Labor Market Response to Monetary Policy: Financing Frictions and the Wage Effect *

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Abstract

We extend the theoretical frameworks traditionally used to analyze monetary policy and investment to examine firms' decisions regarding labor input. Specifically, we consider a model with financing constraints and firms that vary in their degree of exposure to these constraints. The model incorporates key features such as a working capital constraint, the financial accelerator effect of monetary policy, and an upward-sloping marginal cost curve—elements typically employed to study the impact of monetary policy on investment. Our analysis introduces the *wage effect*, an input cost absent in traditional studies on monetary policy and investment. The findings reveal that uniform wage changes can produce heterogeneous employment responses between financially constrained and unconstrained firms, operating through the wage channel.

JEL classification: $E24$, $E52$, $J23$, $L25$
Keywords: Heterogeneous firms, financing constraints, labor market, monetary policy

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1 Introduction

Firms exhibit rich heterogeneity in their responses to monetary policy shocks. We study a model with financing frictions to show that changes in the labor cost encountered by all firms could lead to heterogeneous employment decisions across firms, depending on the degree of financing frictions they are subject to.[1] We employ a state-of-the-art heterogeneous firm model featuring a working capital constraint, the financial accelerator effect of Bernanke, Gertler, and Gilchrist (1999), and the marginal cost channel of Ottonello and Winberry (2020). These two channels of monetary policy transmission generate opposing effects on firm responses. With a stronger financial accelerator effect, financially constrained firms are expected to react strongly to monetary policy shocks. In contrast, when the financial accelerator effect is weaker, financially constrained firms are likely to respond more sluggishly compared to their unconstrained counterparts, due to the marginal cost channel of Ottonello and Winberry (2020).

Our theoretical contribution is to consider the response of the average labor cost in the above model. Incorporating the *wage channel*, we show that the employment response to a monetary policy shock due to this channel could differ across financially constrained and unconstrained firms, even when wages respond identically across the two firms' types. We show that the wage channel weakens the responsiveness of financially constrained firms to monetary policy shocks. As a result, these firms may exhibit a slower overall response to monetary policy shocks compared to unconstrained firms, even when the financial accelerator effect is pronounced.

Financing constraints constitute the leading mechanism of monetary policy transmission in the literature. The largest strand of this literature focuses on the effects of monetary policy on the investment and sales of heterogeneous firms, e.g., Gertler and Gilchrist (1994), Chari, Christiano, and Kehoe (2013), Kudlyak and Sanchez (2017), Jeenas (2019), Crouzet and Mehrotra (2020), Ottonello and Winberry (2020), Howes (2021), Kroner (2021), Gnewuch and Zhang (2022). Based on earlier findings that small firms face tighter financing constraints (e.g. Fazzari, Hubbard, and Petersen, 1988), Gertler and Gilchrist

[1] Heterogeneous responses of firms' employment has been documented, e.g., by Yu, 2021, Bahaj et al., 2022, and Singh et al., 2023.

(1994) show that after tight money episodes sales and inventories of small (in terms of assets) firms are more responsive than those of larger firms. Their paper emphasizes the credit channel and the financial accelerator mechanism of Bernanke, Gertler, and Gilchrist (1999). Recent research by Jeenas (2019), Ottonello and Winberry (2020), and Cloyne, Ferreira, Froemel, and Surico (2023) explores the strength of the investment channel.

In our paper, we retain the structure of the models used for investment, to study the transmission of monetary policy to employment. Specifically, we use a model of heterogeneous firms that features a working capital constraint and a spread that financially constrained firms pay for financing their labor input. In the model, there are three channels through which the employment response to a monetary policy shock of financially constrained firms might differ from that of unconstrained firms. The first channel relies on the financial accelerator mechanism (Bernanke, Gertler, and Gilchrist, 1999) which in the presence of working capital constraints causes the employment of constrained firms to react more to a monetary policy shock compared to unconstrained firms. The second channel involves the upward-sloping marginal cost curve, which is flatter for unconstrained firms than constrained firms (Ottonello and Winberry, 2020). These two opposing mechanisms through which monetary policy affects investment (Ottonello and Winberry, 2020) and employment (Bahaj, Foulis, Pinter, and Surico, 2022) have been previously emphasized in the literature.

Studying the labor market response to monetary policy relative to investment response, a new channel becomes relevant; the wage channel. In our empirical part we show that this channel is active, i.e., that the average cost for hiring workers responds to monetary policy shocks. In the theoretical part of this paper, we examine how the wage channel operates within the existing model of financing frictions. A related channel, exploiting changes in wages in different environments was also considered by Zervou (2014) and Manea (2020). In Zervou (2014), the wage changes introduce heterogeneous employment response to monetary policy across firms due to constrained firms using external finance versus unconstrained firms that do not. In Manea (2020), output responses across firms differ due to constrained firms using collateral to finance labor while unconstrained do not. In our work, heterogeneity in employment is due to changes in the spread paid by constrained firms because of changes in the average cost of hiring, and borrowing to cover this cost, after monetary policy shocks.

To illustrate the mechanism, consider a monetary contraction leading to a reduction in wages. Although the wage decrease is uniform across firms, employment, and hiring responses vary. This divergence occurs because financially constrained firms incur borrowing costs that include a spread, which diminishes as their borrowing decreases. Consequently, a lower wage cost reduces the borrowing spread, enabling constrained firms to expand hiring and employment compared to unconstrained firms. The wage channel constitutes a source of variation in employment dynamics: during a monetary contraction, financially constrained firms benefit by increasing hiring and employment growth. Conversely, during a monetary expansion, these firms reduce hiring and employment growth less than unconstrained firms, due to the wage channel.

The empirical literature on the response of wages suggests a procyclical response to monetary policy shocks. It is sometimes emphasized that this response is slow-moving (e.g. Christiano, Eichenbaum, and Evans, 2005), or stagger-set (e.g. Olivei and Tenreyro, 2007), but the empirical evidence points to decreases in wages paid to employees after monetary contractions. For example, Normandin (2006) for the US (among other countries), and McCallum and Smets (2007) for Europe, find that wages, nominal and real, decrease with a monetary policy contraction. Our empirical investigation supports that finding as well.

The paper is organized as follows. Section 2 introduces the model. Section 2.2 presents the firms' problem. Section 2.3 introduces monetary policy shocks. Section 3 presents our empirical evidence on the effects of monetary policy shocks on the employee's pay. Section 4 demonstrates how the additional channel analyzed here, introduces heterogeneous employment responses among firms. Finally, Section 5 concludes.

2 Model

We present a theoretical model demonstrating how a homogeneous, non-zero response of wages to monetary policy shocks produces asymmetric employment responses across firms with different degrees of financing frictions. Our starting point is the partial equilibrium heterogeneous firms employment-focused model of Bahaj, Foulis, Pinter, and Surico (2022), based on Ottonello and Winberry (2020) and Bernanke, Gertler, and Gilchrist (1999) channels of monetary transmission. The models of Ottonello and Winberry (2020) for investment and of Bahaj, Foulis, Pinter, and Surico (2022) for employment feature two opposing channels of monetary transmission: (i) the convex marginal cost channel and (ii) the financial accelerator channel. We incorporate a third channel, the *wage* channel, motivated by the countercyclical response of wages to monetary policy shocks as shown in Section 3 and supported by previous literature (e.g., Christiano, Eichenbaum, and Evans, 2005; Olivei and Tenreyro, 2007; McCallum and Smets, 2007; Normandin, 2006).

Wages are often financed with working capital (as also argued in e.g., Mendoza, 2010, Arellano, Bai, and Kehoe, 2019 and Bahaj, Foulis, Pinter, and Surico, 2022). In the model, we show that monetary policy affects the firms' labor choices through the incorporated working capital constraint. If a firm needs to borrow to finance its wage bill, an increase in the interest rate decreases its labor demand, holding all else constant. Many papers have introduced working capital constraints to emphasize the transmission mechanism where shocks impact employment demand through financing constraints (e.g., Mendoza, 2010 for productivity shocks, Arellano, Bai, and Kehoe, 2019 for uncertainty shocks; Bahaj, Foulis, Pinter, and Surico, 2022 for monetary shocks). Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017) provide empirical support showing that external financing is important for firms. The working capital constraint has been traditionally thought of as a cash-in-advance constraint in production, as introduced by Fuerst (1992). However, Schwartzman (2014) interprets this constraint as a time-to-produce constraint through which firms use and pay for the labor input before the output is supplied. This interpretation allows for wider applicability of the working capital constraints.

2.1 Set-up

We present the basic setup of the model. Firms j are heterogeneous on the dimensions explained below. Firm j produces good Y^j using labor input N^j according to the Cobb-Douglas production function

$$Y_t^j = A_t^j (N_t^j)^{\alpha},$$

where $\alpha \leq 1$ and A_t^j with $\mathrm{E}_t(A_t^j) = 1$ is the idiosyncratic stochastic productivity that is realized at the end of the period. The final good is homogeneous across firms and each firm sells its output at the price P_t. Each firm enters the period with the firm-specific amounts of liquid resources D_t^j and illiquid resources L^j. Let Q_t be the price of the illiquid resource. Assume that the liquid resource can be used to finance the operations of the firm, which faces working capital constraints, but the illiquid resource cannot be used for that purpose. While Bahaj, Foulis, Pinter, and Surico (2022) consider land as an illiquid resource, we allow for a broader interpretation, including firms' land and physical capital, but also intangible capital, such as payback reputation or trust in repaying the loan. In the empirical literature, firms' size or age is often an available observable; this broader interpretation allows firms' age or size to be used as a proxy for L^j, differentiating firms' type.

Firms borrow B_t^j at the beginning of the period in order to pay their labor input, while their output is sold at the end of the period. They borrow $B_t^j = \max\{W_t^j N_t^j - D_t^j, 0\}$, where W_t^j is a firm-specific nominal wage. The wage paid by each firm is the same for all employees, and thus in the model, firm-level wage and average employee earnings are equivalent.[2] We assume that firms face working capital constraints and need to borrow externally if their liquid resources D_t^j are insufficient to pay their labor input. We also assume that firms do not distribute dividends and that firms cannot raise funds by issuing new equity.

If a firm needs to borrow, it pays the gross interest rate equal to the short-term nominal interest rate i_t plus additional spread, $\lambda(B_t^j, Q_t L^j) \equiv \lambda_t^j \geq 0$, which depends on both B_t^j and the value of the collateral, $Q_t L^j$. The spread is assumed to increase with borrowing, $\frac{\partial \lambda_t^j}{\partial B_t^j} = \lambda_1^j \geq 0$ at an increasing rate, $\lambda_{11}^j \geq 0$. It is also assumed to decrease with the value of illiquid resources, $\lambda_2^j \leq 0$. However, the rate at which the spread increases with the firm's borrowing is decreasing with the value of the firm's illiquid assets, that is $\lambda_{12}^j \leq 0$. In addition, we assume that $\frac{\partial Q}{\partial i} < 0$, i.e., the price of the illiquid resource decreases with the interest rate.

[2] We show later on that in the presence of composition effects, we could use average employees' earnings instead of wages.

The next period liquid resources of firm j can be written as

$$D_{t+1}^j = P_t Y_t^j - (1+i_t)(W_t^j N_t^j - D_t^j) - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}. \quad (1)$$

In this economy, the aggregate state is given by $S_t = \{P_t, i_t, Q_t\}$ and $\{W_t^j\}$. This is a partial equilibrium model where the wage is exogenous. However, when the monetary authority changes the nominal interest rate i_t, it impacts the aggregate state vector and the wage. We examine changes in the labor input cost as a response to monetary shocks, regarding the model implications for employment.

2.2 Heterogeneous Firms

The value of the firm depends on the liquid resources. The firm's problem is to choose the labor input to maximize its expected value subject to equation (1), that is

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1+i_t} \mathrm{E}_t [V(D_{t+1}^j; S_{t+1})] \quad (2)$$

where we assume that the firm does not default.[3] Substituting in the above equation the firm's next period cash, we can re-write the optimization problem as:

$$\max_{N_t^j} V(D_t^j; S_t) = \frac{1}{1+i_t} \mathrm{E}_t \left[V(P_t A_t^j (N_t^j)^\alpha - (1+i_t)(W_t^j N_t^j - D_t^j) - \lambda_t^j \max\{W_t^j N_t^j - D_t^j, 0\}; S_{t+1})\right] \quad (3)$$

with the following transversality condition $\lim_{s\to\infty} \prod_{k=0}^{s} (1+i_{t+k})^{-1} D_{t+k}^j \geq 0$.

We denote the indicator function for $W_t^j N_t^j > D_t^j$ as $\mathbb{1}_{(B_t^j > 0)}$. The first-order condition for firm j is as follows

$$\mathrm{E}_t [V'(D_{t+1}^j; S_{t+1})] \left[P_t A_t^j \alpha (N_t^j)^{\alpha-1} - (1+i_t) W_t^j - \mathbb{1}_{(B_t^j>0)} \left(\lambda_t^j W_t^j + (W_t^j N_t^j - D_t^j) \lambda_1^j \frac{\partial B_t^j}{\partial N_t^j} \right) \right] = 0. \quad (4)$$

Simplifying equation (4), suppressing time subscripts and substituting in $\frac{\partial B^j}{\partial N^j} = W^j$ we

[3] Here we think of L^j as an illiquid asset; alternatively, we assume that the firm, even if it has to finance all labor employed by borrowing, having an upper bound of spread $\bar{\lambda}$, it still finds it suboptimal to liquidate its illiquid asset, i.e., there is an N^j such that $(N_t^j)^a - (1+i_t+\bar{\lambda})(W_t^j N_t^j) > i_t Q_t L^j$.

have:

$$\alpha P(N^j)^{\alpha-1} = \left[1 + i + \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right)\right] W^j.$$

Defining the expected value of the marginal product of labor as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ and taking logs of the first-order condition, we get the following equation:

$$\log MPN^j = \log\left((1+i) + \mathbb{1}_{(B^j>0)}\left[\lambda^j + (W_t^j N^j - D^j)\lambda_1^i\right]\right) + \log W^j.$$

Taking a first-order Taylor expansion of $i + \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right)$ around zero and defining the value of the marginal product of labor as $MPN^j \equiv P\alpha(N^j)^{\alpha-1}$ we derive the following expression:[4]

$$\log(MPN^j) - \log W^j - i = \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right). \tag{5}$$

Define

$$MB^j \equiv \log(MPN^j) - \log W^j - i = \log P + \log\alpha + (\alpha-1)\log N^j - \log W^j - i \tag{6}$$

as the marginal benefit from hiring an additional worker. Similarly, we define the marginal spread on the borrowing cost to finance the wage of the marginal worker as

$$MS^j \equiv \mathbb{1}_{(B^j>0)}\left(\lambda^j + (W^j N^j - D^j)\lambda_1^j\right). \tag{7}$$

For all firms, we have that $MB^j - MS^j = 0$, with $MS^j = 0$ for firms that do not need to borrow, i.e. $B^j = 0$,.

2.3 Monetary policy shocks

We now study the effects of monetary policy shocks on firms' employment decisions. To see the impact of changes in the nominal interest rate on employment through the model, we

[4]As usually, approximating $\log(1+i+x)$ around $i+x=0$, gives $\log(1+i+x) \simeq i+x$. We use $=$ in place of the formal $\simeq$ for what follows.

use the implicit function theorem on equation (5). The resulting equation is given below:

$$\frac{dN^j}{di} = -\frac{\frac{\partial MB^j}{\partial i} - \frac{\partial MS^j}{\partial i}}{\frac{\partial MB^j}{\partial N^j} - \frac{\partial MS^j}{\partial N^j}}.$$

Since

$$\frac{\partial MB^j}{\partial N^j} = \frac{\partial MPN^j}{\partial N^j} = \frac{\alpha - 1}{N^j}$$

and, for $B_j > 0$,

$$\frac{\partial MS^j}{\partial N^j} = \frac{\partial \lambda^j}{\partial N^j} + W^j \lambda_1^j + \left(W^j N^j - D^j\right) \frac{\partial \lambda_1^j}{\partial N^j} = (2\lambda_1^j + \lambda_{11}^j \left(W^j N^j - D^j\right)) W^j$$

we can transform this equation to be

$$\frac{dN^j}{di} = \frac{\frac{\partial MB^j}{\partial i} - \frac{\partial MS^j}{\partial i}}{\frac{1-\alpha}{N^j} - \mathbb{1}_{(B^j>0)} \left(2\lambda_1^j + \lambda_{11}^j (W^j N^j - D^j)\right) W^j}. \tag{8}$$

Note that because of our assumptions regarding the spread, the denominator in equation (8) is positive, and assumed strictly positive for the implicit function theorem to hold. In addition, for the firms that borrow it is true that the higher the amount of illiquid asset L^j, the lower the denominator. This is because, although a firm with more illiquid assets enjoys the same extra benefit from hiring an extra worker as the firm with less illiquid assets, a firm with more illiquid assets has a lower cost of hiring the extra worker because it pays a lower spread for borrowing than a firm with a less illiquid asset.[5] This is the effect analyzed by Ottonello and Winberry (2020) and the reason why firms with higher illiquid assets in the model, respond more to a change in the nominal interest rate (and in general).

We now focus on the numerator of equation (5). It depends on the responses of the net marginal benefit, MB^j, and of the marginal spread, MS^j, to nominal interest rate changes. This is where we incorporate the employees' wage effect, which introduces an additional channel for firms' differential response to monetary policy shocks, that has not been studied before.

[5]This is beacuse $\frac{\partial\left(\frac{1-\alpha}{N^j} + 2\lambda_1^j W^j + \lambda_{11}^j (W^j N^j - D^j) W^j\right)}{\partial L^j} = 2W^j \lambda_{12}^j Q \leq 0$ given that $\lambda_{12}^j \leq 0$.

In what follows, we analyze the impact of a monetary contraction, emphasizing the reduction in wages paid by firms. We first present, in Section 3, empirical evidence on how average earnings paid by firms to their employees respond to monetary policy shocks.

A comment regarding composition effects is in order here, as those effects could prevent us from modeling changes in average earnings, our empirical fact, into changes in wages, our modeling assumption. As discussed in Gertler, Huckfeldt, and Trigari (2020) and Hazell and Taska (2020), average earnings response does not necessarily translate into the equivalent wage changes, given composition effects that could be triggered after monetary policy shocks. For example, the decline in average earnings during monetary contractions could be due to interest rate cuts stimulating low-wage job creation within a firm, lowering average earnings paid. Yet, what matters for the firms in the model is not the individual wage response per se, but that the average earnings paid to employees respond to monetary policy shocks; when this is so, then firms' borrowing and spread respond too, affecting employment decisions.

3 Empirical evidence

In this section, we present empirical evidence that monetary policy contractions induce a decrease in the earnings of employees paid by firms. Then, in Section 4, we incorporate our empirical findings and show the impact of financing frictions on the employment decisions of firms.

3.1 Data and methodology

We use the Quarterly Workforce Indicators (QWI) dataset, derived from the Longitudinal Employer Household Dynamics (LEHD) program of the U.S. Census Bureau. This quarterly dataset from 1995:1-2019:2 includes all private, state, and local government (but not federal) employers covered by unemployment insurance in the U.S. and thus have good coverage. The data are seasonally adjusted using X-12-ARIMA method by the U.S. Census Bureau. We deflate both variables used with the Producer Price Index (PPI).

One advantage of the dataset is that it includes information about the average earnings paid to newly hired employees which allows us to measure changes in the relevant labor costs, not driven by previous wage contracts and negotiations. We consider two relevant variables. The first variable, *EarnHirNS*, represents the average earnings of workers who began a job that lasted a full quarter. These hires were employed by an employer during the specified quarter but had not worked for that employer in any of the preceding four quarters. The second variable, *EarnHirAS*, also captures the average earnings of workers who started a job that turned into a full-quarter position. However, this variable includes workers who, during the specified quarter, were new hires but may have been employed by the same employer in some of the previous four quarters—excluding the immediate quarter before the current one. These workers may have experienced a temporary break in their employment with the same employer.

Another advantage of the QWI dataset is that it reports earnings paid to employees for five firm size categories: size one has 0-19 employees, size two has 20-49, size three has 50-249, size four has 250-499, and size five has more than 500 employees. We take advantage of the firm size information to examine if the earnings paid to employees by firms of different sizes respond differently to monetary policy shocks.

Our monetary policy shock is the *federal funds rate factor* series constructed by Swanson (2021), based on the high-frequency futures market identification approach first developed by Kuttner (2001).[6] We focus on the short-run effect of changes on the federal funds target rate surprises, using the series of Swanson (2021)'s federal funds rate (ffr) factor, which isolates the effect of the short-term movements in asset prices.[7] Moreover, we aggregate the series to construct quarterly measures, as is common in the literature. Our analysis covers the period 1995:1-2019:2, starting our sample in 1995 to concentrate on the monetary policy era of formal target announcements.

To measure the impact of the federal fed factor shocks on the earnings of new employees, we employ the local projection method developed in Jordà (2005). Equation (9) below, is

[6]The monetary policy shocks are constructed using the three principal components of the asset price responses to each announcement of the Federal Reserve's Federal Open Market Committee (FOMC) within the 30-minute window. See Swanson (2021) for more details.

[7]Swanson (2021) identifies three factors of monetary policy, the short-run federal funds rate, the forward guidance and the large-scale asset purchases factor present after the Great Recession. The latter factor is relevant only in the period after 2008, and therefore, we do not focus on it given our larger sample. The second factor has an unclear interpretation, given that it also includes, besides the forward guidance effect, a possible information effect, as pointed out by Campbell, Evans, Fisher, and Justiniano (2012). The third factor captures short-run movements in asset prices and is the relevant factor for measuring monetary policy shocks in this study.

our baseline empirical specification on the aggregate QWI data:

$$\Delta_h w_{t+h} = \alpha + \beta^h_{ffr}\epsilon^{ffr}_t + \Gamma^{h\prime} Z_t + u^h_{t+h}. \tag{9}$$

The dependent variable is the cumulative growth rates of the earnings of new hires, $\Delta_h w_{t+h} \equiv \log w_{t+h} - \log w_t$, h periods after the monetary policy shock in period t. The coefficient of interest is β^h_{ffr} which is used to construct the impulse response functions presented below. Z includes one lag of the federal funds rate, lagged value of the dependent variable (1-period growth rate of wages) and the capacity utilization. Since we are using the Jordà (2005)'s methodology, the errors are autocorrelated by construction. To control for those correlations we use Newey and West (1987) standard errors.

In the empirical specification in equation (10) below we control for industry effects.

$$\Delta_h w_{is,t+h} = \alpha^h_{is} + \beta^h_{s,ffr}\epsilon^{ffr}_t \mathbb{I}_s + \Gamma^{h\prime} Z_t + u^h_{is,t+h}. \tag{10}$$

The dependent variable is the cumulative growth rate of the earnings of new hires, that is $\Delta_h w_{is,t+h} \equiv \log w_{is,t+h} - \log w_{is,t}$, which is the cumulative difference of the log earnings w in industry i, firm-size s, h periods after the monetary policy shock in period t. We control for industry fixed effects, α^h_i.[8] The coefficient of interest is $\beta^h_{s,ffr}$ interacted with firm size, where $\mathbb{I}_s$ is the indicator for size.

[8]We exclude Agriculture, Forestry, Fishing and Hunting, and Public Administration and Finance and Insurance, and Real Estate (FIRE), and Rental and Leasing.

3.2 Empirical results

Figure 1 depicts the response to a monetary policy contraction of the growth rate of real earnings paid to newly hired employees who have not worked for the employer the last four quarters (left panel) and all newly hired employees, including those who have taken a break and rehired by the current employer (right panel). From there we see that a monetary policy contraction of 100 basis points, decreases the real earnings paid to the employees by 5% (right figure) to 10% (left figure) after 6 quarters. The decrease is persistent, strong, and significant.[9]

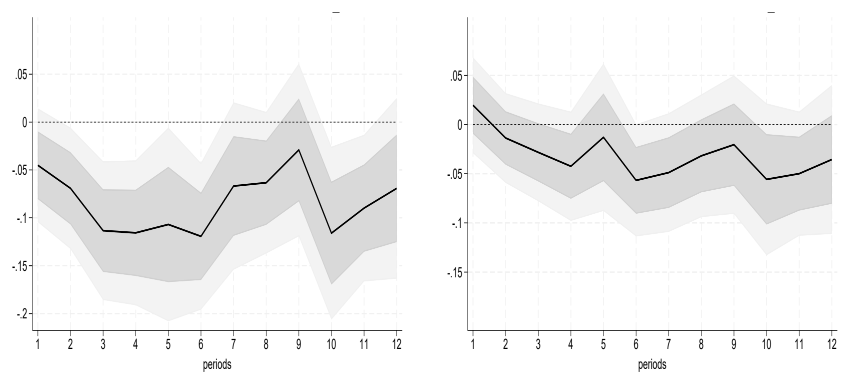

Figure 1: Response of the growth rate of real earnings paid to newly hired employees to a federal funds rate factor shock.

Notes: The figure plots the responses of the growth rate of average real earnings paid to newly hired employees in stable jobs, for employees who have not worked for the employer in the last four quarters (left panel) and of the growth rate of average real earnings paid to all newly hired employees in stable jobs (right panel), to an increase in the federal funds rate factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a 100 basis points shock. The shaded area depicts 90% confidence bands.

Figures 2 and 3 plot results for the two earnings series, separately for small (left panel) and large (right panel) firms. For both firm types, we see that the response of the growth rate of real earnings paid to newly hired employees who have not worked for the employer in the last four quarters (Figure 2) and all newly hired employees including those who have taken a break and rehired by the current employer (Figure 3), decreases after a monetary

[9] While the Swanson (2021) shocks have a sharp interpretation and are not influenced by forward guidance or information effects, they are rather small. As a result, we analyze and interpret our findings using both 68% and 90% confidence intervals. Larger intervals (corresponding to a one-standard deviation) are used in related literature e.g., in Coibion, Gorodnichenko, Kueng, and Silvia (2017) and Graves, Huckfeldt, and Swanson (2022).

policy contraction. Specifically, a contractionary monetary policy surprise of 100 basis points decreases the real earnings paid to the newly hired employees by 8% (Figure 3) to 15% (Figure 2) after 6 quarters for small firms and by 5% (Figure 3) to 11% (Figure 2) after 6 quarters for large firms. These decreases are not only persistent but also significant both statistically and economically.

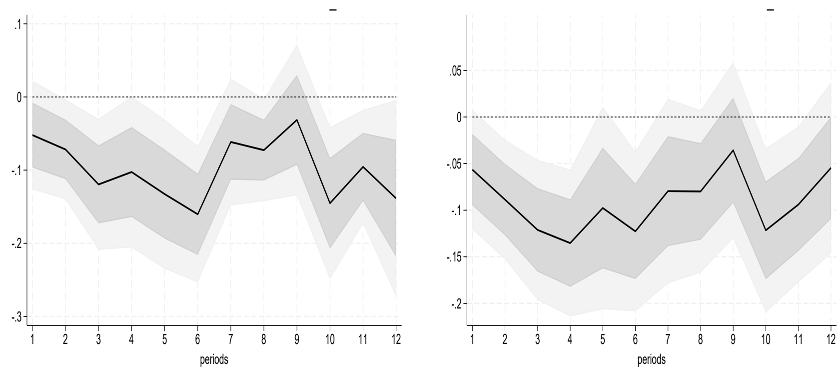

Figure 2: Response of the growth rate of real earnings paid to newly hired employees in small and large firms to a federal funds rate factor shock-rearnhirns.

Notes: The figure plots the responses of the growth rate of average real earnings paid to newly hired employees in stable jobs, for employees who have not worked for the employer in the last four quarters, in small firms (left panel) and large firms (right panel), to an increase in the federal funds rate factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a 100 basis points shock. The shaded area depicts 90% confidence bands.

We also present results controlling for industry effects, estimating equation (10). Figure 4 shows that after a 100 basis points tightening, the real earnings paid to the employees decrease by about 15% in both types of firms.

Therefore, our empirical results show that a monetary contraction reduces the average earnings firms pay to new hires. This is also true for different types of firms and, in some cases, is more pronounced for smaller firms. In what follows, we leverage these empirical findings, to illustrate within the theoretical model how a decrease in unit labor costs differentially impacts firms' employment decisions.

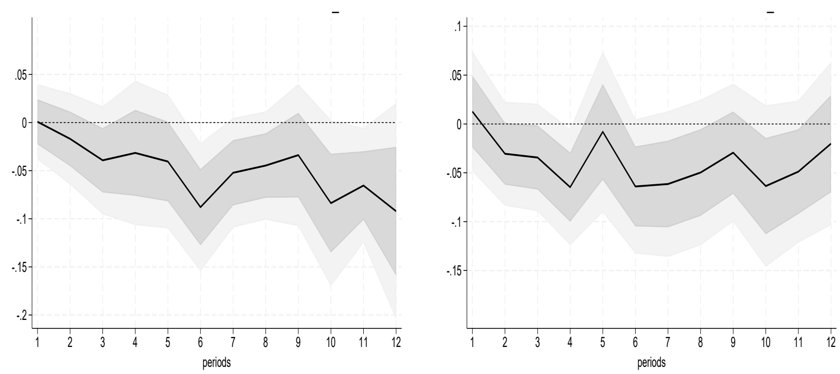

Figure 3: Response of the growth rate of real earnings paid to newly hired employees in small and large firms, to a federal funds rate factor shock-rearnhiras.

Notes: The figure plots responses of the growth rate of average real earnings paid to newly hired employees in stable jobs, in small firms (left panel) and large firms (right panel), to an increase in the federal funds rate factor shock. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a 100 basis points shock. The shaded area depicts 90% confidence bands.

4 Homogeneous wage responses and heterogeneous employment responses

We will now use the model to show how wage changes could lead to heterogeneous employment responses across firm types.

First, focusing on the numerator of equation (5), consider the effect of interest rate increase i on the net marginal benefit MB^j. Differentiating equation (6) we have:

$$\frac{\partial MB^j}{\partial i} = \frac{\partial \left(\log P + \log \alpha + (\alpha - 1)\log N^j - \log W^j - i\right)}{\partial i} = \frac{1}{P}\frac{\partial P}{\partial i} - \frac{1}{W^j}\frac{\partial W^j}{\partial i} - 1.$$

In addition, differentiating equation (7) the effect of the interest rate on the marginal spread MS^j is:

$$\frac{\partial MS^j}{\partial i} = \frac{\partial Q}{\partial i} L^j (\lambda_2^j + (W^j N^j - D^j)\lambda_{12}^j) + \frac{\partial W^j}{\partial i} N^j (2\lambda_1^j + \lambda_{11}^j (W^j N^j - D^j)).$$

In our empirical evidence Section 3 we considered real average employees' earnings, which decrease after a monetary contraction. This is true for all firms (Figure 1), but also for small and large firms (Figures 2 and 3) with a slightly greater response from small firms compared to large ones. In the model, however, we take a conservative approach and

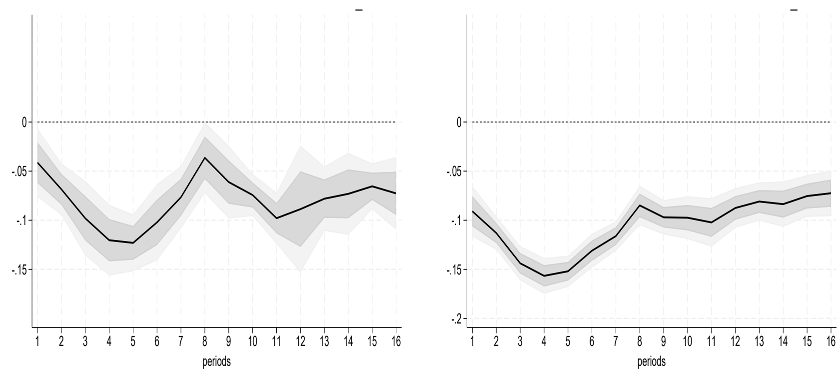

Figure 4: Response of the growth rate of real earnings paid to newly hired employees in small and large firms, to a federal funds rate factor shock controlling for industry effects-rearnhirns.

Notes: The figure plots smoothed responses of the growth rate of average real earnings paid to newly hired employees in stable jobs, for employees who have not worked for the employer in the last four quarters, in small firms (left panel) and large firms (right panel), to an increase in the federal funds rate factor shock. The regression controls for industry effects. The horizontal axis measures time (in quarters) and the vertical axis measures the response in percent to a 100 basis points shock. The shaded area depicts 68% and 90% confidence bands.

assume that the interest rate hike reduces wages to the same extent across the j firms, i.e., we can drop the j superscript from the real wage growth expression $\frac{1}{w^j}\frac{\partial w^j}{\partial i}$ and thus $\frac{\partial MB^j}{\partial i} < 0$. If we consider small firms' wages responding more than large ones, we will only make the wage channel stronger.

We also show here the case of analyzing nominal wages. Again, we consider an interest rate hike that reduces wages to the same extent across the j firms, and thus we drop the j superscript from the wage growth expression $\frac{1}{W^j}\frac{\partial W^j}{\partial i}$. In addition, the price level may also change in response to changes in the nominal interest rate i. Then, $\frac{\partial MB^j}{\partial i} = \frac{1}{P}\frac{\partial P}{\partial i} - \frac{1}{W}\frac{\partial W}{\partial i} - 1$, where we see that we can drop the j superscript from $\frac{\partial MB}{\partial i}$ since this effect is also homogeneous across firms. Note that, if there is no price puzzle or stickiness, we expect $\frac{\partial P}{\partial i} < 0$. However, we do not need to restrict the response of the price level, which given the empirical evidence in the literature, could increase, decrease, or stay constant after monetary policy shocks. For our purposes, it suffices to make the less restrictive assumption that $\frac{\partial MB}{\partial i} \leq 0$, so monetary policy tightening lowers the net marginal benefit from employing. Finally, substituting in equation (8) the response of the marginal spread to changes in interest rate, we get:

$$\frac{\partial N^j}{\partial i} = -\frac{\frac{\partial MB}{\partial i} - \left[\frac{\partial Q}{\partial i} L^j(\lambda_2^j + (W^j N^j - D^j)\lambda_{12}^j) + \frac{\partial W^j}{\partial i} N^j(2\lambda_1^j + \lambda_{11}^j(W^j N^j - D^j))\right]}{\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j(W^j N^j - D^j)W^j}. \quad (11)$$

In equation (11), the heterogeneous response of firms via the effect of interest rate on the marginal spread MS^j (i.e., the second term of the numerator which is inside the square brackets), can be analyzed in two parts. The first part captures the effect through the value of the illiquid asset, Q. Given that $\frac{\partial Q}{\partial i} < 0$ and $\lambda_2, \lambda_{12} \leq 0$, this first part is positive. That is, an increase in the interest rate decreases the value of the illiquid asset, and increases the marginal spread, decreasing input demand. This is the financial accelerator effect that traditionally has been used for understanding the response of investment to monetary policy (e.g., Bernanke, Gertler, and Gilchrist, 1999), or recently for studying the response of labor demand to monetary policy (as in Bahaj, Foulis, Pinter, and Surico, 2022).

The effect of the second part of the term in the square bracket in equation (11) has not been studied before and is novel in our work. This term summarizes the effect of wage changes, with $\frac{\partial W^j}{\partial i} < 0$. This term was assumed to be zero in Bahaj, Foulis, Pinter, and Surico (2022) and Ottonello and Winberry (2020). Given that $\lambda_{11} > 0$ and for $\frac{\partial W^j}{\partial i} < 0$, this term is negative, decreasing the spread that firms need to pay to finance employment after a decrease in employees' wages. The intuition is that as a monetary tightening decreases earnings, it decreases the total borrowing by a firm and hence lowers the marginal spread. This force tends to increase employment after a monetary tightening, holding all else constant.

A note is in order here given possible composition effects in data analysis that does not allow observing the effect of monetary policy on wages. In $\frac{\partial MS}{\partial i}$, we can split the earnings effect ($\frac{\partial W}{\partial i}N$) into the sum of the non-observed typically in aggregate data change of the individual kth worker wage ($\frac{\partial W^k}{\partial i}$) and the typically observed change in average earnings AE for the rest of the k-1 employees ($\frac{\partial AE}{\partial i}N^{k-1}$, where N^{k-1} denotes the number of the k-1 workers). In Section 3 we show that $\frac{\partial AE}{\partial i} < 0$; as such, the response of the average earnings is important for the wage channel, which is still valid in the presence of composition effects.

How does employment change in constrained and unconstrained firms in response to a change in monetary policy? We let $j = U$ be the *unconstrained* firm that we assume does not pay spread for the relevant employment levels hired, and hence $\lambda^U = 0$ and $MS^U = 0$. The *constrained* firm is denoted by $j = C$, where $B^C > 0$, pays spread $\lambda^C > 0$ and $MS^C > 0$. We denote $\Lambda^j \equiv -\frac{1}{\frac{\alpha-1}{N^j} - 2\lambda_1^j W^j - \lambda_{11}^j (W^j N^j - D^j) W^j}$. For unconstrained firms we have $\Lambda^U = -\frac{1}{\frac{\alpha-1}{N^U}}$, with $\Lambda^U \geq \Lambda^C$. Then we can write the difference between the interest rate effect on the employment of constrained versus unconstrained firms as:

$$\frac{\partial N^C}{\partial i} - \frac{\partial N^U}{\partial i} = (\Lambda^C - \Lambda^U)\frac{\partial MB}{\partial i} - \Lambda^C \left[\frac{\partial Q}{\partial i} L^C [\lambda_2^C + (W^C N^C - D^C)\lambda_{12}^C]\right] - \Lambda^C \left[\frac{\partial W^C}{\partial i} N^C [2\lambda_1^C + \lambda_{11}^C (W^C N^C - D^C)]\right]. \tag{12}$$

We analyze how monetary policy shocks impact constrained versus unconstrained firms differently, using equation (12). Given that $\Lambda^C - \Lambda^U < 0$, unconstrained firms are expected to respond more through the first term; this is the channel emphasized by Ottonello and Winberry (2020) where constrained firms scale down less than unconstrained ones after an interest rate increase.[10] This is because when decreasing labor input, the constrained firms which are the ones that pay spread, need to borrow less and pay a lower spread. As a result, constrained firms do not decrease the labor input as much as unconstrained firms do. This effect is depicted by the steeper slope of the MS^C curve (with respect to N) versus the MS^U curve in Figure 5. The second term in equation (12) is the financial accelerator effect; given our assumptions, this term suggests that constrained firms tend to react more to the change of the interest rate. These two opposing forces have been examined in Ottonello and Winberry (2020) for investment and in Bahaj, Foulis, Pinter, and Surico (2022) for employment. These two opposing channels suggest that if the accelerator effect is strong, then constrained firms respond more than unconstrained firms to monetary policy shocks; if the accelerator effect is weak, then unconstrained firms respond more than constrained firms to monetary policy shocks.

Examining the effects of the third term in equation (12) is our contribution to the existing literature; it suggests that unconstrained firms tend to react more to monetary policy shocks compared to constrained ones due to the wage effect. This is because, in the

[10] Note that $0 < \Lambda^C < \Lambda^U$ and $\frac{\partial MB}{\partial i} < 0$, so $(\Lambda^C - \Lambda^U)\frac{\partial MB}{\partial i} > 0$ and the first term of equation (12) implies that $-\frac{\partial N^C}{\partial i} < -\frac{\partial N^U}{\partial i}$, i.e., unconstrained firms contract more after an interest rate hike.

case of a monetary tightening accompanied by lower wages paid to employees, constrained firms need to borrow less to finance employment, pay a lower spread and thus scale down less than the unconstrained firms. The existence of this third channel allows the overall effect of monetary policy on unconstrained firms to be stronger than that on constrained firms, even in the presence of a strong accelerator channel, relative to the previous literature.

Graphically these 3 effects are depicted in Figures 5-7. In all figures, the vertical axes measure the net marginal benefit MB and the marginal spread MS, and the horizontal axes measure employment N. The downward sloping MB curve is the same for all firms in this first version with homogeneous changes in employees' earnings among firms. The convex MS curves differ for the two types of firms, constrained (steeper/blue) and unconstrained (flatter/black). For the unconstrained firms, the MS curve is flat for the levels of employment considered, although it is not for the constrained firms.

Figure 5 shows the response of the two types of firms to a monetary contraction, ignoring the effect of the financial accelerator and the wage effect, therefore capturing only the first term in equation (12). As noted earlier, because the constrained firms have to pay a spread while the unconstrained firms do not have to, unconstrained firms are more responsive and scale down more than constrained firms.

The financial accelerator effect is incorporated in Figure 6. This effect steepens and shifts inwards the MS curves (shifting from solid blue to dashed blue for the constrained firms and from solid black to dashed black for the unconstrained firms); we depict a strong accelerator effect, which results in constrained firms scaling down more than the unconstrained ones, as in Bahaj, Foulis, Pinter, and Surico (2022).

In Figure 7 we add the wage effect, depicting all three effects combined. The wage effect makes the marginal spread MS curve flatter than what it was in Figure 6, shifting from dashed blue to yellow for the constrained firms and from dashed black to green for the unconstrained firms. In this case, unconstrained firms respond more than constrained ones to monetary policy shocks, even in the presence of a strong accelerator effect. This is because the new effect we incorporate, coming from the response of employees' earnings, suggests that constrained firms tend to react less. This picture is drawn to show that financially constrained firms decrease hiring and employment growth less than unconstrained firms af-

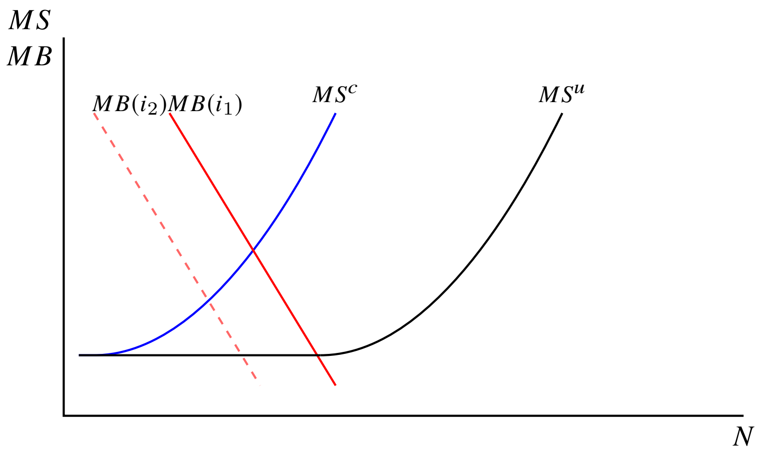

Figure 5: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. Model without taking into account the accelerator effect and the change in spread due to change in employees' earnings.

ter a monetary policy tightening that decreases wages, even when the financial accelerator channel is strong.

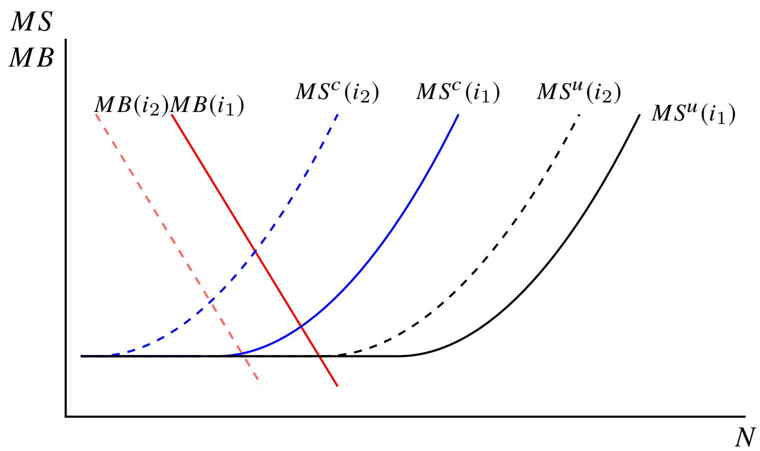

Figure 6: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Model without taking into account the change in spread due to change in employees' earnings.

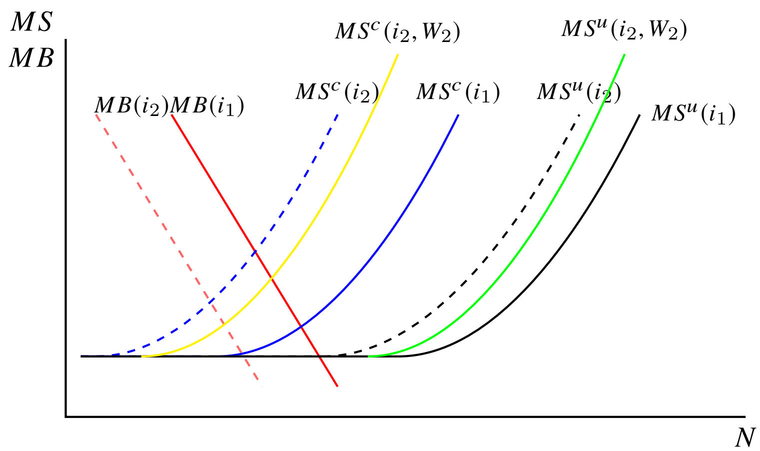

Figure 7: The figure plots MB, MS and choice of labor of constrained (blue MS curve) and unconstrained (black MS curve) firms. After a monetary contraction $i_2 > i_1$ the MB curve moves from red solid to dashed. The financial accelerator effect moves the MS curve of constrained firms to blue dashed and of unconstrained to black dashed curves. Taking into account the employees' earnings effect moves those curves to yellow for constrained and to green for unconstrained firms. Model with homogeneous changes in earnings growth.

5 Conclusion

This paper presents a theoretical model that studies how monetary policy affects financially constrained and unconstrained firms differently, with a focus on the labor market, an area less explored compared to investment in prior research. We incorporate in existing models of monetary transmission the effect of monetary policy on wages. We show how this additional effect influences firms' hiring behavior through financing constraints. We show that a uniform decrease in wages after monetary contractions leads to heterogeneous employment effects.

The mechanism emphasizes that financially constrained firms incur a borrowing spread that decreases as wages fall during a monetary policy contraction. In this context, monetary contraction, through the wage effect, eases financing constraints for small firms. Consequently, this dynamic weakens the rationale for implementing additional policies aimed at accelerating small firms' hiring growth relative to larger firms during monetary contractions. However, monetary expansion could present a more effective occasion for such targeted policy interventions.

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