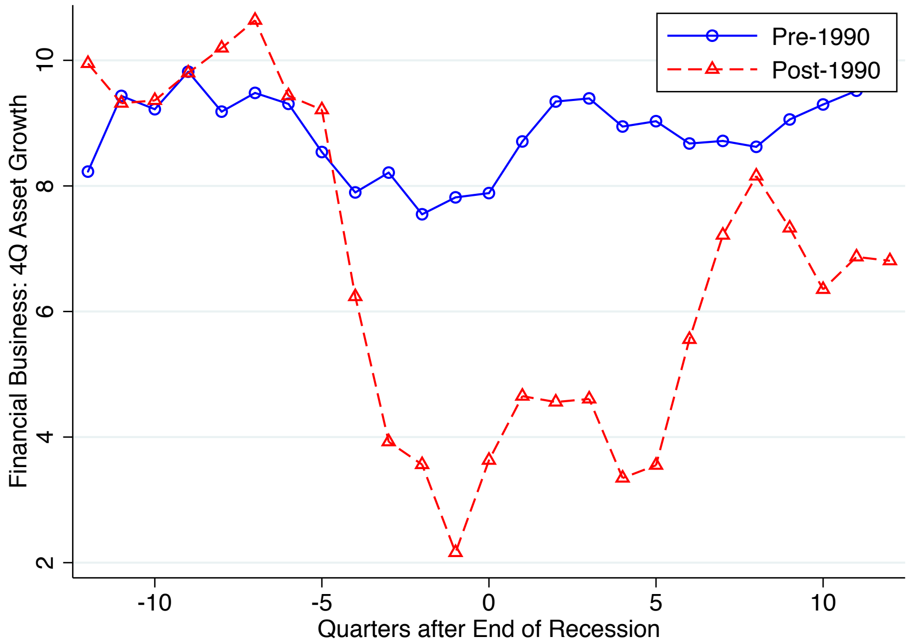
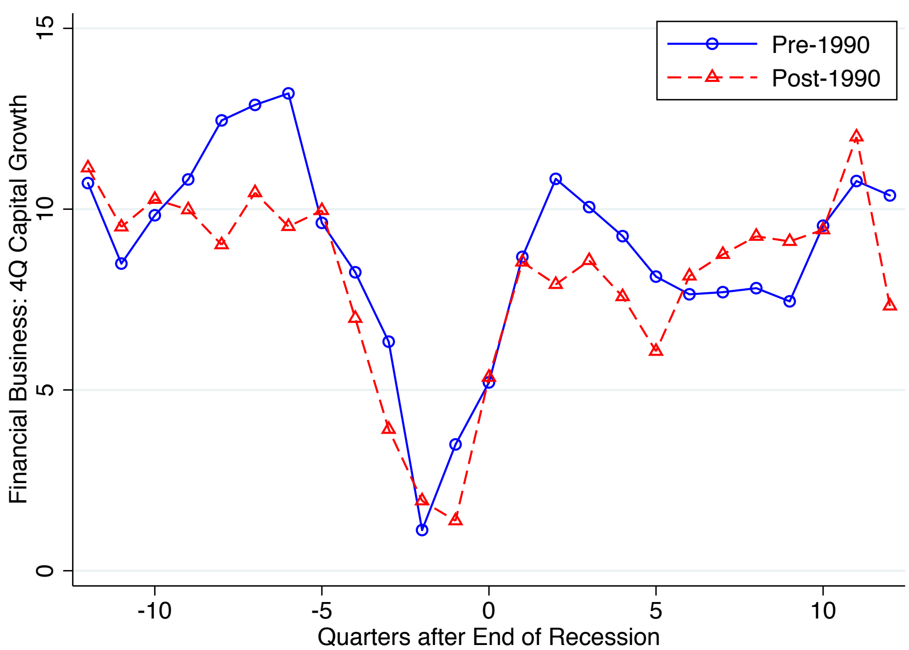


Figure 3: Leverage of the U.S. financial sector averaged over pre- and post-1990 recessions and centered around recession end dates. De-trended using a HP-filter with smoothing-parameter $\lambda = 10000$ and centered at the end of recessions. Source: U.S. Flow of Funds.

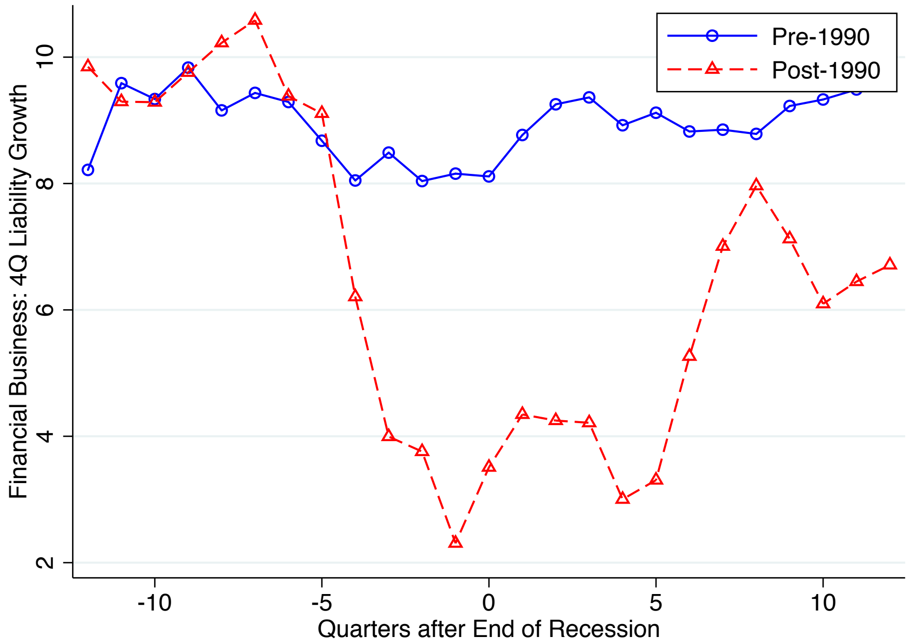


(a) Total assets, financial sector

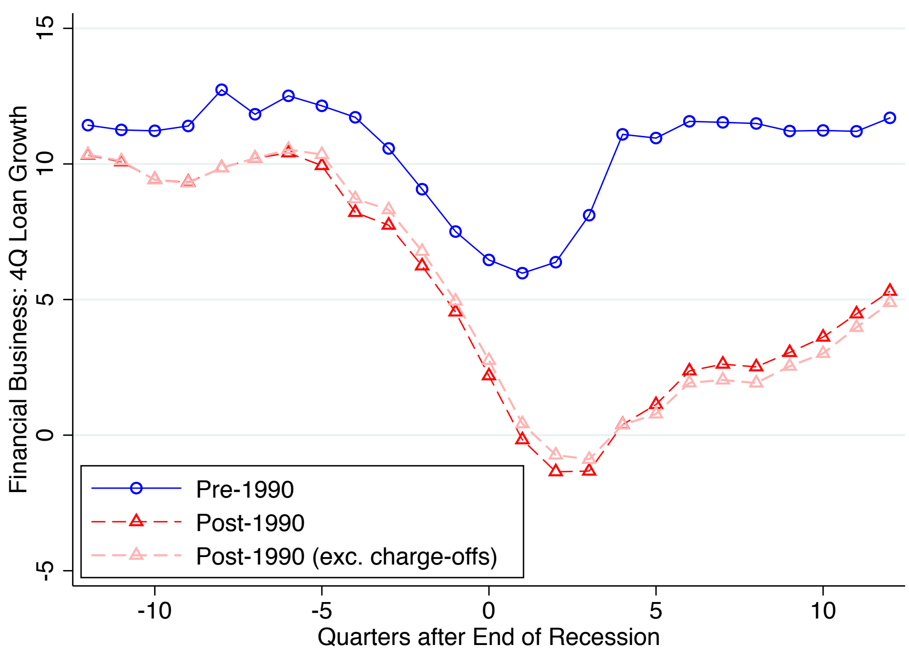


(b) Overall capital, financial sector

Figure 4: Four quarter growth in total assets and equity capital for the U.S. financial sector averaged over pre- and post-1990 recessions and centered around recession end dates. Source: U.S. Flow of Funds.



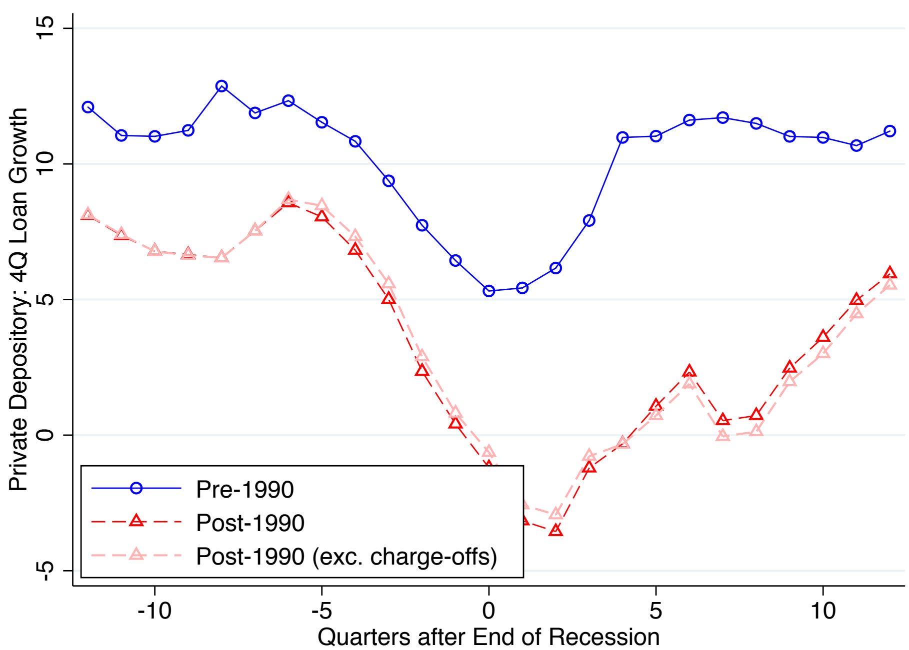
(a) Liabilities, financial sector



(b) Loans, financial sector

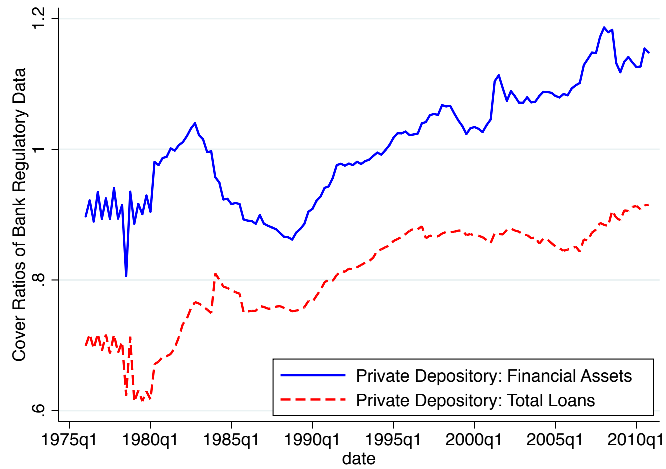
Figure 5: Four quarter growth rates of total liabilities, loans, and loans excluding charge-offs for the U.S. financial sector averaged over pre- and post-1990 recessions and centered around recession end dates. Source: U.S. Flow of Funds and Bank call reports.

(a) Total assets, depository institutions

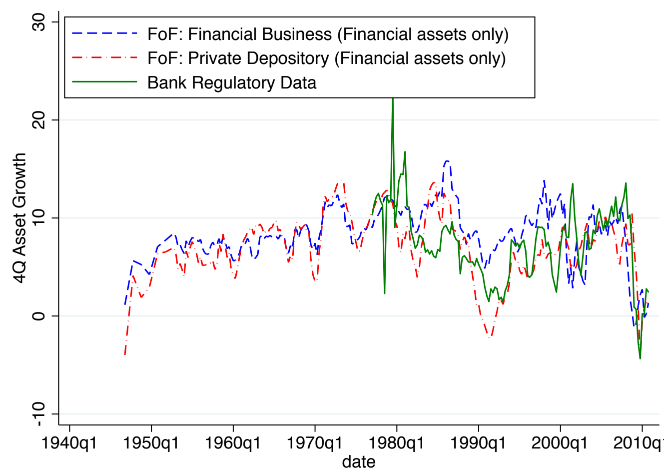


(b) Loans, depository institutions

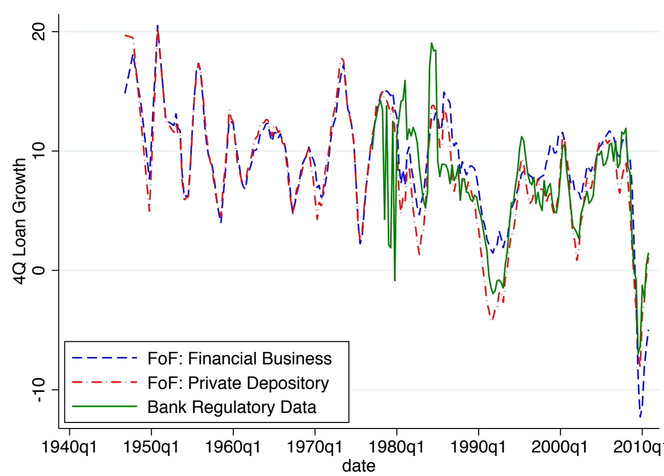
Figure 6: Four quarter growth rates of total assets, loans and loans excluding charge-offs for the U.S. depository institutions averaged over pre- and post-1990 recessions and centered around recession end dates. Source: U.S. Flow of Funds and Bank call reports.



(a) Cover Ratios



(b) Assets: 4Q Growth



(c) Loans: 4Q Growth

Figure 7: Comparison of aggregated commercial bank microdata with flow of funds depository institutions and entire financial sector.

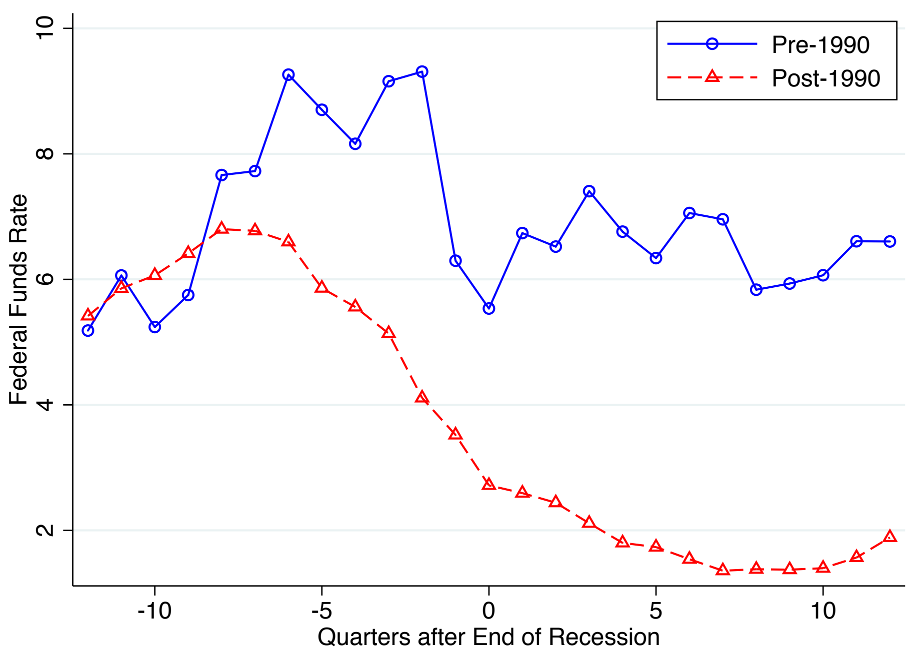


Figure 8: Average federal funds rate in pre- and post-1990 recessions. Plots are centered at the end of recessions.

Table 1: Log leverage of the U.S. financial sector by recession.

Recession	Business Cycle Peak	8 Quarters after Recession	Difference
1960Q2-1961Q1	2.554	2.542	-0.012
1969Q4-1970Q4	2.647	2.704	0.058
1973Q4-1975Q1	2.663	2.708	0.045
1980Q1-1980Q3	2.671	2.702	0.030
1981Q3-1982Q4	2.722	2.795	0.072
1990Q3-1991Q1	2.787	2.722	-0.066
2001Q1-2001Q4	2.910	2.816	-0.094
2007Q4-2009Q2	2.675	2.616	-0.059

Notes: Leverage data is from the Flow of Funds. Business Cycle Peaks are as defined by the NBER business cycle dating committee. For the 1980 recession we tabulate log leverage 4 quarters after the end of the recession (rather than eight quarters), because the 1981-2 recession begins 5 quarters after the 1980 recession.

Table 2: Leverage: pre and post-1990 recessions

	Log level (*100)		HP-filtered log level (*100)				4Q growth (%)	
			$\lambda = 14400$		$\lambda = 1600$			
Indicators								
Recession/Recovery × Post-1990	−9.84**	−3.07**	−3.27*	−1.59**	−1.55	−1.11+	−3.86**	−5.24**
	(1.90)	(0.75)	(1.64)	(0.61)	(1.24)	(0.60)	(1.45)	(1.63)
Recession/Recovery	4.70**	1.37**	1.98	0.84+	1.28	0.71	1.14	1.73
	(1.36)	(0.49)	(1.25)	(0.48)	(1.02)	(0.49)	(1.07)	(1.07)
Dependent Variable								
Lag 1		0.75**		0.70**		0.63**		
		(0.06)		(0.06)		(0.07)		
Lag 4								−0.17
								(0.12)
Recession FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	186	177	186	177	186	177	180	148

Notes: Regression of leverage variables on recession/recovery indicators. The regressions are conducted over a symmetric 25 quarter window around each recession end date. The recession/recovery indicator is equal to one starting one quarter after the business cycle peak and remains equal to one for the 12 quarters after the recession. If another recession begins within those 12 quarters, then that recession and subsequent observations are dropped. The post-1990 indicator is equal to one for all recessions that occurred on or after 1990. All specifications include recession fixed effects. Newey-West standard errors with four lags are used. + p<0.10, * p<0.05, ** p<0.010.

Table 3: Asset, Liabilities and Capital: pre and post-1990 recessions

	Log total assets		Log total liabilities		Log total capital	
	4Q growth	HP-filtered	4Q growth	HP-filtered	4Q growth	HP-filtered
Indicators						
Recession/Recovery × Post-1990	−3.53**	−1.16**	−3.81**	−1.37**	0.33	−0.03
	(1.14)	(0.40)	(1.07)	(0.39)	(1.98)	(0.78)
Recession/Recovery	0.03	−0.07	0.14	−0.06	−1.11	−0.85
	(0.50)	(0.19)	(0.30)	(0.13)	(1.31)	(0.52)
Dependent Variable						
L.yvar		0.83**		0.80**		0.76**
		(0.03)		(0.03)		(0.05)
Recession FE	Yes	Yes	Yes	Yes	Yes	Yes
N	180	177	243	230	180	177

Notes: Regression of asset, liability and capital variables on recession/recovery indicators. 4Q-growth refers to the four-quarter growth rate. The HP-filtered columns use a smoothing parameter of $\lambda = 14400$. The regressions are conducted over a symmetric 25 quarter window around each recession end date. The recession/recovery indicator is equal to one starting one quarter after the business cycle peak and remains equal to one for the 12 quarters after the recession. If another recession begins within those 12 quarters, then that recession and subsequent observations are dropped. The post-1990 indicator is equal to one for all recessions that occurred on or after 1990. All specifications include recession fixed effects. Newey-West standard errors with four lags are used. + p<0.10, * p<0.05, ** p<0.010.

Table 4: Summary Statistics

	Mean	SD	p10	p25	p50	p75	p90	N
Assets	449.3	10505.8	10.7	21.2	47.4	116.4	311.7	1610979
Liabilities	409.9	9603.7	9.54	19.0	42.8	105.4	282.9	1607822
Loans	263.8	5307.2	4.96	10.5	25.3	68.5	194.9	1603663
Log Leverage	2.40	0.38	1.99	2.24	2.44	2.61	2.75	1605666
Cash-to-Asset ratio	7.56	11.9	2.51	3.73	5.79	9.10	14.1	1577897
Median Market Share	0.0074	0.10	0.00035	0.00061	0.0012	0.0024	0.0058	1610979
Log Asset Growth	2.21	5.96	-3.29	-0.73	1.66	4.38	8.02	1575672
Log Loan Growth	2.52	7.70	-4.20	-0.98	1.91	5.13	9.31	1565163
4Q Log Asset Growth	8.66	13.1	-2.74	2.01	6.92	12.7	21.1	1500473

Notes: Summary statistics are computed over the entire sample, 1976-2010. Assets, Liabilities and Loans are in Million Dollars. Cash-to-Asset ratio and median market share are in %. Growth rates are log growth rates multiplied by 100. Growth rates that 5 (original) standard deviations above and below the mean were dropped as in Kashyap and Stein (2000).

Table 5: Forecasting Leverage and Asset Growth

	4Q Asset Growth		4Q Leverage Growth	
	Baseline	Fixed Effects	Baseline	Fixed Effects
Lagged 4Q Asset Growth	0.31**	0.31**	0.21**	0.21**
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	1032321	1032321	1026193	1026193
R^2	0.119	0.131	0.021	0.069
Time-FE	No	Yes	No	Yes

Notes: Forecasting four-quarter leverage growth and asset growth from $t-4$ to t using four-quarter asset growth from $t-8$ to $t-4$. Standard errors are robust and clustered at the bank-level. $^{+}$ p<0.10, * p<0.05, ** p<0.010.

Table 6: Impact of Monetary Policy Shock: Baseline specification

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
$r_{t-0} *$ De-leveraging$_{t-1}$	0.35	0.28	-1.77**	-1.74**	-2.65**	-2.63**
	(0.29)	(0.29)	(0.32)	(0.32)	(0.73)	(0.73)
$r_{t-1} *$ De-leveraging$_{t-2}$	0.03	0.01	-0.83**	-0.82**	-1.71*	-1.70*
	(0.28)	(0.28)	(0.30)	(0.30)	(0.71)	(0.72)
$r_{t-2} *$ De-leveraging$_{t-3}$	-0.09	-0.16	-0.97**	-0.97**	-0.11	-0.14
	(0.28)	(0.28)	(0.32)	(0.32)	(0.69)	(0.69)
$r_{t-3} *$ De-leveraging$_{t-4}$	-0.92**	-0.98**	0.08	0.08	-0.17	-0.13
	(0.26)	(0.26)	(0.30)	(0.30)	(0.71)	(0.71)
$r_{t-4} *$ De-leveraging$_{t-5}$	-0.22	-0.28	-1.15**	-1.11**	-0.44	-0.44
	(0.26)	(0.26)	(0.30)	(0.30)	(0.74)	(0.74)
$r_{t-5} *$ De-leveraging$_{t-6}$	-1.31**	-1.31**	-1.30**	-1.31**	0.72	0.69
	(0.26)	(0.26)	(0.29)	(0.29)	(0.67)	(0.67)
$r_{t-6} *$ De-leveraging$_{t-7}$	-1.66**	-1.65**	-0.99**	-0.92**	-1.53*	-1.52*
	(0.23)	(0.23)	(0.29)	(0.29)	(0.72)	(0.72)
$r_{t-7} *$ De-leveraging$_{t-8}$	0.12	0.11	0.26	0.25	-0.07	-0.06
	(0.22)	(0.22)	(0.25)	(0.25)	(0.61)	(0.61)
$r_{t-8} *$ De-leveraging$_{t-9}$	-0.81**	-0.81**	-0.33	-0.33	-0.28	-0.27
	(0.20)	(0.20)	(0.22)	(0.23)	(0.57)	(0.57)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	968540	968540	972141	972141	932739	932739
R^2	0.081	0.085	0.087	0.088	0.021	0.021
Sum: r * Leverage	0.18	0.48	-1.08	-0.87	-1.44	-1.18
p-val	0.38	0.02	0.00	0.00	0.05	0.11
Sum: r * De-leveraging	-4.50	-4.79	-7.00	-6.87	-6.24	-6.19
p-val	0.00	0.00	0.00	0.00	0.00	0.00
Sum: r * De-lev. * Lev.	-5.32	-5.05	5.35	5.03	2.32	2.20
p-val	0.04	0.05	0.05	0.06	0.74	0.75
Sum: r * Liquidity		0.79		0.36		0.54
p-val		0.00		0.00		0.04
Sum: r * Size		108.24		294.30		434.89
p-val		0.37		0.16		0.13

Notes: The deleveraging variable is lagged four-quarter total asset growth, $\ln \frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. $^{+}$ $p<0.10$, * $p<0.05$, ** $p<0.010$.

Table 7: Impact of Monetary Policy Shock: De-leveraging bank-level de-medianed

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
r_{t-0} * De-leveraging$_{t-1}$	-0.04	-0.09	-0.99**	-0.97**	-1.66*	-1.66*
	(0.33)	(0.33)	(0.35)	(0.35)	(0.80)	(0.80)
r_{t-1} * De-leveraging$_{t-2}$	-0.06	-0.08	-0.14	-0.14	-1.43+	-1.43+
	(0.32)	(0.32)	(0.34)	(0.34)	(0.79)	(0.79)
r_{t-2} * De-leveraging$_{t-3}$	0.37	0.32	-0.70+	-0.71+	-0.49	-0.50
	(0.32)	(0.32)	(0.36)	(0.36)	(0.76)	(0.76)
r_{t-3} * De-leveraging$_{t-4}$	-0.56+	-0.59*	-0.03	-0.04	0.24	0.24
	(0.30)	(0.30)	(0.33)	(0.33)	(0.81)	(0.81)
r_{t-4} * De-leveraging$_{t-5}$	-0.36	-0.40	-0.46	-0.44	-0.04	-0.05
	(0.29)	(0.29)	(0.33)	(0.33)	(0.82)	(0.82)
r_{t-5} * De-leveraging$_{t-6}$	-0.92**	-0.93**	-0.99**	-0.99**	0.44	0.42
	(0.29)	(0.29)	(0.33)	(0.33)	(0.74)	(0.74)
r_{t-6} * De-leveraging$_{t-7}$	-0.89**	-0.88**	-0.53	-0.49	-1.68*	-1.67*
	(0.26)	(0.25)	(0.33)	(0.32)	(0.81)	(0.81)
r_{t-7} * De-leveraging$_{t-8}$	0.53*	0.53*	0.25	0.24	-0.37	-0.38
	(0.24)	(0.24)	(0.28)	(0.28)	(0.68)	(0.68)
r_{t-8} * De-leveraging$_{t-9}$	-0.55*	-0.56*	-0.25	-0.24	-0.24	-0.22
	(0.23)	(0.23)	(0.25)	(0.25)	(0.62)	(0.62)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	968540	968540	972141	972141	932739	932739
R^2	0.081	0.084	0.087	0.088	0.021	0.021
Sum: r * Leverage	-0.24	0.07	-1.01	-0.82	-1.45	-1.20
p-val	0.17	0.71	0.00	0.00	0.02	0.05
Sum: r * De-leveraging	-2.48	-2.67	-3.84	-3.79	-5.23	-5.24
p-val	0.01	0.01	0.00	0.00	0.02	0.02
Sum: r * De-lev. * Lev.	-2.81	-2.61	4.38	4.12	-0.66	-0.79
p-val	0.37	0.40	0.14	0.16	0.93	0.92
Sum: r * Liquidity		0.79		0.35		0.53
p-val		0.00		0.00		0.04
Sum: r * Size		104.33		288.76		436.87
p-val		0.39		0.17		0.13

Notes: The deleveraging variable is lagged four-quarter total asset growth ago minus its bank-level median, $\ln \frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}} - \text{Median}\left(\left\{\ln \frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}\right\}_{t=0}^{T_i}\right)$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. + $p<0.10$, * $p<0.05$, ** $p<0.010$.

Table 8: Impact of Monetary Policy Shock: De-leveraging excluding C&I Loans

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
r_{t-0} * De-leveraging$_{t-1}$	0.17	0.12	-1.44**	-1.42**	-1.93**	-1.91**
	(0.26)	(0.26)	(0.29)	(0.29)	(0.67)	(0.67)
r_{t-1} * De-leveraging$_{t-2}$	0.03	0.01	-0.61*	-0.61*	-1.79**	-1.79**
	(0.25)	(0.25)	(0.28)	(0.28)	(0.66)	(0.66)
r_{t-2} * De-leveraging$_{t-3}$	-0.19	-0.27	-0.72*	-0.72**	-0.29	-0.32
	(0.25)	(0.25)	(0.28)	(0.28)	(0.63)	(0.63)
r_{t-3} * De-leveraging$_{t-4}$	-0.54*	-0.60*	0.01	0.00	0.39	0.43
	(0.25)	(0.25)	(0.27)	(0.27)	(0.66)	(0.66)
r_{t-4} * De-leveraging$_{t-5}$	-0.20	-0.24	-0.86**	-0.82**	-0.02	-0.02
	(0.24)	(0.23)	(0.27)	(0.27)	(0.67)	(0.67)
r_{t-5} * De-leveraging$_{t-6}$	-1.28**	-1.27**	-1.17**	-1.18**	0.31	0.27
	(0.24)	(0.24)	(0.27)	(0.27)	(0.62)	(0.62)
r_{t-6} * De-leveraging$_{t-7}$	-1.55**	-1.55**	-0.93**	-0.87**	-1.95**	-1.94**
	(0.21)	(0.21)	(0.26)	(0.26)	(0.67)	(0.67)
r_{t-7} * De-leveraging$_{t-8}$	0.02	0.00	0.05	0.03	-0.57	-0.57
	(0.20)	(0.20)	(0.23)	(0.23)	(0.56)	(0.56)
r_{t-8} * De-leveraging$_{t-9}$	-0.59**	-0.59**	-0.18	-0.19	0.05	0.07
	(0.19)	(0.19)	(0.20)	(0.20)	(0.52)	(0.52)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	968398	968398	971675	971675	932267	932267
R^2	0.083	0.087	0.087	0.087	0.021	0.021
Sum: r * Leverage	0.18	0.47	-0.94	-0.72	-1.31	-1.02
p-val	0.36	0.03	0.00	0.00	0.05	0.14
Sum: r * De-leveraging	-4.14	-4.39	-5.87	-5.78	-5.80	-5.78
p-val	0.00	0.00	0.00	0.00	0.00	0.00
Sum: r * De-lev. * Lev.	-5.71	-5.39	2.54	2.17	3.71	3.61
p-val	0.02	0.02	0.36	0.44	0.54	0.55
Sum: r * Liquidity		0.77		0.37		0.59
p-val		0.00		0.00		0.02
Sum: r * Size		82.27		326.75		446.43
p-val		0.50		0.14		0.12

Notes: The deleveraging variable is lagged four-quarter total asset growth, where assets are net of C&I loans, $\ln \frac{(Q_{t-1-j}a_{i,t-1-j} - Q^{CI}_{t-1-j}a^{CI}_{i,t-1-j})}{(Q_{t-5-j}a_{i,t-5-j} - Q^{CI}_{t-5-j}a^{CI}_{i,t-5-j})}$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. $^+$ $p<0.10$, * $p<0.05$, ** $p<0.010$.

Table 9: Impact of Monetary Policy Shock: Excluding pre-1987

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
r_{t-0} * De-leveraging$_{t-1}$	0.68*	0.58^{+}	-0.70^{+}	-0.68^{+}	-2.51**	-2.50**
	(0.33)	(0.33)	(0.37)	(0.37)	(0.81)	(0.81)
r_{t-1} * De-leveraging$_{t-2}$	0.66*	0.62*	-0.66^{+}	-0.66^{+}	-1.34^{+}	-1.34^{+}
	(0.31)	(0.31)	(0.35)	(0.35)	(0.81)	(0.81)
r_{t-2} * De-leveraging$_{t-3}$	-0.69*	-0.75*	-1.56**	-1.55**	-0.25	-0.24
	(0.31)	(0.31)	(0.36)	(0.36)	(0.78)	(0.78)
r_{t-3} * De-leveraging$_{t-4}$	-0.97**	-1.03**	0.44	0.44	-0.35	-0.33
	(0.29)	(0.29)	(0.33)	(0.33)	(0.77)	(0.77)
r_{t-4} * De-leveraging$_{t-5}$	-0.52^{+}	-0.54^{+}	-1.15**	-1.13**	-0.28	-0.26
	(0.28)	(0.28)	(0.33)	(0.33)	(0.79)	(0.79)
r_{t-5} * De-leveraging$_{t-6}$	-1.55**	-1.55**	-1.86**	-1.85**	0.21	0.20
	(0.30)	(0.30)	(0.33)	(0.33)	(0.75)	(0.75)
r_{t-6} * De-leveraging$_{t-7}$	-1.93**	-1.94**	-0.21	-0.19	-0.73	-0.74
	(0.27)	(0.27)	(0.33)	(0.33)	(0.73)	(0.73)
r_{t-7} * De-leveraging$_{t-8}$	0.09	0.08	0.25	0.26	-0.64	-0.62
	(0.27)	(0.27)	(0.31)	(0.31)	(0.72)	(0.72)
r_{t-8} * De-leveraging$_{t-9}$	-0.64*	-0.66*	-1.55**	-1.54**	-0.47	-0.47
	(0.27)	(0.27)	(0.29)	(0.29)	(0.71)	(0.71)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	759995	759995	765777	765777	734129	734129
R^2	0.077	0.081	0.092	0.092	0.022	0.022
Sum: r * Leverage	0.37	0.73	-0.70	-0.45	-0.18	0.17
p-val	0.08	0.00	0.01	0.08	0.81	0.83
Sum: r * De-leveraging	-4.88	-5.18	-6.99	-6.90	-6.36	-6.31
p-val	0.00	0.00	0.00	0.00	0.00	0.00
Sum: r * De-lev. * Lev.	-3.95	-3.74	4.33	4.01	3.01	2.88
p-val	0.17	0.21	0.15	0.19	0.69	0.71
Sum: r * Liquidity		0.77		0.48		0.78
p-val		0.00		0.00		0.00
Sum: r * Size		167.73		419.64		641.62
p-val		0.20		0.09		0.06

Notes: Sub-sample including only data from 1987 onwards. The deleveraging variable is lagged four-quarter total asset growth, $\ln \frac{Q_{t-4-j}a_{i,t-4-j}}{Q_{t-8-j}a_{i,t-8-j}}$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. $^{+}$ p<0.10, * p<0.05, ** p<0.010.

Table 10: Impact of Monetary Policy Shock: 5% largest banks

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
r_{t-0} * De-leveraging$_{t-1}$	-0.69	-0.69	-3.81*	-3.72*	-2.86	-2.74
	(1.49)	(1.47)	(1.55)	(1.54)	(2.81)	(2.81)
r_{t-1} * De-leveraging$_{t-2}$	-1.28	-1.06	-0.10	-0.14	-5.45*	-5.32*
	(1.30)	(1.31)	(1.53)	(1.54)	(2.15)	(2.17)
r_{t-2} * De-leveraging$_{t-3}$	-1.94	-1.75	-1.62	-1.69	-0.33	-0.38
	(1.20)	(1.17)	(1.16)	(1.17)	(2.67)	(2.68)
r_{t-3} * De-leveraging$_{t-4}$	-3.06**	-2.90**	-1.89^{+}	-2.04^{+}	-3.08	-3.19
	(1.13)	(1.12)	(1.11)	(1.12)	(2.16)	(2.17)
r_{t-4} * De-leveraging$_{t-5}$	-3.65**	-3.77**	-1.62	-1.62	0.79	0.61
	(1.24)	(1.21)	(1.58)	(1.58)	(2.44)	(2.46)
r_{t-5} * De-leveraging$_{t-6}$	-2.11^{+}	-2.26^{+}	-3.65**	-3.63**	-1.29	-1.63
	(1.18)	(1.17)	(1.30)	(1.32)	(2.30)	(2.30)
r_{t-6} * De-leveraging$_{t-7}$	-3.16**	-3.50**	-0.77	-0.68	-1.93	-1.93
	(1.08)	(1.05)	(1.13)	(1.13)	(2.16)	(2.18)
r_{t-7} * De-leveraging$_{t-8}$	1.05	1.12	-2.02^{+}	-1.92^{+}	0.69	0.65
	(1.04)	(1.02)	(1.14)	(1.15)	(1.68)	(1.68)
r_{t-8} * De-leveraging$_{t-9}$	-0.76	-0.98	-0.79	-0.91	1.99	1.93
	(0.87)	(0.88)	(0.88)	(0.88)	(1.71)	(1.70)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35596	35596	35100	35100	34165	34165
R^2	0.066	0.075	0.031	0.033	0.020	0.021
Sum: r * Leverage	3.48	2.76	1.61	1.56	1.71	2.37
p-val	0.01	0.06	0.37	0.38	0.60	0.50
Sum: r * De-leveraging	-15.60	-15.80	-16.28	-16.35	-11.47	-12.01
p-val	0.00	0.00	0.00	0.00	0.18	0.16
Sum: r * De-lev. * Lev.	-24.46	-18.39	-10.26	-12.55	-23.29	-27.46
p-val	0.02	0.11	0.38	0.30	0.32	0.27
Sum: r * Liquidity		1.61		0.04		1.85
p-val		0.00		0.95		0.05
Sum: r * Size		298.76		516.05		683.46
p-val		0.04		0.03		0.02

Notes: Sub-sample including only the 5% largest banks. The deleveraging variable is lagged four-quarter total asset growth, $\ln \frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. $^{+}$ p<0.10, * p<0.05, ** p<0.010.

Table 11: Investment and output effects of financial dampening

Scenario 1: Recessions vs. Expansions	$\phi^{L/A}$	$\frac{I}{K}$ Effect (% cum.)	Output-effect (% cum.)	Output-effect (% p.a.)
Type of firm				
Representative firm	0.285	0.223	0.93	0.31
Large Compustat firms	0.16	0.036	0.15	0.05
Small firms	0.41	0.412	1.71	0.57
Scenario 2: Pre- vs. Post-1990 Recessions	$\phi^{L/A}$	$\frac{I}{K}$ Effect (% cum.)	Output-effect (% cum.)	Output-effect (% p.a.)
Type of firm				
Representative firm	0.285	0.135	0.56	0.18
Large Compustat firms	0.16	0.021	0.09	0.031
Small firms	0.41	0.25	1	0.35

Notes: Counterfactuals combine observed interest rate policy of Fed in recessions with baseline estimates of financial dampening effects in previous tables. Counterfactual loan supply growth is 1.86% in scenario 1 and 1.13% for scenario 2. For details, see main text. Estimates of the impact of loan supply on investment and output use baseline results from Amiti and Weinstein (2013) on the impact of loan supply on the investment-capital ratio of firms combined with various assumptions on loan-to-asset ratio $\phi^{L/A}$. Calibrated values of loan-to-asset ratios ($\phi^{L/A}$) are from Sufi (2009) and the Survey of Small Business Finances. The third column reports cumulative output effect for 3 years of the described monetary policy or 2 years after the end of the recession, in percentage points. Calibrated capital-output ratio is 4.166, as described in the text. Last column reports annualized output effect.

A Derivation of Econometric Specification

After substituting and grouping:

$$
\begin{aligned}
\frac{\mathrm{d}\ln\frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}}}{\mathrm{d}r_t} = & \underbrace{\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\xi}{1+\xi}\frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}}_{\text{Aggregate effect}} + \underbrace{\left[\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right]}_{\text{Cross-sectional effect: Leverage}} \frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}} \\
& \underbrace{-\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{De-leveraging}}(\ln a_{i,t-1} - \ln a_{i,t-2}) \\
& \underbrace{-\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right]}_{\text{Interaction}}\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}}(\ln a_{i,t-1} - \ln a_{i,t-2}) \\
& \underbrace{-\frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{Noise}}(\nu_t + \varepsilon_{it})
\end{aligned}
$$

Since we cannot measure physical quantities of assets, we do the following manipulation:

$$
\begin{aligned}
\frac{\mathrm{d}\ln\frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}}}{\mathrm{d}r_t} = & \underbrace{\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\xi}{1+\xi}\frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t} + \frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]\left(\ln\frac{Q_{t-1}}{Q_{t-2}}\right)}_{\text{Aggregate effect}} \\
& + \underbrace{\left[\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\psi\xi\mu}{(1+\xi)^2}\left(-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right)\left(\ln\frac{Q_{t-1}}{Q_{t-2}}\right)\right]}_{\text{Cross-sectional effect: Leverage}}\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}} \\
& \underbrace{-\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{De-leveraging}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \\
& \underbrace{-\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right]}_{\text{Interaction}}\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \\
& \underbrace{-\frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{Noise}}(\nu_t + \varepsilon_{it})
\end{aligned}
$$

Subtract average to get:

$$
\begin{aligned}
\frac{\mathrm{d}\ln\frac{Q_t a_{it}}{Q_{t-1}a_{i,t-1}} - \ln\frac{Q_t a_t}{Q_{t-1}a_{t-1}}}{\mathrm{d}r_t} = &\underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]\ln\frac{Q_{t-1}a_{t-1}}{Q_{t-2}a_{t-2}}}_{\text{Aggregate effect}} \\
&+ \underbrace{\left[\frac{1}{1+\xi}\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\psi\xi\mu}{(1+\xi)^2}\left(-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right)\left(\ln\frac{Q_{t-1}}{Q_{t-2}}\right)\right]}_{\text{Cross-sectional effect: Leverage}}\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}} \\
&- \underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]}_{\text{De-leveraging}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \\
&- \underbrace{\frac{\psi\xi\mu}{(1+\xi)^2}\left[-\frac{\mathrm{d}R_t^Q}{\mathrm{d}r_t}\phi_{t-1}\right]}_{\text{Interaction}}\frac{\phi_{i,t-1}-\phi_{t-1}}{\phi_{t-1}}\ln\frac{Q_{t-1}a_{i,t-1}}{Q_{t-2}a_{i,t-2}} \\
&\underbrace{-\frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1}\right]\nu_t - \frac{\psi\xi}{(1+\xi)^3}\left[-\frac{\mathrm{d}\ln R_t^Q}{\mathrm{d}r_t}\phi_{i,t-1} + \frac{\mathrm{d}\ln\frac{Q_t}{Q_{t-1}}}{\mathrm{d}r_t}\right]\varepsilon_{it}}_{\text{Noise}}
\end{aligned}
$$

B Long Results Tables

Table 12: Impact of Monetary Policy Shock: Baseline specification

	Asset Growth		Loan Growth		C&I Loan Growth	
	Baseline	Controls	Baseline	Controls	Baseline	Controls
$r_{t-0} * \text{Leverage}_{t-1}$	0.38^{**}	0.33^{**}	-0.32^{**}	-0.30^{**}	-0.86^{**}	-0.88^{**}
	(0.08)	(0.08)	(0.11)	(0.11)	(0.27)	(0.27)
$r_{t-1} * \text{Leverage}_{t-2}$	0.23^{**}	0.25^{**}	-0.59^{**}	-0.56^{**}	-0.04	-0.01
	(0.08)	(0.08)	(0.11)	(0.11)	(0.29)	(0.30)
$r_{t-2} * \text{Leverage}_{t-3}$	-0.06	0.05	0.25^{*}	0.30^{**}	0.51^{+}	0.59^{*}
	(0.09)	(0.08)	(0.12)	(0.11)	(0.28)	(0.28)
$r_{t-3} * \text{Leverage}_{t-4}$	-0.16^{+}	-0.08	0.31^{**}	0.36^{**}	-0.29	-0.32
	(0.08)	(0.08)	(0.11)	(0.11)	(0.29)	(0.29)
$r_{t-4} * \text{Leverage}_{t-5}$	0.32^{**}	0.41^{**}	-0.58^{**}	-0.60^{**}	-0.53^{+}	-0.47
	(0.08)	(0.08)	(0.12)	(0.12)	(0.31)	(0.32)
$r_{t-5} * \text{Leverage}_{t-6}$	-0.07	-0.03	-0.27^{*}	-0.22^{*}	0.55^{+}	0.64^{*}
	(0.08)	(0.08)	(0.11)	(0.11)	(0.29)	(0.29)
$r_{t-6} * \text{Leverage}_{t-7}$	-0.08	-0.10	-0.16	-0.20^{+}	-0.34	-0.32
	(0.08)	(0.08)	(0.11)	(0.11)	(0.30)	(0.30)
$r_{t-7} * \text{Leverage}_{t-8}$	-0.43^{**}	-0.39^{**}	0.37^{**}	0.40^{**}	0.44^{+}	0.47^{+}
	(0.07)	(0.07)	(0.10)	(0.10)	(0.25)	(0.25)
$r_{t-8} * \text{Leverage}_{t-9}$	0.04	0.06	-0.08	-0.05	-0.90^{**}	-0.89^{**}
	(0.07)	(0.07)	(0.09)	(0.09)	(0.26)	(0.26)
$r_{t-0} * \text{De-leveraging}_{t-1}$	0.35	0.28	-1.77^{**}	-1.74^{**}	-2.65^{**}	-2.63^{**}
	(0.29)	(0.29)	(0.32)	(0.32)	(0.73)	(0.73)
$r_{t-1} * \text{De-leveraging}_{t-2}$	0.03	0.01	-0.83^{**}	-0.82^{**}	-1.71^{*}	-1.70^{*}
	(0.28)	(0.28)	(0.30)	(0.30)	(0.71)	(0.72)
$r_{t-2} * \text{De-leveraging}_{t-3}$	-0.09	-0.16	-0.97^{**}	-0.97^{**}	-0.11	-0.14
	(0.28)	(0.28)	(0.32)	(0.32)	(0.69)	(0.69)
$r_{t-3} * \text{De-leveraging}_{t-4}$	-0.92^{**}	-0.98^{**}	0.08	0.08	-0.17	-0.13
	(0.26)	(0.26)	(0.30)	(0.30)	(0.71)	(0.71)
$r_{t-4} * \text{De-leveraging}_{t-5}$	-0.22	-0.28	-1.15^{**}	-1.11^{**}	-0.44	-0.44
	(0.26)	(0.26)	(0.30)	(0.30)	(0.74)	(0.74)
$r_{t-5} * \text{De-leveraging}_{t-6}$	-1.31^{**}	-1.31^{**}	-1.30^{**}	-1.31^{**}	0.72	0.69
	(0.26)	(0.26)	(0.29)	(0.29)	(0.67)	(0.67)
$r_{t-6} * \text{De-leveraging}_{t-7}$	-1.66^{**}	-1.65^{**}	-0.99^{**}	-0.92^{**}	-1.53^{*}	-1.52^{*}
	(0.23)	(0.23)	(0.29)	(0.29)	(0.72)	(0.72)
$r_{t-7} * \text{De-leveraging}_{t-8}$	0.12	0.11	0.26	0.25	-0.07	-0.06
	(0.22)	(0.22)	(0.25)	(0.25)	(0.61)	(0.61)
$r_{t-8} * \text{De-leveraging}_{t-9}$	-0.81^{**}	-0.81^{**}	-0.33	-0.33	-0.28	-0.27
	(0.20)	(0.20)	(0.22)	(0.23)	(0.57)	(0.57)
$r_{t-0} * \text{De-lev} * \text{Lev.}_{t-1}$	-2.03^{*}	-1.88^{*}	-0.19	-0.25	1.30	1.22
	(0.92)	(0.91)	(1.12)	(1.12)	(2.36)	(2.36)
$r_{t-1} * \text{De-lev} * \text{Lev.}_{t-2}$	-1.70^{+}	-1.66^{+}	2.11^{+}	2.02^{+}	-2.33	-2.36

	(0.91)	(0.93)	(1.09)	(1.08)	(2.48)	(2.48)
$r_{t-2} * \text{De-lev} * \text{Lev.}_{t-3}$	0.41	0.42	-0.46	-0.45	1.19	1.27
	(0.92)	(0.90)	(0.96)	(0.97)	(2.02)	(2.02)
$r_{t-3} * \text{De-lev} * \text{Lev.}_{t-4}$	0.93	0.89	0.79	0.79	-0.05	-0.17
	(0.82)	(0.81)	(1.05)	(1.05)	(2.35)	(2.35)
$r_{t-4} * \text{De-lev} * \text{Lev.}_{t-5}$	-0.89	-0.96	1.21	1.10	0.50	0.51
	(0.75)	(0.75)	(0.97)	(0.96)	(2.16)	(2.16)
$r_{t-5} * \text{De-lev} * \text{Lev.}_{t-6}$	-1.70*	-1.63*	-1.18	-1.18	-2.17	-2.11
	(0.82)	(0.83)	(0.84)	(0.84)	(1.86)	(1.85)
$r_{t-6} * \text{De-lev} * \text{Lev.}_{t-7}$	-0.68	-0.65	1.70*	1.61*	-1.18	-1.20
	(0.61)	(0.61)	(0.81)	(0.81)	(1.80)	(1.80)
$r_{t-7} * \text{De-lev} * \text{Lev.}_{t-8}$	0.85	0.93^{+}	0.66	0.68	0.99	0.99
	(0.56)	(0.55)	(0.62)	(0.62)	(1.33)	(1.33)
$r_{t-8} * \text{De-lev} * \text{Lev.}_{t-9}$	-0.50	-0.52	0.71	0.72	4.07**	4.05**
	(0.42)	(0.42)	(0.47)	(0.47)	(1.19)	(1.19)
$r_{t-0} * \text{Liquidity}_{t-1}$		-0.06		0.02		-0.08
		(0.04)		(0.05)		(0.12)
$r_{t-1} * \text{Liquidity}_{t-2}$		0.06		0.05		0.05
		(0.04)		(0.05)		(0.14)
$r_{t-2} * \text{Liquidity}_{t-3}$		0.22**		0.11^{+}		0.26*
		(0.04)		(0.06)		(0.13)
$r_{t-3} * \text{Liquidity}_{t-4}$		0.18**		0.11*		-0.14
		(0.04)		(0.05)		(0.13)
$r_{t-4} * \text{Liquidity}_{t-5}$		0.20**		-0.11*		0.11
		(0.04)		(0.05)		(0.12)
$r_{t-5} * \text{Liquidity}_{t-6}$		0.08*		0.10^{+}		0.24^{+}
		(0.04)		(0.06)		(0.13)
$r_{t-6} * \text{Liquidity}_{t-7}$		-0.01		-0.16**		0.04
		(0.04)		(0.05)		(0.12)
$r_{t-7} * \text{Liquidity}_{t-8}$		0.10**		0.15**		0.08
		(0.04)		(0.05)		(0.12)
$r_{t-8} * \text{Liquidity}_{t-9}$		0.01		0.07		-0.02
		(0.04)		(0.05)		(0.13)
$r_{t-0} * \text{Size}_{t-1}$		110.03**		36.23		62.57
		(33.84)		(57.47)		(63.97)
$r_{t-1} * \text{Size}_{t-2}$		55.43		53.38		42.65
		(43.91)		(73.04)		(69.79)
$r_{t-2} * \text{Size}_{t-3}$		-41.86		86.91^{+}		168.07*
		(25.83)		(51.43)		(77.75)
$r_{t-3} * \text{Size}_{t-4}$		10.29		50.29		88.21^{+}
		(28.96)		(41.93)		(46.42)
$r_{t-4} * \text{Size}_{t-5}$		-40.78^{+}		-17.58		1.24
		(21.22)		(36.58)		(49.23)
$r_{t-5} * \text{Size}_{t-6}$		-10.39		0.54		38.97
		(22.59)		(21.56)		(29.45)

$r_{t-6} * \text{Size}_{t-7}$		-4.85		16.56		18.56
		(20.48)		(49.18)		(54.78)
$r_{t-7} * \text{Size}_{t-8}$		19.51		91.88^{**}		71.61
		(20.04)		(32.93)		(46.31)
$r_{t-8} * \text{Size}_{t-9}$		10.86		-23.92		-56.99
		(24.27)		(33.74)		(37.39)
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank-FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	968540	968540	972141	972141	932739	932739
R^2	0.081	0.085	0.087	0.088	0.021	0.021
Sum: Shock * Leverage	0.18	0.48	-1.08	-0.87	-1.44	-1.18
SD*Sum	0.06	0.17	-0.37	-0.30	-0.49	-0.40
χ^2-test	0.76	5.11	18.30	12.15	3.94	2.59
p-val	0.38	0.02	0.00	0.00	0.05	0.11
Sum: Shock * De-leveraging	-4.50	-4.79	-7.00	-6.87	-6.24	-6.19
SD*Sum	-0.48	-0.51	-0.79	-0.77	-0.71	-0.70
χ^2-test	32.49	36.39	74.59	72.13	11.55	11.36
p-val	0.00	0.00	0.00	0.00	0.00	0.00
Sum: Shock * De-lev. * Lev.	-5.32	-5.05	5.35	5.03	2.32	2.20
SD*Sum	-0.27	-0.25	0.27	0.25	0.11	0.11
χ^2-test	4.27	3.74	3.95	3.47	0.11	0.10
p-val	0.04	0.05	0.05	0.06	0.74	0.75
Sum: Shock * Liquidity		0.79		0.36		0.54
SD*Sum		1.95		0.84		1.25
χ^2-test		111.29		9.73		4.41
p-val		0.00		0.00		0.04
Sum: Shock * Size		108.24		294.30		434.89
SD*Sum		0.27		0.73		1.10
χ^2-test		0.79		1.96		2.35
p-val		0.37		0.16		0.13

Notes: The deleveraging variable is lagged four-quarter total asset growth, $\ln \frac{Q_{t-1-j} a_{i,t-1-j}}{Q_{t-5-j} a_{i,t-5-j}}$. The dependent variables are four-quarter asset growth relative to median asset growth in a year and four quarter loan growth relative to median asset growth in a year. The "baseline" columns (1) and (3) report estimates from equation (16) without any controls. The "control" columns include controls for liquidity (cash-to-asset ratio) and size (median market share over lifetime). Similarly to the leverage variables, these control variables enter with lag $t-4$ and are also interacted with the monetary shocks. All regressions include bank fixed effects and time dummies as indicated. The bottom rows tabulate the sum of coefficients for the monetary shock interacted with a variable of interest. Standard errors are robust and clustered at the bank-level. $^{+}$ $p<0.10$, * $p<0.05$, ** $p<0.010$.