Financing of Firms, Labor Reallocation and the Distributional Role of Monetary Policy

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April 1, 2016

Abstract

We analyze monetary policy in a heterogeneous firms environment where cash constrained firms finance operations through external financing and cash unconstrained firms operate by using internal funds. We find that firms respond differently to shocks: expansionary monetary policy sharply increases the relative employment of the cash constrained firms while positive productivity shocks induce a rise in the relative employment of the cash unconstrained firms. Our analysis points out to a clear role of monetary policy in reallocating resources across sectors that differ in their financing capabilities. Furthermore, the predictions of our model match the empirical evidence revealing that financially constrained firms react sharply to monetary policy shocks but are less cyclical than unconstrained firms following productivity shocks.

\textit{JEL classification:} E32; E44; E52.

\textit{Keywords:} Heterogeneous Firms; Monetary Policy; Labor Reallocation; Firms’ financing.

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1 Introduction

Firms are heterogenous in terms of financing opportunities in that a large share of them depends on borrowing in order to finance operations.\(^1\) Recent empirical evidence shows that heterogeneous firms react differently to economic shocks (Gertler and Gilchrist, 1994; Chari et al., 2007; Jansen and Tsai, 2010; Kudlyak et al., 2010; Moscarini and Postel-Vinay, 2012; Fort et al., 2013; Haltiwanger et al., 2013; Gilchrist et al., 2014). We present a model and a quantitative exercise in order to understand the underlying sources behind those differences. Specifically, we construct a limited participation monetary model where one type of firms uses internal funds and the rest rely on costly external financing in order to operate. The model predicts that firms that finance production externally are less cyclical after productivity shocks compared to firms that use internal financing, which is consistent with recent empirical findings (Moscarini and Postel-Vinay, 2012). On the other hand, firms that use external financing are more cyclical to monetary policy shocks, in line with earlier empirical evidence (Gertler and Gilchrist, 1994).\(^2\) We find that both monetary and productivity shocks affect the allocation of resources across firms, but monetary policy shocks are having profounder distributional effects.

In our baseline model the two types of firms differ only in their financing schemes: the cash constrained firms need to borrow in advance in order to operate while the cash unconstrained firms operate using internal sources. Therefore, changes in relative employment across the two sectors are driven by changes in the cost of external financing. Expansionary monetary policy decreases the interest rate, directly benefiting the cash constrained firms, increasing their production and employment. Importantly, while monetary policy raises production and employment of the unconstrained firms as well, the allocation of labor tilts in favor of the cash constrained ones. In this respect, monetary policy is not only effective in stimulating aggregate economic activity, but also plays a great role in the distribution of economic activity across sectors.

Apropos of productivity shocks, our model suggests that a positive shock increases the production of both types of firms. Yet, it increases the cost of external financing and thus benefits the cash unconstrained firms more than the constrained ones. The relative employment of the cash unconstrained firms increases, making the unconstrained firms more cyclical to productivity shocks. In our baseline case, where we assume the same

\(^1\)For example, Rajan and Zingales (1998) reports that more than 30% of the operation of the US firms was depending on external finance during the 1980s.

\(^2\)In all that follows, we make the conjecture that young/small firms are the most likely to be cash constrained, as Fazzari et al. (1988) have convincingly argued, and most of the literature has thereafter followed.
productivity for all firms, the effects of productivity shocks on the allocation of labor across sectors is considerably smaller than the effects of monetary policy disturbances. However, when we allow higher productivity for the cash unconstrained firms or a muted rise in the productivity of the constrained firms (which could reflect a slower adoption of new production technologies by small firms), then the effects of productivity shocks on relative employment of the constrained and unconstrained firms are greatly magnified. Yet, even in that case, the response of relative employment to productivity innovations is weaker than its response to monetary policy shocks.

Those results are in line with the empirical literature. Specifically, Gertler and Gilchrist (1994) conclude that in a downturn, identified through Romer and Romer (1989) monetary policy shocks dates, smaller firms react more than larger firms; they severely reduce their sales and inventories and, thus, are more cyclical than larger ones after monetary policy shocks. Relatedly, Beck et al. (2008) use cross-industry, cross-country data and find that improvements in the operation of the financial system will have cross-firm distributional effects; specifically, financial development helps small firms more than large ones. One explanation for their finding is that financial innovations ease the credit constraints of small firms more than those of large firms.

Regarding productivity shocks, a recent study by Moscarini and Postel-Vinay (2012) finds that large firms react more sharply to the business cycle compared to smaller firms. That work identifies recessions using the NBER dates, and argues that large firms are more cyclically sensitive than small firms; they create more jobs during an expansion, albeit they lay off extensively during a recession. In addition, Moscarini and Postel-Vinay (2012) and Haltiwanger et al. (2013) find that young/small firms increase their relative employment during a recession, justifying the widespread argument that young/small businesses fuel jobs’ creation during recessions.3 In line with our findings, Chari et al. (2007) find that larger firms react more than smaller ones to the cycle as identified by NBER dates, but smaller firms react more than larger ones to monetary policy shocks. Monetary policy shocks are found to be more severe in producing those differences across firms, consistent with our results.

Previous literature on financial frictions and monetary policy has focused on the costly state verification of firms affected by idiosyncratic shocks (Bernanke et al., 1999; Carlstrom et al., 2010; Fiore et al., 2011). Our work concentrates on heterogenous firms in terms of their ability to use internal finance. This type of heterogeneity affects the way that

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3Specifically, Moscarini and Postel-Vinay (2012) focus their analysis on firms’ size, while Haltiwanger et al. (2013) on firms’ age. For our purposes, these results indicate that constrained firms, which are usually small and young, are less cyclical than unconstrained firms, which are usually large and old.
aggregate productivity and monetary policy shocks transmit across different sectors of the model. In addition, it implies an important role for monetary policy in terms of the allocation of resources across the various sectors of the economy.

Another strand of the literature we relate to has studied the asymmetric effects that monetary policy has across heterogenous agents in the economy (e.g., Alvarez et al., 2001; Williamson, 2005; Williamson, 2006; Zervou, 2013). Our model studies asymmetric effects of monetary policy too, focusing on firms’ heterogeneity. We use a large family model (Lucas, 1990) and the limited participation literature (Fuerst, 1992; Christiano and Eichenbaum, 1995), where firms are subject to a cash-in-advance constraint and borrow in order to pay upfront the inputs’ suppliers. We enhance these models with firms’ heterogeneity. Our work also derives intuition from Palivos et al. (1993), who use a modified cash-in-advance model, where only a fraction of the firms’ operation is financed with credit, in order to study velocity changes.

The rest of the paper is organized as follows. Section 2 introduces the model economy. Section 3 presents our quantitative exercise and Section 4 shows empirical evidence that supports our parameter choices. Section 5 presents our results and Section 6 performs robustness analysis. Section 7 introduces an alternative model specification by allowing for different productivity levels across firms. Section 8 concludes.

2 The Model Economy

We use a limited participation model that is inspired by Fuerst (1992) and Williamson (2005). We enrich these models with firms’ heterogeneity, allowing a fraction of firms to be cash constrained, while the rest are unconstrained. There are monetary policy shocks hitting a Taylor-type of rule, and there are also productivity shocks.

2.1 Households

We employ a representation of the economy following Lucas (1990) where the model economy is populated by infinitely lived large families. Households derive utility from two consumption goods: $c_{c,t}$, which is produced by the constrained firms, and $c_{u,t}$, which is produced by the unconstrained firms. Households also supply labor $H_t$. All families are identical and seek to maximize their lifetime utility:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t [U(c_{c,t}, c_{u,t}) - D(H_t)] \right\},$$

(1)
with \( E_t \) being the expectations operator and \( 0 < \beta < 1 \) the family’s subjective discount factor. We assume that \( U_t \equiv \frac{\partial U}{\partial c_{i,t}} > 0, U_{i,i} \equiv \frac{\partial^2 U}{\partial c_{i,t}^2} < 0, U_t(0) = \infty, U_t(\infty) = 0, \) for \( i = c, u \).

Similarly, \( D(.) \) denotes disutility from working a fraction \( H_t \in [0, 1] \) of time in period \( t \), with \( 0 < D'(.) < \infty \) and \( D''(.) > 0 \).

We now describe how trade takes place in this model economy. Each household consists of three members: a shopper, a worker and a financial transactor. All family members leave the family at the same time, in order for each of them to execute a specific task. The shopper receives part of the family’s initial money balances and travels to the goods markets in order to purchase consumption goods from the two industries. The financial transactor receives a fraction of the initial money balances in order to make loans in the loanable funds market. Finally, the worker leaves the family in order to work for the two types of firms.

In order for money to be valuable, we assume a cash-in-advance constraint on the consumption of the two goods. Moreover, there is a cash-in-advance constraint in the production of the cash constrained firms. These firms, contrary to the cash unconstrained ones, cannot hire labor with credit, but rather need to have cash balances in advance in order to pay their wage bill in the beginning of the period.\(^4\)

The cash constrained firms may borrow cash balances from the loanable funds market. The quantity of loanable funds supplied partly comes from the money balances that the financial transactor carries, \( N_t \). The monetary authority alters the nominal interest rate through a Taylor-type rule, which in turn affects the cost of borrowing of these firms. In this way, monetary policy affects directly only the cash constrained firms, which are the ones that participate in the financial markets. Having the nominal interest rate being determined, the monetary authority transfers cash to the financial intermediary, \( T_t \), so that \( \tilde{M}_t = \tilde{M}_{t-1} + T_t \), where \( \tilde{M}_t \) is money supply in period \( t \).

The shopper travels to the goods market where she buys consumption good \( c_{c,t} \) from the cash constrained firms at the price \( P_{c,t} \geq 0 \), and consumption good \( c_{u,t} \) from the cash unconstrained firms at the price \( P_{u,t} \geq 0 \). The worker travels to the labor market, where she may work for a cash constrained or unconstrained firm, earning in either case the competitive wage, \( W_t \geq 0 \). The financial transactor travels to the loanable funds market holding \( N_t \) amount of cash. Without loss of generality we will assume that for non-negative nominal interest rate paid on loans, \( R_t \geq 0 \), the intermediary lends out all its cash. The profit that the intermediary attains, \( T_t(1 + R_t) \), is transferred to the household at the end.

\(^4\)Our assumption of cash constrained and unconstrained firms has the flavor of purchasing a subset of goods with cash, as analyzed by Lucas and Stokey (1983).
of the period. Consumption can only be financed with cash, according to the following cash-in-advance constraint:

\[ M_{t-1} - N_t + W_t H_t \geq P_{c,t} c_{c,t} + P_{u,t} c_{u,t}, \]

where \( M_{t-1} \) is the family’s initial cash balances in period \( t \). The family’s budget constraint is as follows:

\[ M_{t-1} + W_t H_t + (1 + R_t) N_t + (1 + R_t) T_t + \Pi_t \geq M_t + N_t + P_{c,t} c_{c,t} + P_{u,t} c_{u,t}, \]

where \( \Pi_t \) is the combined profit of the two production industries.

By dividing both sides of the cash-in-advance and budget constraint by the aggregate price level \( (P_t) \), the real version of those constraints reads:

\[ \frac{m_{t-1}}{1 + \pi_t} - n_t + w_t H_t \geq p_{c,t} c_{c,t} + p_{u,t} c_{u,t}, \quad (2) \]

and

\[ \frac{m_{t-1}}{1 + \pi_t} + w_t H_t + (1 + R_t) n_t + (1 + R_t) T_t + \tilde{\Pi}_t \geq m_t + n_t + p_{c,t} c_{c,t} + p_{u,t} c_{u,t}, \quad (3) \]

with \( \pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} \) being the inflation rate, \( \tilde{\Pi}_t \) the real profits, \( p_{c,t} \) the relative price of the good produced by the constrained firms and \( p_{u,t} \) the relative price of the good produced by the unconstrained firms. The rest of the lower-case variables correspond to the real value of their upper-case counterparts.

Optimization by households is described in Appendix A and yields:

\[ \frac{U_{c,t}}{U_{u,t}} = \frac{p_{c,t}}{p_{u,t}}, \quad (4) \]

with \( U_{c,t} \) and \( U_{u,t} \) being the marginal utility from the good produced by the constrained firms and unconstrained firms, respectively. As expected, it suggests that the marginal rate of substitution (MRS) between the two types of good is equal to their relative price.

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5 With the supply of loanable funds being \( N_t + T_t = B_{s,t} \), the intermediary profits are \( N_t + T_t + B_{d,t}(1 + R_t) - N_t(1 + R_t) - B_{d,t} \). By imposing equilibrium on the funds market, i.e., equating demand and supply of loanable funds, \( B_{d,t} = B_{s,t} = N_t + T_t \), these profit are: \( T_t(1 + R_t) \).
2.2 The Production Sector

Firms hire labor in a competitive labor market, produce and ship their products to the goods markets. There is a unit mass of constrained firms and similarly, a unit mass of unconstrained ones. Firms use the production functions $y_{u,t} = f^u(H_{u,t}, \theta_t) = \theta_t H_{u,t}$ and $y_{c,t} = f^c(H_{c,t}, \theta_t) = \theta_t H_{c,t}$, with $H_{c,t}$ and $H_{u,t}$ denoting labor of the constrained and unconstrained firms respectively. Note that we let the two types of firms differ only in their financing possibilities; therefore, we let total factor productivity $0 < \theta_t < \infty$ be common to all firms in both sectors.\footnote{For an extension with different productivity across firms see Section 7.}

The cash unconstrained firms can operate through credit. After realizing the productivity and monetary shocks they decide how much labor to hire. They promise to pay the worker the competitive wage $w_t$, which they pay after they complete their production process and earn revenues. The profit for the cash unconstrained firms is given below:

$$\Pi_{u,t} = p_{u,t} \theta_t H_{u,t} - w_t H_{u,t}. \quad (5)$$

The cash constrained firms, after realizing the productivity and monetary shocks, decide to borrow $b_{d,t}$ amount of cash from the loanable funds market in order to hire $H_{c,t}$ amount of labor. These firms need to acquire cash in advance in order to start their production process; they pay the competitive wage $w_t$ upfront for hiring workers. After they produce and sell their goods, the cash constrained firms repay their loans with net nominal interest $R_t$. The profit for the cash constrained firms is as follows:

$$\Pi_{c,t} = p_{c,t} \theta_t H_{c,t} - w_t H_{c,t} - R_t b_{d,t}. \quad (6)$$

The cash constrained firms’ profit maximization problem is subject to a cash-in-advance constraint, $w_t H_{c,t} \leq b_{d,t}$, so that the amount of loanable funds demanded needs to cover at least the labor cost of the cash constrained firms. The first order conditions imply that $R_t = \zeta_t$ and $p_{c,t} \theta_t = w_t (1 + \zeta_t)$, where $\zeta_t$ is the multiplier of the constrained firms’ cash-in-advance constraint.

After the production process takes place and profit is determined, both types of firms pay profits to the household. The firms’ profit maximization conditions are as follows:

$$p_{c,t} \theta_t = w_t (1 + R_t), \quad (7)$$

$$p_{u,t} \theta_t = w_t, \quad (8)$$
which imply that:

\[ p_{c,t} = (1 + R_t)p_{u,t}. \]  

(9)

Condition (7) reveals that, for the cash constrained firms, the nominal interest rate drives a wedge between the marginal product of labor and the competitive real wage. Alternatively, the cost per unit of labor is higher than the real wage, and it crucially depends on the interest rate at which constrained firms borrow from the loanable funds market. As condition (7) clearly shows, this effect does not exist for the unconstrained firms. Furthermore, condition (9) suggests that the nominal interest rate creates a wedge between the price of the two goods.

The combination of conditions (4) and (9) yields:

\[ \frac{U_{c,t}}{U_{u,t}} = 1 + R_t, \]  

(10)

which shows that the MRS is a function of the nominal interest rate. A decline in \( R_t \) reduces \( \frac{U_{c,t}}{U_{u,t}} \), suggesting that the consumption of the product of constrained firms rises relative to the consumption of the product of unconstrained firms. This is the first result that we establish about the role of monetary policy in tilting consumption across sectors.

In what follows, we show how monetary policy leads to changes in the allocation of labor across sectors.

2.3 Market Clearing and Monetary Policy

We will look at an equilibrium where prices \( w_t \) and \( p_{c,t}, p_{u,t} \) are strictly positive, and \( n_t, H_{c,t}, H_{u,t} \) are interior and bounded between zero and one. Also, the multipliers are strictly positive. Binding cash-in-advance constraint implies:

\[ \frac{m_t - 1}{1 + \pi_t} - n_t + w_t H_t = p_{c,t}c_{c,t} + p_{u,t}c_{u,t}. \]  

(11)

There are four markets in the model. The market clearing conditions are as follows:

The goods markets clear:

\[ c_{c,t} = \theta_t H_{c,t}, \]  

(12)

and

\[ c_{u,t} = \theta_t H_{u,t}. \]  

(13)

The labor market clears:

\[ H_{c,t} + H_{u,t} = H_t. \]  

(14)
The loanable funds market clears:

\[ w_t H_{c,t} = n_t + \tau_t. \]  (15)

The monetary authority affects the nominal interest rate through a Taylor-type rule. Using the money market, the cash that the monetary authority injects into the economy, \( \tau_t \), is given by: \( \bar{m}_t = \frac{\bar{m}_{t-1}}{1 + \pi_t} + \tau_t \). The money market clears:

\[ m_t = \bar{m}_t. \]  (16)

This concludes the description of the model.

3 Calibration

We start by describing the functional forms used and deriving the key condition that relates the firms’ relative employment to the interest rate. Then, we describe the parameterization of the model.

3.1 Functional Forms

We assume Constant Elasticity of Substitution (CES) utility functions for consuming the two types of goods and convex disutility function of labor. The period utility function of the family is given by:

\[ U(c_{c,t}, c_{u,t}) - D(H_t) = \left[ \frac{\xi-1}{\kappa c_{c,t}^{\xi}} + (1 - \kappa)c_{u,t}^{\xi} \right]^{\frac{\xi}{\xi-1}} - \alpha \frac{H^{1+\eta}}{1 + \eta}, \]  (17)

with \( \xi \) being the elasticity of substitution between the good produced by constrained firms and the good produced by unconstrained firms, \( \kappa \) is the share of consumption of constrained firms out of total consumption, \( \eta \) is the intertemporal elasticity of substitution of labor supply and \( \alpha \) is a scaling parameter that measures the disutility from supplying labor.

Given the CES utility function the corresponding aggregate price level index reads:

\[ P_t = \left[ \kappa P_{c,t}^{1-\xi} + (1 - \kappa)P_{u,t}^{1-\xi} \right]^{\frac{1}{1-\xi}}. \]  (18)

Also, using the specified functional forms, conditions (10) and (12)-(13) yield:

\[ \frac{H_{c,t}}{H_{u,t}} = \left( \frac{\kappa}{1 - \kappa} \right)^{\xi} \left( \frac{1}{1 + R_t} \right)^{\xi}. \]  (19)
This condition well captures the effects of monetary policy on the allocation of labor across sectors. Other things equal, a rise in the interest rate leads to a decline in the relative amount of labor employed by the constrained firms. This effect depends on the size of the elasticity of substitution between the products of the two types of firms ($\xi$): the larger $\xi$, the stronger this channel is, and the more responsive is relative employment to changes on the interest rate.

### 3.2 Parameterization

We assume a time unit of one quarter. We set $\beta = 0.99$, implying an annual real interest rate of roughly 4%, as is conventional in the literature. We set $\eta = 0.5$ so that the labor supply elasticity is within the traditional levels in macroeconomic models and to help capture the volatility of total hours in this model that does not account for labor market frictions. In each experiment we run, $\alpha$ will be set so that the steady state value of hours worked relative to total hours ($H$) is 0.21, capturing an average workweek of 35 hours (out of 168), which is consistent with its historical average in the United States. Produced through the model-based empirical evidence that we provide in Section 4, we set $\kappa = 0.353$ and $\xi = 1.4$.

We then provide results using alternative values of these two parameters in the robustness analysis, Section 6.

There are two shocks in the model economy: total factor productivity (TFP) shock and monetary policy shock. The exogenous process of TFP is given by:

$$\ln \theta_t = (1 - \rho_\theta) \ln \theta + \rho_\theta \ln \theta_{t-1} + \epsilon_{\theta,t},$$

with $\theta = 1$, autocorrelation $\rho_\theta = 0.90$ and a standard error $\sigma_\theta = 0.02.$

Monetary policy is governed by the following Taylor-type rule:

$$\ln \left( \frac{1 + R_t}{1 + R} \right) = \phi_R \ln \left( \frac{1 + R_{t-1}}{1 + R} \right) + (1 - \phi_R) \left[ \phi_\pi \ln \left( \frac{1 + \pi_t}{1 + \pi} \right) + \phi_y \ln \left( \frac{y_t}{y} \right) \right] + \varepsilon_{r,t},$$

with $y_t$ being the total production (output) in the economy and the undated variables denoting the steady state values of their respective variables. We set the standard values $\phi_\pi = 1.5$ and $\phi_y = 0.5/4$ for the coefficients of inflation and output respectively, in the monetary policy rule. Also, $\varepsilon_{r,t}$ is the monetary policy shock and $\phi_R = 0.9$ is the interest-rate smoothing parameter that is set to match the persistence of the nominal interest rate. In what follows, we will also consider the case of $\phi_R = 0$ (see Section 6.). In each exercise,

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7The value of $\sigma_\theta$ is chosen so to match the average volatility of US gross domestic product, i.e., we let standard deviation of US output be 0.018.
the standard deviation of the shock is set to match the standard deviation of the U.S. gross domestic product. Here, the standard deviation of the shock is $\sigma_r = 0.06$.

4 Empirical Analysis

4.1 Overview

In this section, we provide empirical support regarding the effects of interest rate changes on the employment shares of constrained and unconstrained firms. From our estimation we will get information about the values of the two key parameters of the model, $\kappa$ and $\xi$. As explained earlier, we follow previous literature and consider small firms as constrained, and large firms as unconstrained.

The classification of firms as “small” in the literature varies, but it mostly corresponds to firms with up to 19 employees (as, for example, in Fort et al., 2013) or firms with up to 49 employees (e.g. Moscarini and Postel-Vinay, 2012). For this reason we base our analysis on both definitions. Given that our model accounts for two sectors only, the mapping between the relative employment of the constrained firms in the model ($H_{c,t}/H_{u,t}$) and the data, requires us to use all other firms (medium and large) as the alternative. A caveat here is that firms with 20-499 employees or 50-499 employees, which are thought as medium sized, are categorized as large firms in our analysis, i.e., they are the unconstrained firms. In the robustness analysis (Section 6) we discuss quantitative results that are produced using the classification of Carlstrom et al. (2010) who considered “small firms” as employing up to 499 workers and large firms otherwise.

Our sample covers the period 1993:Q1-2014:Q2 due to the availability of quarterly data on the distribution of employment by firm size, given by the United States Census Bureau. To account for the cost of borrowing by small firms, we use the interest rate on borrowing that is provided by the National Federation of Independent Businesses (NFIB). The data sample starts in 1986. This interest rate reflects the average cost of borrowing of small businesses as have been reported by these businesses to the NFIB. We use this series for two reasons. First, it better captures the cost of borrowing of small businesses than the policy interest rate or the interest rates on short-term treasury bonds. Second, the federal funds rate and the interest rates on short-term treasury securities have been at the zero-lower bound between late 2008 and late 2015. However, the actual cost of borrowing of firms has not been zero. To overcome this shortcoming and to avoid ending the sample in 2008:Q3, we use the NFIB’s series.\footnote{We have also performed the same exercise with a different interest rate, the Moody’s Seasoned Cor-}
Figure 1 shows the co-movement between the relative employment of small firms and the above mentioned interest rate. For most of the sample period, the two series exhibit a clear negative correlation: a correlation coefficient of $-0.33$ when firms with up to 19 employees are considered small, and a correlation coefficient of $-0.23$ when small firms are defined as having up to 49 employees. The negative correlation appears to become stronger since the mid 1990s using both definitions of small firms. Therefore, from Figure 1 we conclude that a rise in the cost of borrowing is associated with a decline in the employment of small firms relative to employment of large firms.

![Figure 1: The cyclical components of relative employment of small firms (over total employment) and the cost of borrowing of small firms. Data sources: NFIB (interest rate) and United States Census Bureau (Employment). Note: annual averages. The data are HP-Filtered with a smoothing parameter of 1600.](image)

### 4.2 Econometric Analysis

We turn to formally test whether an increase in the cost of borrowing of small firms reduces their relative employment. In addition, we can estimate the parameters $\xi$ and $\kappa$ by making use of condition (19). Taking natural logarithms on both sides of this condition gives:

$$
\ln \left( \frac{H_{e,t}}{H_{u,t}} \right) = \xi \ln \left( \frac{\kappa}{1 - \kappa} \right) - \xi \ln (1 + R_t).
$$

(22)

To estimate this equation, we use the above mentioned data on employment and interest rate. We conduct our analysis using both Ordinary Least Squares (OLS) and Generalized Methods of Moments (GMM) with instrumental variables (IVs). A clear advantage of this analysis is that the slope of the gross interest rate is equal to $\xi$, for which we have no prior corporate Bond Yield (BAA), and the main conclusions of the paper do not change. Namely, the rise in the interest rate leads to a decline in the relative employment of small firms.
information. In this respect, $\xi$ shows up as the elasticity of the relative employment with respect to changes in the cost of borrowing.

In line with existing studies in macroeconomics (e.g. Gali and Gertler, 1999, Murray, 2006, Ravenna and Walsh, 2006, and Gali et al., 2007) we use the lags of variables as instruments. As West et al. (2009) point out, the basis for using the lags of variables as instruments is that, usually, if a variable is a legitimate instrument, then so are lags of that variable. Using the lags of the variables helps with overcoming the possibility of endogeneity and bi-directional causality: the current value of the dependent variable (relative employment of small firms) is unlikely to affect the past values of the independent variable (the cost of borrowing of firms). As instruments, we use four lags of the interest rate, output gap and the unit labor cost (which measures the average cost of labor per unit of output). The output gap is added to account for the possibility of co-movement of both the relative employment and interest rate over the business cycle, and the unit labor cost is added to control for the overall costs of firms.

The estimation results for firms up to 19 employees and up to 49 employees are summarized in Table 1. In all cases, the coefficient of $1 + R_t$ is negative and significant, so that an increase in the interest rate reduces the relative employment of small firms. Also, in most cases, the coefficient is above 1 in absolute value, suggesting that there exists more than one-for-one relationship between changes in the interest rate and the relative employment. The analysis also reveals that for firms with 0-49 employees the response is weaker than it is for firms with 0-19 employees. This finding suggests that the smallest firms are the ones affected the most by interest rate changes.

<table>
<thead>
<tr>
<th>Firm Size</th>
<th>OLS 0-19</th>
<th>OLS 0-49</th>
<th>GMM 0-19</th>
<th>GMM 0-49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const.</td>
<td>-1.118*** (0.045)</td>
<td>-0.571*** (0.043)</td>
<td>-1.024*** (0.058)</td>
<td>-0.488*** (0.060)</td>
</tr>
<tr>
<td>$\ln(1 + R_t)$</td>
<td>-1.101** (0.442)</td>
<td>-0.923** (0.431)</td>
<td>-1.936*** (0.602)</td>
<td>-1.653*** (0.628)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.266</td>
<td>0.350</td>
<td>0.371</td>
<td>0.427</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.716</td>
<td>0.776</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| J-Stat | 10.419 | 10.490 |
| P-Value | 0.405 | 0.3986 |

| $N$ | 86 | 86 | 86 | 86 |

**Table 1**: Dependent variable: natural logarithm of the relative employment of small firms ($H_t^c/H_t^u$). Results of estimating condition (22). Standard errors in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level. J-Stat is the statistic for the hypothesis that the over-identifying restrictions are satisfied. IVs for GMM estimation: four lags of the interest rate, output gap and unit labor cost. Time trend included. Sample period: 1993:1-2014:2.
Given the lack of conjecture on what constitutes a small firm and the exact number of workers that a small firm employs, we use the average of the coefficients that the two definitions produce. As shown in Table 1, the average coefficient of $1 + R_t$ with OLS is $-1.012$. With GMM, the average coefficient, in absolute value, is higher, $-1.79$. For our baseline exercise we use the average across the results of OLS and GMM and both definitions, and therefore we set $\xi = 1.4$.

The bottom row of the table presents the implied value of $\kappa$. Similar to the choice of $\xi$, we produce our baseline parameter for $\kappa = 0.353$ using the average of the four columns of Table 1. In the robustness analysis, we use an alternative value of this parameter as well as an alternative value of the parameter $\xi$.

5 Quantitative Results

We perform a quantitative exercise in order to assess the importance of firms heterogeneity in their response to productivity and monetary shocks. The results are presented in Figures 2 and 3. Figure 2 shows the effects of a decrease in the nominal interest rate through the Taylor-type rule. All variables, with the exception of the nominal interest rate, are in natural logarithms. Expansionary monetary policy induces a rise in the production and employment of both types of firms and, therefore, implies higher total output and employment. Consistent with condition (19), due to the decrease in the interest rate, the cost of external financing of the constrained firms declines, which leads to a rise in their relative employment. The response of constrained firms to changes in the nominal interest is clearly larger than the response of unconstrained firms, suggesting that the constrained firms are more cyclic after monetary policy shocks.

Figure 3 presents the response of the economy to a positive TFP shock. The improvement in technology leads to a rise in the production and labor of both sectors. The rise in the nominal interest rate that occurs in response to a rise in aggregate economic activity lowers the labor of constrained firms relative to the labor of unconstrained firms. Therefore, while the rise in productivity is favorable for both types of firms, unconstrained firms benefit from the improved technology more: since unconstrained firms do not rely on external funds, they can hire labor easier than constrained firms, inducing a decrease in the relative employment of constrained firms. Put differently, the advancement in technology

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9For all GMM specifications, the $J$ Test indicates that the over-identification restrictions are satisfied.  
10The behavior of $\frac{H_{u,t} - H_t}{H_t}$ is not a mirror image of the behavior of $\frac{H_{c,t} - H_t}{H_t}$ because both variables are presented in natural logarithms. This can be seen by noting that: $\ln(\frac{H_{u,t} - H_t}{H_t}) = \ln(1 - \frac{H_{c,t} - H_t}{H_t})$. This presentation will be maintained throughout the entire paper.
disproportionately favors the firms that do not need to pay the external finance premium, i.e., the unconstrained firms.

Figure 2: Percentage deviations from steady state after a one standard-deviation positive monetary policy shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external financing and nominal interest rate. Note: $\phi_R = 0.9$.

Table 2 shows the volatility of key variables relative to the volatility of aggregate output. A shock to the nominal interest rate generates considerably more volatility in the production of the constrained firms than a shock to TFP does (2.642 vs. 0.985). And, an interest rate shock generates four times more volatility in the labor of the constrained firms compared to a TFP shock (2.642 vs. 0.649). On the other hand, unconstrained firms are considerably more reactive to TFP shocks than to monetary policy shocks. For the unconstrained firms, a TFP shock generates three times more output volatility than what the monetary policy shock does (1.007 vs. 0.305) and two times more employment volatility (0.670 vs. 0.305). These findings largely align with the empirical evidence that small firms react sharply to monetary shocks (Gertler and Gilchrist, 1994) but are less cyclical than unconstrained firms.
following productivity shocks (e.g., Moscarini and Postel-Vinay, 2012).\textsuperscript{11}

Figure 3: Percentage deviations from steady state after a one standard-deviation positive productivity shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external financing and nominal interest rate. Note: $\phi_R = 0.9$.

Our results indicate a very important and noticeable difference between monetary policy shocks and TFP shocks: while monetary policy shocks induce a strong response in the employment and production of the constrained firms, productivity shocks have considerably smaller effects on the redistribution of labor across firms. This is because the cost of external financing is affected strongly by monetary policy, although it is only mildly affected by productivity shocks.\textsuperscript{12} For this reason, productivity shocks are less redistributive than monetary policy shocks.

\textsuperscript{11}Specifically, Moscarini and Postel-Vinay (2012) look at employment growth and find that the differential growth of employment between large and small firms covaries positively with GDP growth. Our findings hold for growth employment differentials too. That is, the model implies that the differential growth of employment between cash unconstrained and constrained firms increases after a positive productivity shock.

\textsuperscript{12}Empirically, most interest rates are strongly affected by monetary policy (see for example Kuttner, 2001). The effects of productivity shocks are more controversial as they depend on the circumstances of the specific recession, the response of monetary policy to the surge in economic activity, etc.
The difference between monetary policy shocks and TFP shocks in affecting the distribution of labor across firms is well illustrated by Table 2. From the last column we see that the volatility produced in the relative employment of cash constrained firms is much higher after a monetary shock than after a productivity shock (1.642 vs. 0.015). These results align with empirical findings suggesting that comparing the two types of shocks, monetary policy ones generate considerably larger differences between firms than productivity shocks (Chari et al., 2007).

Our focus is on the differential effects of the shocks on the relative employment of cash constrained and unconstrained firms. However, our model produces responses of aggregate variables as well, which we can compare to earlier work and quantitative models. Christiano et al. (1996) find that a roughly 75 basis points decrease in the federal funds rate produced by a VAR monetary policy shock implies a roughly 65 basis points increase in real GDP, 45 basis points increase in employment and 45 basis points increase in prices (commodity prices). In our exercise, 75 basis points decrease in the nominal interest rate is associated with 44.5 basis points increase in total output and employment, and a 73.57 basis points increase in inflation.

For the productivity shock we compare our findings to those of the business cycle model of King and Rebelo (1999). In King and Rebelo (1999), a productivity shock that increases output by about 1.5% increases labor input by 0.7% and the real interest rate by 22 basis points. In our model, an increase in productivity that increases output by 1.5%, increases total employment by almost 1%, and the real interest rate by 7.3 basis points. Overall, our results match the findings of earlier work qualitatively. Furthermore, although we compare results from very different models, most of our results are also close to previous work quantitatively.

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13 Christiano et al. (1996) use various methods but produce similar results. We use the first row of Figures 3 and 4 of their study, from which we roughly infer the maximum effects of the policy shock. Note that they show the effects of an increase in the federal funds rate while we report the effects of a decrease in the federal funds rate.

14 We use King and Rebelo (1999)’ Figure 11 from where we roughly infer the maximum effects of the productivity shock.
6 Robustness Analysis

In this section we conduct the following robustness analysis: i) we consider alternative values for the parameters $\phi_R$, $\kappa$ and $\xi$, and ii) we evaluate the effects of a shock to the parameter that governs the disutility of labor ($\alpha$) and the weight of the constrained firms’ output in the utility function ($\kappa$). The results are presented in Appendix B.

6.1 Alternative Parameter Values

We first present the results of our quantitative exercise without interest-rate smoothing in the Taylor-type of rule ($\phi_R = 0$). Figure B.1 shows that an expansionary monetary policy shock leads to a rise in the production and labor of both types of firms. Key to our analysis is that labor of the constrained firms rises relatively to the labor of unconstrained firms. However, these effects are short-lived and the system reverts back to the initial steady state quickly. A shock to TFP has similar implications to the shock to TFP with interest rate smoothing, but with some quantitative differences (Figure B.2). In either case, this analysis supports our findings regarding the implications of monetary policy and TFP shocks for the distribution of labor across sectors that differ in their financing schemes.

We next consider a higher value of $\kappa$; in particular, we set $\kappa = 0.53$ to match the average share of firms of up to 499 employees (implying that we consider larger firms than before for the small firms category, in line with Carlstrom et al., 2010). All other parameters remain as in the benchmark analysis. Figures B.3 and B.4 present the impulse response functions for a monetary policy shock and a TFP shock, respectively. Overall, the response of the economy to both shocks is similar to the benchmark analysis. In particular, expansionary monetary policy stimulates economic activity and leads to a rise in the relative employment of the constrained firms. A rise in TFP induces a rise in output and labor of both types of firms, but the labor of the constrained firm falls relative to the labor of the unconstrained firms. In addition, as in the benchmark analysis, the effects of TFP on the redistribution of labor is muted compared to the effects of a monetary policy shock that directly affects the relative employment of the constrained firms.

We then consider a higher value of $\xi = 1.94$ which, through condition (19) implies a stronger response of the relative employment of constrained firms to changes in the cost of borrowing. The results for a monetary policy shock and a TFP shock are shown in Figure B.5 and Figure B.6, respectively (all other parameters, including $\kappa$, are as in the benchmark case). Our analysis confirms that the production of constrained firms as well as the relative amount of labor of these firms respond stronger than in the benchmark
case, particularly following a monetary policy shock. In this respect, the substitutability between the two types of products is an important factor in determining the response of each sector to exogenous shocks. Furthermore, the results of this subsection indicate that our main findings are robust to changing the key parameters of the model.

6.2 Labor Disutility and Preference Shocks

In this subsection we show the results of two experiments. First, we compute the response of constrained and unconstrained firms to changes in the disutility of work ($\alpha$), which we think of as a shift in the supply or work. Second, we show the response of firms to changes in the preferences of households over output of the constrained firms vs. output of the unconstrained firms (namely, a change in $\kappa$). We label a shock to $\kappa$ as a preference shock.

As we see from Figure B.7 in Appendix B, a decline in $\alpha$ induces a rise in labor supply and total labor ($H_t$) in equilibrium. The increase in the total amount of labor is split between both types of firms, leading to a rise in labor and production of both types of firms. The rise in economic activity renders the interest rate higher, increases the external financing cost and, thus, reduces the relative employment of the constrained firms. In this respect, the shift in labor supply is met with a higher increase in labor demanded by the unconstrained firms (compared to the constrained ones), which induces a rise in their relative employment.

On the other hand, Figure B.8 shows that if consumers’ preferences suddenly shift towards the output of constrained firms, then labor and production of these firms will rise while labor and production of the unconstrained firms will decline. Consequently, the relative amount of labor of constrained firm rises dramatically (because we have a simultaneous rise in $H_{c,t}$ and a decline in $H_{u,t}$). The increase in labor demand from the constrained firms increases the demand for loanable funds and in turns increases the nominal interest rate. With the exception of this scenario (a shift towards the good of the constrained firms) that clearly affects the demand for loanable funds, a rise in the nominal interest rate is associated with unfavorable effects on the share of labor of the constrained firms, as we show in all previous experiments.

7 Different Productivity Levels

Our analysis so far assumed that constrained and unconstrained firms have the same access to technology and, as a result, the same level of productivity. We now modify this assumption by letting the two types of firms have different levels of productivity. The key
motivation behind this exercise is that small firms are likely to have worse access to newer technologies. Letting $\theta_{c,t}$ and $\theta_{u,t}$ be the productivity of the constrained and unconstrained firms respectively, the solutions to the profit-maximization problems of the two types of firms yield:

$$p_{c,t}\theta_{c,t} = w_t(1 + R_t), \quad (23)$$

$$p_{u,t}\theta_{u,t} = w_t, \quad (24)$$

which imply the following:

$$p_{c,t} = (1 + R_t)p_{u,t}. \quad (25)$$

Since we allow for movements of labor between sectors, we are assuming that both types of firms are paying the same wage $w_t$. Then, using the specified functional forms we have:

$$\frac{H_{c,t}}{H_{u,t}} = \left(\frac{\kappa}{1 - \kappa}\right)^\xi \left(\frac{\theta_{c,t}}{\theta_{u,t}}\right)^{\xi - 1} \left(\frac{1}{1 + R_t}\right)^\xi. \quad (26)$$

This modification does not alter the observation that the cost of borrowing negatively affects the relative employment of constrained firms. Yet, it introduces the ratio of productivity levels as a factor affecting the distribution of labor across firms. In particular, the relative amount of labor employed by the constrained firms is positively related to their relative productivity. In addition, since $\xi > 1$, this condition shows that the constrained firms’ relative employment is more sensitive to interest rate changes than what it is to changes in the the relative productivity.

We consider two cases. First, the productivity of the unconstrained firms improves while that of the constrained firms remains unchanged (and both types of firms have the same steady-state productivity levels). Second, the steady-state productivity of the constrained firms is lower than the steady-state productivity of the unconstrained firms and it changes slower than the productivity of the unconstrained firms (i.e. the rise in the productivity of constrained firms following an improvement in technology is smaller).

For the second experiment, we calculate the difference between the average productivity of small and large firms using U.S. data, with average productivity being measured as the ratio of receipts (revenues) to employment. This definition is consistent with our production function, namely $\theta_{c,t} = y_{c,t}/H_{c,t}$ and $\theta_{u,t} = y_{u,t}/H_{u,t}$. The data are available for 1997, 2002 and 2007, and they yield an average difference of 39% over this period. Therefore, for the second case we have: $\theta_{c,t} = 0.61\theta_{u,t}$.

Figure 4 shows the results of these two exercises and the benchmark case. The response of the production and employment of both types of firms is milder compared to the bench-
mark case. The difference is sharper for the constrained firms. The increase in constrained firms' output is reduced by nearly a third when $\theta_{c,t}$ is constant and by two thirds when $\theta_{c,t}$ rises by less than $\theta_{u,t}$. Note that the relative employment of the constrained firms declines more under the two new cases compared to the benchmark, despite smaller difference in the reaction of the interest rate. This occurs because under the two experiments that we consider here, changes in productivity have direct effects on the distribution of labor, regardless of the nominal interest rate, as equation (26) makes clear.

Figure 4: Percentage deviations from steady state after a one standard-deviation positive productivity shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external financing and nominal interest rate.

Therefore, this section suggests that if the two types of firms differ in their access to technology, a positive productivity shock will benefit the unconstrained firms more than the constrained ones, and the difference between them is amplified compared to the benchmark case. Now there is a clear difference in the response of the two types of firms, making the
unconstrained firms considerably more cyclical than the constrained ones when it comes to productivity shocks. These results are in line with Moscarini and Postel-Vinay (2012)’ empirical evidence.

8 Conclusion

We use a model with heterogenous firms that differ in their labor financing schemes and, therefore, their labor hiring decisions. The cash constrained firms rely on external funding and are subject to an external finance premium, while the cash unconstrained ones finance activities internally. Because of the dissimilarity in the way the two types of firms finance their operations, productivity and monetary policy shocks affect them differently.

The cash constrained firms are directly affected by the actions of the monetary authority; specifically, a lower nominal interest rate decreases the cost of financing and increases their relative employment. On the other hand, monetary policy tightening increases the cost of financing and decreases relative employment of the cash constrained firms. Our analysis indicates that cash constrained firms are more cyclical compared to unconstrained firms following monetary policy shocks. In this respect, monetary policy is playing a crucial role in the distribution of labor, and by extension in the distribution of economic activity, across sectors that differ in their financing opportunities. Our results concerning the effects of monetary policy shocks are consistent with the empirical literature (Gertler and Gilchrist, 1994; Chari et al., 2007).

On the other hand, a positive productivity shock increases the relative employment of the cash unconstrained firms and reduces the relative employment of the cash constrained firms. This happens because a positive productivity shock increases the cost of financing and, thus, exposes the cash constrained firms to a negative effect. The cash unconstrained firms are not exposed to this negative effect as they operate using internal funds. Basically, when technology improves, both types of firms are better off, but the cash unconstrained firms benefit more because they have an easier path to hiring labor compared to the constrained firms. Low productivity shocks have the opposite results. A decrease in productivity hurts both types of firms; it leads to a decline in their output levels. Yet, to the extent that the interest rate declines in response to the decline in economic activity, external financing becomes less of a burden for the cash constrained firms, leading to a rise in their relative employment. The effects of a change in productivity on the distribution of labor, however, are considerably smaller than the effects of monetary policy. The latter remains the main force in creating disparities between firms.
Considering that small/young firms are more financially constrained than large/old firms, our results regarding the effects of productivity shocks are consistent with the empirical findings of Moscarini and Postel-Vinay (2012) and Haltiwanger et al. (2013). Furthermore, the rise in the relative employment of the cash constrained firms following a recessionary TFP shock can be seen as consistent with the empirical finding and popular view that small/young firms are the engine of job creation during recessions.

Empirical evidence also suggests that during the Great Recession young/small firms were more affected than old/large ones (Fort et al., 2013). Given that the Great Recession is considered more of a financial shock than a productivity shock, affecting the loanable funds market, we can compare its effects to the effects of a monetary policy shock in our model. To the extent that constrained firms are seen as the young/small ones, our quantitative conclusions are consistent with these empirical findings.

Our work identifies a new channel through which monetary policy affects the economy, namely through the reallocation of labor across firms. This result motivates future empirical research in order to study differential effects of shocks on heterogeneous firms’ production and employment, and the reallocation of resources across firms following these shocks.

References


24


A Household’s Problem

The family solves:

\[ v(m_{t-1}) = \max_{c_1,t,c_2,t,H,t,n_t,m_t} [U(c_1,t,c_2,t) - D(H_t) + \beta E(\theta_{t+1},\varepsilon_{t+1}) v(m_t)], \]  
(A.1)

under the constraints 2 and 3:

\[ \frac{m_{t-1}}{1 + \pi_t} - n_t + w_t H_t \geq p_{1,t} c_{1,t} + p_{2,t} c_{2,t}, \]
and

\[ \frac{m_{t-1}}{1 + \pi_t} + w_t H_t + R_t n_t + (1 + R_t) \tau_t + \Pi_t \geq m_t + p_{1,t} c_{1,t} + p_{2,t} c_{2,t}. \]

Let \( \gamma_t, \delta_t \geq 0 \) be the multipliers for equations (2) and (3) respectively. The first order conditions for the household’s maximization problem are given below:

With respect to \( n_t \):

\[ - \gamma_t + \delta_t R_t = 0, \]  
(A.2)

with respect to \( c_{1,t} \):

\[ U_{1,t} - p_{1,t} \gamma_t - p_{1,t} \delta_t = 0, \]  
(A.3)

with respect to \( c_{2,t} \):

\[ U_{2,t} - p_{2,t} \gamma_t - p_{2,t} \delta_t = 0, \]  
(A.4)

with respect to \( H_t \):

\[ - D'(H_t) + w_t \delta_t + w_t \gamma_t = 0, \]  
(A.5)

and with respect to \( m_t \):

\[ - \delta_t + \beta E(\theta_{t+1},\varepsilon_{t+1})(\gamma_{t+1} + \delta_{t+1}) \frac{1}{1 + \pi_{t+1}} = 0. \]  
(A.6)

From (A.3) and (A.4) we have that: \( \frac{U_{1,t}}{p_{1,t}} = \frac{U_{2,t}}{p_{2,t}} \). Because of (A.2) equation (A.3) becomes

\[ \frac{U_{1,t}}{p_{1,t}} = \delta_t + \delta_t R_t. \]

Also, from (A.6) and (A.3) we have: \( \delta_t = \beta E(\theta_{t+1},\varepsilon_{t+1}) \frac{U_{1,t+1}}{p_{1,t+1}} \frac{1}{1 + \pi_{t+1}} (1 + R_t) \). Using the last equation of the last paragraph we have that: \( \frac{U_{1,t}}{p_{1,t}} = \frac{U_{2,t}}{p_{2,t}} \).

Finally, from (A.5), (A.3) and (A.4) we have that \( \frac{D'(H_t)}{w_t} = \frac{U_{1,t}}{p_{1,t}} = \frac{U_{2,t}}{p_{2,t}} \).
B Robustness Figures

Figure B.1: Percentage deviations from steady state after a one standard-deviation positive monetary policy shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\phi_R = 0$ (Section 6.1).

Figure B.2: Percentage deviations from steady state after a one standard-deviation positive productivity shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\phi_R = 0$ (Section 6.1).
Figure B.3: Percentage deviations from steady state after a one standard-deviation positive monetary policy shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\kappa = 0.53$ (Section 6.1).

Figure B.4: Percentage deviations from steady state after a one standard-deviation positive productivity shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\kappa = 0.53$ (Section 6.1).
Figure B.5: Percentage deviations from steady state after a one standard-deviation positive monetary policy shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\xi = 1.94$ (Section 6.1).

Figure B.6: Percentage deviations from steady state after a one standard-deviation positive productivity shock for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate. Note: $\xi = 1.94$ (Section 6.1).
Figure B.7: Percentage deviations from steady state after a one standard-deviation shock to $\alpha$ for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate (Section 6.2). 

$$\ln \alpha_t = (1 - \rho_\alpha) \ln \alpha + \rho_\alpha \ln \alpha_{t-1} + \epsilon_{\alpha,t},$$ with $\epsilon_{\alpha,t} \sim N(0, \sigma^2_\alpha)$. $\alpha = 1.155, \rho_\alpha = 0.9$ and $\sigma_\alpha = 0.03$.

Figure B.8: Percentage deviations from steady state after a one standard-deviation shock to $\kappa$ for the constrained firms production, unconstrained firms production, total employment, employment of cash constrained firms, employment of unconstrained firms, relative employment of cash constrained firms, relative employment of unconstrained firms, cost of external finance and nominal interest rate (Section 6.2). 

$$\ln \kappa_t = (1 - \rho_\kappa) \ln \kappa + \rho_\kappa \ln \kappa_{t-1} + \epsilon_{\kappa,t},$$ with $\epsilon_{\kappa,t} \sim N(0, \sigma^2_\kappa)$. $\kappa = 0.353, \rho_\kappa = 0.93$ and $\sigma_\kappa = 0.1$. 

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