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Abstract

One of the most robust stylized facts in macroeconomics is the forecasting power of the term spread for future real activity. We propose a possible causal mechanism for the forecasting power of the term spread, deriving from the balance sheet management of financial intermediaries and the risk-taking channel of monetary policy. Monetary tightening leads to the flattening of the term spread, reducing net interest margin and credit supply. We provide empirical support for the risk-taking channel.

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Risk-Taking Channel of Monetary Policy*

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Abstract

One of the most robust stylized facts in macroeconomics is the forecasting power of the term spread for future real activity. We propose a possible causal mechanism for the forecasting power of the term spread, deriving from the balance sheet management of financial intermediaries and the "risk-taking channel of monetary policy". Monetary tightening leads to the flattening of the term spread, reducing net interest margin and credit supply. We provide empirical support for the risk-taking channel.

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1 Introduction

A traditional view in monetary economics is that interest rates are transmitted via the money demand function, and that the level of interest rates affects real consumption and investment. However, beginning in the mid-1980s, the relationship between money and economic activity became highly unstable as rapid changes in the financial system started to change the nature and composition of monetary aggregates.

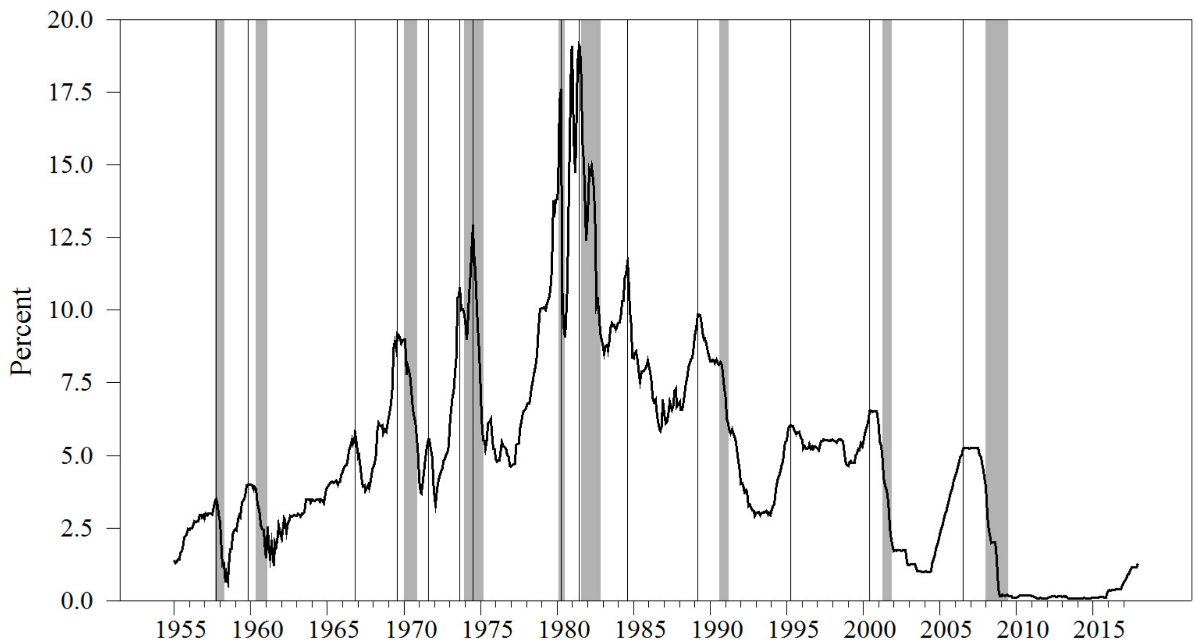
As a result, theories of monetary transmission that explicitly include quantities have lost prominence. Instead, attention has turned to expectations-based channels of monetary policy, which emphasize the expectations theory of the yield curve and the role of expected future short term interest rates in determining the long-term interest rate.

In this paper, we re-examine the transmission of monetary policy to the real economy by connecting two strands of literature that have thus far been largely separate: the forecasting power of the term spread for future real activity and the balance sheet management of financial intermediaries.

One of the most robust features of macroeconomics is the forecasting power of the term spread for future real activity, with an inverted yield curve being a harbinger of recessions within a 12 to 18 month period (see Arturo Estrella and Gikas Hardouvelis (1989, 1991), Campbell Harvey (1989), and James Stock and Mark Watson (1989, 1993)). Since 1955, twelve recessions have occurred, each of which has been preceded by an inversion of the yield curve. Conversely, there has only been one episode in the United States since 1955 where an inversion of the yield curve in 1966 was not followed by a recession (however, that episode was followed by an increase in unemployment). In addition, the yield curve has been demonstrated to predict recessions even prior to 1955 (Michael Bordo and Joseph Haubrich (2004)), and across countries (Henri Bernard and Stefan Gerlach (1996), and Estrella, Anthony P. Rodrigues, and Sebastian Schich (2003)).

Tobias Adrian and Estrella (2008) link monetary tightening cycles and subsequent economic outcomes to the term spread of interest rates. Figure Figure 1 here is updated from Adrian and Estella (2008) with an expanded time series through the end of 2017. In this plot, monetary

Figure 1. **The Fed Funds rate, end of tightening cycles (grid), and NBER recessions (shading)**

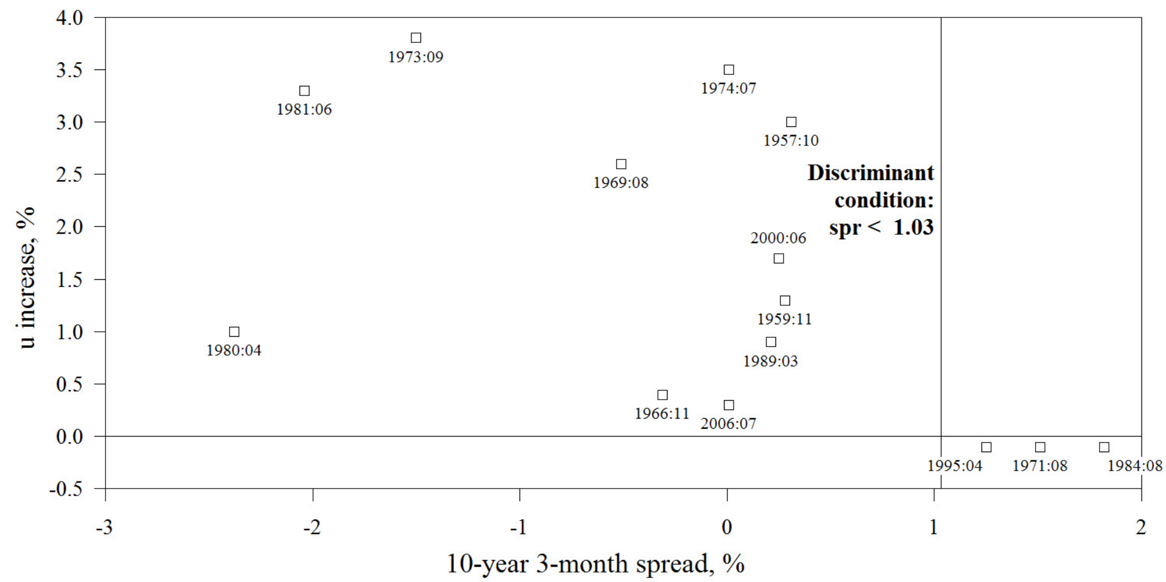


tightening cycles are defined as local peaks of the effective Fed Funds rate.[1] The plot shows fourteen tightening cycles since 1955. Ten of these tightening cycles were followed by recessions within 18 months after the peak of the Fed Funds rate. Of the four monetary cycles that were not followed by a recession, the peak in 1966 was followed by an increase in unemployment (Milton Friedman (1970) argues that 1967 was, in fact, a recession). The three other tightening cycles were "soft landings"; i.e., they were not followed by recessions.

Adrian and Estrella (2008) show that the term spread at the end of the tightening cycles perfectly discriminates between subsequent real outcomes, while various measures of interest

[1]Adrian and Estrella (2008) compute the end of a monetary tightening cycle when either one of these criteria is met: (1) the federal funds rate is higher than at any time from 12 months before to 9 months after and is at least 50 basis points higher than at the beginning of this period, or (2) the federal funds rate is higher than at any time from 6 months before to 6 months after and is 150 basis points higher than the average at these endpoints. The first criterion by itself identifies most of the cycles, but misses three (Aug. 1971, Sept. 1973, Apr. 1980) that involve quick substantial increases in the funds rate.

Figure 2. **The 10-year minus 3-month spread and subsequent unemployment increases**



rate levels do not. The perfect discrimination between subsequent real outcomes is illustrated in Figure 2, which plots the unemployment increases following peaks of the Fed Funds rate against the 10-year/3-month Treasury term spread. The discriminant condition shows that monetary tightening cycles are followed by increases in unemployment whenever the term spread is below 103 basis points, and it is followed by a decline in unemployment in the three cases when the spread is above that level. The level of the nominal interest rate, the real interest rate, or the deviation of the interest rate from its "natural level" (as estimated by Thomas Laubach and John Williams (2003)) does not discriminate between subsequent real outcomes.

The traditional explanation offered for the forecasting power of the term spread rests on the informational value of the yield curve for future short rates. An inverted yield curve is seen as reflecting expectations of low future short rates which, in turn, are attributed to weakness in expected credit demand, diminished inflation expectations, and central bank policy in response to subdued economic conditions. In this sense, the mechanism is purely informational, rather than offering a causal mechanism.

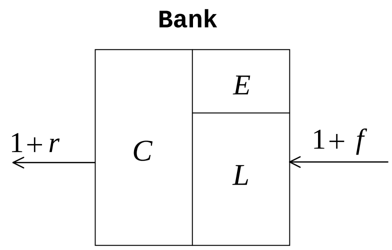
In this paper, we offer a possible causal mechanism that operates via the role of financial intermediaries and their active management of balance sheets in response to changing economic conditions. Banks and other financial intermediaries typically borrow in order to lend. Since the loans offered by banks tend to be of longer maturity than the liabilities that fund those loans, the term spread is indicative of the marginal profitability of an extra dollar of loans on intermediaries' balance sheets. For any risk premium prevailing in the market, the compression of the term spread may mean that the marginal loan becomes uneconomic and ceases to be a feasible project from the bank's point of view. There will, therefore, be an impact on the supply of credit to the economy, and, to the extent that the reduction in the supply of credit has a dampening effect on real activity, a compression of the term spread will be a causal signal of subdued real activity. Adrian and Hyun Song Shin (2010 a, b) argue that the reduced supply of credit also has an amplifying effect due to the widening of the risk premiums demanded by the intermediaries, putting a further downward spiral on real activity.

We explore this hypothesis by first formulating a theory of credit supply in which monetary policy affects credit supply through changes in the net interest margin (NIM) of financial intermediaries. We then explore the empirical evidence to ascertain whether the facts are consistent with our theory. We find strong evidence that backs up our hypothesis. Our results lend weight to an alternative transmission mechanism of monetary policy—the "risk taking channel" — that emphasizes the fluctuations in the supply of credit to the economy. We review the relevant literature later in our paper.

2 Monetary Policy and Credit Supply

We first outline a theory of credit supply by banks in which the policy rate of the central bank enters through the cost of funding for a bank. Our model of bank credit supply as the flip side of a credit risk model, where banks maximize profit subject to a Value-at-Risk (VaR) constraint that limits the probability of bank failure. The VaR constraint stipulates that the probability of bank failure has to be no higher than some (small) threshold level $\alpha > 0$. The particular model of credit risk that drives the VaR constraint will be the workhorse Vasicek (2002) model, which has served as the backbone of the international capital standards set by the Basel Committee for Banking Supervision (BCBS (2005)).

Figure 3. **Notation for bank balance sheet. C is the amount lent out at date 0, financed with equity E and deposits D.**

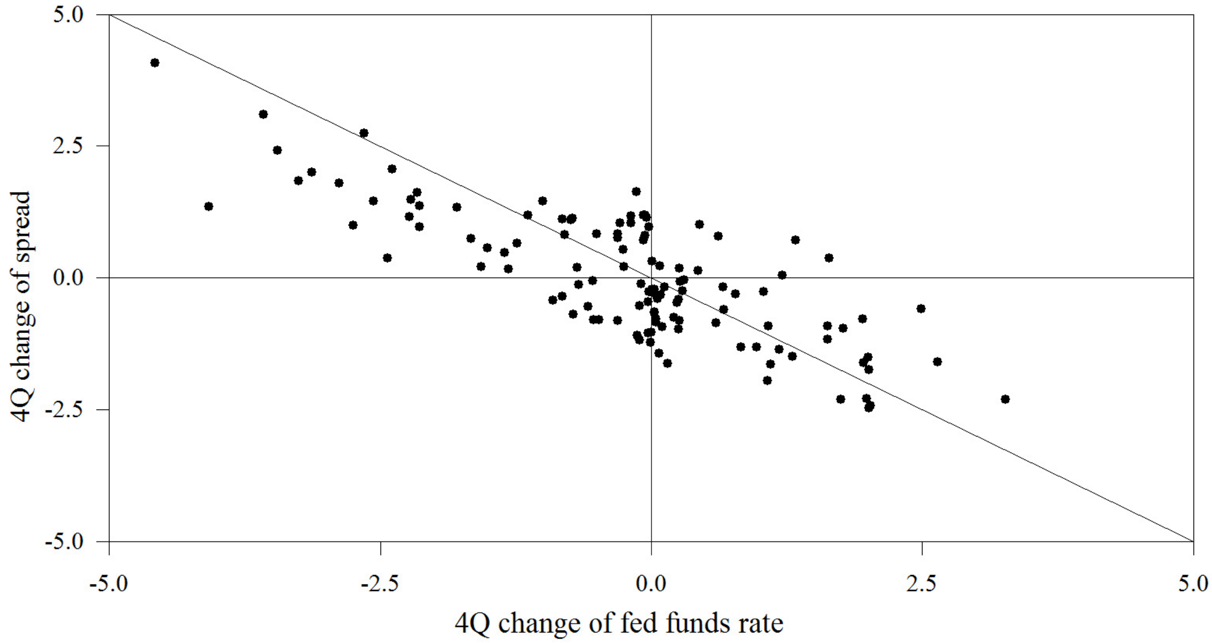


The notation to be used is given in Figure 3. The bank lends out amount C (with "C" standing for "credit") at date 0 at the lending rate r, so that the bank is owed $(1 + r)\,C$ in date 1 (its notional assets). The lending is financed from the combination of equity E and debt funding L, where L encompasses deposit and money market funding. The cost of debt financing is f so that the bank owes $(1 + f)\,L$ at date 1 (its notional liabilities). The difference between the lending rate r and the borrowing rate f can be interpreted as the *net interest margin* (NIM) on lending, which is defined as the difference between the bank's total interest income and its interest expense, expressed as a proportion of the earning assets of the bank.

The net interest margin is an *average* concept defined in terms of the total interest income and expense, rather than in terms of the marginal increase in profit to an additional dollar's lending. However, due to the relatively longer maturity of loans compared to the liabilities of the bank, we may interpret r as being more "sticky" than the funding rate f.

Figure 4 shows that there is a near perfect negative one-to-one relationship between 4-quarter changes of the Fed Funds rate and 4-quarter changes of the term spread (the plot uses data from 1987q1 to 2017q3). Variations in the target affect real activity because they change the profitability of financial intermediaries, thus shifting the supply of credit.

Figure 4. **Changes in the Fed Funds Rate and the Term Spread**



If all the bank's liabilities are short-term, we could see f as closely tracking the central bank's policy rate. In the extreme case where all loans are long term but the bank's funding is short term, the effect of a cut in the central bank policy rate will be to lower the funding cost f while leaving the lending rate r largely unchanged. Therefore a cut in the central bank policy rate will increase in the net interest margin (NIM) of the bank. Conversely, a tightening of monetary policy through a hike in the central bank's policy rate will squeeze the bank's net interest margin. This is the comparative statics exercise that we will examine below. Therefore, we will make the following simplifying assumption for our comparative statics exercise.

Assumption. The lending rate r is constant, but the funding rate f tracks the central bank's policy rate.

We now describe the nature of credit risk on the bank's lending. The economy has a continuum of binary projects, each of which succeeds with probability $1-\varepsilon$ and fails with probability ε. If the project fails, the lender suffers credit loss of 1.[2] The correlation in defaults across loans follows the Vasicek (2002) model. Project j succeeds (so that borrower j repays the loan) when $Z_j > 0$, where Z_j is the random variable

$$Z_j = -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{1}$$

where $\Phi(.)$ is the c.d.f. of the standard normal, Y and $\{X_j\}$ are independent standard normals, and ρ is a constant between zero and one. Y has the interpretation of the economy-wide fundamental factor that affects all projects, while X_j is the idiosyncratic factor for project j. The parameter ρ is the weight on the common factor, which limits the extent of diversification that investors can achieve. Note that the probability of default is given by

$$\begin{aligned} \Pr(Z_j < 0) &= \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j < \Phi^{-1}(\varepsilon)\right) \\ &= \Phi\left(\Phi^{-1}(\varepsilon)\right) = \varepsilon \end{aligned} \tag{2}$$

Banks are able to diversify their loan book by lending small amounts to a large number of borrowers. Conditional on Y, defaults are independent. The bank can remove idiosyncratic risk by keeping C fixed but diversifying across borrowers - that is, by increasing number of borrowers but reducing the face value of individual loans. In the limit, the realized value of assets is function of Y only, by the law of large numbers. The realized value of the bank's assets at date 1 is given by the random variable $w(Y)$ where

$$\begin{aligned} w(Y) &\equiv (1+r)C \cdot \Pr(Z_j \geq 0|Y) \\ &= (1+r)C \cdot \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}(\varepsilon)|Y\right) \\ &= (1+r)C \cdot \Phi\left(\tfrac{Y\sqrt{\rho}-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \end{aligned} \tag{3}$$

[2]We continue with our static interpretation of the model, but we may interpret ε as the constant hazard rate that a particular loan will default in a dynamic context where the bank follows the myopic VaR decision rule.

Then, the c.d.f. of $w(Y)$ is given by

$$\begin{aligned} F(z) &= \Pr(w \le z) \\ &= \Pr\left(Y \le w^{-1}(z)\right) \\ &= \Phi\left(w^{-1}(z)\right) \\ &= \Phi\left(\frac{1}{\sqrt{\rho}}\left(\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\Phi^{-1}\left(\frac{z}{(1+r)C}\right)\right)\right) \end{aligned} \tag{4}$$

The density over the realized assets of the bank is the derivative of (4) with respect to z.

Figure 5 plots the densities over asset realizations, and shows how the density shifts to changes in the default probability ε (left hand panel) or to changes in ρ (right hand panel). Higher values of ε imply a first degree stochastic dominance shift left for the asset realization density, while shifts in ρ imply a mean-preserving shift in the density around the mean realization $1-\varepsilon$.

The bank takes its equity E as given and adjusts the size of its loan book C and funding L so as as to keep its probability of default to $\alpha > 0$.[3] Since the bank is risk-neutral and maximizes profit, the VaR constraint binds whenever expected profit to lending is positive. The constraint is that the bank limits lending so as to keep the probability of its own failure to α. Since the bank fails when the asset realization falls below its notional liabilities $(1+f)L$, the bank's credit supply C satisfies

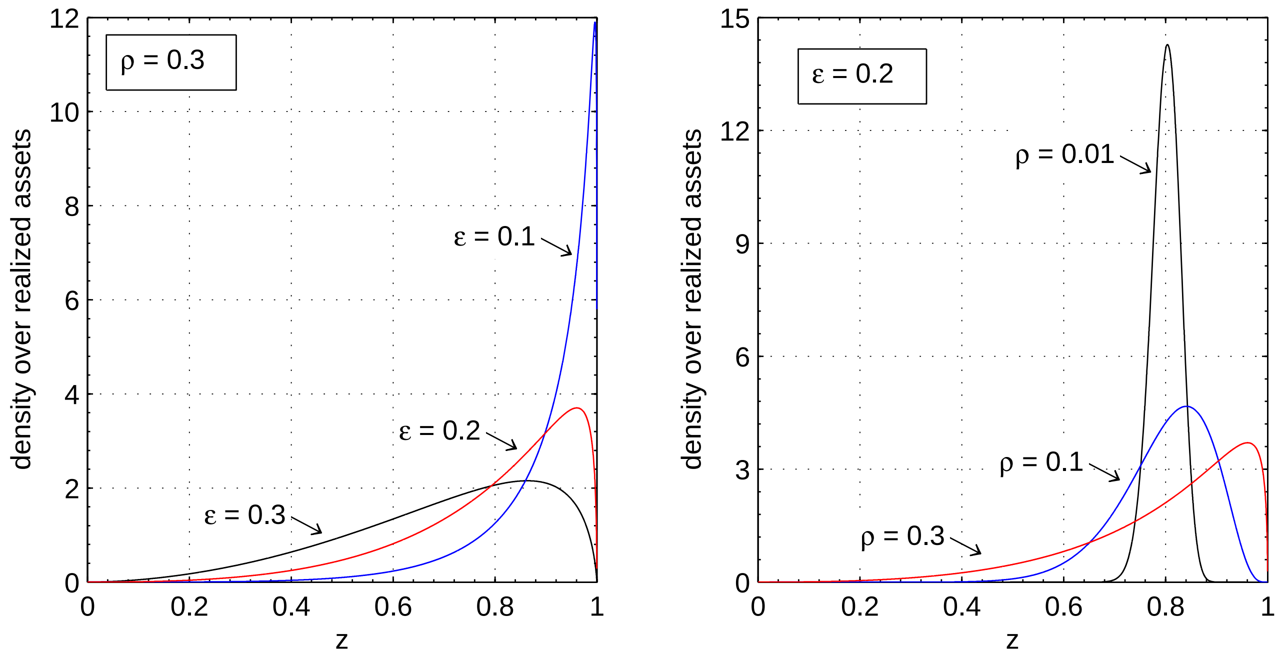
$$\Pr(w < (1+f)L) = \Phi\left(\frac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}\left(\frac{(1+f)L}{(1+r)C}\right)}{\sqrt{\rho}}\right) = \alpha \tag{5}$$

Re-arranging (5), we can derive an expression for the ratio of notional liabilities to notional assets for the bank.

$$\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1+f)L}{(1+r)C} = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{6}$$

[3]See Adrian and Shin (2010a, 2014) for empirical evidence that banks take equity as given and adjust leverage by adjusting the size of their balance sheet.

Figure 5. **The two charts plot the densities over realized assets when $C(1+r)=1$. The left hand charts plots the density over asset realizations of the bank when $\rho=0.1$ and ε is varied from 0.1 to 0.3. The right hand chart plots the asset realization density when $\varepsilon=0.2$ and ρ varies from 0.01 to 0.3.**



From here on, we will use the shorthand φ to denote this ratio of notional liabilities to notational assets. That is,

$$\varphi(\alpha,\varepsilon,\rho) \equiv \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{7}$$

φ can be seen as a normalized leverage ratio, lying between zero and one. The higher is φ, the higher is bank leverage and the greater is credit supply.

We can solve for bank credit supply C and demand for deposit funding L from (6) and the balance sheet identity $C=E+L$ to give

$$C=\frac{E}{1-\frac{1+r}{1+f}\cdot\varphi} \qquad \text{and} \qquad L=\frac{E}{\frac{1+f}{1+r}\cdot\frac{1}{\varphi}-1} \tag{8}$$

Note that both C and L are proportional to bank equity E, so that an aggregation property holds for bank lending and bank funding. Therefore, the leverage of the *bank* and the *banking sector* are interchangeable in our model, and is given by

$$\text{Leverage } = \frac{C}{E} = \frac{1}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{9}$$

The expression for C in equation 8 is the key to our paper. The risk-taking channel of monetary policy rests on the effect of shifts in the central bank's policy rate on the credit supply of the banking sector through changes in the net interest margin of the bank. In equation 8, the net interest margin is given by

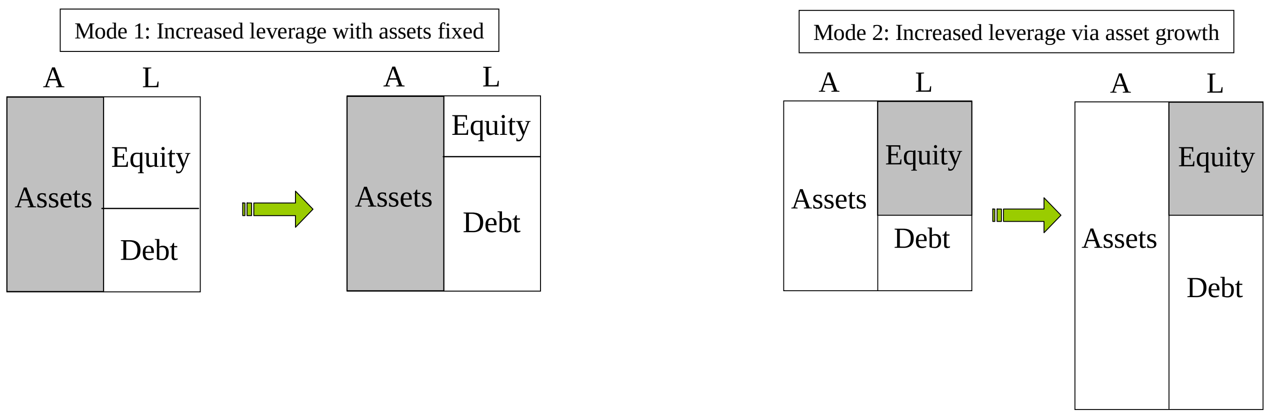
$$\frac{1+r}{1+f} \tag{10}$$

From our earlier assumption, we treat r as being constant in our comparative statics exercise, while treating f as moving one for one with the central bank's policy rate. The final piece of our argument is to show that we can turn the credit risk model on its head, and interpret it as a credit supply function. In a credit risk model, the question is posed as follows. Given a level of credit exposure, how much capital is necessary to meet that exposure? Instead, we turn the question around and ask, given some fixed level of bank equity, how much lending can the bank support given the need to maintain equity to meet the Value-at-Risk? For this final step, we need to argue that bank equity E in equation 8 can be treated as being "sticky", so that we may treat it as an exogenous variable in the comparative statics exercise.

In textbook discussions of corporate financing decisions, the set of positive net present value (NPV) projects is often taken as being given, with the implication that the size of the balance sheet is fixed. Instead, attention falls on how those assets are financed. Leverage increases by substituting equity for debt, such as through an equity buy-back financed by a debt issue, as depicted by the left hand panel in Figure 6.

However, the left hand panel in Figure 6 turns out not to be a good description of the way that the banking sector leverage varies over the financial cycle. For US investment and commercial banks, Adrian and Shin (2010a, 2014) show that leverage fluctuates through changes in the total size of the balance sheet with equity being the pre-determined variable. Hence, leverage and total assets tend to move in lock-step, as depicted in the right hand panel of Figure 6. Figure 7

Figure 6. **Two Modes of Leveraging Up. In the left panel, the firm keeps assets fixed but replaces equity with debt. In the right panel, the firm keeps equity fixed and increases the size of its balance sheet.**

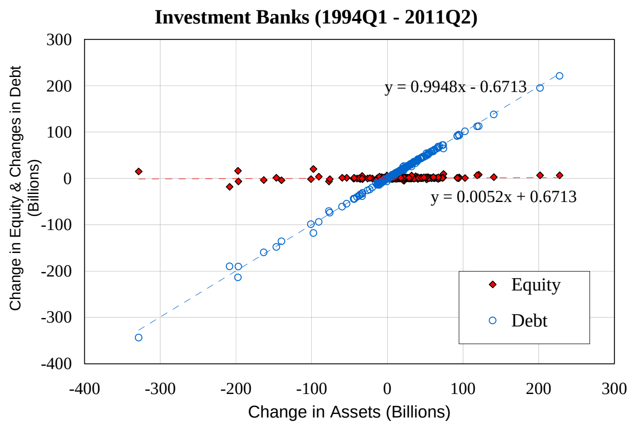


is the scatter plot of the quarterly change in total assets of the sector consisting of the five US investment banks examined in Adrian and Shin (2010a) where we plot both the changes in assets against equity, as well as changes in assets against equity. More precisely, it plots $\{(\Delta A_t, \Delta E_t)\}$ and $\{(\Delta A_t, \Delta D_t)\}$ where ΔA_t is the change in total assets of the investment bank sector at quarter t, and where ΔE_t and ΔD_t are the change in equity and change in debt of the sector, respectively.

We see from Figure 7 that US investment banks conform to the right hand panel of Figure 6 in the way that they manage their balance sheets. The fitted line through $\{(\Delta A_t, \Delta D_t)\}$ has slope very close to 1, meaning that the change in assets in any one quarter is almost all accounted for by the change in debt, while equity is virtually unchanged. The slope of the fitted line through the points $\{(\Delta A_t, \Delta E_t)\}$ is close to zero. Both features capture the picture of bank balance sheet management given by the right hand panel in Figure 6.

Notice that the slopes of the two fitted lines add up to 1 in Figure 7. This is a consequence of the balance sheet identity: $\Delta A_t = \Delta E_t + \Delta D_t$. The sum consisting of the slope of the fitted

Figure 7. **Scatter chart of $\{(\Delta A_t, \Delta E_t)\}$ and $\{(\Delta A_t, \Delta D_t)\}$ for changes in assets, equity and debt of US investment bank sector consisting of Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch and Morgan Stanley between 1994Q1 and 2011Q2 (Source: SEC 10Q filings).**



line through $\{(\Delta A_t, \Delta D_t)\}$ and the slope of the fitted line through $\{(\Delta A_t, \Delta E_t)\}$ is given by

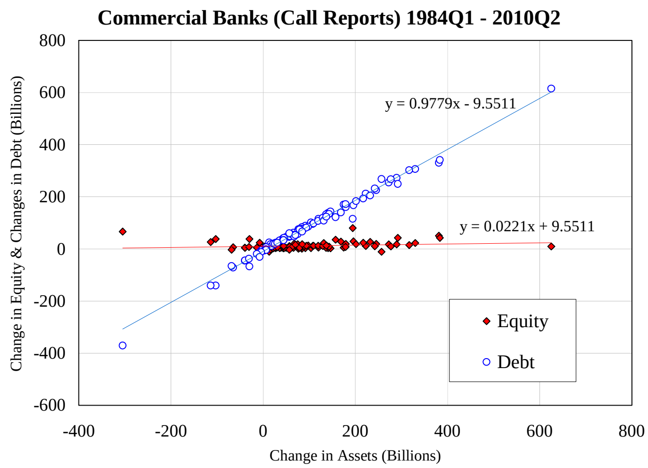
$$\begin{aligned} \text{sum of slopes} &= \frac{Cov\left(\Delta A_t, \Delta D_t\right)}{Var\left(\Delta A_t\right)} + \frac{Cov\left(\Delta A_t, \Delta E_t\right)}{Var\left(\Delta A_t\right)} \\ &= \frac{Cov\left(\Delta A_t, \Delta D_t + \Delta E_t\right)}{Var\left(\Delta A_t\right)} \\ &= 1 \end{aligned}$$

Commercial banks show a similar pattern to investment banks in the way they manage their balance sheets. Figure 8 is the analogous scatter plot of the quarterly change in total assets of the US commercial bank sector which plots $\{(\Delta A_t, \Delta E_t)\}$ and $\{(\Delta A_t, \Delta D_t)\}$ using the FDIC Call Reports. The sample period is between Q1:1984 and Q2:2010.

We see essentially the same pattern as for investment banks, where every dollar of new assets is matched by a dollar in debt, with equity remaining virtually unchanged. Bank lending rises and falls dollar for dollar through a change in debt financing, while equity remaining largely unchanged.

A consequence of this feature is that equity should be seen as the pre-determined variable when modeling bank lending, and we can see banks as choosing their leverage given the fixed level of bank equity. This is the approach we will take, and we summarize our discussion by

Figure 8. **Scatter chart of $\{(\Delta A_t, \Delta E_t)\}$ and $\{(\Delta A_t, \Delta D_t)\}$ for changes in assets, equity and debt of US commercial bank sector at t between 1984Q1 and 2010Q2 (Source: FDIC call reports).**



means of the following proposition.

Proposition 1 *An increase in the central bank's policy rate reduces the net interest margin of the banking sector and reduces overall credit supply by the banking sector.*

This proposition points to the direct impact of the increase in the central bank policy rate, but we may expect feedback effects that result from the decrease in credit supply that operate through market prices. A sharp reduction in bank credit supply will be associated with a spike in credit spreads, as shown by Adrian, Colla and Shin (2013). To the extent that the normalized leverage measure φ depends on market measures of stress, we may expect second or third round effects that operate through the notional leverage of the banking sector.

3 Empirical Investigation

The connection between financial intermediary balance sheet management, the slope of the yield curve, and real economic activity in the United States is investigated via a vector autoregression (VAR) in Table 1. We include quarterly GDP growth as a measure of real activity from the Bureau of Economic Analysis, the 10-year/3-month term Treasury spread from the Federal

Reserve Board, the net interest margin (NIM) of large commercial banks from their Y-9C filings, the quarterly asset growth of shadow banks, the 3-month Treasury yield as a measure of the short term interest rate, and the quarterly change in the Chicago Board Options Exchange Volatility Index (VIX) as a measure of risk. The total assets of shadow banks are defined as the sum of total assets of asset-backed securities issuers (ABS), finance companies, and funding corporations (each component is pulled from the Federal Reserve's Flow of Funds). The VAR includes one lag of each of the variables, as suggested by the Bayesian Information Criterion, and is estimated over the period from 1990Q3 to 2017Q3, where the starting date is determined by availability of the VIX data.

Over the last thirty years, the U.S. financial system has undergone a major transformation, transitioning from a primarily bank-based financial system to one based on market-based intermediaries holding marketable securities. In line with the growth of this market-based financial system, the evidence in Adrian and Shin (2009, 2010b) points to the importance of the total assets of the shadow banking system in conveying information on the credit conditions ruling in the economy. For this reason, we use the total asset growth of shadow banks, rather than commercial banks, as our measure of total lending. Unfortunately, information on the net interest margin is only available for commercial banks. Therefore, we conduct our empirical investigation using a hybrid set of variables – the balance sheet data from the shadow banks, but the profitability information from the commercial banks. To the extent that the pricing conditions apply similarly throughout the economy, our mixed use of data will still be able to capture the interactions we are interested in.

Table 1 exhibits the following logic: an increase in the term spread tends to increase net interest margin. This is fairly mechanical as the term spread directly impacts net interest margin for newly originated loans funded with shorter-term liabilities. Higher net interest margin — a major source of profits for financial intermediaries — leads to an increase in total assets of financial intermediaries: as lending becomes more profitable, the supply of credit is expanded and intermediaries' balance sheets grow. Larger asset growth of intermediaries, in turn, predicts higher GDP growth, which we interpret as a shift in the supply of credit curve. One detail to be held in mind is that the term spread indicates the profitability of the marginal loan that is added to the balance sheet, while the net interest margin is an average concept that applies to the stock of all loans and liabilities on the balance sheet. Thus, we would expect the net interest margin to trail the term spread.

Table 1. **Macro-Financial Intermediary VAR**

	GDP Growth	Term Spread	Net Interest Margin	Asset Growth	Short Rate	VIX Change
GDP Growth (lag)	0.226**	-0.252***	0.003	0.681*	0.207***	1.474
Term Spread (lag)	-0.098	0.892**	0.055***	-0.474	-0.024	0.193
Net Interest Margin (lag)	0.542**	-0.11	0.867***	1.249	0.15	-1.762
Asset Growth (lag)	0.062***	0.006	0.001	0.397***	0.029*	-0.414*
Short Rate (lag)	-0.130**	-0.019	0.032**	0.131	0.906***	0.833
VIX Change (lag)	-0.025**	-0.016**	-0.001	0.016	-0.008	-0.035
Constant	-1.107*	-0.015	0.297**	-3.839*	-0.482	3.506
Observations	109	109	109	109	109	109

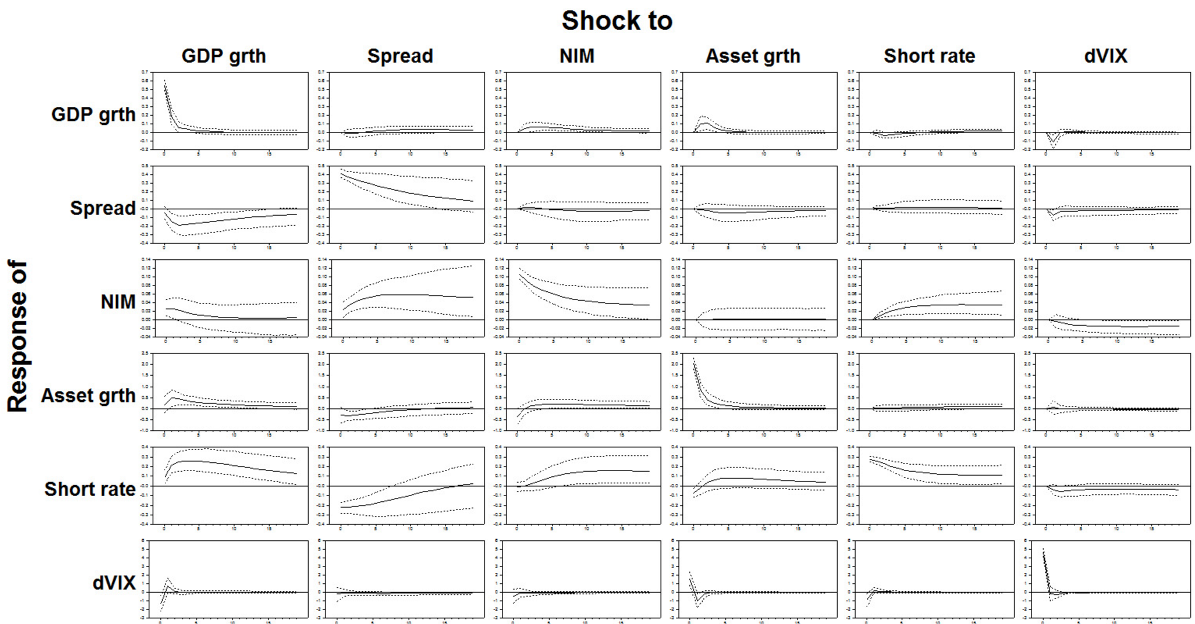
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, Estimation period: 1990Q3 to 2017Q3

Since the VAR in Table 1 includes only one lag of each variable, the significance levels of the coefficients may also be interpreted as a set of Granger causality tests. These tests are consistent with our hypothesis of a causal chain that runs from the term spread to net interest margin to lending volume and finally to real growth.

We also confirm and extend these results by examining impulse response functions. For identification, we apply a Cholesky decomposition using the contemporaneous ordering of variables as listed in Table 1, though the results are not very sensitive to the choice of ordering. Results are presented in Figure 9, which includes all the impulse responses, and in Figure 10, which focuses on the impulse responses corresponding to the causal chain in our basic hypothesis. The figures also include 90% confidence bands computed by Monte Carlo integration.

A positive shock to the term spread leads to statistically significant increases in net interest

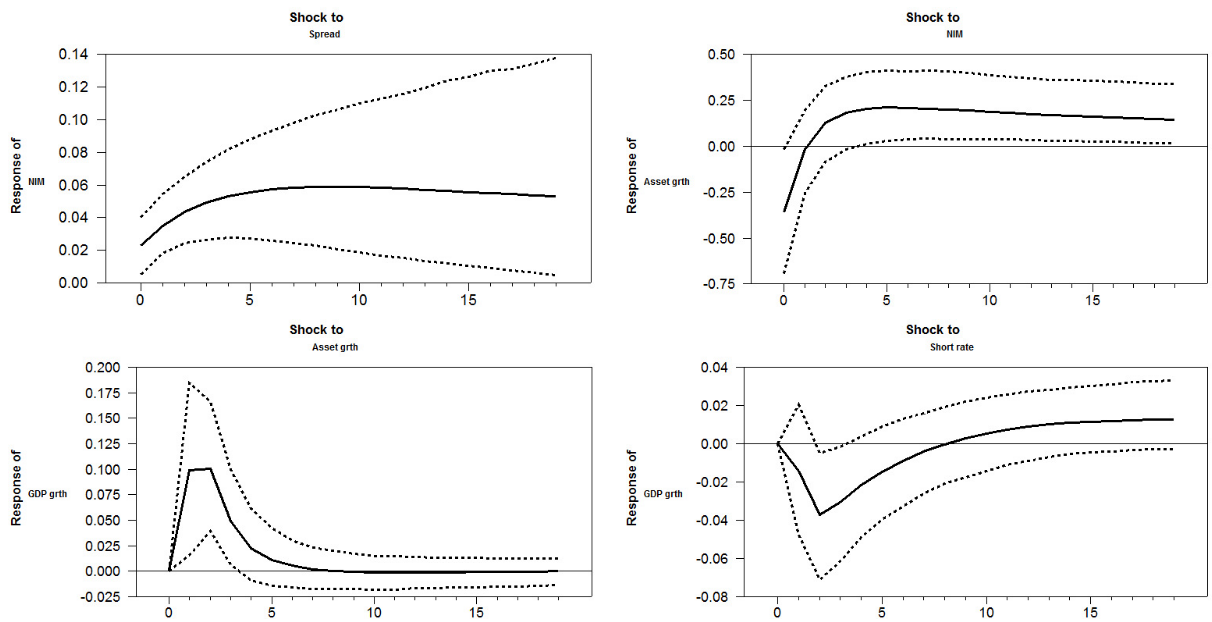
Figure 9. **Impulse-response functions**



margin over a considerable horizon, as shown in the upper left graph in Figure 10. The shape of these responses is also consistent with the fact that average net interest margin tends to trail marginal changes in the term spread, as argued before. In the upper right graph, a positive shock to net interest margin tends to increase lending by the shadow banking sector. In this case, the response is statistically significant after two quarters, perhaps also due to the use of average net interest margin. Finally, a shock to asset growth in shadow banking (lower left) has a quick and significant effect on real economic growth. For comparison, the graph in the lower right shows that the empirical response of real GDP growth to an increase in the short-term interest rate is negative, as traditional theory would suggest, but not at all significant.

These findings from our VAR are at variance with an older literature that examines the link between levels and slopes of interest rates and bank profitability (see Flannery (1983) and Hancock (1985)). The extent to which our results are due to the different time period or due to

Figure 10. **Selected impulse-response functions**



our estimation methodology is a question for future research.

4 Probit Results

Table 2 provides an explanation for the forecasting power of the term spread. Column (1) presents the classic Estrella and Hardouvelis (1991) probit regression with the recession dummy as the dependent variable, and the four-quarter lag of the term spread as the independent variable. The estimation period is 1985Q1 to 2017Q3. The regression shows that the term spread is a highly significant forecasting variable, giving rise to an 18% pseudo R-squared over the sample period.

Column (2) of Table 2, estimated from 1990Q1 to 2017Q3, shows that recessions are associated with low net interest margin in the previous quarter, and with contemporaneous low shadow

Table 2. **Probit Regressions**

	(1)	(2)	(3)
Spread(t-4)	-0.844***		
Net Interest Margin (t-1)		-1.841	
Asset Growth		-0.052	
GDP Growth		-1.776***	
Short Rate		0.229	
VIX		-0.166**	
Spread Decomposition			
$\text{Spread}^{\text{NIM}}$(t-4)			-33.207
$\text{Spread}^{\text{Asset Growth}}$(t-4)			-0.527
$\text{Spread}^{\text{GDP Growth}}$(t-4)			-3.899***
$\text{Spread}^{\text{Short Rate}}$(t-4)			-1.177
$\text{Spread}^{\text{VIX}}$(t-4)			-4.440**
Constant	-0.365	1.626	56.453
Observations	131	111	111
R-Squared	18%	47%	47%

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Estimation period: (1) 1985Q1 to 2017Q3, (2)-(3) 1990Q1 to 2017Q3

bank asset growth and low GDP growth. In fact, 47% of the recession variable is explained by these three variables.

The key insight of Table 2 can be seen in column (3), also estimated from 1990Q1 to 2017Q3. To produce column (3), we first construct five orthogonal components of the term spread: the first is correlated with the net interest margin three quarters in the future; the second is correlated with shadow bank asset growth four quarters in the future, but orthogonal to future net interest margin; the third component is correlated with GDP growth four quarters in the future, but orthogonal to future net interest margin and future asset growth; the fourth component is correlated with future short rates, but orthogonal to future net interest margin, future asset growth, and future GDP growth; and, finally, the fifth component is that part of the term spread correlated with future VIX, but orthogonal to future net interest margin, future asset growth, future GDP growth, and the future short rate (the OLS regressions that are used to construct the five components are reported in Table 3).

Table 3. **Constructing the Term Spread Components**

	Term Spread				
	Spread	$\text{Resid}^{\text{NIM}}$	$\text{Resid}^{\text{Asset}}$	$\text{Resid}^{\text{GDP}}$	$\text{Resid}^{\text{Short}}$
NIM(t+3)	0.055				
Asset growth(t+4)		-0.098***			
GDP growth(t+4)			0.455***		
Short rate(t+4)				-0.195***	
VIX(t+4)					-0.037***
Constant	1.568*	0.126	-0.273**	0.553***	0.726***
Observations	111	111	111	111	111
R-squared	0.1%	6.5%		18.2%	7.7%

*** p<0.01, ** p<0.05, * p<0.1

The interpretation of column (3) of Table 2 is that the term spread forecasts recessions because it forecasts lower future net interest margin, lower future asset growth, and lower future GDP growth. Significantly, there is no additional effect of future short rates that appears significant. Note that by construction, the R-squared of the regression with the five term spread components is equal to the R-squared of regressing the recession indicator directly onto the five variables.

Our results should be contrasted with the literature from the 1990s that examined the consequences of commercial bank lending for the real economy. That earlier literature proved inconclusive, with no clear evidence of a "credit crunch" on the real economy (see Ben Bernanke and Cara Lown (1991) and Anil Kashyap and Jeremy Stein (1994)). One possible reason for the inconclusive results is that commercial banks play the role of a buffer for long-standing customers with pre-arranged credit lines, or for longer-term relationship reasons. The increase of assets on commercial banks' balance sheets in the recent crisis (from the end of 2007 to the middle of 2009) bears out this buffer role of commercial banks. It is for this reason that the total assets of the market-based intermediaries, such as the shadow banks, can be seen to hold more reliable information on overall credit conditions.

5 Implications for Monetary Policy

The evidence that we have documented is supportive of the following transmission channel for monetary policy. The extent to which variations in short term interest rates lead to real economic outcomes depends primarily on the impact on the slope of the yield curve: whenever tighter policy leads to a term spread below a threshold level of 93 basis points, increases in unemployment tend to follow.

Our interpretation of this evidence is an economic mechanism that operates via the balance sheet management of financial intermediaries, who borrow short and lend long. Tighter policy leads to a compression of net interest margin and causes intermediaries to reduce lending. The flatter the term spread at the end of the tightening cycle, the greater the subsequent reduction in lending activity. This has a direct effect on the supply of credit to the real economy.

While the probit regressions presented in Section II document the linkage of the term spread to declines in GDP via intermediary balance sheet management, the VAR results of Section I show that the logic works in both directions. A steep yield curve may be conducive to recovery from an economic slowdown in that it helps to restore the profitability of new lending and, thus, increases the supply of credit to the real economy.

Our empirical evidence is consistent with the "risk taking channel" of monetary policy (see Adrian and Shin (2010b) and Claudio Borio and Haibin Zhu (2008)). The key ingredient to the risk taking channel is that variations in monetary policy affect the effective "risk appetite" of financial intermediaries, thus shifting the supply curve for credit to the real economy. The risk taking channel is distinct from "credit channels" of monetary policy transmission (see Bernanke and Alan Blinder (1992) for the credit channel tied to reserve holdings and Kenneth Kuttner and Patricia Mosser (2002) for an overview of a broader set of credit channels of monetary policy transmission). There has been a renewed focus on the lender in the latest literature (Mark Gertler and Nobuhiro Kiyotaki (2010), and Markus Brunnermeier and Yuliy Sannikov (2014)). Our paper joins this recent group of papers and provides further corroboration of the importance of the supply of credit and its impact on the real economy. The emphasis of these latter papers, and the current paper, is on the supply of credit and the balance sheet condition of the lender, rather than the demand for credit due to fluctuations in the creditworthiness of the borrower.

Our results shed light on the recent debate about the "interest rate conundrum." When the FOMC raised the Fed Funds target by 425 basis points between June 2004 and June 2006 (from from 1 to 5.25 percent), the 10-year Treasury yield only increased by 38 basis points over that same time period (from 4.73 to 5.11 percent). Alan Greenspan (2005) referred to this behavior of longer term yields as a conundrum for monetary policy makers. In the traditional, expectations driven view of monetary transmission, policy works as increases in short term rates lead to increases in longer term rates, which ultimately matter for real activity.

Our findings suggest that the monetary tightening of the 2004-2006 period ultimately did achieve a slowdown in real activity not because of its impact on the level of longer term interest rates, but rather because of its impact on the slope of the yield curve. In fact, while the level of the 10-year yield only increased from 38 basis points between June 2004 and 2006, the term spread declined 325 basis points (from 3.44 to .19 percent). The fact that the slope flattened meant that intermediary profitability was compressed, thus shifting the supply of credit, and hence inducing changes in real activity. The .19 percent at the end of the monetary tightening cycle is below the threshold of .92 percent, and, as a result, a recession occurred within 18 months of the end of the tightening cycle (the NBER dated the start of the recession as December 2007). The 18 month lag between the end of the tightening cycle, and the beginning of the recession is within the historical length.

In our view, a tightening of monetary policy induced by higher short-term rates does not require that long-term rates rise as well in order to obtain real effects. The flattening of the yield curve produced by a rise in short-term rates may be sufficient to affect bank profitability, bank lending, and subsequent real economic activity. Thus, a long-term rate "conundrum" may be perfectly compatible with effective monetary tightening. In fact, monetary policy may be even more powerful, through the channel identified in this article, if long-term rates remain stable in the face of tightening at the short end.

The insights of this paper restore a connection between "quantities" and "prices" in the transmission of monetary policy. However, in contrast to the traditional monetary literature, the crucial ingredient to the relation between quantities and prices is not the money demand function, but rather the connection between interest rate policy and financial intermediary balance sheet management (see Adrian and Shin (2010 a, b)). The key quantities that determine the transmission of monetary policy are intermediary asset growth. Liquidity matters—but, in our framework—liquidity should be defined as the growth rate of assets on key intermediary balance sheets, not the quantity of money.

References

Adrian, Tobias, Paolo Colla and Hyun Song Shin. 2013. "Which Financial Frictions? Parsing the Evidence from the Financial Crisis of 2007-9" *NBER Macroeconomics Annual 2012*, Vol 27 edited by Daron Acemoglu, Jonathan Parker, and Michael Woodford, May 2013, pp. 159 - 214.

Adrian, Tobias, and Arturo Estrella. 2008. "Monetary Tightening Cycles and the Predictability of Economic Activity." *Economics Letters*, 99(2): 260 – 264.

Adrian, Tobias and Hyun Song Shin. 2009. "The Shadow Banking System: Implications for Financial Regulation," *Banque de France Financial Stability Review*, 13, September 2009, pp. 1-10.

Adrian, Tobias and Hyun Song Shin. 2010a. "Liquidity and Leverage," *Journal of Financial Intermediation*, 19(3), July 2010, pp. 418?437.

Adrian, Tobias and Hyun Song Shin. 2010b. "Financial Intermediaries and Monetary Economics" in *Handbook of Monetary Economics*, Benjamin Friedman and Michael Woodford (eds), Elsevier, chapter 12, 601-650, 2010.

Adrian, Tobias and Hyun Song Shin. 2014. "Procyclical Leverage and Value-at-Risk" *Review of Financial Studies*, 27(2), February 2014, pp. 373-403.

Bernanke, Ben S., and Alan S. Blinder. 1992. "The Federal Funds Rate and the Channels of Monetary Transmission." *American Economic Review*, 82(4): 901-921.

Bernanke, Ben S., and Cara Lown. 1991. "The Credit Crunch." *Brookings Papers on Economic Activity*, 2: 205-247.

Bernard, Henri, and Stefan Gerlach. 1996. "Does the Term Structure Predict Recessions? The International Evidence." Working Paper No. 37, Bank for International Settlements.

Bordo, Michael D., and Joseph G. Haubrich. 2004. "The Yield Curve, Recessions and the Credibility of the Monetary Regime: Long Run Evidence 1875-1997." *National Bureau of Economic Research Working Paper* 10431.

Borio, Claudio, and Haibin Zhu. 2008. "Capital Regulation, Risk-taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Bank for International Settlements Working Paper* 268.

Brunnermeier, Markus, and Yuliy Sannikov. 2014. "A Macroeconomic Model with a Financial Sector." *American Economic Review* 104 (2), 379-421.

Estrella, Arturo, and Gikas Hardouvelis. 1989. "The Term Structure as a Predictor of Real Economic Activity." Federal Reserve Bank of New York Research Paper, May.

Estrella, Arturo, and Gikas Hardouvelis. 1991. "The Term Structure as a Predictor of Real Economic Activity." Journal of Finance, 46: 555-576.

Estrella, Arturo, Anthony P. Rodrigues, and Sebastian Schich. 2003. "How Stable is the Predictive Power of the Yield Curve? Evidence from Germany and the United States." *Review of Economics and Statistics*, 85: 629-644.

Flannery, Mark J. 1983. "Interest Rates and Bank Profitability: Additional Evidence." *Journal of Money, Credit and Banking*, 15(3): 355-362.

Friedman, Milton. 1970. "Controls on Interest Rates Paid by Banks." *Journal of Money, Credit and Banking*, 2(1), 15-32.

Gertler, Mark, and Nobuhiro Kiyotaki. 2010. "Financial Intermediation and Credit Policy in Business Cycle Analysis." In *Handbook of Monetary Economics*, Vol. 3, ed. Benjamin Friedman and Michael Woodford. North-Holland.

Greenspan, Alan. 2005. Federal Reserve Board's semiannual Monetary Policy Report to the Congress before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, Feb 16.

Hancock, Diana. 1985. "Bank Profitability, Interest Rates, and Monetary Policy." *Journal of Money, Credit and Banking*, 17(2): 189-202.

Harvey, Campbell R. 1989. "Forecasts of Economic Growth from the Bond and Stock Markets." *Financial Analysts Journal*, September/October: 38-45.

Kashyap, Anil, and Jeremy Stein. 1994. "Monetary Policy and Bank Lending." In *Monetary Policy*, ed. Gregory Mankiw. Chicago, IL: University of Chicago Press.

Kuttner, Kenneth N., and Patricia C. Mosser. 2002. "The Monetary Transmission Mechanism: Some Answers and Further Questions." *Economic Policy Review*, 15-26.

Laubach, Thomas, and J.C. Williams. 2003. "Measuring the Natural Rate of Interest." *Review of Economics and Statistics*, 85: 1063-1070.

Stock, James, and Mark Watson. 1989. "New Indexes of Coincident and Leading Indicators." In NBER *Macroeconomic Annual 1988*, ed. Olivier Blanchard and Stanley Fischer, 351-394.

Stock, James, and Mark Watson. 1993. "A Procedure for Predicting Recessions with Leading Indicators: Econometric Issues and Recent Performance." In *Business Cycles, Indicators, and Forecasting*, ed. James Stock and Mark Watson. Chicago, IL: University of Chicago Press.

Vasiceck, Oldrich. 2002. "The Distribution of Loan Portfolio Value" *Risk*, December 2002, http://www.moodyskmv.com/conf04/pdf/papers/dist_loan_port_val.pdf.