The Real and Financial Impact of Uncertainty Shocks

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Abstract

We show theoretically and empirically how real and financial frictions amplify the impact of uncertainty shocks on firms' investment, employment, debt (term structure of debt growth), and cash holding. We start by building a model with real and financial frictions, alongside uncertainty shocks, and show how adding financial frictions to the model almost doubles the negative impact of uncertainty shocks on investment and hiring. The reason is higher uncertainty induces the standard negative real-options effects on the demand for capital and labor, but also leads firms to hoard cash and cut debt to hedge against future shocks, further reducing investment and hiring. We then test the model using a panel of US firms and a novel instrumentation strategy for uncertainty exploiting differential firm exposure to exchange rate and factor price volatility. We find that higher uncertainty significantly reduces real investment and hiring, while also leading firms to take a more cautious financial position by increasing cash holdings and cutting debt, dividends and stock-buy backs. This highlights not only the importance of financial frictions for amplifying the impact of uncertainty shocks, but how in periods with greater financial frictions – like during the global-financial-crisis – uncertainty can be particularly damaging.

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1 Introduction

We study theoretically and empirically the impact of uncertainty shocks on firms' real and financial activity including investment, employment, debt, payout, and cash holding. We start by building a model with real and financial frictions, alongside uncertainty shocks, and show how adding financial frictions to the model almost doubles the negative impact of uncertainty shocks on investment and hiring. The reason is higher uncertainty induces the standard negative real-options effects on the demand for capital and labor, but also leads firms to hoard cash and cut debt to hedge against future shocks, further reducing investment and hiring. Furthermore, firms cut short-term debt more than long-term debt, causing a negative relation between uncertainty and the term structure of debt issuance. We then test the model using a panel of US firms and a novel instrumentation strategy for uncertainty exploiting differential firm exposure to exchange rate and factor price volatility. We find that higher uncertainty significantly reduces real investment and hiring, while also leading firms to take a more cautious financial position by increasing cash holdings and cutting debt, dividends and stock-buy backs. Consistent with the model, the growth rate of the short-term debt to long-term debt ratio is negatively related with uncertainty shocks across firms. These findings highlight not only the importance of financial frictions for amplifying the impact of uncertainty shocks, but how in periods with greater financial frictions – like during the global-financial-crisis – how uncertainty can be particularly damaging.

To understand the effects of uncertainty shocks on real activity and financial flows, we build a dynamic structural model including both real and financial frictions that amplify the impact of uncertainty shocks . It features a large cross section of firms where heterogeneity is driven by firm-specific productivity. More important, uncertainty is time-varying, so the model includes shocks to both the level of firms' productivity (the first moment) and its conditional volatility (the second moment). On the real side, investment incur fixed cost and is partially irreversible (Bloom 2009), while employment is frictionless adjusted. On the financing side, different from the existing literature on capital structure models (e.g., Hennessy and Whited 2005), firms issue both short-term and long-term debt to finance investment, both of which are costly to issue. Long-term debt has a longer maturity than short-term debt and pays out a periodic coupon. The adjustment costs on short-term and long-term debt captures the cost of liquidity risk on short-term debt (e.g., Diamond 1991) and the agency costs (asset substitution) associated with long-term debt (e.g., Myers 1977, Barclay and Smith 1995, Hoven Stohs and Mauer 1996). In addition, both short-term and long-term debt are subject to collateral constraints which limit firms' debt capacity. However, short-term debt faces a tighter collateral constraint than long-term debt. This assumption captures the fact that short-term debt is due sooner than long-term debt, which imposes a higher liquidation risk on firms. When short-debt debt takes on negative values, firms save in cash. Firms also issue external equity in addition to debt to finance investment. External equity is assumed to be costly to capture equity flotation cost and information cost on equity issuance. Firms make investment, long-term debt, and short-term debt issuance/cash saving decisions to maximize the market value of equity. In the model, firms face the trade-off between the liquidation and issuance cost and the tax benefit of short-term debt and long-term debt in presence of time-varying uncertainty. Additionally, firms also manage the trade-off between total debt, equity, and cash in financing capital investment.

The model highlights the endogenous interactions between uncertainty shocks, investment, short-term and long-term debt issuance, and cash saving decisions. Intuitively, when uncertainty shock is high, firms reduce capital investment and employment, a standard prediction implied by investment models with fixed cost and partial irreversibility on investment. Furthermore, firms with higher uncertainty reduce the short-term debt and increase their cash holding. This happens because firms' internal funds fall following the drop in investment and employment when uncertainty is high; to pay off the short-term debt due, firms can either use external equity or issue new debt. However external equity is costly to issue to substitute for short-term debt, and issuing new short-term to pay off existing debt is also costly, thus firms reduce short-term debt when uncertainty is high.

Firms save more in cash to hedge the uncertainty shock due to precautionary saving motive when external financing is costly. Different from the response of short-term debt, firms with higher uncertainty shocks reduce the long-term debt a lot less than the short-term debt. This occurs because the long-term debt in the model is a substitute for short-term debt, and the periodic coupon payment of the long-term debt (coupon plus retirement of existing debt) only constitutes a small portion of total debt payment due, thus firms with high uncertainty reduce long-term debt less than the short-term debt because short-term debt has higher liquidation risk. Therefore, the model implies a negative relation between firms' term structure of debt growth (the ratio of short-term debt growth to long-term debt growth) and uncertainty. Lastly, firms with higher uncertainty also cut their dividend payout.

We then test the model in the US data. Figure 1 shows the correlations of the quarterly VIX index which proxies for the aggregate uncertainty and the aggregate real and financial variables. The top two panels show that times of high aggregate real investment rate and employment growth are negatively correlated with the low VIX. The middle two panels show that the total debt (sum of the short-term and long-term debt) growth and the term structure of the debt growth (short-term debt growth to long-term debt growth ratio) are negatively related with the VIX, implying firms cut the short-term debt more than the long-term debt when uncertainty shock is high. The bottom two panels show that cash holding is positively while dividend payout and equity repurchase are negatively related to the VIX. Turning to our major empirical analysis, we use a panel of firms in the US to the test model cross-sectionally. We tackle endogeneity concerns by developing an instrumentation strategy that exploits firm's differential exposure to energy and currency volatility (as measured by at-the-money forward call options for oil and 7 widely traded currencies). Moreover, we further instrument lagged firm volatility with firm's exposure to political uncertainty. We find that higher uncertainty significantly reduces real investment and hiring, while also leading firms to take a more cautious financial position by increasing cash holdings and cutting debt, dividends and stock-buy backs. Furthermore, high uncertainty also cause firms to adjust the term structure of debt growth towards to the long-term debt, i.e., firms cut the long-term debt than the short-term debt facing high uncertainty shocks. These results are consistent with the model predictions.

Related literature Our paper relates to the investment literature that studies the impact of real frictions on investment dynamics (e.g., Doms and Dunne (1998), Davis and Haltiwanger (1992), Caballero, Engel, and Haltiwanger (1995), Cooper and Haltiwanger (2006)). In particular, we are complementary to Abel and Eberly (1996) who show that costly reversibility is important to explain the real investment dynamics. We differ in that we show that time-vary uncertainty and financial frictions also play important roles in capturing firm-level real investment activity in addition to real frictions.

This paper also contributes to the growing literature that studies the impact of uncertainty shocks on firms real decisions and business cycle fluctuations. Bloom, Bond, and Van Reenen (2007) and Bloom (2009) show that uncertainty shocks have a substantial impact on firms' investment and labor hiring decisions. Bloom et. al. (2012) further show that uncertainty shocks also drive business cycle fluctuations in a DSGE model. Segal, Shaliastovich, and Yaron (2015) decompose aggregate uncertainty into 'good' and 'bad' volatility components, and investigate their different impact for macroeconomic quantities and asset prices. Our paper differs in that we study the impact of uncertainty shocks on firms' financing decisions.

Our empirical analysis relates to the empirical corporate finance literature that studies the determinants of capital structure choice, e.g., Rajan and Zingalas (1995), Welch (2004), etc. We are complementary to these studies by showing that uncertainty shocks have significant impact on firms' financial flows. Our paper is closely related to Chen et. al. (2014) who also look at the impact of uncertainty shocks on firms' financing decisions. We differ in that empirically we use the instrumentation approach to study the causal effect of past uncertainty on the future changes of firms' financing flows and also build a structural model to interpret our results, while Chen et. al. (2014) focus on the contemporaneous relations between realized volatility and capital structure.

This paper also relates to the literature that examines the impact of financial frictions on corporate investment and financial flows. Hennessy and Whited (2005) study firms' leverage choice and investment decisions in the presence of financial distress costs and equity flotation costs. Bolton, Chen, and Wang (2013) study firms' investment, financing, and cash management decisions in a dynamic q-theoretic framework in which, external financing conditions are stochastic. Our analysis is complementary to these studies in that we focus on the impact of uncertainty shocks on firms' capital structure choice, a dimension that is not studied in these papers. The paper closest to us is Chen (2016) who investigates how firms manage their savings, equity financing, and investment when aggregate uncertainty is time-varying. We differ in that we study the impact of firms' uncertainty on the debt and the term-structure choice in addition to liquidity management and empirically we use the instrumentation approach to identify the causal effect of uncertainty on real and financial additivity.

The rest of the paper is laid out as follows. In section 2 we write down the model. In section 3 we present the main quantitative results of the model. In section 4 we describe the international data that we use in the paper. In section 5 we present the empirical findings on uncertainty shocks and financial flows. Section 6 concludes.

2 Model

The model features a continuum of heterogeneous firms facing uncertainty shocks and financial frictions. Firms take on both short-term debt (or save in cash) and long-term debt and trade off the tax benefit of debt and liquidation cost. Firms choose optimal levels of physical capital investment, labor, and short-term debt (cash) and long-term debt each period to maximize the market value of equity.

2.1 Technology

Firms use physical capital (K_t) and labor (H_t) to produce a homogeneous good (Y_t). To save on notation, we omit firm index whenever possible. The production function is given by

$$Y_t = Z_t K_t^{\alpha} H_t^{1-\alpha}, \tag{1}$$

in which Z_t is firm-specific productivity. The firm faces an isoelastic demand curve with elasticity (ε),

$$Q_t = X P_t^{-\varepsilon},$$

where X is a demand shifter. These can be combined into a revenue function $R\left(Z_t, X, K_t, H_t\right) = Z_t^{1-1/\varepsilon} X^{1/\varepsilon} K_t^{\alpha(1-1/\varepsilon)} \left(H_t\right)^{(1-\alpha)(1-1/\varepsilon)}$. For analytical tractability we define $a = \alpha\left(1 - 1/\varepsilon\right)$ and $b = \left(1-\alpha\right)\left(1 - 1/\varepsilon\right)$, and substitute $\tilde{Z}_t^{1-a-b} = \tilde{Z}_t^{1-1/\varepsilon} X^{1/\varepsilon}$. With these redefinitions we have

$$S\left(Z, K, H\right) = \tilde{Z}_t^{1-a-b} K_t^a H_t^b.$$

Wages are normalized to 1. Given employment is flexible, we can obtain optimal labor. Note that labor can be pre-optimized out even with financial frictions which will be discussed later.

Firm-specific productivity follows the AR(1) process

$$z_{t+1} = \bar{z}(1-\rho_z) + \rho_z z_t + \sigma_t \varepsilon_{t+1}^z, \tag{2}$$

in which $z_{t+1} = \log(Z_{t+1})$, ε_{t+1}^z is an i.i.d. standard normal shock that is uncorrelated across all firms in the economy, and $\bar{z}$, ρ_z, and σ_t are the mean, autocorrelation, and conditional volatility of firm-specific productivity, respectively.

The stochastic volatility process σ_t is assumed for simplicity to follow two-point Markov chains

$$\sigma_t \in \left\{\sigma_L, \sigma_H\right\}, \text{where } \Pr\left(\sigma_{t+1} = \sigma_j | \sigma_t = \sigma_k\right) = \pi_{k,j}^{\sigma}.$$

Physical capital accumulation is given by

$$K_{t+1} = (1 - \delta)K_t + I_t, \tag{3}$$

where I_t represents investment and δ denotes the capital depreciation rate.

We assume that capital investment is costly reversible and entails nonconvex adjustment costs, denoted as G_t, which are given by:

$$G_t = I_t^+ + \left(1 - c_k^P\right) I_t^- + b_k K_t \mathbf{1}_{\{I_t \neq 0\}} \tag{4}$$

in which $c_k^P, b_k > 0$ are constants. I_t^+ and I_t^- are positive and negative investment, respectively. The capital adjustment costs include planning and installation costs, learning the use of new equipment, or the fact that production is temporarily interrupted. The nonconvex costs $b_k K_t \mathbf{1}_{\{I_t \neq 0\}}$ capture the costs of adjusting capital that are independent of the size of the investment. The costly reversibility can arise because of resale losses due to transaction costs or the market for lemons phenomenon. The resale loss of capital is labelled c_k^P and is denominated as a fraction of the relative purchase price of capital.

2.2 Long-term and short-term debt and collateral constraint

Firms use equity and both of the short-term (one period) debt and long-term (multi-periods) debt to finance investment. At the beginning of time t, firms can issue an amount of short-term debt, denoted as B_t^S, which must be repaid at the beginning of period $t+1$. Following Hackbarth, Miao, and Morellec (2006) we model long-term debt with finite maturity via sinking funds provisions. We denote by B_t^L the book value of long-term debt that firms have outstanding at time t. Long-term corporate bonds pay a fixed coupon c in every period and a fraction θ is paid back each period (after payment of the coupon) with $0 < \theta < 1$. The average maturity of these long-term bonds then corresponds to $1/\theta$ periods. Denoting new long-term bond issuance by N_t, the amount of long-term corporate bonds evolves as

$$B_{t+1}^L = (1-\theta)\, B_t^L + N_t \tag{5}$$

The firm's ability to borrow is bounded by the limited enforceability as firms can default on their obligations. Following Hennessy and Whited (2005), we assume that the only asset available for liquidation is the physical capital K_t. In particular, we require that the respective liquidation values of capital is greater than or equal to the short and the long-term bonds, and that the sum of the short-term and long-term bonds cannot exceed the liquidation value of capital either. It follows that the collateral constraints are given by

$$B_{t+1}^S \;\leq\; \varphi^S K_t. \tag{6}$$

$$B_{t+1}^L \;\leq\; \varphi^L K_t. \tag{7}$$

The parameters φ^S, φ^L are constants satisfying the constraints $0 < \varphi^S < \varphi^L < 1$, $0 < \varphi^S + \varphi^L \leq 1$ which affect the tightness of the collateral constraints, and therefore, the borrowing capacity of the firm. Due to the collateral constraints, the interest rate, denoted by r_f, is the risk-free rate which is assumed constant.

Firms can also save on cash when the short-term debt B_t^S takes on negative values. Firms also incur adjustment costs on debt, denoted by Φ_t when changing the amount of short-term debt and long-term debt outstanding,

$$\Phi_t = b^S K_t \mathbf{1}_{\{\Delta B_t^S \neq 0 \text{ and } B_t^S > 0\}} + b^L K_t \mathbf{1}_{\{N_t \neq 0\}} \tag{8}$$

where $\Delta B_t^S = B_t^S - B_{t-1}^S$, and $b^S, b^L > 0$. The debt adjustment costs capture the fact that adjusting capital structure is costly. For short-term debt, it captures the cost associated with liquidity risk, e.g., borrowers are forced into inefficient liquidation because refinancing is not available, thus prefer long-term contract (Diamond 1991). For long-term debt, it captures the agency costs associated with long-term debt (Myers 1977), e.g., the under-investment problem associated with debt overhang in the long-term debt contract. It also captures the information cost associated with long-term contract as borrowers with favorable inside information may avoid locking in their financing cost with long-term debt contracts. Lastly, cash is freely adjusted.

2.3 Costly external equity financing

Taxable corporate profits are equal to output less capital depreciation and interest expenses: $S_t - \bar{W}H_t - \delta K_t - r_f B_t^S \mathbf{1}_{\{B_t^S > 0\}} - cB_t^L$. It follows that the firm's budget constraint can be written as

$$\begin{aligned} E_t &= (1-\tau)\left(S_t - \bar{W}H_t\right) + \tau\delta K_t + \tau r_f B_t^S \mathbf{1}_{\{B_t^S \geq 0\}} + \tau c B_t^L - I_t - G_t + B_{t+1}^S - (1+r_s)B_t^S \\ &\quad + N_t - (c+\theta)\, B_t^L - \Phi_t, \end{aligned} \tag{9}$$

in which τ is the corporate tax rate, $\tau\delta K_t$ is the depreciation tax shield, $\tau r_f B_t \mathbf{1}_{\{B_t^S > 0\}}$ and $\tau c B_t^L$ are the interest tax shields where c is the coupon rate, and E_t is the firm's payout. When $B_t^S > 0$, short-term debt interest rate is r_f.

When the sum of investment, capital, and debt adjustment costs exceeds the sum of after tax operating profits and debt financing, firms can take external funds by means of seasoned equity offerings. External equity O_t is given by

$$O_t = \max\left(-E_t, 0\right). \tag{10}$$

In practice, firms face external equity financing costs, which involve both direct and indirect costs. We do not explicitly model the sources of these costs. Rather, we attempt to capture the effect of the costs in a reduced-form fashion. The external equity costs are assumed to be linear for simplicity. More specifically, we parameterize the equity issuance costs as:

$$\Psi\left(O_t\right) = \eta O_t \mathbf{1}_{\{O_t>0\}}. \tag{11}$$

Finally, firms do not incur costs when paying dividends or repurchasing shares. The effective cash flow D_t distributed to shareholders is given by

$$D_t = E_t - \Psi_t. \tag{12}$$

2.4 Firm's problem

Firms solve the maximization problem by choosing capital investment, labor, short-term debt/cash and long-term debt optimally:

$$V_t = \max_{I_t, H_t, B^S_{t+1}, B^L_{t+1}} D_t + \beta \mathbb{E}_t V_{t+1}, \tag{13}$$

subject to firms' capital accumulation equation (Eq. 3), collateral constraints (Eq. 6 and 7), budget constraint (Eq. 9), and cash flow equation (Eq. 12).

3 Main results

This section presents the model solution and the main results. We first calibrate the model, then we simulate the model and study the quantitative implications of model for the relationship between uncertainty shocks and firms' real activity and financial flows.

3.1 Calibration

The model is solved at a monthly frequency. Because all the firm-level accounting variables in the data are only available at an annual frequency, we time-aggregate the simulated accounting data to make the model-implied moments comparable with those in the data.

Table 1 reports the parameter values used in the baseline calibration of the model. The model is calibrated using parameter values reported in previous studies, whenever possible, or by matching the selected moments in the data reported in Table 2. To evaluate the model fit, the table reports the target moments in both the data and the model. To generate the model's implied moments, we simulate $3,000$ firms for $1,000$ monthly periods. We drop the first 400 months to neutralize the impact of the initial condition. The remaining 600 months of simulated data are treated as those from the economy's stationary distribution. We then simulate 100 artificial samples and report the cross-sample average results as model moments.

[Insert Table 1 here]

[Insert Table 2 here]

We split the parameters into two groups. The first group includes those parameters which are based on the estimates in the previous literature including $\left\{\alpha, \varepsilon, \delta, \beta, c, \theta, \eta, \rho_z, \sigma_L, \sigma_H, \pi^{\sigma}_{L,H}, \pi^{\sigma}_{H,H}, \bar{z}\right\}$. We set the share of capital the production function at $1/3$, and the elasticity of demand ε to 4 which implies a markup of 33%, consistent with Hall (1988). The capital depreciation rate δ is set to be 1% per month. The discount factor β is set so that the real firms' discount rate $r_f = 4\%$ per annum, close the average of the real annual S&P index return in the data. This implies $\beta = 0.9967$ monthly. The rate of retirement of the long-term debt $\theta = 1/120$, implying the length of the long-term contract is 10 years, close to the empirical estimate in Guedes and Opler (1996). The coupon rate c is set $5\%/12$ per month, implying that the average term premium is 1% per annum, close to the average in the U.S. We set the equity issuance cost parameters $\eta = 0.08$, close to Hennessy and Whited (2007). It also implies the variable equity issuance cost no more than 8% of issuance proceeds, consistent with the estimates in Altinkilic and Hansen (2000) and the estimates in Hennessy and Whited (2007). The fraction of equity issuance implied by the model is 16% close to the data at 17% estimated in Belo, Lin, and Yang (2016). We set the persistence of firms' productivity as $\rho_z = 0.97$ following Kahn and Thomas (2008). We set the baseline volatility $\sigma_L = 0.10$ and the high uncertainty state $\sigma_H = 2 * \sigma_L$ close to those in Bloom (2009). We set transition probabilities of $\pi^{\sigma}_{L,H} = 1/36$, and $\pi^{\sigma}_{H,H} = 1 - 1/36$, consistent with one uncertainty shock every three years. The long-run average level of firm-specific productivity, $\bar{z}$, is a scaling variable. We set $\bar{z} = -3$, which implies that the average detrended long-run capital level in the economy is 1.

The second group contains the six parameters calibrated to match some moments in the data, including $\left\{c^P_k, b_k, b^S, b^L, \varphi^S, \varphi^L\right\}$. We calibrate the capital adjustment cost parameters to match several cross-sectional and time-series moments of firms' investment rates. Table 2 shows that this calibration of the model matches reasonably well the volatility of firm-level investment rate. The investment resale loss parameter c^P_k is set at 2.5% to match the inaction region in investment rate. Investment fixed cost parameter b_k is set at 0.01. The implied volatility of investment rate is 24%, close to the data moment at 23%. We calibrate the short-term and long-term debt adjustment cost parameters $b^S = b^L = 0.03\%$ and the tightness of the collateral constraint for short-term and long-term debt $\varphi^S = 0.3$ and $\varphi^L = 0.55$ to match the average level of financial leverage at 0.55 and the short-term debt to long-term ratio at 0.27 in the data. The model implied average leverage is 0.54 and the implied short-term debt to long-term ratio is 0.23, close to the data moment.

3.2 Uncertainty shocks, real and financing flows

In this subsection, we conduct the panel regression analysis using the artificial data obtained from the simulation of the model. Table 3 presents the result. In the panel regressions, we regress future investment rate, employment growth, short-term debt and long-debt growth rates, the term structure of debt growth (the ratio of the short-term debt growth to the long-term debt growth), cash holding growth, and payout (dividend plus share repurchase) growth on past annual stock return volatilities which are used to proxy the true uncertainty shock. To align simulated results with real data results we aggregate monthly simulated data to annual values (summing flow variables like sales over the year and taking year end values for stock variables like capital, as is done in company accounts) and regress current outcomes on lagged uncertainty.

Panel A in Table 3 presents the benchmark calibration result while panel E presents the data moments which will be discussed in detail in section 5. The model predicts a negative relation between past return volatility and investment rate, and employment growth in the univariate regressions. The model implied univariate regression slopes of investment and employment growth are -0.012 and -0.011, close to the data moments at -0.020 and -0.022, respectively. Turning to financial flows, the model also predicts a negative relation between past return volatility and short-term debt growth and a negative relation between past return volatility and the term structure of debt growth. The model implied slope coefficients on debt growth and the term structure of debt growth are -0.017 and -0.238, respectively, reasonably close to the data moments are -0.045 and -0.103. Furthermore, cash holding growth and past return volatility are positively correlated; the model implied slope is 0.229, somewhat higher than the data at 0.078. Dividend payout growth is negatively correlated with past return volatility; the model implied moment is -0.109, smaller than the data slope at -0.257. So, overall the basic predictions from the model fit the data extremely well.

[Insert Table 3 here]

3.3 Inspecting the mechanism

In this section we first study the impulse responses of the real and financial variables in the benchmark model and then compare them to a model without financial frictions.

To simulate the impulse response, we set the level of the firm's productivity at the long-run average level and raise the volatility from low state to high state for all firms. We perform this analysis for the benchmark model with both real and financial adjustment costs and a model without financial adjustment costs, i.e., debt and equity issuance costs are zero. Figure 2 plots the impulse responses of the main real and financial variables. For the real variables, upon impact shutting down financial adjustment costs makes the responses of investment rate and employment growth slightly smaller than those in the benchmark calibration (the top two subplots). However, turning off financial frictions significant reduces the responses of financial variables after volatility increases from low to high state (the bottom four subplots). In particular, both of the short-term and long-term debt in the benchmark model drop much more than the model without financial frictions with short-term debt dropping more than long-term debt. Dividend in the benchmark falls when volatility is high while dividend rises in the model without financial frictions which is opposite to the data. Cash significantly rises in the benchmark model after volatility rises; interestingly in the model without financial frictions, because precautionary saving motive is minimal when external sources of financing is free, firms do not save in cash, thus the response in cash is plotted as a flat line.

Lastly figure 3 plots the impulse responses of output in the benchmark model and the model without financial frictions. Upon impact, output falls with similar magnitudes when volatility is high in both two cases. However, after the impact, the response of output in the model without financial frictions revert to the stead state level immediately whereas the response of output in the benchmark model with financial frictions persists for more than 12 months before reverting to the long-run level. Taken together, financial frictions clearly amplify the impact of uncertainty shocks on real and financial variables.

Next we perform several comparative statics analyses to show the economic forces driving the overall good fit of the model. Panels B and C in Table 3 present the results. We consider two specifications:

- A model without real frictions (no partial irreversibility $c_k^P = 0$ and fixed cost is zero $b_k = 0$, and
- A model without financial frictions (no debt and equity issuance costs $b^S = b^L = \eta = 0$).

The results without real frictions are reported in panel B of Table 3. We see the responses of investment rate, employment and cash growth drop substantially relative to the benchmark. For example, the slope on investment drops from -0.012 in the benchmark to -0.002, employment growth from -0.011 to -0.009, and cash growth from 0.229 to 0.079.

Furthermore, the term structure of debt growth loads positively, 0.010 compared to -0.238 in the benchmark and -0.103 in the data, which is counterfactual to the data. The slope on dividend growth does not change significantly (-0.109 in the benchmark compared to -0.108 in Panel A). Hence, as is well known in the literature, real-frictions are needed to get reasonable real - and in this case financial - variable responses to uncertainty shocks.

When we shut down the financial frictions in panel C (i.e., both short-term and long-term debt and equity issuances are free), the slope coefficients on investment rate and employment growth drop by around one third (from -0.012 in the benchmark to -0.007 for investment and from -0.011 to -0.008 for employment growth). This finding shows that financial frictions play an important role amplifying the effect of uncertainty shocks on real quantities. In addition, the coefficient on debt growth falls from -0.017 to -0.005, by more than two thirds. The term structure of debt growth becomes unresponsive to the volatility shock, the slopes drops to zero, compared to -0.238 in the benchmark. Turning to cash, because all marginal sources of external financing are free now (debt up to the collateral constraints), firms do not save precautionarily, thus the equilibrium cash holding is zero. Similar to Panel C, dividend growth does not drop significantly, from -0.109 in the benchmark to -0.094. Taken together, these comparative analyses show that both real frictions and financial frictions amplify the impact of the uncertainty shocks and are jointly important for the model to capture the quantitative effect of uncertainty shocks on real and financial activity.

Lastly, we study the impact of uncertainty shock for real and financial activity in recessions. To simulate a recession in the model, we first induce an aggregate productivity shock in month 1 and then let firms productivity evolve following the standard transition process (so the man slowly mean reverts to the steady state). The productivity shock is induced by moving all firms down two productivity levels if possible - so firms are position 5 move to 3, those at 4 to 2 and those at 3 or less down to 1. Panel D in Table 3 reports the result. Interestingly, the responses of both real and financial variables are much stronger than those in the benchmark calibration during the recession, because financial and real constraints become fare more binding. For example, the slope coefficients on investment and employment growth are -0.031 and -0.030, respectively, about 50% bigger in absolute magnitude than the benchmark. The slope coefficients on financial variables including debt, term structure of debt growth, cash growth and payout are -0.043, -0.468, 0.438, and -0.243, respectively, about twice as big in magnitudes as those implied in the benchmark calibration. This result suggests that the impact of uncertainty shocks is particularly strong in recessions when firms' average productivity is low and financial and real constraints are more likely to be binding.

4 Data and Instruments

We first describe the data and variable construction, then the identification strategy.

4.1 Data

Stock returns are from CRSP and annual accounting variables are from Compustat. The sample period is from January 1963 through December 2014. Financial, utilities and public sector firms are excluded (i.e., SIC between 6000 and 6999, 4900 and 4999, and above 9000). Compustat variables are at the annual frequency.[1] Our main empirical tests involve regressions of changes in real and financial variables on changes in lagged uncertainty. Thus, our sample requires firms to have at least 3 consecutive non-missing data values (this restriction deals with firms with too few observations in Compustat, which are likely backfilled, e.g., Fama and French (2002 and 2003)). Firm-years with less than 9 months or more than 15 months of data in any accounting year are dropped.

In measuring firm-level uncertainty we employ both realized annual uncertainty from CRSP stock returns and option-implied uncertainty from OptionMetrics. Uncertainty

[1] Sample is also restricted to firms with common shares (shrcd = 10 and 11) and whose stocks are traded on the New York Stock Exchange, the American Stock Exchange, or NASDAQ (exchcd = 1,2, or 3). Microcaps with a market value of equity of less than USD $50 million are excluded.

measured from stock-returns is the standard-deviation of returns over the accounting year (which typically spans about 250 days). OptionMetrics provides daily implied volatility data for underlying securities from January 1996 through December 2014, with our principal measure being the "at-the-money" "91-day" implied volatility. Additional information about the OptionMetrics data is provided in Appendix (B).

For all variables growth is defined following Davis and Haltiwanger (1992), where for any variable x_t we define $\Delta x_t = (x_t - x_{t-1})/(\frac{1}{2}x_t + \frac{1}{2}x_{t-1})$, which yields growth rates bounded between -2 and 2. The only exception is capital for which the investment rate (implicitly the change in gross capital stock) is defined as $I_{i,t} = \frac{CAPEX_{i,t}}{0.5*(K_{i,t-1}+K_{i,t})}$ where K is net property plant and equipment, and $CAPEX$ is capital expenditures. The changes and ratios of real and financial variables are winsorized at the 1 and 99 percentiles to eliminate the impact of any potential outliers.

4.2 Identification Strategy

Our identification strategy exploits firms' differential exposure to energy and currency exposure to generate exogenous changes in firm-level uncertainty. The ideas is that some firms are very sensitive to, for example, oil prices (e.g. energy intensive manufacturing and mining firms) while others are not (e.g. retailers and business service firms), so that when oil-price volatility rises this shifts up firm-level volatility in the former group relative to the latter group. Likewise, some industries have different trading intensity with Europe versus Mexico (e.g. industrial machinery versus agricultural produce firms), so changes in bilateral exchange rate volatility generates differential moves in firm-level uncertainty.

This approach is conceptually similar to the classic Bartik (1991) identification strategy which exploits different regions exposure to different industry level shocks, and builds on most recently the paper by Stone and Stein (2013).

The sensitivities to energy and current prices are estimated at the industry as the factor loadings on price changes in a regression of firm stock returns on energy or currency prices and the overall market return. That is, for firm i in industry j , $sensitivity_i^c = \beta_j^c$ is estimated as follows

$$r_{i,t} = \alpha_i + \beta_i \cdot r_t^{S\&P500} + \sum_c \beta_j^c \cdot r_t^c + \epsilon_{i,t} \tag{14}$$

where $r_{i,t}$ is the return on firm i (including dividends and adjusted for delisting), $r_t^{S\&P500}$ is the value-weighted return on the $S\&P500$ from CRSP, and r_t^c is the change in the price of commodity c . The sensitivities are estimated using daily price data from the fifteen years (1985 to 1999) prior to the main two stage least squares (2SLS) estimation period. This estimation is run at the SIC 2-digit industry level to yield sufficient sample size to identify the crucial β_j^c coefficients, with insignificant values set to zero.

For energy we use the crude-oil price, and for exchange rates we select the 7 "major" currencies used by the Federal Board in constructing the nominal and real trade-weighted U.S. Dollar Index of Major Currencies. [2] For these eight market prices (the oil price and the seven exchange rate prices) we need not only their levels (for calculating the sensitivities β_j^c in equation 14) but also their implied volatilities $\sigma_{j,t}^c$ as a measure of their uncertainty. The composite of these two terms - $\beta_j^c \sigma_t^c$ - is then an industry-by-year instrument for uncertainty. Our instrumental variables estimation uses these eight instruments (oil price and for the seven currencies) individually to maximize first-stage power (which as we see in the results section yields an F-statistic of 20 or greater) and to enable a first-stage over-identification test (which these instruments do not reject with p-values of 0.5 or above).

[2] see `http://www.federalreserve.gov/pubs/bulletin/2005/winter05_index.pdf`. These include: the euro, Canadian dollar, Japanese yen, British pound, Swiss franc, Australian dollar, and Swedish krona. Each one of these trades widely in currency markets outside their respective home areas, and (along with the U.S. dollar) are referred to by the Board staff as major currencies.

5 Empirical findings

We start by examining how volatility relates to future real outcomes followed by financial variables.

Table 4 examines how uncertainty influences future capital investment. Column 1 presents the univariate Ordinary Least Squares regression results of investment rate on lagged annual realized stock return volatility. We observe highly statistically significant coefficients on return volatility, showing that firms tend to invest more when their firm-specific uncertainty is low. Column 2 proxies uncertainty with that implied by forward looking options on the firm's underlying security. The coefficient sign is consistent with the OLS regression, but the point estimate is half the OLS magnitude (which is likely attributed to the reduced sample size and availability of implied uncertainty data mostly on large firms in OptionMetrics). Despite their initial usefulness, both realized and implied uncertainty suffer from endogeneity concerns. We address such concerns by instrumenting uncertainty by exposure to energy and currency markets volatility. Column 3 shows the univariate 2SLS results when instrument lagged realized uncertainty. Quite interesting the point estimate of the coefficient on uncertainty is very near that of the OLS analogue in column 1 (while reaming highly statistically significant).

A more rigorous test is ran in columns 4 and 5, where we include our main set of controls. Column 4 presents the OLS multivariate results while column 5 shows the 2SLS results. In both cases, rises in uncertainty remains a strong predictor of future reductions in capital investment even after controlling for lagged changes in Tobin's Q and changes in various measures of a firm's status (such as firm return on assets and sales). Interestingly, the point estimates for OLS in column 4 and IV in column 5 are similar in magnitude, suggesting the upward OLS endogeneity bias (from future investment plans increasing current uncertainty) and downward attenuation bias (from measurement error in uncertainty) are roughly offsetting.

[Insert Table 4 here]

Table 6 examines the predictive implications of uncertainty on other important *real* outcomes. Panel A examines employment changes, Panel B changes in cost of goods sold, and Panel C changes in selling, general, and administrative expenses. In each panel we present 5 columns of regression results. The specifications in each column follow the regression specifications described in the investment rate Table 4. Moreover, to preserve space we only report the point coefficient estimates on lagged changes in uncertainty. The three panels show that realized and implied volatility is negatively related to real future outcomes in employment, cost of goods sold, and firm expenses. These results are largely confirmed in specifications 3 and 5 where we instrument realized uncertainty by volatility exposure to commodity markets. In particular, the negative coefficient estimates are quite pronounced and highly statistically significant for both cost of goods sold and firm expenditures (both in univariate and multivariate regressions). Uncertainty also shows a negative causal relation with employment in the univariate regression results. However, the statistical significance is weaker when controlling for our full set of regressors. Yet, as is well know with instrumental variables, the standard errors are larger and drive the statistical significance downward.

[Insert Table 6 here]

Table 7 examines how firm uncertainty affects future total debt and the debt maturity structure. Panel A shows that increases in uncertainty reduces the willingness of firm's to increases their overall debt. The correlations are strong in OLS regressions and less so in instrumental variable regressions. More interestingly, the reduction in debt is stronger for short-term than long-term debt, as seen in Panel B which regresses changes in the ratio of short to long term debt. Uncertainty has a strong negative sign in both OLS and 2SLS regression, univariate and multivariate, indicating that firm's cut their short-term debt more strongly than their long-term debt. Panels C and D examine how uncertainty affects corporate payout and cash holding policies. Consistent with a precautionary saving motive, rises in a firm's uncertainty associates with reduced cash dividend payments and increases in cash holdings. The 2SLS results are statistically significant in both cases, but stronger for cash payout reductions.

[Insert Table 7 here]

6 Conclusion

This paper studies the impact of uncertainty shocks on firms' real and financial activity both theoretically and empirically. We build a dynamic capital structure model which highlights the interactions between the time-varying uncertainty and the external financial frictions and the real frictions. The model generates the links between uncertainty shocks and real and financial activity observed in the data. We show that both real and financial frictions significantly amplify the impact of uncertainty shocks on firms's real and financing decisions. Empirically, we test the model and show that uncertainty shocks cause firms to reduce investment and employment on real side and furthermore, reduce their total debt and the term structure of debt, while increase the cash holding and cut dividend payout on financial side. Taken together, our theoretical and empirical analyses show that real and financial frictions are quantitatively crucial to amplify the impact of uncertainty shocks on firms' activity.

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A Numerical algorithm

To solve the model numerically, we use the value function iteration procedure to solve the firm's maximization problem. We specify three grids of 22 points for capital, long-term debt, and short-term debt/cash, respectively, with upper bounds $\bar{k}$, $\bar{n}$ and $\bar{b}$ that are large enough to be nonbinding. The grids for capital, short-term debt and long-term debt are constructed recursively, following McGrattan (1999), that is, $k_i = k_{i-1} + c_{k1}\exp(c_{k2}(i-2))$, where $i = 1,...,n$ is the index of grids points and c_{k1} and c_{k2} are two constants chosen to provide the desired number of grid points and two upper bounds $\bar{k}, \bar{n}$ and $\bar{b}$, given three pre-specified lower bounds $\underline{k}$, $\underline{n}$, and $\underline{b}$. The advantage of this recursive construction is that more grid points are assigned around $\underline{k}$, $\underline{n}$ and $\underline{\mathrm{b}}$, where the value function has most of its curvature.

We use Tauchen (1986) method augmented with two state Markov process of time-varying conditional volatility to discretize the process of idiosyncratic productivity z. We use 5 grid points for the z process. In all cases, the results are robust to finer grids as well. Once the discrete state space is available, the conditional expectation can be carried out simply as a matrix multiplication. Linear interpolation is used extensively to obtain optimal investment, short-term debt/cash and long-term debt that do not lie directly on the grid points. Finally, we use a simple discrete global search routine in maximizing the firm's problem.

B Data Appendix

The Compustat accounting data, CRSP stock-returns and option metrics data are detailed here. We also provide a table of descriptive statistics in Table

B.1 Compustat

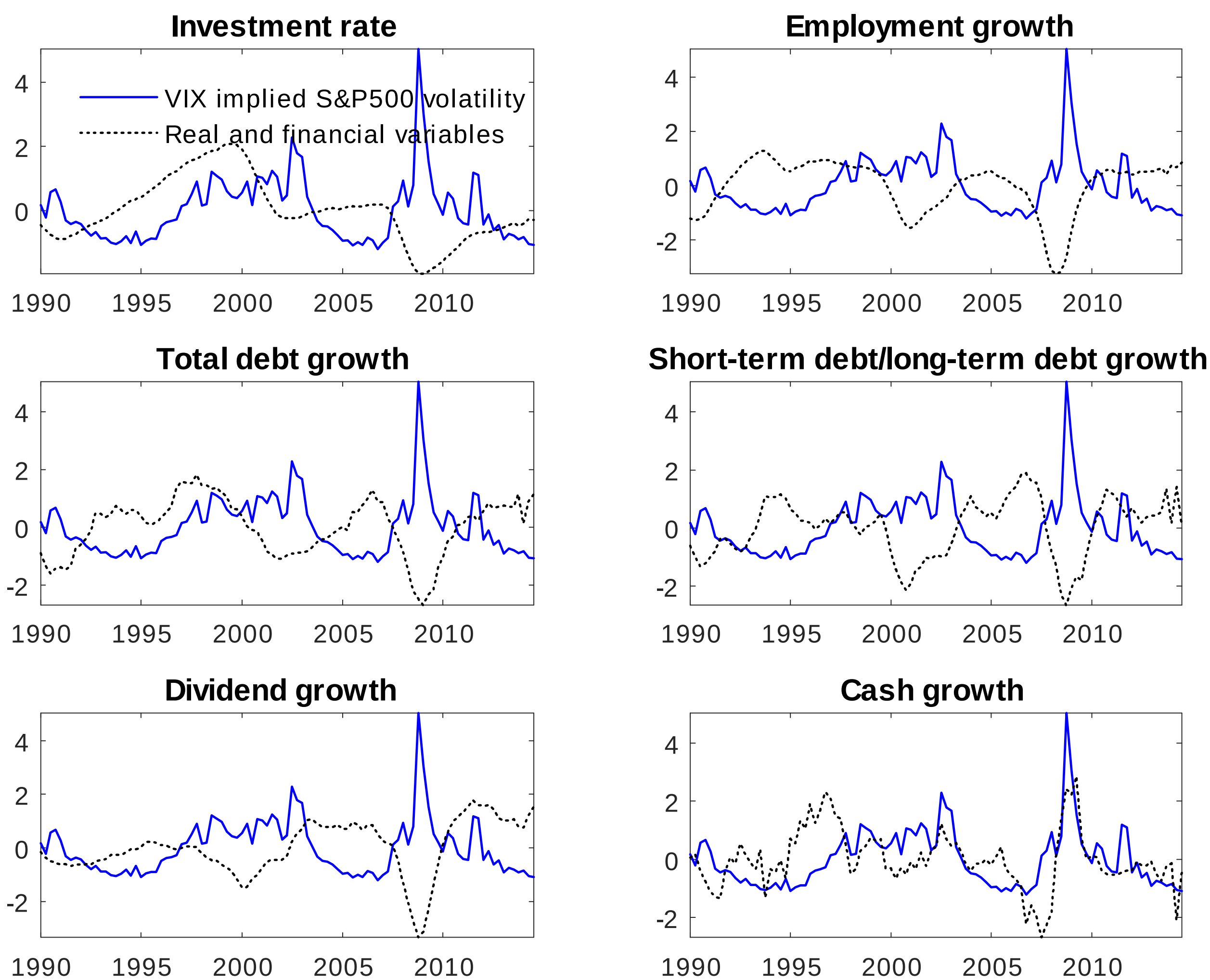
We define total debt as $Debt = DLC + DLTT$, where DLC and DLTT are short-term and long-term debt from Compustat. We define corporate payout as $Payout = DV + PRSTKC$, where DV is cash dividends and PRSTKC is purchase of common and preferred stock from Compustat. Cash holdings is the level of cash and short-term investments (CHE) from Compustat.

We measure firm stock return in the 12-month fiscal-year period. $Tangibility_t$ is gross property, plant, and equipment divided by total assets. Tobin's Q is computed as in Kaplan and Zingales (1997). Specifically, $Q_{i,t} = (total\ assets\ +\ market\ value\ of\ common\ equity - book\ equity)\ /\ (0.9 *\ book\ assets + 0.1 *\ market\ value\ assets)$. We handle outliers in Tobin's Q by bounding Q above at 10. Return on assets, ROA_t , is earnings before interest and tax (EBIT) divided by total assets. $book - to - debt - ratio_t = \frac{CEQ_t}{ME_t}$ where CEQ and ME are Compustat book equity and CRSP market value of equity (i.e. stock price times shares outstanding), correspondingly. Tax rate is defined as $tax_t = TXT_t/(EPSPI * CSHPRI + TXT)$, where TXT is total income tax, $EPSPI$ is earnings per share including extraordinary items, and $CSHPRI$ is common shares used to calculate earnings per share. Moreover, we further control for capital investment $I_{i,t} = CAPX_{i,t}/AT_{i,t-1}$, where AT is total assets. $Cash(ratio)$ is computed as cash on balance sheet divided by interest expenses. As a measure of the degree of external financing need, we control for financial deficit $DEF_{i,t} = [(INV_{i,t} + \Delta(WC_{i,t}) - (NI_{i,t} - DVD_{i,t} + DEP_{i,t} + DT_{i,t})]/sales_{i,t}$. Where $INV = PPE_{i,t} - PPE_{i,t-1}$ is investment in capital capital assets. $\Delta WC_{i,t}$ is the change in working capital from $t-1$ to t. $NI_{i,t}$ is net income, $DVD_{i,t}$ is dividend, $DEP_{i,t}$ is depreciation and amortization, and $DT_{i,t}$ is deferred taxes. Lastly, we also control for the overall macroeconomic condition using the return and volatility of the $S\&P500$ and the industrial production index growth ΔIP_t from year $t-1$ to t.

B.2 Summary Statistics

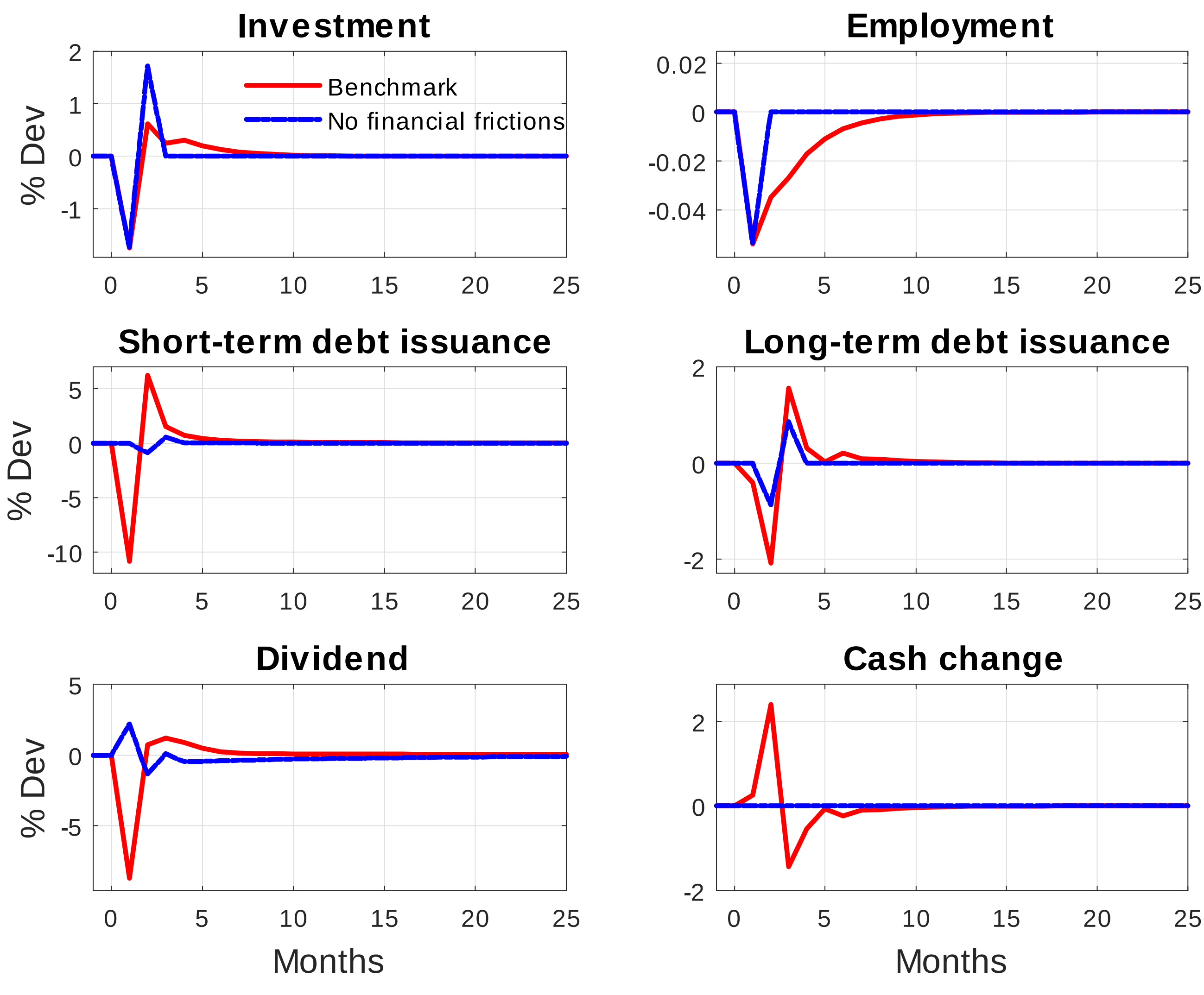
Descriptive statistics of the key variables are reported in Table **??**. The average active change in book leverage of firms is 0.04% with a standard deviation of 9.82% and a median of 0.52%. The average change of long term debt is -1.99% with a standard deviation of 70.99%, whereas short term debt is on average -0.92% with a standard deviation of 90.68%. Moreover, the firms' average change in debt is 53.77 with a standard deviation of 350.92% The firms' total liabilities changed 17.21% on average with a standard deviation of 54.86%. Their average book debt ratio is 55.49% with a standard deviation of 103.45% and a median of 53.33%. The average stock and net stock issuances are 0.06 and 0.03 with a standard deviation of 0.22 and 0.21, respectively. In terms of equity, the firms experienced an average change of 15.70% with a standard deviation of 102.51% and a median of 2.66%. The firms' average return on assets is 5.18% with a standard deviation of 16.37%. The average stock return is 13.79% with a standard deviation of 75.12%, in addition to an average stock return volatility of 3.58% with a standard deviation of 2.14% and a median of 3.02%. Furthermore, the firms' average capital investment rate is 22.79% with a standard deviation of 19.45% and a median of 18.56%.

Figure 1 Uncertainty shocks and aggregate real and financial flows



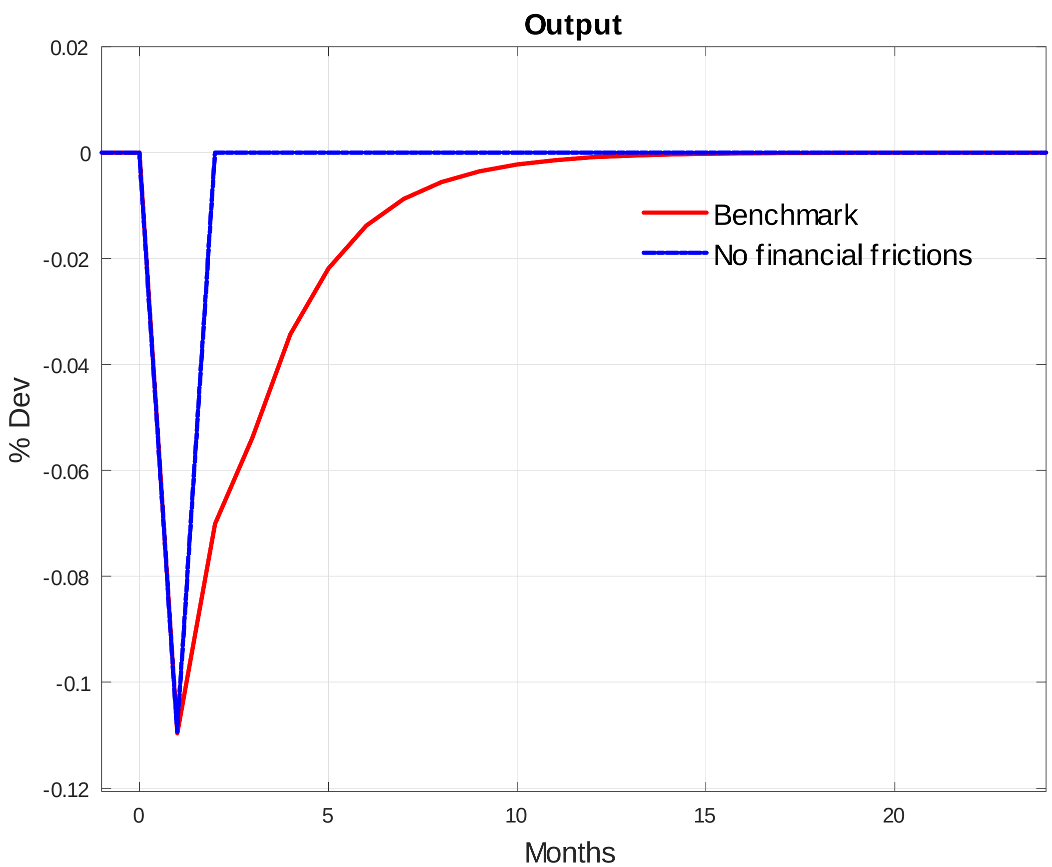
This figure plots the aggregate stock market volatility and the selected real and financial variables. Stock market volatility is the quarterly average of the monthly VIX. We construct quarterly series of the aggregate investment rate following Bachmann et al. (2011) using investment and capital data from the national account and fixed asset tables, available from the Bureau of Economic Analysis (BEA). Employment is the quarterly average of seasonally adjusted total private employment from BLS with the ID of CES0500000025. Short-term debt, long-term debt, and cash are from the NIPA Integrated Macroeconomic Accounts Table S.5.q nonfinancial corporate business. Short-term debt is the sum of open market paper (line 123) and short-term loans (line 127). Long-term debt is the sum of bonds (line 125) and mortgages (line 130). Cash is the sum of currency and transferable deposits (line 97) and time and savings deposits (line 98). Dividend is the quarterly average of the aggregate read dividend from the stock market data on Robert Shiller's webpage http://www.econ.yale.edu/~shiller/data.htm. We scale the nominal short-term and long-term debt and cash by the quarterly consumer price index from NIPA table 1.1.4 (line 1) to get the real variables. The growth rates of all the real and financial variables are the moving average with a window of 5 quarters ahead and then standardized. The market volatility is standardized too.

Figure 2 Impulse responses of real and financial flows



This figure plots the impulse responses of the real and financial variables from the low volatility state to high volatility state while fixing the level of productivity at the long-run average level. There are two model specifications: i) the benchmark model (solid line) and ii) a model without financial frictions (no debt and equity issuance costs $b^S = b^L = \eta = 0$, dotted line).

Figure 3 Impulse response of output



This figure plots the impulse responses of output from the low volatility state to high volatility state while fixing the level of productivity at the long-run average level. There are two model specifications: i) the benchmark model (solid line) and ii) a model without financial frictions (no debt and equity issuance costs $b^S = b^L = \eta = 0$, dotted line).

Table 1
Parameter values under benchmark calibration

Description	Notation	Value	Justification
Predetermined parameters			
Subjective discount factor	β	0.996	Long-run average for U.S. firm-level discount rate at 4% annually
Share on capital	α	0.33	Capital share in output is one-third, labor share is two-thirds
Markup	ε	4	33% markup (Hall 1988)
Wage	$\bar{w}$	1	Wage rate normalized to 1
Rate of depreciation for capital	δ	0.01	Capital depreciation rate assumed 1% per month (about 10% annually)
Linear equity issuance cost	η	0.08	Linear equity issuance cost (Hennessy and Whited 2005)
Coupon rate of long-term debt	c	0.05/12	Coupon rate of long-term debt (typical term premium on Corp.+ T. Bills)
Maturity of long-term debt	$1/\theta$	120	Avg. maturity of long-term debt as 10 years (Guedes and Opler 1996)
Monthly conditional volatility of idio. productivity	σ_L	0.10	Baseline uncertainty (Bloom 2009)
Monthly conditional volatility in high idio. uncertainty state	σ_H	0.20	Uncertainty shocks 2 times baseline uncertainty (Bloom 2009)
Monthly transition prob. from low to high uncertainty	$\pi_{L,H}$	0.0278	Uncertainty shocks expected every 3 years (Bloom 2009)
Monthly transition prob. of remaining in high uncertainty	$\pi_{H,H}$	0.9722	Probability of high uncertainty state remaining at the high state
Persistence of logged idio. productivity	ρ_z	0.97	Persistence of logged idiosyncratic productivity (Belo et al 2014).
Average of logged idio. productivity	$\bar{z}$	-3	Scalor; average long-term debt is 0.5
Calibrated parameters			
Fixed cost of investment	b_k	0.01	Fixed cost of investment
Partial irreversibility parameter on investment	c_k^P	0.025	Investment resale loss
Adj. cost parameters in short-term debt	b^S	0.3%	Adj. cost parameters in short-term debt
Adj. cost parameters in long-term debt	b^L	0.3%	Adj. cost parameters in long-term debt
Tightness of collateral constraint for short-term debt	ϕ^S	0.30	Tightness of collateral constraint for short-term debt
Tightness of collateral constraint for long-term debt	ϕ^L	0.55	Tightness of collateral constraint for long-term debt (match S/L ratio)

This table presents the predetermined and the calibrated parameter values of the benchmark model.

Table 2
Unconditional moments under the benchmark calibration

Moments	Data	Model
Std. dev. of investment rate	0.21	0.19
Std. dev. of net hiring rate	0.23	0.24
Mean of financial leverage	0.56	0.55
Average fraction of the firms holding cash	0.50	0.49
Short term to long term debt ratio	0.27	0.23
Average fraction of the firms issuing equity	0.17	0.16

This table presents the selected moments in the data and implied by the model under the benchmark calibration. The reported statistics in the model are averages from 100 samples of simulated data, each with 3000 firms and 600 monthly observations (50 years). We report the cross-simulation averaged annual moments.

Table 3
Coefficient on lagged changes in volatility for real and financial variables.

	Real		**Financial**			
	I/K	dEmp	dDebt	ST/LT	dCash	dDiv
A: Benchmark model						
Volatility	-0.012	-0.011	-0.017	-0.238	0.229	-0.109
B: No real frictions						
Volatility	-0.002	-0.009	-0.015	0.010	0.079	-0.108
C: No financial frictions						
Volatility	-0.007	-0.008	-0.005	0.000	na	-0.094
D: Recessions						
Volatility	-0.031	-0.030	-0.043	-0.468	0.438	-0.243
E: Data						
Volatility	-0.020	-0.022	-0.045	-0.103	0.078	-0.257

This table reports the model regression results of real and financial variables on lagged stock return volatility. The reported statistics in the model are averages from 100 samples of simulated data, each with 3000 firms and 600 monthly observations. We report the cross-simulation averaged annual moments. I/K is the investment rate, dEmp is the employment growth, dDebt is the total debt growth, ST/LT is the short-term debt to long-term debt growth, dCash is the cash growth rate, and dDiv the dividend growth in the model and cash dividend plus repurchase growth in the data.

Table 4
Investment rate

Investment rate	(1) OLS Realized	(2) OLS Implied	(3) IV Realized	(4) OLS Realized	(5) IV Realized
Volatility	-0.024***	-0.044***	-0.060***	-0.023***	-0.041*
	(-13.430)	(-10.269)	(-2.646)	(-13.164)	(-1.799)
Tobin's Q				-0.044***	0.010
				(-12.052)	(1.041)
Book to Debt ratio				-0.010***	-0.008***
				(-11.316)	(-3.982)
Stock Return				0.066***	0.025***
				(41.031)	(6.677)
Log(sales)				0.049***	0.062***
				(10.186)	(3.876)
Return on Assets				0.000	-0.000
				(0.201)	(-0.845)
Tangibility				-0.074***	-0.086***
				(-23.638)	(-10.726)
F-test of 1st stage			37.16		23.60
Observations	148,785	26,210	21,176	128,641	17,296

This table present the regression results for investment rate on lagged changes in uncertainty and controls. Sample period is annual from 1963 to 2014. Specification 1,2, and 4 are OLS regressions, while 4 and 5 are 2SLS regressions. The latter instrument lagged changes in realized volatility by lagged changes in volatility exposure to energy and currency markets (measures by at-the-money implied volatility of oil and 7 widely traded currencies). See sections 4 and 5 for the details on the construction of variables and data.

Table 5
Investment rate - 2SLS 1st Stage Results

	Univariate 2SLS 1st Stage Realized vol Benchmark 9 IV	Multivariate 2SLS 1st Stage Realized vol Benchmark 9 IV	Univariate 2SLS 1st Stage Realized vol Single IV	Multivariate 2SLS 1st Stage Realized vol Single IV
change vol exposure oil	0.102***	0.122***	0.315***	0.342***
t-stat	(3.140)	(3.470)	(11.480)	(11.200)
change vol exposure cad	0.036	0.043	0.372***	0.380***
t-stat	(0.630)	(0.710)	(9.730)	(8.820)
change vol exposure euro	-0.014	-0.037	0.359***	0.368***
t-stat	(-0.350)	(-0.880)	(10.730)	(9.960)
change vol exposure jpy	0.113***	0.142***	0.416***	0.452***
t-stat	(2.610)	(3.170)	(10.830)	(10.590)
change vol exposure aud	0.092***	0.071*	0.354***	0.350***
t-stat	(2.460)	(1.700)	(11.240)	(10.030)
change vol exposure sek	0.070	0.088	0.398***	0.426***
t-stat	(1.220)	(1.490)	(11.280)	(10.720)
change vol exposure chf	0.153***	0.174***	0.497***	0.541***
t-stat	(2.830)	(2.920)	(12.480)	(12.480)
change vol exposure gbp	0.122***	0.142***	0.423***	0.452***
t-stat	(2.710)	(2.920)	(11.780)	(11.430)
change vol exposure Policy	0.626***	0.566***	1.529***	1.502***
t-stat	(3.790)	(3.160)	(9.080)	(7.980)
F-test	37.16	23.60		
Hansen J Chi-sq(8) P-val	0.443	0.5127		

This table presents the first stage results of the univariate and multivariate 2SLS regression of investment rate on lagged change in volatility (columns 1 and 3) and main set of controls (columns 2 and 4). Columns 1 and 2 instrument lagged changes in volatility with the benchmark set of 9 instruments (lagged changes in oil, 7 widely traded currencies, and policy uncertainty). Columns 3 and 4 instrument lagged change in volatility using only one the 9 instruments at a time. See sections 4 and 5 for the details on the construction of variables and data.

Table 6
Additional real quantities

	(1) OLS Realized	(2) OLS Implied	(3) IV Realized	(4) OLS Realized	(5) IV Realized
A: Employment					
Volatility	-0.028***	-0.078***	-0.034	-0.028***	-0.010
	(-11.185)	(-12.165)	(-1.020)	(-10.316)	(-0.277)
F-test of 1st stage			41.13		35.86
Observations	143,567	25,885	23,030	124,295	17,040
B: Cost of Goods Sold					
Volatility	-0.039***	-0.098***	-0.260***	-0.041***	-0.155***
	(-12.089)	(-11.434)	(-4.732)	(-12.221)	(-3.052)
F-test of 1st stage			40.59		36.37
Observations	151,061	26,379	23,385	130,063	17,300
C: Expenses					
Volatility	-0.043***	-0.077***	-0.111***	-0.047***	-0.054*
	(-17.648)	(-12.925)	(-3.026)	(-18.931)	(-1.653)
F-test of 1st stage			39.49		36.68
Observations	137,430	23,970	21,524	119,026	16,141

This table reports the regression results of changes in employment (Panel A), changes in cost of goods sold (Panel B), and changes in selling, general, and administrative expenses (Panel C). See sections 4 and 5 for the details on the construction of variables and data.

Table 7
Uncertainty and financial flows

	(1) OLS Realized	(2) OLS Implied	(3) IV Realized	(4) OLS Realized	(5) IV Realized
A: Total Debt					
Volatility	-0.054***	-0.061***	-0.343***	-0.051***	-0.289**
	(-7.755)	(-2.903)	(-3.062)	(-7.062)	(-2.493)
F-test of 1st stage			40.04		36.39
Observations	149,719	26,212	23,261	129,983	17,274
B: Short term/Long term					
Uncertainty (volatility)	-0.056***	-0.076*	0.139	-0.061***	0.204
	(-5.022)	(-1.944)	(0.690)	(-5.188)	(0.978)
F-test of 1st stage			38.98		39.57
Observations	120,228	20,248	16,319	115,368	14,583
C: Payout					
Volatility	-0.132***	-0.283***	-0.789***	-0.131***	-0.686***
	(-14.265)	(-8.995)	(-4.285)	(-12.547)	(-3.458)
F-test of 1st stage			40.47		36.39
Observations	151,460	26,392	23,419	130,160	17,303
D: Cash holding					
Volatility	0.021***	-0.004	0.179	0.025***	0.202
	(2.859)	(-0.223)	(1.623)	(2.944)	(1.578)
F-test of 1st stage			40.31		36.12
Observations	150,747	26,317	23,353	129,659	17,249

This table reports the regression results of changes in total debt (Panel A), changes in the ratio of short- to long- term debt (Panel B), changes in the payout (sum of cash dividend and share repurchase; Panel C), and changes in cash holdings (Panel D). See sections 4 and 5 for the details on the construction of variables and data.

Table 8
Volatility 2SLS Full Sample vs Financial Crisis Estimates

Period	2007-2014	2008-2010		2007-2014	2008-2010
Real Variables			**Financial Variables**		
Investment Rate	-0.041*	-0.058**	Debt Total	-0.289**	-0.279**
	(-1.799)	(-2.171)		(-2.493)	(-1.993)
Employment	-0.010	-0.018	Short / Long Term	0.204	0.091
	(-0.277)	(-0.487)		(0.978)	(0.370)
Cost of Goods	-0.155***	-0.242***	Payout	-0.686***	-1.200***
	(-3.052)	(-4.290)		(-3.458)	(-5.172)
Expenses	-0.054*	-0.116***	Cash Holding	0.202	0.389***
	(-1.653)	(-3.157)		(1.578)	(2.716)
Benchmark 9 IV	Yes	Yes		Yes	Yes
Firm FE	Yes	Yes		Yes	Yes
Time FE	Yes	Yes		Yes	Yes
Main Controls	Yes	Yes		Yes	Yes
weighted by:	N/A	N/A		N/A	N/A

This table compares the coefficient estimates on lagged changes in volatility of the 2SLS regression of changes in real and financial variables for the full sample vs the subsample of the Great Recession. All specifications instrument lagged changes in volatility with the benchmark set of 9 instruments (lagged changes in oil, 7 widely traded currencies, and policy uncertainty) . The main set of controls are included in each multivariate 2SLS specification. See sections 4 and 5 for the details on the construction of variables and data.