Macroeconomic Effects of Financial Shocks*
PRELIMINARY AND INCOMPLETE

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Abstract
In this paper we document the cyclical properties of U.S. firms’ financial flows. Equity payouts are procyclical, and debt payments are countercyclical. 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 boom and bust cycle around the year 2000 was strongly influenced by changes in the credit environment.
1 Introduction

Recent economic events starting with the subprime crisis in the summer of 2007 suggest once again that the financial sector plays an important role in the transmission and as the origin 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 the economic boom and bust cycle in the U.S. around the year 2000 was strongly influenced by changes in the credit environment.

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-

\(^1\)There 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.
pirical 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 non-corporate business owners). Debt is defined as ‘credit market liabilities’ which include only liabilities that are directly related to credit markets 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
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 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 $F(z_t, k_t, l_t) = (1 - \delta)k_t + e^{zt}k^{\theta}l^{1-\theta}$. The variable $z_t$ is a productivity shock, $k_t$ is the input of capital, $l_t$ is the input of labor.

Firms use equity and debt to finance their operations. Debt is in general preferred to equity (pecking order) because of its tax advantage as in Hennessy and Whited (2005). Given $R_t = 1 + r_t$ the gross interest rate, the effective rate is $(1 - \tau)R_t$, where $\tau$ determines the tax advantage.\footnote{This is an approximation to $1 + r_t(1 - \hat{\tau})$ where $\hat{\tau}$ is the tax advantage from the deductability of interest payments. The approximation is made for analytical simplicity.}
The ability to borrow is bounded by the limited enforceability of debt contracts. Let $V_t$ be the value of the firm for the shareholders at the end of the period, after paying dividends. This is the market 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, as derived later, and $d_{t+j}$ are the net payments to the shareholders. The firm's value $V_t$ is typically decreasing in the debt, because, everything else equal, debt reduces the future payments that the firm can make to the shareholders.

Limited enforcement implies that firms can default on the debt. In the case of default, the firm diverts the working capital which we assume to be proportional to the payment of wages $w_t l_t$ and renegotiate the debt. Appendix B shows that this leads to the following enforcement constraint:

$$V_t \geq \phi \cdot w_t l_t + \xi_t.$$  \hfill (1)

This constraint imposes that the equity value of the firm (the term on the left hand side), cannot be smaller than the value of defaulting (the expression of the right hand side). The value of defaulting is the value that the firms retain in the renegotiation stage. This depends on two terms. The first term is the working capital $w_t l_t$, which the firm can divert in case of default. The second term derives from a cost incurred in the liquidation of the firm. This cost is stochastic and captures the liquidity in the market for the sales of firms. The detailed description of the renegotiation process through which we derive the above enforcement constraint is provided in the appendix.

We assume that $\xi_t$ is stochastic and follows an exogenous Markov process. Fluctuations in $\xi_t$ affect directly the firms’ ability to borrow, and therefore, we refer to them as “credit shocks”. 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.

An increase in $\xi_t$ tightens the enforcement constraint and reduces the borrowing capacity. If the firm cannot raise equity capital and increase the

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3 Alternative assumptions about the determinants of the working capital generate similar properties. For example, we could assume that working capital depends on both labor and capital. What matters is that the value of default depends on the scale of production. We have chosen the wage payments because this leads to simpler analytical expressions.
equity value of the firm to the new required level, it has to reduce the right-hand-side of the enforcement constraint by cutting employment. Therefore, an increase in $\xi_t$ reduces the demand for labor and through this it can generate a reduction in output.

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 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.

We would also like to point out that, in alternative to the adjustment cost on equity payouts, we could use a quadratic cost on the change of debt, which would imply very 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 market incompleteness. As we will see, when $\kappa = 0$, the economy is essentially equivalent to a frictionless economy. In this case, debt adjustments triggered by the enforcement constraint can be quickly accommodated through changes in firm equity. When $\kappa > 0$, the substitution between debt and equity becomes costly and firms readjust the source 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, specified 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:

\[
V(s; k, b) = \max_{d,l,k',b'} \left\{ d + E m' V(s'; k', b') \right\}
\]  

subject to:

\[
F(z, k, l) - w l + \frac{b'}{(1 - \tau) R} - b - \varphi(d) - k' = 0
\]

\[
E m' V(s'; k', b') \geq \phi \cdot w l + \xi
\]

The optimization problem is subject to the budget and the enforcement constraints. The function \( V(s; k, b) \) is the cum-dividend 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.

Taking the first-order conditions we get:

\[
F_l(z, k, l) = w \cdot \left( 1 + \phi \mu \varphi_d(d) \right),
\]  

\[
(1 + \mu) E m' \left( \frac{\varphi_d(d)}{\varphi_d(d')} \right) F_k(z', k', l') = 1,
\]  

\[
(1 + \mu)(1 - \tau) R E m' \left( \frac{\varphi_d(d)}{\varphi_d(d')} \right) = 1,
\]

where \( \mu \) is the lagrange multiplier for the enforcement constraint and subscripts denote derivatives. The detailed derivation is in Appendix C.

To build some intuition, let’s consider first the case without adjustment costs, that is, \( \kappa = 0 \). Thus, \( \varphi_d(d) = \varphi_d(d') = 1 \) and condition (5) becomes
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 $\mu$ 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.

Things are different with productivity shocks. Let's consider again the case with $\kappa = 0$. In this case conditions (3) and (4) are affected directly by the productivity shock because it affects the marginal revenues from labor and capital. Therefore, even if the aggregate prices do not change, the demand for labor and investment will respond. This, in turn, will induce general equilibrium effects that are typical of the standard real business cycle model.

With a positive value of $\kappa$, the impact of a productivity shock is somewhat altered in the way we will see later. But in general, we can infer that, the higher is the value of $\kappa$, the more important is the relative contribution of credit shocks to business cycle fluctuations. In the limiting case of $\kappa = 0$, only the productivity shocks matter.

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:

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

where $w_t$ and $R_t$ are the wage and gross 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 $T_t = (B'/R)[\tau/(1 - \tau)]$ 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:

$$w_t U_c(c_t, l_t) + U_h(c_t, l_t) = 0$$  \hspace{1cm} (6)

$$U_c(c_t, l_t) - \beta R_t EU_c(c_{t+1}, l_{t+1}) = 0$$  \hspace{1cm} (7)

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

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

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, $s = (z, \xi, K, B)$.

**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 satisfy 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 $\xi$. 

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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 $m = 1/R$. Because in the steady state $\varphi_d(d) = \varphi_d(d') = 1$, the first order condition for debt, equation (5), can be rewritten as $m = 1/[(1 + \mu)(1 - \tau)R]$. This implies that $\mu = \tau/(1 - \tau)$. Therefore, as long as there is tax advantage in issuing debt, that is, $\tau > 0$, 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. In this case the constraint is always binding if $\tau$ is sufficiently large.

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 $(1 + \mu)(1 - \tau)REm' = 1$. From the household’s first order condition (7) we have that $REm' = 1$. This implies that $\mu$ is constant and equal to $\tau/(1 - \tau)$. Now consider an innovation in $A$ 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 changes in $\xi$ cancel each other out because there is no cost associated with changing equity payout. For these reasons, the conjectured unchanged sequence of prices is an equilibrium outcome.

When $\kappa = 0$, business cycle movements driven by fluctuations in the aggregate productivity $z$ are essentially the same as in the standard RBC model. That is, the existence of the enforcement constraint does not affect the transmission of a productivity shock to the economy’s real variables. There is one small difference with respect to the standard RBC model due
to the subsidy to corporate debt. This somewhat distorts the deterministic steady state. However, this has only very minor effects on the dynamic properties of the model.

When $\kappa > 0$, that is, when the substitution between equity and debt is costly, the model behaves differently. For instance, an increase in $\xi$ requires a reduction in debt. Because this requires a reduction in $d_t$, which is costly, the adjustment is done only gradually. In the short-run the firm is forced to reduce labor. In addition, productivity shocks may then be amplified (or dampened) by the effect of the enforcement constraint on labor and capital choices. These mechanisms will be examined in the quantitative analysis.

4 Quantitative analysis

In this section we study the quantitative properties of the model and address the following questions. First, can the model with only productivity shocks account for the cyclical movements of real and financial variables? After showing that the model with only productivity shocks fails in some key dimensions, we show that adding credit shocks not only improves the model’s predictions for the financial flows, but also improves the performance of the model in replicating the business cycle properties of certain macroeconomic variables, in particular working hours. We also use the model to recover the series of credit shocks implied by recent movements in GDP and Productivity. The series for the credit shocks shows a tightening of the credit conditions in 2008 and this is the predominant force underlying the current recession. The series for equity and debt flows generated by the model follow closely their empirical counterparts.

4.1 Calibration

The parameters from the real side of our model are calibrated in line with the literature. 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 tax advantage parameter is set to $\tau = 0.0062$. In terms of tax deductibility of interests this corresponds to 35 percent. Capital depreciation $\delta$ is at 2.5%. The utility function takes the form $U(c, l) = \ln(c) + \alpha \cdot \ln(1 - l)$ where $\alpha$ is chosen to have an average working time of 0.3.
The productivity and credit shocks are assumed to be independent. Productivity follows the autoregressive process:

\[ z_{t+1} = \rho_z z_t + \epsilon_{t+1}, \quad \epsilon \sim N(0, \sigma_z). \]

After linearly detrending the empirical Solow residuals over the period 1984:1-2008:3, we estimate the persistence \( \rho_z = 0.95 \) and the standard deviation of the innovations \( \sigma_z = 0.0041 \).

This leaves the adjustment cost parameter \( \kappa \), \( \phi \) in the enforcement constraint, as well as the process for the credit shocks which we represent through \( \xi_t = \bar{\xi} e^{x_t} \), with

\[ x_{t+1} = \rho_x x_t + \varepsilon_{t+1} \quad \varepsilon \sim N(0, \sigma_x). \]

\( \bar{\xi} \) is set to 2.77 to generate a steady state leverage (debt over capital) of 46 percent (conditional on the values for \( \kappa \) and \( \phi \)). This value corresponds to the average leverage obtained from the Flow of Funds for the Nonfarm Nonfinancial Corporate and Noncorporate Business during the period 1984:1-2008:3.\(^4\) We use the model to estimate the persistence and the standard deviation of the innovations, \( \rho_x \) and \( \sigma_x \), so as to match the empirical standard deviation of GDP and of the Equity Payout ratios. We find \( \rho_x = 0.923 \) and \( \sigma_x = 0.0141 \); this is conditional on all the other parameter values in the model.

We limit the set of possible values for \( \kappa \) to relatively small values, because high values of \( \kappa \) optimally make the firm chose a slack enforcement constraint and therefore dramatically reduce the impact of the financial friction. With \( \kappa = 0.3 \), the firm effectively remains constrained throughout. With this value for \( \kappa \) the amount lost through the payout cost function is negligible. For the benchmark case with the two shocks, the percentage loss at a 2 standard deviation distance for the payout from its steady state level is roughly 1/5 of a percent. The corresponding marginal cost is about 1.4\%. We set \( \phi = 2 \). Significantly smaller values for \( \phi \) also force the firm off the constraint and do not allow financial shocks to be sufficiently potent to match output volatility.

\(^4\)The leverage is measured as total liabilities divided by total assets. This is equal to 0.46 for the Nonfinancial Corporate Business (table B.102) and 0.366 for the Nonfarm Nonfinancial Business (table B.102 and B.103).
Table 1: Parametrization.

<table>
<thead>
<tr>
<th>Calibrated parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor, $\beta$</td>
<td>0.9825</td>
</tr>
<tr>
<td>Tax advantage, $\tau$</td>
<td>0.0062</td>
</tr>
<tr>
<td>Utility parameter, $\alpha$</td>
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</tr>
<tr>
<td>Production technology, $\theta$</td>
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<tr>
<td>Depreciation rate, $\delta$</td>
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<tr>
<td>Enforcement parameter, $\xi$</td>
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</tr>
<tr>
<td>Enforcement parameter, $\phi$</td>
<td>2</td>
</tr>
<tr>
<td>Payout cost parameter, $\kappa$</td>
<td>0.3</td>
</tr>
<tr>
<td>Productivity shock persistence and volatility, $\rho_z$ and $\sigma_z$</td>
<td>0.95, 0.0041</td>
</tr>
<tr>
<td>Credit shock persistence and volatility, $\rho_x$ and $\sigma_x$</td>
<td>0.923, 0.0141</td>
</tr>
</tbody>
</table>

4.2 Findings

4.2.1 Productivity shocks only

The model driven only by productivity shocks fails along a number of dimensions. Consider first the well known implications of the basic RBC model, which is obtained by setting $\kappa = 0$. The statistics are reported in the second column of Table 3. While this model does a reasonable job with the main aggregates, its fit is far from perfect. Overall business cycle volatility falls short of the empirical 0.85% standard deviation of GDP, with the model producing only 0.66%. Hours worked are too smooth and investment volatility remains substantially below its empirical counterpart. The model completely fails explaining the volatility of equity payouts and doesn’t do much better for debt repurchases. Introducing financial frictions into this benchmark, by setting $\kappa = 0.3$, as reported in the third column of the table has a very minor effect on business cycle properties and further dampens financial flows.

As shown in column 4 and 5 of the table, the behavior of financial flows in the model with productivity shocks is quite sensitive to the persistence of the shock. If instead of using the estimated persistence of 0.95, we use the more persistent 0.999, equity and debt flows become substantially more volatile, although with volatilities that are still below their empirical counterparts. For instance, a positive productivity shock now has a big effect on the left hand side of the enforcement constraint, equation (1). This induces the firm to increase debt and equity payouts. If the financial friction is turned on, that is if $\kappa = 0.3$, the increase in debt and equity is smaller, and there is
an additional real effect because the labor supply will take up some of the slack in the enforcement constraint. Therefore, in this case, the productivity shock is now amplified through a financial accelerator effect. Figures 2 and 3 show the corresponding impulse responses of key macroeconomic and financial variables.

4.2.2 Credit shocks and productivity shocks

Adding credit shocks leads to a substantial improvement in the model’s ability to match financial and real variables. As explained in the calibration section, the model is now able to match output and equity payout volatility with shock process persistence and innovation volatility of 0.923 and 0.41, respectively. Not surprisingly, the model then also generates higher volatility for debt flows. As shown in Table 4, this is now somewhat higher than in the data, while it was considerably below the empirical target without the credit shocks. Credit shocks lead to a dramatic improvement in the model’s ability to produce volatile hours, they also contribute to more volatile investment. Figure 4 displays the impulse response functions of a credit shock that tightens the constraint by an innovation that accounts for 1 standard deviation.

4.2.3 Implied credit shock series

Having demonstrated that the model with financial frictions and credit shocks does a good job reproducing volatility levels of macroeconomic and financial variables, we now compare the model implied paths for some key series with their empirical counterparts for the recent period. Consistent with our findings in matching second moments, credit shocks are shown to make a substantial contribution as drivers of business cycles. Moreover, the model implied equity payout and debt flows closely match their empirical counterparts’ low frequency movements.

We run the following experiment. Conditional on the empirical realization of the Solow residuals for the period 1984:1-2008:3, we compute the model implied realizations of the credit shocks in order to perfectly match the empirical series of U.S. GDP. All series have been linearly detrended but are otherwise unfiltered. The left panel in Figure 5 shows that output series generated by the model in response to the actual productivity shocks doesn’t track actual GDP (in boldface) very well. In particular, the strong increase
in U.S. GDP throughout the 1990s is only moderately driven by an increase in total factor productivity. Moreover, while GDP deviations from the linear growth trend are declining starting in 2000, model output implied by Solow residuals continues its strong growth through 2004. The fact that the standard RBC cannot capture the macroeconomic expansion of the 1990s, especially in working hours, has already been pointed out in McGrattan and Prescott (2007).

Since 2007, productivity implied output is roughly flat relative to trend, while actual GDP has decreased. This suggests a role for credit shocks in the most recent downturn. Indeed, as shown in the right panel of Figure 5, the level of the credit shock, and thus the tightness of the no-default constraint, shows an uptick in 2008. Overall, the behavior of the implied credit shock series is dominated by the contrasting evolution of actual GDP and the model generated output given the measured Solow residuals before and after 2000. To justify the strong performance in GDP growth in the second half of the nineties, the model suggests that favorable credit conditions played an important role. The downturn after 2000 is then driven by a reversal of these favorable conditions. The model’s story seems consistent with the boom and bust cycle in stock prices and IPOs through that time period.5

As a cross-check of the model, we also compare model implied and actual series for equity payouts and debt repurchases as shown in Figure 6. While this parsimonious model is obviously not able to replicate every wiggle in these empirical time series, it is nevertheless striking how well the model tracks the low frequency movements in equity and debt flows over the last 25 years. The model also does a great job in matching the most recent turning points in 2007 in the empirical series for equity and debt flows.

5As far as the macroeconomic performance of the 1990s is concerned, McGrattan and Prescott (2007) propose a different interpretation based on the productivity increase in the sector that produces intangible investment.

5 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 matching second moments of key business cycle variables. In our
model we explicitly incorporate debt and equity flows and we further show that productivity shocks are not sufficient to generate realistic movements in financial flows. Shocks to firms’ ability to borrow, combined with some rigidities in the ability to rearrange the financial structures of firms, are shown to bring the model closer to the data.

When we use the model to interpret recent economic events we reach two main conclusions. First, the recent events in the financial sector show up clearly in our model as a tightening of firms’ financing conditions and as a cause for a downturn in GDP growth. Second, the boom and bust cycle in the U.S. around the year 2000 seems to be strongly driven by changes in the firms’ credit environment.
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  Enforcement constraint

In addition to $k_t$, production requires working capital. Denote the working capital by $D_t$. Working capital consists of liquid funds that are used at the beginning of the period and are recovered at the end of the period when all transactions are completed. The firm borrows these funds at the beginning of the period and returns them at the end of the period. This is in addition to the debt $b_{t+1}$. Because this is an intra-period loan, there are no interests.

The firm could divert these funds at the end of the period and default. Default leads to the renegotiation of the loan. Suppose that in case of default the lender can sell the firm and recover a fraction $\psi$ of its value, that is, $\psi V_t$. However, in order to do so, the lender has to pay a cost $\chi_t$, which is stochastic. The stochastic nature of this cost could reflect the liquidity conditions in the market.

Denote by $\eta$ the bargaining power of the firm and $1 - \eta$ the bargaining power of the lender. Bargaining is over the repayment of the debt, which we denote by $e_t$. By reaching an agreement, the firm gets $D_t + V_t - e_t$ and the lender gets $e_t$. Without agreement, the firm gets the threat value $\overline{D}_t$ and the lender gets the liquidation value $\psi V_t - \chi_t$. Therefore, the net value of reaching an agreement for the firm is $V_t - e_t$ and for the lender is $e_t - \psi V_t + \chi_t$. The bargaining problem
solves:

\[
\max_{e_t} \left\{ (V_t - e_t)^\eta (e_t - \psi V_t + \chi_t)^{1-\eta} \right\}
\]

Taking the first order conditions and solving we get \( e_t = \nabla_t [1 - \eta (1 - \psi)] - \eta \chi_t \).

Incentive-compatibility requires that the value of not defaulting, \( V_t \), is not smaller than the value of defaulting, \( D_t + V_t - e_t \). Therefore, the enforcement constraint is \( V_t \geq D_t + V_t - e_t \). Using \( e_t = \nabla_t [1 - \eta (1 - \psi)] - \eta \chi_t \) derived above, the enforcement constraint can be written as:

\[
V_t \geq D_t + \eta (1 - \psi) V_t + \eta \chi_t
\]

Collecting terms and rearranging we get:

\[
V_t \geq \phi \cdot D_t + \xi_t
\]

where \( \phi = 1 /[1 - \eta (1 - \psi)] \) and \( \xi_t = \chi_t / [1 - \eta (1 - \psi)] \)

Using the assumption that working capital is equal to wages, \( D_t = w_t l_t \), we get the enforcement constrained used in the main text of the paper. Notice that alternative assumptions about the working capital requires only a change in the right-hand-side of the constraint.

### 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:

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

The envelope conditions are:

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

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

\[ wU_c(c, l) + U_l(c, l) = 0 \]  
(9)

\[ U_c(c, l) = \beta REU_c(c', l') \]  
(10)

\[ wl + b - \frac{b'}{(1-\tau)R} + d - c = 0 \]  
(11)

\[ F_l(z, k, l) = w \left( 1 + \mu \phi d(d) \right) \]  
(12)

\[ (1 + \mu) E m' \left( \frac{\varphi_d(d)}{\varphi_d(d')} \right) F_k(z', k', l') = 1 \]  
(13)

\[ (1 + \mu)(1 - \tau) RE m' \left( \frac{\varphi_d(d)}{\varphi_d(d')} \right) = 1 \]  
(14)

\[ F(z, k, l) - wl - b + \frac{b'}{(1-\tau)R} - k' - \varphi(d) = 0 \]  
(15)

\[ Em'V' = \phi w + \xi \]  
(16)

\[ V = d + Em'V' \]  
(17)

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.

These are nine dynamic equations which, together with the definition of the discount factor, \( m' = \beta U_c(c', l')/U_c(c, l) \), are used to solve the model. After linearizing around the steady state, we can solve 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


<table>
<thead>
<tr>
<th></th>
<th>$\sigma(j)$</th>
<th>$\sigma(j) / \sigma(Y)$</th>
<th>corr($j,Y$)</th>
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<td>Consumption N &amp; S</td>
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Band-pass filter 1.5-8 years
Logarithms have been taken of the first five variables

*Last updated 1/14/2009*
Table 3  
Business cycle properties  
Productivity Shocks only  
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Band-pass filter 1.5-8 years  
Last updated 1/19/2009
Table 4

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| corr( j, Y) | | | | | |
| EquPay / Y | 0.50 | 0.63 | 0.28 | 0.72 | 0.67 |
| DebRep / Y | -0.77 | -0.75 | -0.99 | -0.80 | -0.84 |
| Consumption | 0.83 | 0.86 | 0.98 | 0.82 | 0.98 |
| Investment | 0.85 | 0.99 | 1.00 | 0.96 | 0.99 |
| Hours | 0.81 | 0.84 | 0.99 | 0.83 | 0.88 |

Band-pass filter 1.5-8 years

Last updated 1/19/2009
Figure 2

- **Productivity Shock - Credit Shock**
- **Output**
- **Equity Payout/Y**
- **Debt Repurchase/Y**
- **Consumption**
- **Investment**
- **Hours**
- **Vf - Equity value (cum div)**
Figure 3

- Productivity Shock - Credit Shock
- Output
- Equity Payout/Y
- Debt Repurchase/Y
- Consumption
- Investment
- Hours
- Vf - Equity value (cum div)
Figure 4

Productivity Shock - Credit Shock.

Output

Equity Payout/Y

Debt Repurchase/Y

Consumption

Investment

Hours

Vf - Equity value (cum div)