A Note on Leverage and the Macroeconomy*

Khandokar Istiak and Apostolos Serletis†
Department of Economics
University of Calgary
Calgary, Alberta T2N 1N4

Forthcoming in: *Macroeconomic Dynamics*

March 30, 2014

*This paper builds on material from Chapter 2 of Khandokar Istiak's Ph.D. dissertation at the University of Calgary. We would like to thank Lutz Kilian and Robert Vigfusson for making their MATLAB code for the impulse response function test available to us. We also thank two anonymous referees and the members of Khandokar's dissertation committee: Frank Atkins, Philip Chang, Herbert Emery, Ron Kneebone, and David Walls.

†Corresponding author. Phone: (403) 220-4092; Fax: (403) 282-5262; E-mail: Serletis@ucalgary.ca; Web: http://econ.ucalgary.ca/serletis.htm.

Abstract:

In this paper we investigate the relationship between leverage and the level of economic activity in the United States, using quarterly data over the 1951 to 2012 period. We address the question for five different measures of leverage — household leverage, nonfinancial firm leverage, commercial bank leverage, broker-dealer leverage, and shadow bank leverage — making a distinction between traditional banks and shadow banks, the latter being a consequence of financial innovation and deregulation in the financial services industry over the past 30 years. We investigate whether the relationship between leverage and the level of economic activity is nonlinear and asymmetric using slope-based tests as well as tests of the null hypothesis of symmetric impulse responses, recently introduced by Kilian and Vigfusson (2011). Our results inform policymakers about the important distinction between traditional banks and market-based financial intermediaries that have been at the center of the global financial crisis of 2007-2009. They also inform about the macroeconomic effects of the deleveraging process that began in 2008 as well as about the need for countercyclical macroprudential policies to reduce the procyclicality of the financial system.

JEL classification: E32, E44, E52.

Keywords: Financial intermediary leverage; Leverage cycles; Shadow banking system.

1 Introduction

In a recent article, discussing the subprime financial crisis in the United States, Geanakoplos (2010a, p. 101) argues that "governments have long monitored and adjusted interest rates in an attempt to ensure that credit did not freeze up and thereby threaten the economic stability of a nation. However, leverage (equivalently, collateral rates) must also be monitored and adjusted if we are to avoid the destruction that the tail end of an outsized leverage cycle can bring." By 'leverage cycle' he means huge moves in collateral rates and describes it as follows: "there are times when leverage is so high that people and institutions can buy many assets with very little money down and times when leverage is so low that buyers must have all or nearly all of the money in hand to purchase those very same assets. When leverage is loose, asset prices go up because buyers can get easy credit and spend more. Similarly, when leverage is highly constrained, that is, when credit is very difficult to obtain, prices plummet."

The mainstream approach to monetary policy ignores the role of money and that of collateral rates in basic monetary theory and monetary policy analysis. It is based on the new Keynesian model and is expressed in terms of a short-term nominal interest rate, such as the federal funds rate in the United States. However, in the aftermath of the global financial crisis and the Great Contraction, short-term interest rates have hardly moved at all, while central bank policies have been the most volatile and extreme in their entire histories. This has discredited the short term interest rate as an indicator of policy and led central banks to look elsewhere. For example, the Federal Reserve and many central banks around the world have departed from the traditional interest-rate targeting approach to monetary policy and are now focusing on their balance sheet instead, using quantitative measures of monetary policy, such as credit easing and quantitative easing.

Another issue with the current mainstream approach to monetary policy is that it ignores the role of the banking sector. In this approach, financial intermediaries play a passive role that the central bank uses as a channel to implement monetary policy. However, banks and other financial intermediaries have been at the center of the financial crisis of 2008 and there is almost universal agreement that the financial intermediary sector is the engine that drives the level of real economic activity. In this perspective on the importance of financial intermediaries, changes in the short-term interest rate shift the slope of the yield curve, thereby affecting term spreads and the marginal profitability of an extra dollar of loans on banks' balance sheets. This in turn influences the price of risk in the economy, the risk appetite of the banking sector, and banks' balance sheets. See Adrian and Shin (2010, 2011) and Geanakoplos (2010b) for more details.

After the recent financial crisis, collateral rates attracted a great deal of attention and it has been argued that leverage on Wall Street increased to 35 to 1 prior to the recent Great Contraction, but never previously in the history of the United States leverage had exceeded 30 to 1 — see Barnett (2012) for an excellent discussion. For example, in early 2007, Bear

Stearns had a record-high leverage ratio of 35 to 1. Around the same time, (then) major Wall Street investment banks (Goldman Sachs, Morgan Stanley, Merrill Lynch, and Lehman Brothers) together averaged leverage ratios of 30 to 1, up from 20 to 1 in 2003. It has also been argued that leverage is procyclical, being high during good times and low during bad times. For example, Geanakoplos (2010a) shows that asset prices for the housing market and AAA securities rise as leverage increases and fall as leverage declines. Also, Adrian and Shin (2010) argue that "the evidence points to financial intermediaries adjusting their balance sheets actively, and doing so in such a way that leverage is high during booms and low during busts." See also Adrian and Shin (2012).

The relationship between leverage and asset prices (as well as total assets) has been recently investigated in detail by Adrian and Shin (2010) and Geanakoplos (2010a), among others. For example, Adrian and Shin (2010) show that there is a negative relationship between household leverage and total assets using quarterly aggregate Flow of Funds data for the United States from 1963 to 2006. They also investigate the same relationship between changes in leverage and changes in total assets for firms, and do so for three different types: nonfinancial (nonfarm) corporations, commercial banks, and security brokers-dealers. Again, using Flow of Funds data for the United States (from 1963 to 2006), they show a (much less) negative relationship between changes in leverage and changes in total assets for nonfinancial firms. However, they show that commercial banks target a fixed leverage ratio and that the relationship between changes in leverage and changes in total assets is strongly positive in the case of security brokers-dealers, suggesting that financial intermediaries (commercial banks and security brokers and dealers) react to changes in assets prices by changing their stance on leverage.

The positive relationship between changes in leverage and changes in total assets (that is, the procyclical nature of leverage) determines the asset-output relationship. This is consistent with the view in Geanakoplos (2010a) who shows that housing prices and those of AAA securities rise as leverage increases and fall as leverage declines. The rise in asset prices increases consumer expenditure (spending by consumers on durable and nondurable goods and services) through a wealth effect and investment spending (the purchase of new investment goods) through a Tobin q effect, both of which in turn lead to an increase in aggregate demand. As we just noted, the relationships between leverage-total assets (as well as asset prices) and total assets-output have attracted considerable attention in the recent literature. However, there are no studies that empirically investigate the effects of leverage on the level of economic activity as it is measured by real GDP. In this paper we fill this gap, using recent advances in macroeconometrics to investigate the relationship between leverage and the level of economic activity in the United States. In doing so, we also make a distinction between traditional banks and shadow banks. Shadow banks are unregulated nonbank financial intermediaries without access to central bank liquidity, and whose balance sheets are almost fully marked to market and potentially hold more information regarding underlying financial conditions than traditional bank balance sheets. They have been at the center of the financial crisis of 2007-2008 and there is almost universal agreement that the financial crisis originated in this unregulated shadow banking system. At the peak of the financial crisis, shadow bank liabilities in the United States were almost twice as large as traditional bank liabilities (close to \$20 trillion).

The outline of the paper is as follows. Section 2 presents the data on real GDP and leverage for five different sectors: households, nonfinancial (nonfarm) corporations, commercial banks, security brokers-dealers, and shadow banks. In Section 3, we investigate whether the relationship between leverage and the level of economic activity is nonlinear and asymmetric and in doing so we use both slope-based tests as well as tests of the null hypothesis of symmetric impulse responses, recently introduced by Kilian and Vigfusson (2011). The final section concludes the paper.

2 The Data

We define leverage, l, as

$$l = \frac{A}{A - L} \tag{1}$$

where A denotes total assets and L liabilities other than net worth (equivalently, capital). Thus, leverage is the ratio of assets to capital and is a measure of how much debt an investor assumes in making an investment; the reciprocal of leverage, $1/l$, is known as the leverage ratio. From equation (1) we can see that if financial intermediaries are passive and do not adjust their balance sheets to changes in capital, then there would be a negative relationship between changes in leverage and changes in total assets, since leverage would fall when total assets rise and it would rise when total assets fall. If, however, financial intermediaries manage their balance sheets actively, then there could be a positive relationship between changes in leverage and changes in total assets, as shown by Adrian and Shin (2010) for the (then) major U.S. investment banks (Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley).

We use quarterly data from the Board of Governors of the Federal Reserve System, over the period from 1951:4 to 2012:4. It is to be noted that shadow bank data are available only since 1983:1 and that by shadow banks we mean finance companies, funding corporations, and asset-backed securities (ABS) issuers. In the case of households and nonfinancial firms, we calculate leverage using the formula

$$l = \frac{\text{Total assets}}{\text{Net worth}}.$$

For commercial banks, security broker-dealers, and shadow banks we use the following leverage formula, recently also used by Adrian *et al.* (2013)

$$l = \frac{\text{Total financial assets}}{\text{Total financial assets} - \text{Total financial liabilities}}.$$

3 Is the Relation Nonlinear and Asymmetric?

One of the primary lessons learned from the global financial crisis and Great Recession is that the macro economy is highly non linear. As Mishkin (2011, p. 83) puts it,

> "The events after the Lehman Brothers bankruptcy showed how nonlinear both the financial system and the macro economy could be. In the aftermath, the financial system seized up and both credit spreads (such as the Baa-Treasury or junk bond Treasury spreads) and liquidity spreads (such as the TED or the LIBOR-OIS spreads) shot up dramatically. The subsequent economic downturn, which saw the collapse of real GDP and world trade during the fourth quarter of 2008 and the first half of 2009, ... , also indicated that the macroeconomy can at times be highly nonlinear"

Following Mishkin (2011), we introduce nonlinearity to explore the leverage-output relationship. In doing so, we follow the recent literature regarding the relationship between the price of oil and the level of economic activity — see, for example, Hamilton (1996, 2003, 2011) and Kilian and Vigfusson (2011).

In particular, we follow Hamilton (2003), Kilian and Vigfusson (2011), and Herrera *et al.* (2011a, 2011b), let l_t denote the level of leverage at time t, and define the net leverage increase over the previous three years (12 quarters), $\tilde{x}_t$, as a nonlinear function of the growth rate of leverage

$$\tilde{x}_t = \max\left[0, \ln l_t - \max\left\{\ln l_{t-1}, \ln l_{t-2}, \ln l_{t-3}, \cdots, \ln l_{t-12}\right\}\right] \tag{2}$$

in order to filter out increases in leverage that represent corrections for recent declines. Then we test the null hypothesis that the optimal one-period ahead forecast of the growth rate (measured as log differences) of real GDP, y_t, is linear in past values of the growth rate (measured as log differences) of leverage, x_t, by estimating (by ordinary least squares) the following predictive regression

$$y_t = \alpha_0 + \sum_{j=1}^{p} \alpha_j y_{t-j} + \sum_{j=1}^{p} \beta_j x_{t-j} + \sum_{j=1}^{p} \gamma_j \tilde{x}_{t-j} + \varepsilon_t \tag{3}$$

where α_0, α_j, β_j, and γ_j are all parameters, ε_t is white noise, and $\tilde{x}_t$ is defined in (2). In (3), testing the joint null of linearity and symmetry is equivalent to testing that the coefficients on $\tilde{x}_t$ are all equal to zero — that is, $\gamma_1 = \gamma_2 = \cdots = \gamma_p = 0$. If the null hypothesis can be rejected, then the conclusion is that the relationship is nonlinear. Based on the p-values reported in panel A of Table 1, the joint null of linearity and symmetry cannot be rejected.

Almost identical test results are obtained using an alternative slope-based test, recently developed in Kilian and Vigfusson (2011) in their investigation of the oil price-output relationship. This modified test includes additional contemporaneous regressors in (3), as follows

$$y_t = \alpha_0 + \sum_{j=1}^{p} \alpha_j y_{t-j} + \sum_{j=0}^{p} \beta_j x_{t-j} + \sum_{j=0}^{p} \gamma_j \tilde{x}_{t-j} + \varepsilon_t \tag{4}$$

and tests the joint null hypothesis of linearity and symmetry by testing the null that the coefficients on $\tilde{x}_t$ are all equal to zero — in this case, $\gamma_0 = \gamma_1 = \cdots = \gamma_p = 0$. As can be seen in panel B of Table 1, we cannot reject the null hypothesis for all leverage series except for household leverage.

The optimal lag length in models (3) and (4) is chosen according to the Akaike information criterion (AIC). We also perform a serial correlation test for models (3) and (4) and the results, shown in the last column of Table 1, indicate no evidence of autocorrelation for both models and for all leverage measures.[1] Finally, it should be noted that the results reported in Table 1 are robust to the use of alternative nonlinear transformations of the leverage measures. In particular, they are robust to using the net leverage decline over the previous three years, the net leverage increase over the previous year (4 quarters), and the net leverage decline over the previous 4 quarters. These results are not reported in the paper, but are available upon request.

Our evidence using slope-based tests is in support of a linear and symmetric relationship between real GDP and all the leverage measures. Recently, however, Kilian and Vigfusson (2011) question the use of slope-based tests to test for nonlinearities and asymmetries and propose a test of symmetric impulse responses to positive and negative shocks based on impulse response functions. As Kilian and Vigfusson (2011, p. 436-437) put it, "what is at issue in conducting this impulse-response-based test is not the existence of asymmetries in the reduced form parameters, but the question of whether possible asymmetries in the reduced-form imply significant asymmetries in the impulse response function."

In this regard, as Serletis and Elder (2011, p. 329-330) also put it in their discussion of the Kilian and Vigfusson (2011) procedure, "slope-based tests (either the traditional or the modified ones) are not informative with respect to whether the asymmetry in the impulse responses is economically or statistically significant. This is because impulse response functions are nonlinear functions of the slope parameters and innovation variances and it is possible for small and statistically insignificant departures from symmetry in the slopes to cause large and statistically significant departures from symmetry in the implied impulse response functions. Similarly, it is possible for large and statistically significant departures from symmetry in the slopes to cause small and statistically insignificant departures from symmetry in the implied impulse response functions. In addition, Kilian and Vig-

[1] It is to be noted that with serial correlation, the parameter estimates are more precise than they really are and thus there is a tendency to reject the null hypothesis when it should not be rejected.

fusson observed that slope-based tests of symmetry cannot allow for the fact that the degree of asymmetry of the response function by construction depends on the magnitude of the shock."

The Kilian and Vigfusson (2011) asymmetry test based on impulse response functions involves estimating (using ordinary least squares) the following structural VAR

$$x_t = \alpha_{10} + \sum_{j=1}^{p} \beta_{11}(j) x_{t-j} + \sum_{j=1}^{p} \beta_{12}(j) y_{t-j} + u_{1t} \tag{5}$$

$$y_t = \alpha_{20} + \sum_{j=0}^{p} \beta_{21}(j) x_{t-j} + \sum_{j=1}^{p} \beta_{22}(j) y_{t-j} + \sum_{j=0}^{p} \delta_{21}(j) \tilde{x}_{t-j} + u_{2t} \tag{6}$$

and the following steps.[2]

Step 1: Let the estimated coefficients, residuals, and residual standard deviations be $(\widehat{\boldsymbol{\beta}}_1, \widehat{u}_{1t}, \widehat{\sigma}_1)$ and $(\widehat{\boldsymbol{\beta}}_2, \widehat{u}_{2t}, \widehat{\sigma}_2)$ for equations (5) and (6), respectively. In the predictive equation (5), leverage growth is regressed on past leverage growth and past output growth. In this equation, $\widehat{u}_{1t}$ represents all other factors excluding past leverage growth and past output growth that can affect present leverage growth, thus representing a leverage shock. We estimate this leverage shock by estimating $\widehat{u}_{1t}$ from (5) using the OLS method and then find the estimated standard deviation $(\widehat{\sigma}_1)$ of the $\widehat{u}_{1t}$ values. We represent typical shocks with $\widehat{\sigma}_1$ and large shocks with $2\widehat{\sigma}_1$. It is also to be noted that we find no evidence of serial correlation in the VAR model for all leverage measures.

Step 2: Take a block of p consecutive values of the x_t and y_t variables. These values make up a history defined by $\boldsymbol{\Omega}_t$. That is,

$$\{x_{t-1}, \cdots, x_{t-p};\ y_{t-1}, \cdots, y_{t-p}\} \in \boldsymbol{\Omega}_t.$$

Then, simulate two paths of x_t as follows

$$x_t^1 = \widehat{\boldsymbol{\beta}}_1 \left(1\ \boldsymbol{\Omega}_t\right) + \delta$$
$$x_t^2 = \widehat{\boldsymbol{\beta}}_1 \left(1\ \boldsymbol{\Omega}_t\right) + u_{1t}$$

where u_{1t} is drawn from the empirical distribution of u_{1t} (i.e., resampled from $\widehat{u}_{1t}$) and δ denotes the size of the shock (in our case, either $\delta = \widehat{\sigma}_1$ or $\delta = 2\widehat{\sigma}_1$).

[2] Kilian and Vigfusson (2011) have used the same model to investigate the relationship between real GDP and the price of oil. They argue that the inclusion of additional macroeconomic variables in the VAR does not affect the econometric points of interest and is not required for consistently estimating the vetted relationship under the maintained assumption of predetermined (or contemporaneously exogenous) oil prices. Herrera *et al.* (2011a, 2011b) also use this bivariate model and the Kilian and Vigfusson (2011) methodology to further explore the oil price-output relation. In using this bivariate VAR, we assume that leverage is exogenous.

Step 3: Using the updated information set, simulate two paths of y_t as follows

$$y_t^1 = \widehat{\boldsymbol{\beta}}_2 \left(1, x_t^1, x_{t-1}, \cdots, x_{t-p};\ y_{t-1}, \cdots, y_{t-p};\ \tilde{x}_t^1, \tilde{x}_{t-1}, \cdots, \tilde{x}_{t-p}\right) + u_{2t}$$
$$y_t^2 = \widehat{\boldsymbol{\beta}}_2 \left(1, x_t^2, x_{t-1}, \cdots, x_{t-p};\ y_{t-1}, \cdots, y_{t-p};\ \tilde{x}_t^2, \tilde{x}_{t-1}, \cdots, \tilde{x}_{t-p}\right) + u_{2t}$$

where

$$\tilde{x}_t^1 = \max\left[0, \ln x_t^1 - \max\left\{\ln x_{t-1}, \ln x_{t-2}, \cdots, \ln x_{t-12}\right\}\right]$$
$$\tilde{x}_t^2 = \max\left[0, \ln x_t^2 - \max\left\{\ln x_{t-1}, \ln x_{t-2}, \cdots, \ln x_{t-12}\right\}\right]$$

and the values of u_{2t} are drawn from the empirical distribution of u_{2t} (i.e., resampled from $\widehat{u}_{2t}$).

Step 4: Next, create a new history

$$\{x_t, x_{t-1}, \cdots, x_{t-p+1};\ y_t, y_{t-1}, \cdots, y_{t-p+1}\} \in \boldsymbol{\Omega}_{t+1}.$$

and simulate two future paths of x_{t+1}, such that

$$\begin{aligned} x_{t+1}^1 &= \widehat{\boldsymbol{\beta}}_1 \left(1, \boldsymbol{\Omega}_{t+1}^1\right) + u_{1,t+1} \\ &= \widehat{\boldsymbol{\beta}}_1 \left(1, x_t^1, x_{t-1}, \cdots, x_{t-p+1}, y_t^1, y_{t-1}, \cdots, y_{t-p+1}\right) + u_{1,t+1} \\ x_{t+1}^2 &= \widehat{\boldsymbol{\beta}}_1 \left(1, \boldsymbol{\Omega}_{t+1}^2\right) + u_{1,t+1} \\ &= \widehat{\boldsymbol{\beta}}_1 \left(1, x_t^2, x_{t-1}, \cdots, x_{t-p+1}, y_t^2, y_{t-1}, \cdots, y_{t-p+1}\right) + u_{1,t+1} \end{aligned}$$

Again, given x_{t+1}^1 and x_{t+1}^2, simulate two future paths of y_{t+1} according to Step 3 and get y_{t+1}^1 and y_{t+1}^2.

Step 5: Repeat Step 4 and find future paths of x_{t+h} and y_{t+h} for horizons $h = 0, 1, \cdots, H$. It should be mentioned that the values of all subsequent shocks $u_{1,t+h}$ and $u_{2,t+h}$ are drawn from their respective marginal distributions. As we assume that errors are uncorrelated, the draws are independent in practice for all $h = 0, 1, \cdots, H$. In our computation, we set $H = 7$.

Step 6: After repeating Steps 2-5 R times, the conditional impulse response function is generated as

$$I_y\left(h, \delta, \boldsymbol{\Omega}_t\right) \xrightarrow{p} \frac{1}{R}\sum_{r=1}^{R} y_{(t+h),r}^1 - \frac{1}{R}\sum_{r=1}^{R} y_{(t+h),r}^2.$$

The above condition is valid if $R \to \infty$. We set $R = 10,000$ and generate the conditional impulse response function as

$$I_y\left(h, \delta, \boldsymbol{\Omega}_t\right) = \frac{1}{R}\sum_{r=1}^{R} y_{(t+h),r}^1 - \frac{1}{R}\sum_{r=1}^{R} y_{(t+h),r}^2.$$

The unconditional impulse response function is generated by repeating the whole process for all possible histories Ω_t ($t = 1, \cdots, T$), and taking the mean over all the histories, as follows

$$I_y(h,\delta) = \frac{1}{T}\sum_{t=1}^{T} I_y\left(h,\delta,\boldsymbol{\Omega}_t\right).$$

In our computations, we set $T = 50$ (that is, 50 histories). The shock δ of the independent variable x_t (the growth rate of leverage) can be either one or two standard deviations. Similarly, we can generate $-I_y(h,-\delta)$, where the shock is negative.

Step 7: The Wald test statistic of the null hypothesis of symmetric impulse responses of y_t to positive and negative leverage growth rate shocks of the same size

$$H_0 : I_y(h,\delta) = -I_y(h,-\delta)$$

for $h = 0, 1, \cdots, H$, is computed as

$$W = \left(\boldsymbol{R}\widehat{\boldsymbol{\vartheta}}\right)'\left(\boldsymbol{R}\widehat{\boldsymbol{\Phi}}\boldsymbol{R}'\right)^{-1}\left(\boldsymbol{R}\widehat{\boldsymbol{\vartheta}}\right) \sim \chi^2_{H+1}$$

where

$$\widehat{\boldsymbol{\vartheta}}_{2(H+1)\times 1} = \begin{bmatrix} I_y(0,\delta) \\ \vdots \\ I_y(H,\delta) \\ I_y(0,-\delta) \\ \vdots \\ I_y(H,-\delta) \end{bmatrix}, \; \boldsymbol{R}_{(H+1)\times 2(H+1)} = \begin{bmatrix} 1 & \dots & 0 & 1 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 1 & 0 & \dots & 1 \end{bmatrix},$$

and

$$\widehat{\boldsymbol{\Phi}}_{2(H+1)\times 2(H+1)} = E\left[\left(\widehat{\boldsymbol{\vartheta}}-\boldsymbol{\vartheta}\right)\left(\widehat{\boldsymbol{\vartheta}}-\boldsymbol{\vartheta}\right)'\right].$$

Figures 1 to 5 show the empirical responses of the real GDP growth rate to one and two standard deviation positive and negative shocks to the growth rate of leverage for each of the five sectors: households, nonfinancial firms, commercial banks, brokers-dealers, and shadow banks, respectively. In particular, these figures plot the response of the real GDP growth rate to a positive shock, $I_y(h,\delta)$, and the negative of the response to a negative shock, $-I_y(h,-\delta)$. In Table 2, we also report p-values of the null hypothesis of symmetric impulse responses of the real GDP growth rate to positive and negative leverage growth rate shocks, $H_0 : I_y(h,\delta) = -I_y(h,-\delta)$. In fact, since the test depends on the size of the shock, we report results for both small or typical shocks (one standard deviation shocks, $\delta = \hat{\sigma}$) and large shocks (two standard deviation shocks, $\delta = 2\hat{\sigma}$).

As can be seen in Table 2, in the case of household leverage, for small shocks the response of the real GDP growth rate is symmetric up to an horizon of three quarters, but then becomes asymmetric at the 5% significance level. For large shocks, the response of real GDP is asymmetric at all horizons. Thus, according to this test based on impulse responses, in general we conclude that the relation between real GDP and household leverage is nonlinear and asymmetric. We also reject the null hypothesis of symmetric impulse responses in the case of nonfinancial firms. Moreover, the impulse response functions in Figures 1 and 2 indicate that positive (negative) household and nonfinancial firm leverage shocks lead to declines (increases) in real GDP for both typical and large shocks, consistent with the negative relationships between changes in household and nonfinancial firm leverage and changes in their total assets documented in Adrian and Shin (2010). This is so because households and nonfinancial firms are passive and do not adjust their balance sheets to changes in capital, so that leverage would fall when total assets rise and it would rise when total assets fall. Thus, for households and nonfinancial firms leverage is not procyclical. Finally, as can be seen in Figure 1, negative typical and large household leverage growth rate shocks have stronger effects on the real GDP growth rate than positive ones, for all horizons. Moreover, Figure 2 shows that negative typical nonfinancial firm leverage growth rate shocks have stronger effects on the real GDP growth rate than positive ones, for all horizons.

For brokers-dealers and shadow banks, in general we reject (at conventional significance levels) the null hypothesis of symmetric impulse responses of the real GDP growth rate to both one and two standard deviation shocks to the leverage growth rate, suggesting that the relation between real GDP and each of broker-dealer leverage and shadow bank leverage is also nonlinear and asymmetric. In the case of brokers-dealers and shadow banks, the impulse response functions in Figures 4 and 5 confirm the procyclical nature of leverage. Moreover, as can be seen in Figures 4 and 5, negative shocks to the leverage growth rate have stronger effects on the real GDP growth rate than positive ones. Finally, in the case of commercial banks there is no evidence against the null hypothesis of symmetry at all horizons, for both one and two standard deviation leverage growth rate shocks — see the p-values in Table 2. Also, the impulse response functions in Figure 3 confirm the procyclical nature of commercial bank leverage; they indicate that positive leverage shocks (both typical and large) lead to an increase in real GDP while negative leverage shocks lead to a decline in real GDP. This is consistent with the fact that commercial banks manage their balance sheets actively and target a fixed leverage ratio.

The effects of leverage growth on the level of economic activity depend on the composition of the balance sheet of financial institutions. Commercial banks are depository institutions and are important in ensuring that the financial system and the economy run smoothly and efficiently. They collect funds from depositors and other creditors to fund loans to households, businesses, or governments as borrowers. Once a loan contract is established, commercial banks are locked into it and cannot change the amount of the loan previously committed. Thus, their activities are stable and less volatile compared to those of broker-dealers and shadow banks. They do not deleverage massively during bad times and thus their leverage has a symmetric effect on the level of economic activity. On the other hand, broker-dealers and shadow banks mostly raise funds in the money market and, unlike commercial banks, their risk asset portfolio is mainly made up of credit market instruments. Moreover, the balance sheets of broker-dealers and shadow banks are almost fully marked to market and hold more information regarding underlying financial conditions than traditional bank balance sheets. In good times, broker-dealers and shadow banks slowly increase leverage, but in bad times they deleverage massively, choking off the lending channel in the economy. Thus, their leverage has an asymmetric effect on the level of economic activity.

The asymmetric relationship between leverage and the level of economic activity can also be interpreted by the leverage-asset-output relation mentioned earlier. In particular, security broker-dealers and shadow banks increase their activities during normal times by leveraging up. This creates an increase in the demand for assets and pushes up their prices, which boosts up real economic activity by increasing consumption and investment. On the other hand, these financial intermediaries reduce their activities during anxious or crisis times by deleveraging. Fostel and Geanakoplos (2012) argue that asset prices decline during bad times, because of the so called 'scary bad news' that raise tail volatility, decrease expectations, and hence reduce leverage. In fact, as Fostel and Geanakoplos (2012, p. 502) put it, "prices also decline because the optimists, who leverage up in the ebullient phase of the cycle, go disproportionately bankrupt when bad news comes and prices start to fall."

Our results are similar to those reported by Greenlaw *et al.* (2008) using methods different than ours. In particular, they use quarterly data from 1983Q1–2007Q4 and perform instrumental variables estimation of the relationship between credit extended by financial intermediaries and GDP. They use domestic non-financial debt (DNFD) as a proxy for credit extended by financial intermediaries and regress the quarterly log difference of GDP (times 400 to convert to an annualized rate) to three of its own lags and the lagged four-quarter (log) change of DNFD (multiplied by 100). They find that a 1 percentage point decline in DNFD growth would predict a decline of 0.34 percentage points of GDP growth in the short run and 0.47 percentage points in the long run. We use a longer sample (from 1951Q4–2012Q4), a structural VAR, and the methodology recently introduced by Kilian and Vigfusson (2011). That is, we test for nonlinearities and asymmetries in the relationship between leverage and real GDP using a test of symmetric impulse responses to positive and negative leverage shocks (of different sizes), based on impulse response functions. We find that the relationship between leverage and GDP growth is nonlinear and asymmetric and that negative leverage growth rate shocks have stronger effects on real GDP as compared to positive shocks. Our results are consistent with the evidence reported by Greenlaw *et al.* (2008) that deleveraging adversely impacts real GDP growth.

4 Conclusion

In the new Keynesian approach to monetary policy, under the assumption of sticky prices, central banks use a short-term nominal interest rate as their operating instrument, but the effects of monetary policy on economic activity stem from how long-term real interest rates respond to the short-term nominal interest rate. However, the recent collapse of stable relationships in financial markets and the decoupling of long-term interest rates from short-term interest rates has significant implications for monetary policy. Moreover, as the federal funds rate has reached the zero lower bound, the Federal Reserve has lost its usual ability to signal policy changes via changes in the federal funds rate. For these reasons, in the aftermath of the global financial crisis and the Great Recession, the Fed and many central banks around the world have departed from the traditional interest-rate targeting approach to monetary policy and are now focusing on their balance sheet instead, using quantitative measures of monetary policy, such as quantitative easing. However, the use of quantitative easing increases the uncertainty surrounding the path of collateral rates and money growth and raises the issue of whether there is a role for leverage and money in today's approach to monetary policy.

In this paper we investigated the relationship between leverage and the level of economic activity, using quarterly U.S. data over the 1951 to 2012 period. We addressed the question for five different measures of leverage — household leverage, nonfinancial firm leverage, commercial bank leverage, broker-dealer leverage, and shadow bank leverage. We have established that in general the relationship between leverage and the level of economic activity is nonlinear and asymmetric and that negative leverage growth rate shocks have stronger effects on real GDP than positive ones. Based on this evidence, and given the procyclical nature of commercial banks, broker-dealers and shadow banks leverage, we conclude that the deleveraging process that began in the United States at the end of 2008 will be long and painful for the economy. As financial intermediaries reduce their leverage to sustainable levels over several years, economic growth will be negatively affected. In fact, as Mendoza (2010) argues, leverage rises during the boom periods and when it rises enough it triggers the collateral constraint. This constraint causes a Fisherian deflation, which reduces the price and quantity of collateral assets. Thus real GDP and factor allocations fall because access to working capital financing becomes extremely limited.

Clearly, there is a need for macroprudential policies to manage the leverage cycle and reduce the procyclicality of the financial system. As the Bank for International Settlements put it in its 2009 annual report, "a procyclical financial system refers to the notion that its dynamics and the dynamics of the real economy reinforce each other, increasing the amplitude of booms and busts and undermining stability of both the financial sector and the real economy." In the case of leverage cycles, for example, lending increases substantially during economic expansions and decreases substantially during contractions. That is, during an economic expansion, a boom in issuing credit drives up asset prices, which in turn fuels the credit boom (either because it increases asset prices and the value of collateral, making it easier to borrow, or because it increases bank capital, giving banks more capacity to lend with unchanging capital requirements), which drives asset prices even higher, and so on. That is, a credit boom can spill over into asset-price bubbles, because the easier credit can be used to purchase particular assets and thereby increase their prices above fundamental values. How the procyclical nature of the financial system leads to such bubbles in asset prices is nicely explained in Adrian *et al.* (2010). They argue that in an expanding economy when asset prices go up, the upward adjustment of leverage entails purchases of more securities compared to the case of constant leverage. Moreover, if there is the possibility of feedback, the adjustment of leverage and price changes will reinforce each other in an amplification of the financial cycle. In this backdrop we argue that, if countercyclical capital requirements were initiated, this would require more capital held at financial institutions during booms, which would reduce lending and help to mitigate credit bubbles that can be damaging later on. Likewise, when the economy goes into a downturn, capital requirements could be lowered, which would encourage more lending and facilitate faster economic growth.

In addition to macroprudential policies designed to manage the leverage cycle, there is also a need to get away from the New Keynesian thinking and back toward a quantity theory approach to monetary policy based on properly measured monetary aggregates consistent with microeconomic aggregation theory and statistical index number theory. Although modern macroeconomics has largely solved a number of problems, including those associated with the Lucas critique, it has so far failed to address the problems of measurement associated with monetary aggregates — the "Barnett critique," to use the phrase coined by Belongia and Ireland (2014) among others. But as the federal funds rate has reached the zero lower bound and the Federal Reserve is in a liquidity trap, the issue is whether there is a useful role of monetary aggregates in monetary policy and business cycle analysis. In this regard, Serletis *et al.* (2013) and Serletis and Gogas (2014) argue that properly measured monetary aggregates, such as the new Center for Financial Stability Divisia monetary aggregates documented in detail by Barnett *et al.* (2013), can and should play an important role in monetary policy and business cycle analysis.

References

[1] Adrian, T. and H.S. Shin. "Liquidity and Leverage." *Journal of Financial Intermediation* 19 (2010), 418–437.

[2] Adrian, T. and H.S. Shin. "Financial Intermediaries and Monetary Economics." In B.M. Friedman and M. Woodford (Eds.), *Monetary Economics* Vol. 3A (2011), 601-650. Amsterdam: North Holland.

[3] Adrian, T. and H.S. Shin. "Procyclical Leverage and Value-at-Risk." Federal Reserve Bank of New York *Staff Report* 338 (2012).

[4] Bank of International Settlements . Annual Report . BIS, Basel (2009).

[5] Barnett, W.A. *Getting it Wrong: How Faulty Monetary Statistics Undermine the Fed, the Financial System, and the Economy.* Cambridge MA: The MIT Press (2012).

[6] Barnett, W.A., J. Liu, R.S. Mattson, and J. van den Noort. "The New CFS Divisia Monetary Aggregates: Design, Construction, and Data Sources." *Open Economies Review* 24 (2013), 101-124.

[7] Belongia, M.T. and P.N. Ireland. "The Barnett Critique After Three Decades: A New Keynesian Analysis." *Journal of Econometrics* (forthcoming, 2014).

[8] Fostel, A. and J. Geanakoplos. "Why Does Bad News Increase Volatility and Decrease Leverage?" *Journal of Economic Theory* 147 (2012), 501–525.

[9] Geanakoplos, J. "Solving the Present Crisis and Managing the Leverage Cycle." Federal Reserve Bank of New York *Economic Policy Review* August (2010a), 101-131.

[10] Geanakoplos, J. "The Leverage Cycle." In D. Acemoglu, K. Rogoff, and M. Woodford (Eds.), NBER Macreoconomics Annual 24 (2010b), 1-65. Chicago: University of Chicago Press.

[11] Greenlaw, D., J. Hatzius, A.K. Kashyap, and H.S. Shin. "Leveraged Losses: Lessons From the Mortgage Market Meltdown." Proceedings of the U.S. Monetary Policy Forum (2008). Available at http://research.chicagobooth.edu/igm/docs/USMPF_FINAL_Print.pdf

[12] Hamilton, J.D. "This is What Happened to the Oil Price-Macroeconomy Relationship." *Journal of Monetary Economics* 38 (1996), 215-220.

[13] Hamilton, J.D. "What is an Oil Shock?" *Journal of Econometrics* 113 (2003), 363-398.

[14] Hamilton, J.D. "Nonlinearities and the Macroeconomic Effects of Oil Prices." *Macroeconomic Dynamics* 15 (Supplement 3) (2011), 364-378.

[15] Herrera, A.M., L.G. Lagalo, and T.Wada. "Oil Price Shocks and Industrial Production: Is The Relationship Linear?" *Macroeconomic Dynamics*, 15 (Supplement 3) (2011a), 472–497.

[16] Herrera, A.M., L.G. Lagalo, and T.Wada. "Nonlinearities in the Oil Price-Industrial Production Relationship: Evidence from 18 OECD Countries." Mimeo, Wayne State University (2011b).

[17] Kilian, L. and R.J. Vigfusson. "Are the Responses of the U.S. Economy Asymmetric in Energy Price Increases and Decreases?" *Quantitative Economics* 2 (2011), 419-453.

[18] Mendoza, E.G. "Sudden Stops, Financial Crises, and Leverage." *American Economic Review* 100 (2010), 1941–1966.

[19] Mishkin, F.S. "Monetary Policy Strategy: Lessons from the Crisis." In Marek Jarocinski, Frank Smets, and Christian Thimann (Eds.), *Monetary Policy Revisited: Lessons from the Crisis*. Sixth ECB Central Banking Conference. European Central Bank: Frankfurt (2011), pp. 67-118.

[20] Serletis, A. and J. Elder. "Introduction to *Macroeconomic Dynamics* Special Issue on *Oil Price Shocks*." *Macroeconomic Dynamics* 15 (Supplement 3) (2011), 327-336.

[21] Serletis, A. and P. Gogas. "Divisia Monetary Aggregates, the Great Ratios, and Classical Money Demand Functions." *Journal of Money, Credit and Banking* 46 (2014), 229-241.

[22] Serletis, A., K. Istiak, and P. Gogas. "Interest Rates, Leverage, and Money." *Open Economies Review* 24 (2013), 51-78.

Table 1. Slope Based Tests of the Null Hypothesis
of Linearity and Symmetry

Leverage series	Lag length	p-value	H_0 : No serial correlation
A. Based on equation (3)			
Households	2	.0800	.6662
Nonfinancial firms	2	.5422	.3500
Commercial banks	2	.6945	.2763
Brokers-dealers	2	.1437	.9228
Shadow banks	2	.0774	.3248
B. Based on the modified equation (4)			
Households	2	.0245	.3710
Nonfinancial firms	2	.3370	.3882
Commercial banks	2	.7748	.5195
Brokers-dealers	2	.1988	.9751
Shadow banks	2	.1198	.4269

Table 2. p-values for $H_0 : I_y(h, \delta) = -I_y(h, -\delta), h = 0, 1, ..., 7$

	Households		Nonfinancial firms		Commercial banks		Brokers-dealers		Shadow banks	
h	$\delta = \widehat{\sigma}$	$\delta = 2\widehat{\sigma}$	$\delta = \widehat{\sigma}$	$\delta = 2\widehat{\sigma}$	$\delta = \widehat{\sigma}$	$\delta = 2\widehat{\sigma}$	$\delta = \widehat{\sigma}$	$\delta = 2\widehat{\sigma}$	$\delta = \widehat{\sigma}$	$\delta = 2\widehat{\sigma}$
0	0.09	0.78	0.01	0.01	0.98	0.63	0.06	0.08	0.00	0.00
1	0.06	0.00	0.01	0.02	0.52	0.22	0.02	0.17	0.00	0.01
2	0.10	0.00	0.03	0.01	0.78	0.85	0.04	0.05	0.00	0.00
3	0.03	0.00	0.06	0.01	0.99	0.84	0.00	0.00	0.00	0.04
4	0.05	0.00	0.10	0.03	0.91	0.99	0.03	0.04	0.00	0.00
5	0.03	0.00	0.01	0.05	0.91	0.97	0.04	0.06	0.01	0.00
6	0.03	0.00	0.02	0.08	0.99	0.95	0.02	0.10	0.03	0.02
7	0.01	0.00	0.04	0.13	0.99	0.99	0.04	0.03	0.04	0.03

Figure 1. Responses to One and Two Standard Deviation, Positive and Negative Shocks to Household Leverage

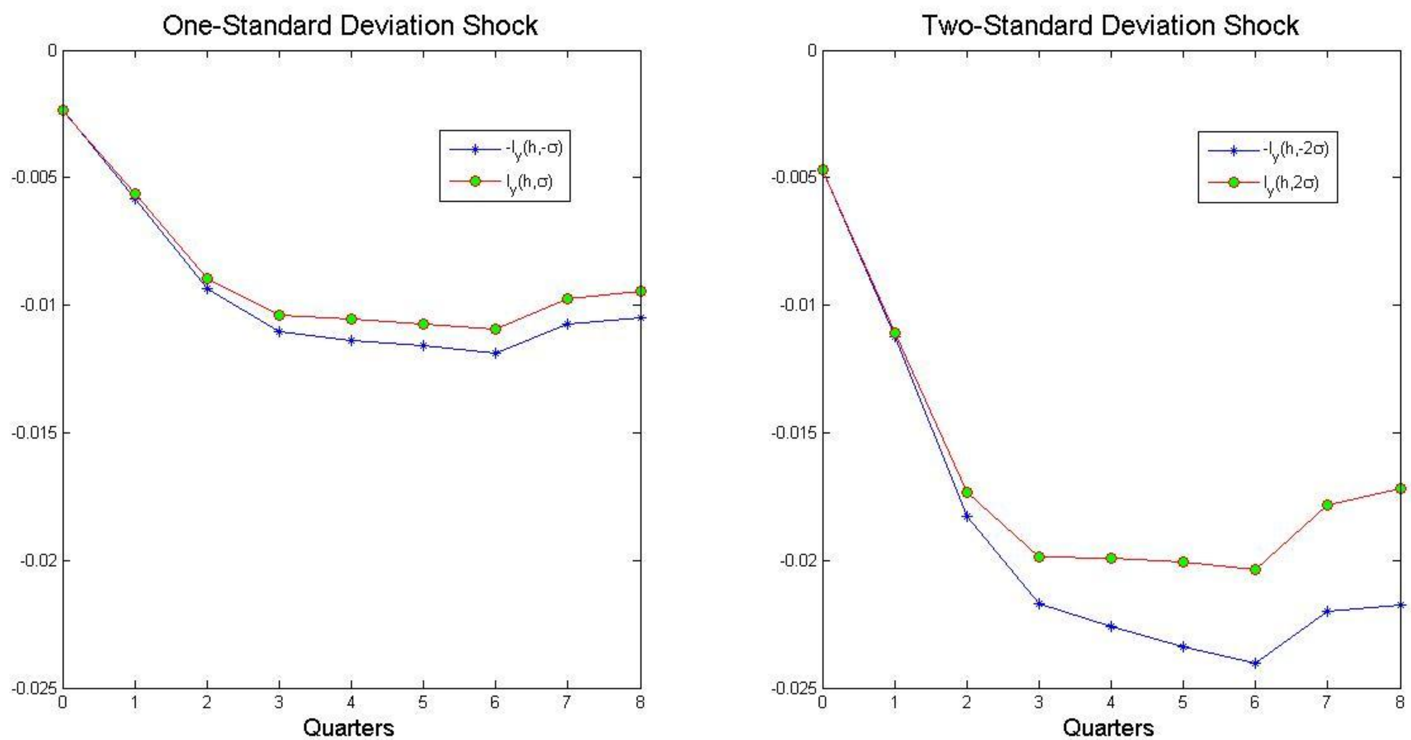

Figure 2. Responses to One and Two Standard Deviation, Positive and Negative Shocks to Nonfinancial Firm Leverage

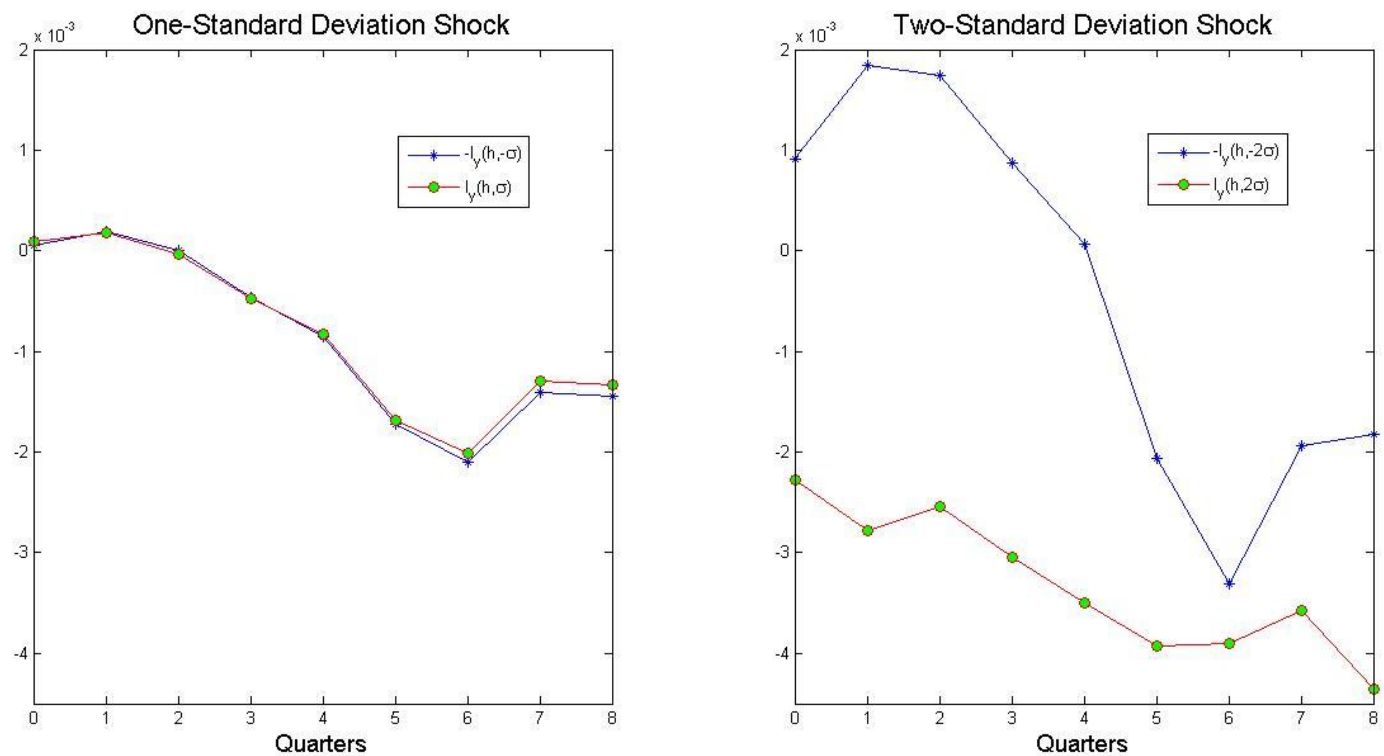

Figure 3. Responses to One and Two Standard Deviation, Positive and Negative Shocks to Commercial Bank Leverage

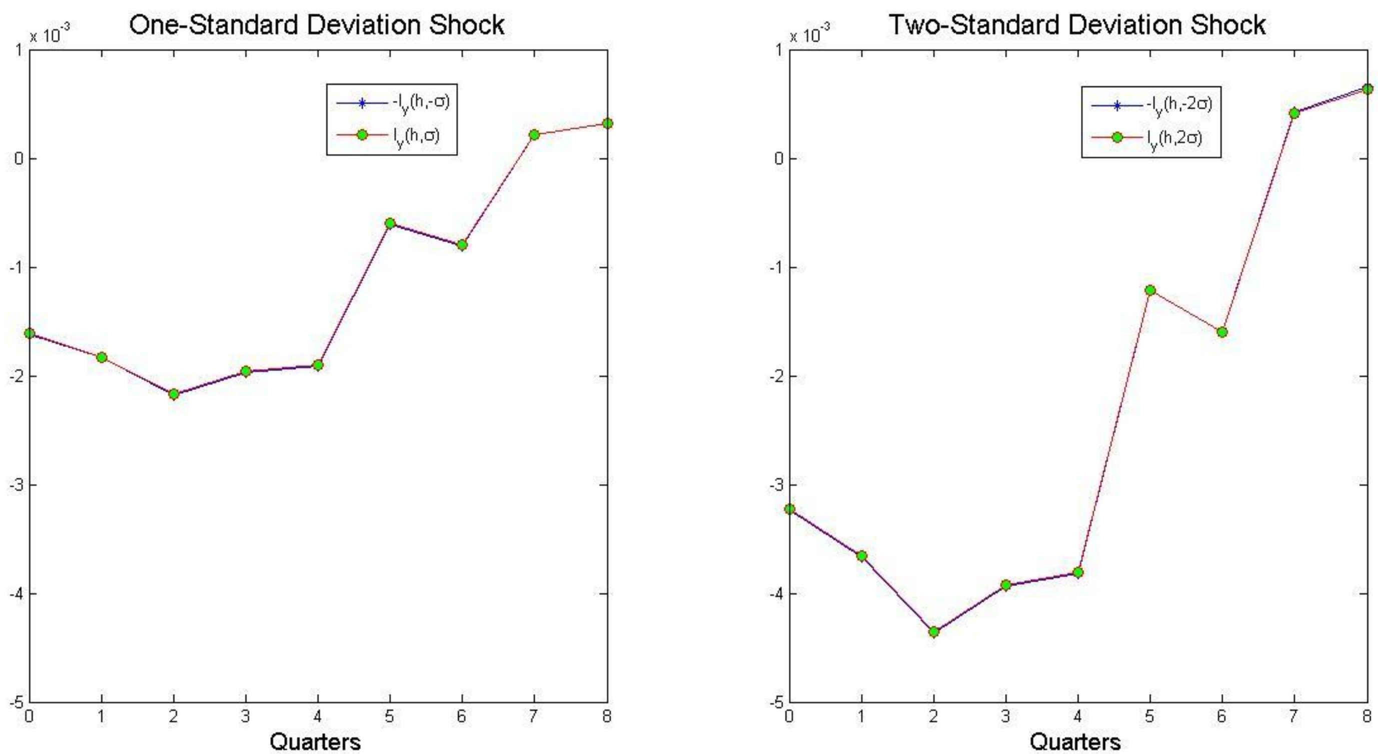

Figure 4. Responses to One and Two Standard Deviation, Positive and Negative Shocks to Broker-Dealer Leverage

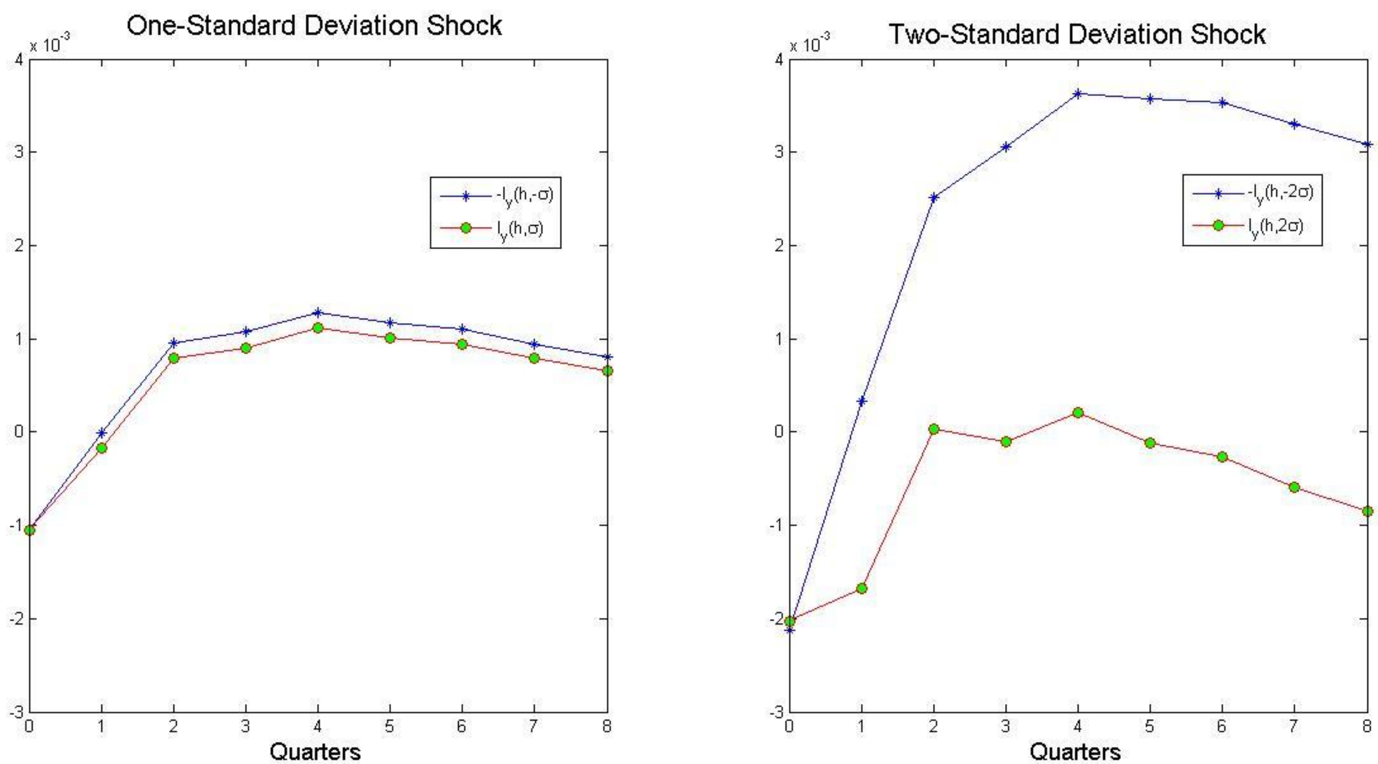

Figure 5. Responses to One and Two Standard Deviation, Positive and Negative Shocks to Shadow Bank Leverage