Macroeconomic Effects of Financial Shocks*

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PRELIMINARY

Abstract

In this paper we document the cyclical properties of U.S. firms’ financial flows. Debt payouts are countercyclical and equity payouts are procyclical. We develop a model with explicit roles for debt and equity financing and we study its business cycle implications. Standard productivity shocks can only partially explain the observed variations in real variables and financial flows. We show that financial shocks that affect firms’ capacity to borrow can bring the model much closer to the data. The recent events in the financial sector show up clearly in our model as a tightening of firms’ financing conditions in 2008 and as a cause for a downturn in GDP growth. The model also suggests that the downturns in 1990 and 2001 were strongly influenced by changes in the credit conditions.

*Some material in this paper was previously incorporated in our companion paper "Financial Innovations and Macroeconomic Volatility."
1 Introduction

Recent economic events starting with the subprime crisis in the summer of 2007 suggest that the financial sector plays an important role in the transmission and as a source of business cycles. While there is a long tradition in macroeconomics to consider financial accelerators, quantitative model building has not focused much on matching simultaneously real aggregates and aggregate flows related to debt and equity financing. Moreover, financial shocks have played a relatively minor role in the business cycle literature. In this paper we attempt to make some progress along these lines.

We start by documenting the cyclical properties of firms’ equity and debt flows at an aggregate level. We then build a business cycle model with explicit roles for firms’ debt and equity financing. We show that the model driven solely by measured productivity shocks fails to match business cycle volatilities and the behavior of equity and debt flows. Augmenting the model with credit shocks that directly affect firms’ ability to borrow brings the model much closer to the data—not only for financial flows but also for some of the real business cycle quantities. When we further characterize these credit shocks, we find that the model implies a worsening of firms’ ability to borrow in 2008, which is in line with the standard interpretation of economic events since the summer of 2007. Moreover, the model implies that economic downturns in 1990 and 2001 were strongly influenced by changes in the credit conditions.

In our model firms finance investment with equity and debt. Debt contracts are not fully enforceable and the ability to borrow is limited by a no-default constraint which depends on the expected lifetime profitability of the firm. As lifetime profitability varies with the business cycle, so does a firm’s ability to borrow. In this regard our model is related to Kiyotaki & Moore (1997), Bernanke, Gertler & Gilchrist (1999), and Mendoza & Smith (2005), in the sense that asset prices movements affect the ability to borrow. Our model, however, differs in one important dimension: we allow firms to issue new equity in addition to reinvesting profits.1

The paper is structured as follows. In Section 2 we consider some em-

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1There are other studies that allow for equity issuance over the business cycle. See, for example, Choe, Masulis & Nanda (1993), Covas and den Haan (2005), Leary and Roberts (2005), and Hennessy & Levy (2005). The main focus of these studies is on the financial behavior of firms, not in the quantitative impact of financial frictions for the propagation of aggregate shocks to the macro economy.
empirical evidence on real and financial cycles in the US economy. Section 3 presents the model and characterizes some of its analytical properties. Model calibration and quantitative findings are presented in Sections 4.

2 Real and financial cycles in the U.S.

This section presents the main empirical observations that motivate the paper. It describes the properties of real and financial business cycles.

We start by reporting the business cycle properties of firms’ aggregate financial flows. To our knowledge, these properties have not been previously documented and explored in the macro literature. Figure 1 plots the net payments to equity holders and the net debt repurchases in the nonfarm business sector. Financial data is from the Flow of Funds Accounts of the Federal Reserve Board. Equity payout is defined as dividends and share repurchases minus equity issues of nonfinancial corporate businesses, minus net proprietor’s investment in nonfarm noncorporate businesses. This captures the net payments to business owners (shareholders of corporations and noncorporate business owners). Debt is defined as ‘Credit Market Instruments’ which include only liabilities that are directly related to credit market instruments. It does not include, for instance, tax liabilities. Debt repurchases are simply the reduction in outstanding debt (or increase if negative). Both variables are expressed as a fraction of nonfarm business GDP. See Appendix A for a more detailed description.

Two patterns are visible in the figure, very strongly so for the second half of the period considered. First, equity payouts are negatively correlated with debt repurchases. This suggests that there is some substitutability between equity and debt financing. Second, while equity payouts tend to increase in booms, debt repurchases increase during or around recessions. This suggests that recessions lead firms to restructure their financial position by cutting debt and reducing the payments made to shareholders.

The properties of real and financial cycles are further characterized in Table 1. The table reports the standard deviations and correlations with GDP for equity payouts and debt repurchases in the nonfinancial corporate sector and in the nonfinancial corporate and noncorporate sectors combined. Statistics for a number of key business cycle variables are also presented. Equity payouts and debt repurchases are normalized by the value added produced in the sector. For these two variables we do not take logs because
Figure 1: Financial flows in the nonfarm, nonfinancial business sector. Source: Flow of Funds, Federal reserve Board.

some observations are negative. All variables are detrended with a band-pass filter that preserves cycles of 1.5-8 years (Baxter and King (1999)).

We focus on the period after 1984 for two related reasons. First, it has been widely documented in relation with the so called Great Moderation that 1984 corresponds to a break in the volatility in many business cycle variables. Second, as documented in Jermann and Quadrini (2008), this time period also saw major changes in U.S. financial markets. In particular, spurred by regulatory clarifications, share repurchases had become more common, and this seemed to have had a major impact on firms’ payout policies and financial flexibility. Therefore, by concentrating on the period after 1984 we do not have to address the causes of the structural break that arose in the early 1980s.

The reported correlations in the table for equity payouts and debt repurchases with output confirm the properties we highlighted in the previous figure. As is clear in the table, equity payouts are procyclical and debt repurchases are countercyclical, and this property holds for the nonfinancial

<table>
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<th>Std(Variable)</th>
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<th>Corr(Variable,GDP)</th>
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<tr>
<td><strong>Macroeconomic variables</strong></td>
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<tr>
<td>GDP</td>
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<tr>
<td>Consumption (N.D.&amp; S.)</td>
<td>0.50</td>
<td>0.59</td>
<td>0.83</td>
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<tr>
<td>Investment</td>
<td>3.98</td>
<td>4.68</td>
<td>0.85</td>
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<tr>
<td>Hours</td>
<td>1.18</td>
<td>1.39</td>
<td>0.81</td>
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<td>TFP</td>
<td>0.50</td>
<td>0.59</td>
<td>0.41</td>
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<tr>
<td><strong>Financial variables</strong></td>
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<tr>
<td>EquPay/GDP (Corporate)</td>
<td>1.27</td>
<td>1.49</td>
<td>0.44</td>
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<td>DebtRep/GDP (Corporate)</td>
<td>1.42</td>
<td>1.67</td>
<td>-0.65</td>
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<tr>
<td>EquPay/GDP (Corp.&amp;Noncorp.)</td>
<td>1.08</td>
<td>1.27</td>
<td>0.50</td>
</tr>
<tr>
<td>DebtRep/GDP (Corp.&amp;Noncorp.)</td>
<td>1.34</td>
<td>1.58</td>
<td>-0.77</td>
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Notes: Financial data is from the Flow of Funds Accounts of the Federal Reserve Board. *Equity payout* in the corporate sector is net dividends minus net issue of corporate equity (net of share repurchases). *Equity payout* in the nonfarm business sector is equity payout in the corporate sector minus proprietor’s net investment. *Debt repurchase* is the negative of the change in credit market liabilities. Both variables are divided by their sectorial GDP. The macroeconomic variables have been logged. All variables are detrended with a band-pass filter that preserves cycles of 1.5-8 years (Baxter and King (1999)). See Appendix A for more details.

corporate sector alone, as well as for the total nonfinancial business sector. The business cycle properties of the real variables are well known, and we will get back to them when comparing our model to the data.

3 Model

We start describing the environment in which an individual firm operates as this is where our model diverges from a more standard business cycle model. We then present the household sector and define the general equilibrium.

3.1 Financial and investment decisions of firms

There is a continuum of firms, in the [0, 1] interval, with a gross revenue function $F(z_t, k_t, l_t) = e^{z_t k_t^\delta l_t^{1-\delta}}$. The variable $z_t$ is a productivity shock, $k_t$ is the input of capital depreciating at rate $\delta$ and $l_t$ is the input of labor.
Firms use equity and debt. Debt is preferred to equity (pecking order) because of its tax advantage as, for example, in Hennessy and Whited (2005). Given \( r_t \) the interest rate, the effective gross rate for the firm is \( R_t = 1 + r_t(1 - \tau) \), where \( \tau \) determines the tax benefit.

The ability to borrow is bounded by the limited enforceability of debt contracts as firms can default on their obligations at the end of the period, after the realization of revenues and the payment of dividends.

Let \( V_t \) be the value of the firm at the end of the period, after paying dividends. This is the value of equity defined as

\[
V_t = E_t \sum_{j=1}^{\infty} m_{t+j} d_{t+j} ,
\]

where \( m_{t+j} \) is the relevant stochastic discount factor which will be derived later, and \( d_{t+j} \) are the net payments to the shareholders. Enforcement requires that the value of default, denoted by \( D_t \), is at least as big as the value of not defaulting, that is:

\[
V_t \geq D_t
\]

What we have to do next is to specify the default value \( D_t \). This requires the detailed specification of the decision timing and flows of funds inside the firm.

Firms start the period with debt \( b_t \). Before producing they choose the labor input, \( l_t \), investment, \( i_t = k_{t+1} - (1 - \delta)k_t \), dividends, \( d_t \), and the next period debt, \( b_{t+1} \). The tilde over the dividend will become clear below. The payments of wages, investments, dividends and previous debt have to be made before the realization of revenues. In order to make these payments the firm contracts a loan to cover the intra-period cash flow mismatch. The intra-period loan is equal to \( b_t = b_t + w_t l_t + i_t + d_t - b_{t+1}/R_t \). This loan is additional to the inter-period loan \( b_{t+1}/R_t \) and it is fully repaid at the end of the period after the realization of revenues. Given the budget constraint,

\[
b_t + w_t l_t + i_t + d_t = F(z_t, k_t, l_t) + b_{t+1}/R_t
\]

we can verify that the intra-period loan \( b_t \) is equal to the firm’s revenue, that is, \( \hat{b}_t = F(z_t, l_t) \). Essentially, the loan finances the working capital of the firm. Because it is repaid within the period, there are no interests.

Default arises after the realization of revenues \( F(z_t, k_t, l_t) \) (and before using the revenues for repaying the intra-period loan). These are liquid funds
that can be easily diverted from the lender. In case of default, the lender has the right to liquidate the residual net assets of the firm. Denoting by \( L_t \) the liquidation value, which we will specify shortly, the net surplus from renegotiating the intra-period loan is \( V_t - L_t \). This is the value that will be bargained in the event of renegotiation. Assuming that the firm has all bargaining power, the value of default is:

\[
D_t = F(z_t, k_t, l_t) + V_t - L_t
\]

that is, the diverted funds plus the value received in the renegotiation stage. Enforcement requires that the value of not defaulting, is not smaller than the value of default, that is, \( V_t \geq F(z_t, k_t, l_t) + V_t - L_t \), which leads to the enforcement condition \( L_t \geq F(z_t, k_t, l_t) \).

What is left is the specification of the liquidation value. As described in the appendix, the liquidation value of the firm takes the form:

\[
L_t = \phi_t \left( k_{t+1} - b_{t+1}/R_t \right) + \xi_t
\]

where \( \phi_t \) and \( \xi_t \) are exogenous stochastic variables capturing the degree of market liquidity along the lines of Kiyotaki and Moore (2008). The variable \( \phi_t \) multiplies the equity of the firm \( k_{t+1} - b_{t+1}/R_t \). Notice that \( b_{t+1} \) is not due until next period. The variable \( \xi_t \) is additive with a mean value of zero.

Although we allowed for two sources of uncertainty in the liquidation value of the firm, whether the uncertainty is additive or multiplicative to the equity of the firm does not matter for the quantitative results of the paper. Therefore, from now on we assume that only the additive component is stochastic while the multiplicative component is constant and equal to \( \phi_t \). For the time being, we assume that \( \phi_t \) is constant because this allows us to derive some analytical results that are not possible to obtain when this variable is stochastic. However, in the quantitative section we will also show that the quantitative results are almost identical when the randomness in the liquidation value of the firm’s assets comes from \( \phi_t \).

Using the specification of the liquidation value, the enforcement constraint can be expressed in its final form:

\[
\phi \left( k_{t+1} - b_{t+1}/R_t \right) + \xi_t \geq F(z_t, k_t, l_t)
\]  

(1)

The ability to borrow \( (b_{t+1}) \) depends on both \( \phi \) and \( \xi_t \). Lower recoverable values (lower \( \phi \) or \( \xi_t \)) decreases the collateral value of the firm, and therefore,
it allows for a smaller value of debt. Because the capacity to borrow fluctuates stochastically through the changes in $\xi_t$, we refer to the stochastic component of this variable as “credit shock”. More specifically, a decrease in $\xi_t$ tightens the enforcement constraint and reduces the borrowing capacity. If the firm cannot raise equity capital and increase equity to the new required level, it has to reduce the right-hand-side of the enforcement constraint by cutting employment and, starting from the next period, the input of capital.\footnote{Notice that credit and productivity shocks are the same for all firms, that is, they are aggregate shocks. Hence, we can concentrate on the symmetric equilibrium where all firms are alike, that is, there is a representative firm.}

This mechanism relies on the assumption that firms are unable to substitute quickly debt with equity. To formalize the rigidities affecting the substitution between debt and equity, we assume that the firm’s payout is subject to a quadratic adjustment cost:

$$\varphi(d_t) = d_t + \kappa \cdot (d_t - \bar{d})^2$$

where $\kappa \geq 0$ and $\bar{d}$ represents the long-run payout target (steady state). This explains the use above of a tilde in the equity payout, that is, $\tilde{d}_t = \varphi(d_t)$.

The equity payout cost should not be interpreted necessarily as a pecuniary cost. It is a simple way of modeling the speed with which firms can change the source of funds when the financial conditions change. Of course, the possible pecuniary costs associated with share repurchases and equity issuance can also be incorporated in the function $\varphi(.)$. The convexity assumption would then be consistent with the work of Hansen & Torregrosa (1992) and Altinkilic & Hansen (2000), showing that underwriting fees display increasing marginal cost in the size of the offering.

Another way of thinking about the adjustment cost is that it captures the preferences of managers for dividend smoothing. Lintner (1956) showed first that managers are concerned about smoothing dividends over time, a fact further confirmed by subsequent studies. This could derive from agency problems associated with the issuance or repurchase of shares as emphasized by several studies in finance. The explicit modeling of these agency conflicts, however, is beyond the scope of this paper.\footnote{As an alternative to the adjustment cost on equity payouts, we could use a quadratic cost on the change of debt, which would lead to similar properties. Therefore, our model can be interpreted more broadly as capturing the rigidities in the adjustment of all sources of funds, not only equity.}
The parameter $\kappa$ is key for determining the impact of financial frictions. When $\kappa = 0$, the economy is almost equivalent to a frictionless economy. In this case, debt adjustments triggered by the credit shocks can be quickly accommodated through changes in firm equity. When $\kappa > 0$, the substitution between debt and equity becomes costly and firms readjust the sources of funds slowly. This implies that, in the short-run, shocks have an impact on the production decision of firms.

**Firm’s problem:** We now write the problem of the firm recursively. The individual states are the capital stock, $k$, and the debt, $b$. The aggregate states, which we will make precise later, are denoted by $s$.

The firm chooses the input of labor, $l$, the equity payout, $d$, the new capital, $k'$, and the new debt, $b'$. The optimization problem is:

$$ V(s; k, b) = \max_{d,k',b'} \left\{ d + Em'V(s'; k', b') \right\} $$

subject to:

$$ (1 - \delta)k + F(z, k, l) - wl + \frac{b'}{R} = b + \varphi(d) + k' $$

$$ \phi \left( k' - \frac{b'}{R} \right) + \xi \geq F(z_t, k_t, l_t) $$

The problem is subject to the budget and the enforcement constraints. The function $V(s; k, b)$ is the cum-dividend (fundamental) market value of the firm and $m'$ is the stochastic discount factor. The variables $w$ and $R$ are, respectively, the wage rate and the gross interest rate. The stochastic discount factor, the wage and interest rate are determined in the general equilibrium and are taken as given by an individual firm.

Denote by $\mu$ the Lagrange multiplier associated with the enforcement constraint. The first-order conditions are:

$$ F_l(z, k, l) = w \cdot \left( \frac{1}{1 - \bar{\mu}} \right), $$

$$ E \bar{m}' \left[ 1 - \delta + (1 - \bar{\mu}')F_k(z', k', l') \right] = 1 - \phi \bar{\mu}, $$
\[ RE \tilde{m}' = 1 - \phi \tilde{\mu}. \]  

(5)

where \( \tilde{m}' = m' \left( \frac{\varphi_d(d)}{\varphi_d(d')} \right) \) is the ‘effective’ stochastic discount factor and \( \tilde{\mu} = \mu \varphi_d(d) \) is the ‘effective’ multiplier for the enforcement constraint. Subscripts denote derivatives. The detailed derivation is in Appendix C.

Especially important is the optimality condition for labor, equation (3), which is key for understanding the main quantitative results we will present later. This is the typical optimality condition in which the marginal productivity of labor is equalized to the marginal cost of labor. The marginal cost is the wage rate augmented by a wedge that depends on the ‘effective’ tightness of the enforcement constraint, that is, \( \tilde{\mu} \). A tightness of the enforcement constraint increases, effectively, the cost of labor for the firm, reducing the demand of labor. Similarly, when the enforcement constraint becomes less tighter, the effective cost of labor declines and increasing the demand of labor. As we will see, this is the main channel of transmission of credit shocks to the economy.

**Additional insights:** To see the importance of the financial frictions, it will be convenient to consider first the case without adjustment costs, that is, \( \kappa = 0 \). Thus, \( \varphi_d(d) = \varphi_d(d') = 1 \) and condition (5) becomes \( REm = 1 - \phi \mu \). This implies that the Lagrange multiplier \( \mu \) is fully determined by aggregate prices, \( R \) and \( Em' \).

Consider a credit shock captured by a change in \( \xi \). From conditions (3) and (4) we can see that the production and investment choices of the firm only depend on aggregate prices. Changes in \( \xi \) affect the policies of the firm only if they change the aggregate prices \( R, Em' \) and \( w \). But as long as the prices are not affected, the production and investment policies do not change.

These properties are key for understanding the behavior of the aggregate economy we will study later: If the policies of the firms are not affected by changes in \( \xi \), the general equilibrium prices will not change either. We will then be able to show that, when \( \kappa = 0 \), credit shocks are irrelevant for the real sector of the economy. They only affect the financial structure of firms.

This result no longer holds when \( \kappa > 0 \). In this case \( \tilde{\mu} \) responds directly to the change in \( \xi \) and this changes the policies of the firm even if the prices do not change. Therefore, credit shocks will have real macroeconomic effects.
3.2 Households sector and general equilibrium

There is a continuum of homogeneous households maximizing the expected lifetime utility $E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t)$, where $c_t$ is consumption, $l_t$ is labor, and $\beta$ is the discount factor. Households are the owners (shareholders) of firms. In addition to equity shares, they hold non-contingent bonds issued by firms. The household’s budget constraint is:

$$w_t l_t + b_t + s_t (d_t + q_t) = \frac{b_{t+1}}{1 + r_t} + s_{t+1} q_t + c_t + T_t$$

where $w_t$ and $r_t$ are the wage and interest rates, $b_t$ is the one-period bond, $s_t$ the equity shares, $d_t$ the equity payout received from the ownership of shares, $q_t$ is the market price of shares, and $T_t = B_{t+1}/[1 + r_t(1 - \tau)] - B_{t+1}/(1 + r_t)$ are lump-sum taxes financing the tax benefits received by firms on debt.

The first order conditions with respect to labor, $l_t$, next period bonds, $b_{t+1}$, and next period shares, $s_{t+1}$, are:

$$w_t U_c(c_t, l_t) + U_h(c_t, l_t) = 0 \quad (6)$$

$$U_c(c_t, l_t) - \beta (1 + r_t) E U_c(c_{t+1}, l_{t+1}) = 0 \quad (7)$$

$$U_c(c_t, l_t) q_t - \beta E (d_{t+1} + q_{t+1}) U_c(c_{t+1}, l_{t+1}) = 0. \quad (8)$$

The first two conditions are key to determine the supply of labor and the risk-free interest rate. The last condition determines the market price of shares. After re-arranging and using forward substitution, this price is:

$$q_t = E_t \sum_{j=1}^{\infty} \left( \frac{\beta^j \cdot U_c(c_{t+j}, l_{t+j})}{U_c(c_t, l_t)} \right) d_{t+j}.$$

Firms’ optimization is consistent with households’ optimization. Therefore, the stochastic discount factor is equal to $m_{t+j} = \beta^j U_c(c_{t+j}, l_{t+j})/U_c(c_t, l_t)$.

We can now provide the definition of a recursive general equilibrium. The set of aggregate states $s$ are given by the current realization of productivity $z$, the current realization of the credit shock $\xi$, the aggregate capital $K$, and the aggregate bonds $B$, that is, $s = (z, \xi, K, B)$. 

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Definition 3.1 (Recursive equilibrium) A recursive competitive equilibrium is defined as a set of functions for (i) households’ policies \( c(s) \) and \( l(s) \); (ii) firms’ policies \( d(s; k, b) \), \( l(s; k, b) \), \( k(s; k, b) \) and \( b(s; k, b) \); (iii) firms’ value \( V(s; k, b) \); (iv) aggregate prices \( w(s) \), \( r(s) \) and \( m(s, s') \); (v) law of motion for the aggregate states \( s' = H(s) \). Such that: (i) household’s policies satisfies the optimality conditions (6)-(7); (ii) firms’ policies are optimal and \( V(s; k, b) \) satisfies the Bellman’s equation (2); (iii) the wage and interest rates are the equilibrium clearing prices in the labor and bond markets and \( m(s, s') = \beta U_c(c_{t+1}, l_{t+1})/U_c(c_t, l_t) \); (iv) the law of motion \( H(s) \) is consistent with individual decisions and the stochastic processes of \( z \) and \( \xi \).

3.3 Some characterization of the equilibrium

To illustrate some of the properties of the model, it will be convenient to look at two special cases in which the equilibrium can be characterized analytically. First, we show that for a deterministic steady state with constant \( z \) and \( \xi \), the default constraint is always binding. Second, if \( \kappa = 0 \), changes in \( \xi \) (credit shocks) have no effect on the real sector of the economy.

Proposition 3.1 The enforcement constraint binds in the steady state.

In a deterministic steady state \( m = 1/(1+r) \). Because in the steady state \( \varphi_d(d) = \varphi_d(d') = 1 \), the first order condition for debt, equation (5), simplifies to \( Rm = 1 - \phi \mu \). Substituting the above definition of \( m \), the condition can be written as \( R = (1+r)(1-\phi \mu) \). Remembering that \( R = 1 + r(1-\tau) \), we have that \( \mu > 0 \) if \( \tau > 0 \). Thus, as long as there is a tax advantage in issuing debt, the enforcement constraint is binding in a steady state.

With uncertainty, however, the constraint may not be binding at all times because firms may reduce their borrowing in anticipation of future shocks. However, the constraint is always binding if \( \tau \) is sufficiently large and the shocks are sufficiently small. This will be the case in the quantitative exercises we conduct in this paper.

Let’s consider now the stochastic economy concentrating on the special case in which \( \kappa = 0 \). We have the following proposition:

Proposition 3.2 With \( \kappa = 0 \), changes in \( \xi \) have no effect on \( l \) and \( k' \).

When \( \kappa = 0 \) we have that \( \varphi_d(d) = \varphi_d(d') = 1 \). Therefore, the first order condition (5) can be written as \( REm' = 1 - \phi \mu \). From the household's
first order condition (7) we have that \((1 + r)Em' = 1\). Combining the two conditions and using \(R = 1 + r(1 - \tau)\) we get \(1 + r(1 - \tau) = (1 + r)(1 - \phi \mu)\). Therefore, \(\mu\) will not change if the interest rate does not change.

Now consider an innovation in \(\xi\) and conjecture that the sequence of prices \(w, r\) and \(m'\) do not change. Because \(\xi\) does not enter the optimality conditions (4)-(5) and \(\mu\) stays constant, changes in \(\xi\) would not affect the production and investment policies of the firm.

Consider now the consumer problem. Changes in debt issuance and equity payout associated with fluctuations in \(\xi\) cancel each other out in the household’s budget constraint. Therefore, the conjecture that the sequence of prices does not change is an equilibrium outcome.

We have then established that, when \(\kappa = 0\), business cycle movements are only driven by fluctuations in aggregate productivity \(z\). If we further set \(\tau = 0\), the model is essentially a standard RBC model. In fact, when \(\kappa = 0\), the key first order conditions become:

\[
\begin{align*}
    wU_c(c, l) + U_l(c, l) &= 0, \\
    F_l(z, k, l) &= w, \\
    E\left(\frac{\beta U_c(c', l')}{U_c(c, l)}\right)\left[1 - \delta + F_k(z', k', l')\right] &= 1.
\end{align*}
\]

which are the exact first order conditions obtained from the standard RBC model.

4 Quantitative analysis

We start the quantitative analysis by showing that the model driven only by productivity shocks performs poorly in replicate the financial and business cycle movements experienced by the U.S. economy since the mid 1980s. We then show that adding credit shocks not only improves the model’s predictions for the financial flows, but also helps the model replicating the business cycle moments of certain macroeconomic variables, especially working hours. The model also does a good job in capturing the GDP downturns of 2008, as well as the downturns in the previous two recessions, 1991 and 2001. This suggests that tighter credit conditions have played an important role in all major recessions experienced by the U.S. economy since the mid 1980s.
4.1 Parametrization

There are two groups of parameters. The first group includes parameters that can be calibrated using steady state targets, some of which are typical in the business cycle literature. The second group includes parameters that cannot be calibrated using steady state targets. Therefore, for these parameters we have to use a different procedure.

**Parameters set with steady state targets**  The period in the model is a quarter. We set $\beta = 0.9825$, implying that the annual steady state return from holding shares is 7.32 percent. The utility function takes the form $U(c, l) = \ln(c) + \alpha \cdot \ln(1 - l)$ where $\alpha = 1.9265$ is chosen to have steady state hours equal to 0.3. The Cobb-Douglas parameter in the production function is set to $\theta = 0.36$ and the depreciation to $\delta = 0.025$. These values are standard in the literature and they are based on the typical steady state targets. Furthermore, the quantitative properties of the model are not very sensitive to this first set of parameters.

Let’s now describe the calibration of two parameters that are not standard in the business cycle literature: $\tau$ and $\phi$. The tax advantage parameter is set to $\tau = 0.35$. This would be the tax benefit of debt if the marginal tax rate is 35 percent.

The parameter $\phi$ is chosen to match the average leverage, that is, the ratio of debt, $b$, over the capital stock, $k$. We impose a steady state leverage of 0.5 which requires $\phi = 0.19$. This is about the average leverage obtained from the Flow of Funds for Nonfinancial Business during the period 1984-2008.

**Parameters that cannot be set with steady state targets**  The parameters that cannot be set with steady state targets are those determining the stochastic properties of the shocks and the cost of equity payout. Of course, in a steady state equilibrium, the stochastic properties of the shocks do not matter and the equity payout is equal to the long-term target. Therefore, we have to use alternative procedures.

Our approach to determine the parameters of the stochastic process for the shocks can be described as follows. We first use the restrictions imposed by the model to construct the sequences of quarterly productivity and credit shocks for the period 1984:2008. Once we have constructed the shock series, we estimate a two dimensional autoregressive system.
For the productivity shocks we follow the standard procedure which is based on the Solow residual. From the production function we have:

$$\log(y_t) = z_t + \theta \log(k_t) + (1 - \theta) \log(l_t)$$

Given series data for $y_t$, $k_t$ and $l_t$, we construct the $z_t$'s as residuals.

The procedure to construct the series of credit shocks is not standard but it is based on the same principle. From the enforcement constraint we have:

$$\phi \left( k_{t+1} - \frac{b_{t+1}}{R_t} \right) + \xi_t = y_t$$

The linearized version can be written as:

$$\phi \left( \bar{k} \hat{k}_{t+1} - \bar{b} \hat{b}_{t+1} \right) + \xi_t = \bar{y} \hat{y}_t$$

where the bar sign denotes the steady state value of the variable and the hat sign the percentage deviation from the steady state. Notice that, to simplify the notation, we have denoted by $\bar{b}$ and $\hat{b}_{t+1}$ the steady state and percentage deviation of the end of period debt $b_{t+1}/R_t$.

We use this equation to construct the credit shocks. This requires the empirical measurement of $\hat{k}_{t+1}$, $\hat{b}_{t+1}$ and $\hat{y}_{t+1}$. We first construct real series for capital, debt and value added in the nonfinancial business sector. The log of these variables are then detrended linearly. The detrend series are the empirical counterparts of $\hat{k}_{t+1}$, $\hat{b}_{t+1}$ and $\hat{y}_{t+1}$. Given the values of $\phi$, $\bar{k}$, $\bar{b}$ and $\bar{y}$ resulting from the model, we can then construct the series for $\xi_t$.

Once we have constructed the series for the two shocks, we estimate the two dimensional system:

$$\begin{pmatrix} z_{t+1} \\ \xi_{t+1} \end{pmatrix} = A \begin{pmatrix} z_t \\ \xi_t \end{pmatrix} + \begin{pmatrix} \eta_{z,t+1} \\ \eta_{\xi,t+1} \end{pmatrix}$$

At this point we are left with the parameter $\kappa$. As shown in the previous section, this parameter affects the severity of the financial frictions, and therefore, the importance of credit shocks for macroeconomic fluctuations. We choose this parameter so that the standard deviation of financial flows (equity payout plus debt repurchase) is equal to the data for the period 1984-2008. The full set of parameters values are reported in Table 2.
Table 2: Parametrization.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.9825$</td>
</tr>
<tr>
<td>Tax advantage</td>
<td>$\tau = 0.3500$</td>
</tr>
<tr>
<td>Utility parameter</td>
<td>$\alpha = 1.9265$</td>
</tr>
<tr>
<td>Production technology</td>
<td>$\theta = 0.3600$</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta = 0.0250$</td>
</tr>
<tr>
<td>Enforcement parameter</td>
<td>$\phi = 0.174$</td>
</tr>
<tr>
<td>Payout cost parameter</td>
<td>$\kappa = 0.109$</td>
</tr>
</tbody>
</table>

Matrix for the shocks process  

$$A = \begin{bmatrix}
0.890 & 0.001 \\
1.212 & 0.974
\end{bmatrix}$$

4.2 Findings

We now conduct the following exercise. Using the constructed series for the productivity and credit shocks as described above, we compute the response of the model to these shocks. Notice that, although we plug the actual shocks, these shocks are not perfectly anticipated by the optimizing agents. They forecast future values using the autoregressive system characterizing the dynamic properties of these shocks. To study the importance of the two shocks with and without financial frictions, we first show the responses of the model without frictions ($\kappa = 0$). Then we show the responses of the model with financial frictions ($\kappa > 0$).

4.2.1 Model without financial frictions

Figure 2 plots the responses of financial flows, output and labor for the model without financial frictions. This is obtained by setting $\kappa = 0$ and $\tau = 0$. For the real sector of the economy this is equivalent to the RBC model. As can be seen from the figure, the series generated by the model are quite different from the data. For the output series, the productivity shocks generate a path for output that is significantly different from the data. In particular, while the data shows an output boom during the 1990s, the productivity shocks generate a decline. It is also worth emphasizing that the model does not
generate the drop in output we have experienced in the last two quarters of 2008. The drops in output experienced by the US economy during the previous two recessions are much smaller than in the data. The performance of the model in terms of labor is even worse. Now the model is also unable to generate enough volatility of hours. Notice that credit shocks are not completely neutral, which seems to contradict Proposition 3.2. This derives from the fact that credit shocks are correlated with productivity shocks: even even and increase in \( \xi \) has not real effects directly, it also increases the productivity \( z \). The increase in \( z \), however, is relatively small and can be ignored. If we had imposed independence between the two shocks, the responses of output and labor to credit shocks would be have perfectly flat.

4.2.2 Model with credit frictions

Now we consider the model with credit frictions (\( \tau = 0.35 \) and \( \kappa = 0.1017 \)). Figure 3 plots the responses to productivity and credit shocks. The responses to productivity shocks are very similar to those generated by the frictionless model, although the amplitude declines somewhat. This is because, for the particular parametrization, financial frictions tend to dampen the response to productivity shocks. In fact, the increase in productivity and consequent increase in output make the enforcement constraint tighter. As a result, the demand for labor increases less than in the frictionless economy.

Let’s look now at the responses to credit shocks. As can be seen from the figure, credit shocks can replicate the output dynamics much better than productivity shocks. In particular we now see a boom in output and hours during the 1990s. Furthermore, credit shocks generate sharp drops in output and labor in all three major recessions: 1991, 2001 and 2008.

The reason credit shocks improve the performance of the model in terms of GDP is because it can capture better the dynamic path of working hours. This is shown in the last panel of Figure 3. Clearly, credit shocks generates much larger fluctuations in working hours. More importantly, it generates large drops in labor during the three recessions, as well as an upward trend during the 1990s.

Why do the credit shocks capture the overall pattern of output and, more importantly, of labor? The key to understand this result is the impact that these shocks have on the demand for labor, which is outlined by the first
order condition (3). For convenience we rewrite this condition here:

\[ F_i(z, k, l) = w \cdot \left( \frac{1}{1 - \tilde{\mu}} \right) \]

where \( \tilde{\mu} \) is the ‘effective’ multiplier for the enforcement constraint. A negative credit shock makes the enforcement constraint tighter, increasing the multiplier \( \tilde{\mu} \) and the wedge on the cost of labor. Intuitively, if the firm wants to keep the same production scale and hire the same number of workers (raising the same level of intra-period loan), it has to reduce the equity payout. Because this is costly, the firm chooses in part to reduce the equity payout and in part to reduce labor. If changing the equity payout was not costly, the credit shock would not have any impact on the demand of labor.

### 4.2.3 Credit and productivity shocks

Figure 4 plots the impulse responses when both shocks are fed into the model. For financial flows and labor, the performance of the model is very similar to the case with only credit shocks. In fact, the movements of these variables are mostly driven by credit shocks. For output, the performance is not as good as in the case with only credit shocks but certainly better than in the case with only productivity shocks. Still, we see that the model predicts sharp drops in output in each of the major recessions experienced during the sample period.

### 5 Sensitivity analysis

To explore the sensitivity of our quantitative findings to some of our assumptions, we report the results for alternative specifications.

First we want to show the sensitivity of the results to the equity payout parameter \( \kappa \). Figure 5 plots the responses of financial flows, output and labor for different values of \( \kappa \). As we would have guessed from the theoretical analysis, lower values of \( \kappa \) reduce the responses of real variables but increase the responses of financial variables.

Next we consider the case in which the credit shock is on the fraction that can be recovered in case of liquidation. The enforcement constraint is now:

\[ \phi_t \left( k_{t+1} - \frac{b_{t+1}}{R_t} \right) + \xi_t \geq F(z_t, k_t, l_t) \]
where $\phi_t$ is stochastic. The construction of the series for the credit shocks is changed accordingly and the responses are shown in Figure 6. As can be verified, the responses with multiplicative shocks are very similar to the responses with additive shocks. Therefore, whether the credit shocks are additive or multiplicative does not matter for the quantitative results.

6 Conclusion

Are financial frictions and shocks in the financial sector important for macroeconomic fluctuations? Our analysis in this paper suggest that they are. Models driven solely by productivity shocks have a number of known shortcomings in replicating key macroeconomic variables. We propose a model that incorporates explicitly the flows of debt and equity. Within this model we show that shocks to firms’ ability to borrow, combined with some rigidities to change their financial structure, can bring the model closer to the data.

When we use the model to interpret recent economic events, the following picture emerges. The recent financial events show up clearly in our model as a tightening of firms’ financing conditions leading to a sharp downturn in GDP growth during the last two quarters of 2008. Tight financial conditions have also been important in the previous GDP downturns of 1990 and 2001.
Appendix

A Data sources

Financial data is from the Flow of Funds Accounts compiled by the Federal Reserve Board. Outstanding debt is ‘Credit Market Instruments’ of Nonfarm Nonfinancial Corporate Business (B.102, line 22) and Nonfarm Noncorporate Business (B.103, line 24). This includes mainly Corporate Bonds (for the corporate part), mortgages and bank loans (for corporate and noncorporate); it doesn’t include trade and tax payables. Debt Repurchases are defined as the negative of ‘Net Increases in Liabilities’ for ‘Credit Market Instruments’ for the Nonfinancial Corporate Business (F.102, line 39) and for the Noncorporate Business (F103, line 22). Equity Payout in the Nonfinancial Corporate Business is ‘Net Dividends’ (F.102, line 3) minus ‘Net New Equity Issue’ (F.102, line 38). Equity Payout in the Noncorporate Sector is the negative of ‘Proprietors’ Net Investment’ (F103, line 29). Total assets and liabilities are as reported by the Flow of Funds in the Nonfinancial Corporate Business (B.102, line 1 and 21) and in the Noncorporate Business (B.103, line 1 and 23). All macro variables are from the Bureau of Economic Analysis (BEA).

B Derivation of the liquidation value

Suppose that in case of liquidation, the intra-period lender sells the residual net assets \( k_{t+1} - b_{t+1}/R_t \) to a newly created firm at a price \( L_t \) negotiated by the lender and the newly created firm. The new firm has an advantage in acquiring the assets of the liquidated firm because it allows to save on the start-up cost (net of the transferring cost). We denote the net save by \( \chi_t \) and assume that it is stochastic. For the lender, reaching an agreement with the new firm is the only possibility of recovering some value.

Denote by \( \phi_t \) the bargaining power of the lender and by \( 1 - \phi_t \) the bargaining power of the new firm. We allow the bargaining power to be stochastic reflecting changing market conditions. The net surplus for the lender is the bargained price, \( L_t \), and for the new firm is \( k_{t+1} - b_{t+1}/R_t + \chi_t - L_t \). The bargaining problem solves:

\[
\max_{L_t} \left\{ L_t^{\phi_t} (k_{t+1} - b_{t+1}/R_t + \chi_t - L_t)^{1-\phi_t} \right\}
\]

Taking the first order conditions and solving we get \( L_t = \phi_t (k_{t+1} - b_{t+1}/R_t + \chi_t) \).

Defining \( \xi_t = \phi_t \chi_t \) we get the final expression used in the main text:

\[
L_t = \phi_t \left( k_{t+1} - \frac{b_{t+1}}{R_t} \right) + \xi_t
\]
C First order conditions

Consider the optimization problem (2) and let $\lambda$ and $\mu$ be the Lagrange multipliers associate with the two constraints. Taking derivatives we get:

\begin{align*}
  d : & \quad 1 - \lambda \varphi_d(d) = 0 \\
  l : & \quad \lambda F_l(z, k, l) - \lambda w - \mu F_l(z, k, l) = 0 \\
  k' : & \quad Em' V_k(s'; k', b') - \lambda + \phi \mu = 0 \\
  b' : & \quad Em' V_b(s'; k', b') + \frac{\lambda}{R} - \frac{\phi \mu}{R} = 0
\end{align*}

The envelope conditions are:

\begin{align*}
  V_k(s; k, b) &= \lambda \left[ 1 - \delta + F_k(z, k, l) \right] - \mu F_k(z, k, l) \\
  V_b(s; k, b) &= -\lambda
\end{align*}

Using the first condition to eliminate $\lambda$ and substituting the envelope conditions we get:

\begin{align*}
  F_l(z, k, l) &= w \left( \frac{1}{1 - \mu \varphi_d(d)} \right) \\
  Em' \left( \frac{\varphi_d(d')}{\varphi_d(d)} \right) \left[ 1 - \delta + (1 - \mu' \varphi_d(d')) F_k(z', k', l') \right] &= 1 - \phi \mu \varphi_d(d) \\
  R Em' \left( \frac{\varphi_d(d')}{\varphi_d(d)} \right) &= 1 - \phi \mu \varphi_d(d)
\end{align*}

Defining $\bar{\mu} = \mu \varphi_d(d)$ and $\bar{m}' = m' \varphi_d(d')/\varphi_d(d)$ and substituting we get (3)-(5).

D Numerical solution

We solve the model after log-linearizing the dynamic system around the steady state. The system of dynamic equations is as follows:

\begin{align*}
  w U_c(c, l) + U_l(c, l) &= 0 \quad \text{(9)} \\
  U_c(c, l) &= \beta (1 + r) EU_c(c', l') \quad \text{(10)} \\
  wl + b - \frac{b'}{R} + d - c &= 0 \quad \text{(11)}
\end{align*}
\[ F_i(z, k, l) = w \left( \frac{1}{1 - \mu} \right) \]

\[ E \tilde{m}(c, l, d, c', l', d') \left[ 1 - \delta + (1 - \tilde{\mu}) F_k(z', k', l') \right] = 1 - \phi \tilde{\mu} \]

\[ RE \tilde{m}(c, l, d, c', l', d') = 1 - \phi \tilde{\mu} \]

\[ F(z, k, l) - w l - b + \frac{b'}{R} - k' - \varphi(d) = 0 \]

\[ \phi \left( k' - \frac{b'}{R} \right) + \xi = F(z, k, l) \]

\[ V = d + E m(c, l, c', l') V' \]

Equations (9)-(11) are the first order conditions for households and their budget constraint. Equations (12)-(14) are the first order conditions for firms and (15)-(17) are the budget constraint, the enforcement constraint and the value function.

We have nine dynamic equations. After linearizing around the steady state, we can solve these equations for the variables \( c_t, d_t, l_t, w_t, R_t, V_t, \mu_t, k_{t+1}, b_{t+1} \), as linear functions of the states, \( z_t, \xi_t, k_t, b_t \).
References


Figure 2: Model without financial frictions.
Figure 3: Model with financial frictions.
Figure 4: Model with financial frictions - Both shocks.
Figure 5: Sensitivity to the equity payout cost $\kappa$. 
Figure 6: Model with financial frictions - Multiplicative credit shocks.