Labor Market Monopsony in the New Keynesian Model: Theory and Evidence

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Link to Current Draft

Abstract

I assess the role of labor market monopsony—finite-elasticity firm-specific labor supply—in the context of a New Keynesian model. Existing models have used this feature as a source of real rigidity, permitting the models to feature flatter Phillips curves, and thus smaller responses of inflation to demand shocks. First, I modify a basic New Keynesian model to include firm-specific labor, and calibrate the elasticity of the firm-specific labor supply elasticity to micro-empirical estimates. Consistent with this mechanism serving as a source of real rigidity, firm-specific labor substantially reduces the slope of the Phillips curve relative to the perfectly competitive labor market benchmark. However, this depends strongly on the elasticity chosen, and requires distinguishing the firm-specific and aggregate labor supply elasticities, which previous work often fails to do. Second, I provide an empirical test for this mechanism, drawing on cross-sectional industry variation in the firm-specific labor supply elasticity. Using data from the Survey of Income and Program Participation, I estimate firm-specific labor supply elasticities by industry using a dynamic monopsony model and estimate industry responses to monetary policy shocks. Contrary to the New Keynesian model, I find no evidence of differential effects of monetary policy shocks on price changes due to differences in firm-specific labor supply elasticities, suggesting that firm-specific labor is not a source of real rigidity.

1 Introduction

Models of business cycles often require strong real rigidities—forces that reduce the responsiveness of firms' desired real prices to change in aggregate demand—to explain short-run fluctuations (Ball and Romer, 1990). Previous work has theorized that firm-specific, rather than homogeneous, labor is a potentially powerful source of real rigidity in New Keynesian models. Firm-specific labor theoretically induces real rigidity because it steepens the marginal cost function of the firm, especially if the labor supply elasticity to the firm is low. At the same time, there is a substantial literature attempting to measure firm-specific labor supply elasticities, often finding that firms exercise considerable monopsony power in the labor market. Despite this, existing work in macroeconomic theory lacks a connection to the micro-empirical estimates of the firm-specific labor supply elasticity (the elasticity of labor supplied to an individual firm to the wage paid by the firm). In addition, there is scant empirical evidence for this real rigidity mechanism. In this paper, I provide a comprehensive and and dedicated theoretical and empirical treatment of the role of firm specific labor in New Keynesian models as a source of real rigidity.

First, I clarify the theoretical role of firm-specific labor supply by constructing and calibrating a simple New Keynesian model with firm-specific labor supply. Importantly, I draw a distinction between the aggregate and firm-specific labor supply elasticities, and calibrate both elasticities to values consistent with the micro-empirical literature on labor supply elasticities. This distinction is important because the two elasticities play opposite roles in determining the extent of real rigidity in a model; a higher aggregate labor supply elasticity increases real rigidity, while a higher firm-specific labor supply elasticity lowers real rigidity.

Second, I use cross-sectional industry variation in the firm-specific labor supply elasticity to empirically evaluate the firm-specific labor real rigidity mechanism. I use dynamic monopsony methods to estimate firm-specific labor supply elasticities at the industry level, and estimate responses of industry variables to monetary policy shocks using local projections. I do not find any evidence that high-elasticity industries exhibit larger price responses to monetary policy shocks. I also find that high-elasticity industries exhibit larger employment falls in response to monetary policy shocks, contrary to the model's predictions. This evidence suggests that firm-specific labor is not a source of real rigidity.

Previous work exploring the modeling implications of firm-specific labor has suggested that firm-specific labor is a potentially important source of real rigidity. Woodford (2003) and Woodford (2005) show that in a simple monetary model, factor specificity matters more than both variable optimal markups and intermediate inputs in terms of generating real rigidities. Matheron (2006) estimates Phillips curves on Euro Area data and shows that modeling labor markets as firm-specific yields estimates of price reset probabilities that are much more consistent with empirical estimates of price reset frequencies than estimates based on models without firm-specific labor. Carvalho and Nechio (2016) analyze New Keynesian models with varying degrees of labor specificity (economy-wide, sector-specific, and firm-specific) and find that firm- and sector-specificity induces greater strategic complementarity and flatter Phillips curves than economy-wide labor markets.[1]

The intuition for how this mechanism operates is as follows. Consider a firm evaluating a given price increase in response to an increase in aggregate demand. The price increase would decrease demand for the firm's output, decreasing the firm's marginal cost due to, e.g., decreasing returns to scale. This decrease in marginal cost attenuates the firm's desire to raise its price—real rigidities. This attenuation is stronger when a firm faces a labor supply curve that is less elastic, since the firm's marginal cost curve is steeper with respect to its own output. The role of firm-specific labor supply is opposite that of aggregate labor supply. The aggregate labor supply elasticity affects how the aggregate wages, and thus all firm's marginal costs, respond to changes in *aggregate* output as opposed to a firm's *own* output. The aggregate labor supply is an example of what Leahy (2011) calls "type 1" real rigidity, which encompasses model features that affect the response of marginal cost to aggregate output. By contrast, firm-specific labor is a type of Leahy (2011)'s "type 2" real rigidity, since it affects how a firm chooses its optimal price in response to changes in its marginal cost. A lower aggregate labor supply elasticity leads to weaker real rigidities, whereas

[1]These papers are part of a larger literature that incorporates firm-specific factor markets into the New Keynesian model to better match inflation dynamics. In particular, the role of firm-specific capital has been used by, e.g. Altig et al. (2011) and Woodford (2005). The intuition behind the two mechanisms is similar–both steepen the relationship between a firm's marginal cost and its own output. Matheron (2006) finds that estimating New Keynesian Phillips curves with firm-specific labor alone yields estimates of price reset probabilities that are consistent with micro empirical estimates of these probabilities, but firm-specific capital alone does not.

lower firm-specific labor supply elasticities lead to stronger real rigidities.

The different roles of the elasticities means that it is important to distinguish between the two elasticities in a modeling context, including calibration. Much of the theoretical work on firm-specific labor has centered on where to put "the" labor elasticity; i.e., whether to aggregate labor supply of different types before or after applying the labor disutility transformation.[2] However, as I will explore in this paper, using one elasticity to play both roles risks overstating the impact of firm-specific labor in generating real rigidity, especially at higher elasticities. This is because if (as intuition might suggest) firm-specific elasticities are higher than aggregate elasticities, using the high firm-specific elasticity calibration for both roles induces a significant amount of real rigidity through the "type 1" aggregate labor supply channel. A firm-specific setup with a single elasticity is a feature of many papers that study or use models that feature firm-specific labor, (e.g. Nakamura and Steinsson, 2014; Gorodnichenko and Weber, 2016; Carvalho and Nechio, 2016).

There exists a substantial microempirical literature measuring both elasticities. Micro estimates of the aggregate labor supply elasticity generally find very low elasticities; in a meta-study, Chetty et al. (2012) finds average aggregate Frisch labor supply elasticities of 0.32 (extensive margin) and 0.86 (aggregate hours). As for the firm-speciifc labor supply elasticity, the literature is too large to fully enumerate here—in a meta-analysis, Sokolova and Sorensen (2020) collect 1,320 estimates from 53 studies. Generally speaking, estimates of the firm-specific labor supply elasticity are higher than those of the aggregate labor supply elasticity.[3] In particular, elasticity estimates using dynamic monopsony methods find particularly low elasticities. Using LEHD data, Webber (2015) finds an average firm-specific labor supply elasticity of 1.08. Using corporate income tax changes as a source of identification, Berger et al. (2021) find short-run labor supply elasticities between 1 and 2, depending on the firm's labor market share, while Bassier et al. (2020) find an elasticity of labor

[2] For example, in a separable utility function with labor types N_i and labor supply elasticity θ, the distinction would be whether to model labor disutility as $\left(\sum_i N_i di\right)^{1+\theta}$ or $\left(\sum_i N_i^{1+\theta} di\right)$. Note that in both examples, θ is the aggregate labor supply elasticity, whereas the firm-specific labor supply elasticity is infinite in the first case and θ in the second.

[3] There are a few studies in particular narrow contexts which yield estimates of the firm-specific labor supply elasticity which are extremely low. For example, using a natural experiment arising from Veterans Affairs compensation changes, Staiger et al. (2010) finds a short-run elasticity for nurses around 0.1. Dube et al. (2018) finds that labor supply for MTurk tasks are also around 0.1.

supply to firm AKM fixed effects of 3 using matched employer-employee data from Oregon. As I will demonstrate later, these estimates are well in the range of elasticities that would generate a substantial amount of real rigidity, relative to a perfectly competitive labor market, but are still above that of the aggregate labor supply elasticity.

If firm-specific labor supply elasticities are low, and firms exercise monopsony power in the labor market, the real rigidity mechanism is potentially very powerful. As I will show later, modifying the simple New Keynesian model from Galí (2008) to include finite firm-specific labor supply elasticities (in addition to, not instead of, the aggregate labor supply elasticity) that are consistent with some empirical estimates can lower the slope of the Phillips curve by as much as two-thirds, substantially muting the inflation responses and amplifying the output responses to demand shocks. The strength of the mechanism depends heavily on the firm-specific labor supply elasticity the model is calibrated to and is much weaker at higher levels (holding the aggregate labor supply elasticity constant).

In light of the theoretical work arguing that firm-specific labor is a strong source of real rigidity and evidence of substantial monopsony power in the labor market, it is surprising that there is little empirical evidence, for or against, as to whether the mechanism actually exists. Previous evidence on this mechanism is indirect; for example, Matheron (2006) calibrates models with and without firm-specific labor and finds that the calibrations with firm-specific labor imply more realistic price reset frequencies. However, no existing work provides direct evidence as to whether or not this real rigidity mechanism is at play.

In this paper, I empirically investigate assess the existence and strength of the firm-specific real rigidity mechanism by using cross-sectional industry variation in firm-specific labor supply elasticities. A multi-sector version of the model with firm-specific labor predicts that sectors with different elasticities exhibit behavior analogous to that of economies with different firm-specific labor supply elasticities; that is, sectors with higher elasticities should experience larger price decreases and smaller output and employment responses to contractionary monetary policy shocks.

I estimate firm-specific labor supply elasticities at the industry level using the dynamic monopsony model from Manning (2013) and data from the Survey of Income and Program Participation (SIPP). Across industries, I find a median firm-specific labor supply elasticity of 1.45 which, compared to a perfectly competitive labor market, would induce a Phillips curve slope that is approximately one-third as steep. There is significant heterogeneity in these elasticities across sectors. The lowest elasticity, in NAICS code 316 ("Leather and Allied Product Manufacturing"), is 0.47; the highest elasticity, in NAICS code 491 ("Postal Services and Contractors"), is 2.93.

To test the mechanism, I estimate "differential impulse-response functions" of industry variables (prices, output, employment, and wages) to monetary policy shocks, which measure how much the industry IRFs vary due to differences in firm-specific labor supply elasticities. I find mixed support for the hypothesis that firm-specific labor supply generates real rigidities. Contrary to the predictions of New Keynesian theory, I do not find that industries with less elastic firm-specific labor supplies (i.e., less competitive) fall less in response to a contractionary monetary policy shock; the firm-specific labor supply elasticity appears to have no detectable effect on industry price responses to contractionary monetary policy shocks. I also find no difference in output and wage responses across industries with different firm-specific labor supply elasticities. I do find that industries with larger firm-specific labor supply elasticities experience larger drops in employment, contrary to the predictions of my model. Overall, my results cast doubt on the firm-specific labor real rigidity mechanism.

This empirical strategy used in this paper is analogous to other work studying New Keynesian mechanics using cross-sectional variation. For example, there is a literature that uses cross-sectional variation in price change frequencies to assess the importance of nominal rigidities, such as Bils et al. (2003), who compares responses to monetary policy shocks of goods with flexible and sticky prices, and Gorodnichenko and Weber (2016), who compares stock returns of firms with high and low frequency of price adjustment. The methodology of this section is closest to that of Dedola and Lippi (2005) and Henkel (2020), who construct industry-level impulse response functions and project them onto industry characteristics.

The rest of the paper proceeds as follows. In Section 2, I construct and analyze the New Keynesian model with firm-specific labor. In Section 3, I estimate firm-specific labor supply elasticities and calibrate the multi-sector version of the model. I present the cross-sectional analysis of industry responses to monetary policy shocks in Section 4 and discuss the results in Section 5. Section 6 concludes.

2 New Keynesian Firm-Specific Labor Supply

In this section, I embed firm-specific labor supply into a standard New Keynesian model (Galí, 2008). The only modification I make to the model is to model labor services as firm-specific, rather than homogeneous. The representative household has CES preferences over the labor services provided to the firms, in addition to convex disutility with respect to aggregate labor supply. This setup allows me to draw a distinction between the aggregate labor supply elasticity and the firm-specific labor supply elasticity by having both parameters present in the model.

When calibrated to micro-empirical estimates of the firm-specific labor supply elasticity, the slope of the Phillips curve is half the slope of the Phillips curve in a model with homogeneous labor. The model with firm-specific labor exhibits smaller price responses and greater output responses to monetary policy shocks, relative to the model with homogeneous labor. However, this difference depends greatly upon the elasticity chosen.

I then extend the model to include multiple sectors which are heterogeneous in (among other things) the firm-specific labor supply elasticity, to generate testable hypotheses about the cross-sectional behavior of sectors with different firm-specific labor supply elasticities. Sectors with lower labor supply elasticities experience smaller price responses and greater output responses to monetary policy shocks, similar to the difference between one-sector model economies with different labor supply elasticities.

2.1 New Keynesian Model with Firm-specific Labor Supply

Households. An infinitely-lived representative household maximizes

$$\max_{\{C_{it}\},\{L_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+1/\eta}}{1+1/\eta} \right), \tag{1}$$

where C_t and L_t are consumption and labor CES aggregates of consumption from and employment at firms, given by

$$C_t = \left(\int_0^1 C_{it}^{1-1/\epsilon} di \right)^{\frac{1}{1-1/\epsilon}} \tag{2}$$

$$L_t = \left(\int_0^1 L_{it}^{1+1/\theta} di \right)^{\frac{1}{1+1/\theta}}, \tag{3}$$

where C_{it} and L_{it} denote the quantity of goods (labor) consumed by (provided by) the household from (to) a continuum of firms, indexed by $i \in [0, 1]$ in period t. In this setup, the firm-specific labor supply elasticity is θ and the aggregate labor supply elasticity is η. The period budget constraint is:

$$\int_0^1 P_{it} C_{it} di + Q_t B_t = \int_0^1 W_{it} L_{it} di + B_{t-1} + D_t \tag{4}$$

where P_{it} is the price of good i, W_{it} is the wage paid to labor at firm i, Q_t is the price of zero coupon bond B_t, and D_t are dividends from ownership of firms. Aggregate price indices for goods and services are given by

$$P_t = \left(\int_0^1 P_{it}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \tag{5}$$

$$W_t = \left(\int_0^1 W_{it}^{1+\theta} di \right)^{\frac{1}{1+\theta}}. \tag{6}$$

As in the standard model with homogeneous labor, the log-linear versions of the optimal consumption and labor supply decisions are

$$w_t - p_t = \sigma c_t + \eta l_t \tag{7}$$

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\sigma} \left(i_t - \mathbb{E}_t \pi_{t+1} + \log \beta \right), \tag{8}$$

where lower-case letters denote log deviations from steady state, the nominal interest rate is $i_t \equiv -\log Q_t$ and the inflation rate is $\pi_t \equiv p_t - p_{t-1}$. The firm-specific labor supply decision is

$$l_{it} = \theta(w_{it} - w_t) + l_t \tag{9}$$

Firms. There is a continuum of goods-producing firms in the economy, indexed by $i \in [0,1]$. Each firm i produces a specific variety and hires firm-specific labor. Output Y of a particular firm is given by

$$Y_{it} = Z_t \left(L_{it}\right)^{1-\alpha}. \tag{10}$$

Firms face Calvo pricing frictions and reset their prices with probability $1-\gamma$ every period. Derivation of the firm's pricing decision, and the Phillips curve, is similar to the standard model and relegated to Appendix Section A.1. The key difference is that the firm internalizes the fact that, as labor hired changes, so too does the required wage to hire that labor.

Monetary Policy. Finally, monetary policy follows a simple interest rate rule:

$$i_t = \rho + \phi_\pi \pi_t + \phi_y (y_t - y_t^n) + v_t. \tag{11}$$

where v_t is an exogenous monetary policy shock that follows an AR(1) process with persistence ρ_v and a shock term ν_t^v.

I calibrate the model at a quarterly frequency following Galí (2008), and report the paramter values in Table 1.

2.2 The Phillips Curve Under Firm-Specific Labor

Phillip Curve. The Phillips curve with firm-specific labor is:

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\gamma)(1-\beta\gamma)}{\gamma} \frac{\sigma + \frac{\alpha+1/\eta}{1-\alpha}}{1+\epsilon\frac{\alpha+1/\theta}{1-\alpha}} (y_t - y_t^n) \tag{12}$$

Table 1: Summary of Parameters

Parameter	Description	Value
β	Discount rate (quarterly)	0.99
σ	Risk aversion parameter	1.0
γ	Frequency of price adjustment	0.75
η	Aggregate labor supply elasticity	0.2
θ	Firm-specific labor supply elasticity	*Varies*
$1-\alpha$	Output elasticity to labor	0.75
ϵ	Product demand elasticity	9.0
ϕ_π	Taylor rule coefficient on inflation	1.5
ϕ_y	Taylor rule coefficient on output	0.125
ρ_v	Persistence of monetary policy shock	0.5

where y_t^n is the natural level of output.

Compared to the standard model, the Phillips curve is modified by the addition of the firm-specific labor supply elasticity parameter, θ, in the denominator of the $\frac{\sigma+\frac{1/\eta+\alpha}{1-\alpha}}{1+\epsilon\frac{\alpha+1/\theta}{1-\alpha}}$ term in Equation (12). One can think of this term as a "real rigidity" term in the Phillips curve, as it captures real rigidity mechanisms in the model. The numerator, $\sigma+\frac{1/\eta+\alpha}{1-\alpha}$, captures the Leahy (2011)"type 1" real rigidity forces, i.e., those that increase a firm's marginal cost when aggregate output increases. When aggregate output increases, marginal costs rise because of increasing aggregate wages (due to falling marginal utility of consumption and convex aggregate labor supply disutility) and decreasing returns to scale in the production function.

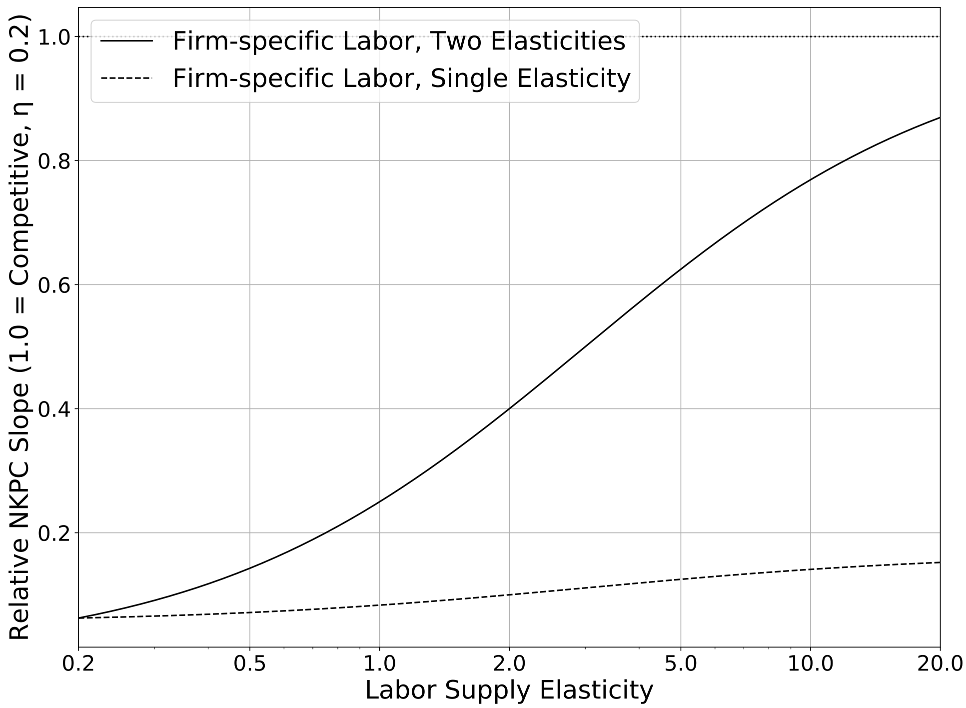
The denominator, $1+\epsilon\frac{\alpha+1/\theta}{1-\alpha}$, captures the "type 2" real rigidity forces, which reduce a firm's desired real price change in response to a change in its own marginal cost. The "type 2" real rigidity in this model arises from the interaction of the steepness of the marginal cost curve and demand elasticity. An increase in a firm's price decreases demand for its product; this decreases demand for its product reduces quantity and thus also the marginal cost. The reduction in marginal cost attenuates the desired price increase, and this attenuation is stronger the steeper the firm's marginal cost curve.

This difference highlights the different roles the two labor supply elasticities play in determining the extent of real rigidity in the economy. The aggregate labor supply elasticity appears in the "type 1" rigidity term; the *higher* the aggregate labor supply elasticity, the less aggregate wages, and therefore marginal costs, increase in response to increases in aggregate output. This induces greater real rigidity, and a lower Phillips curve slope. Meanwhile, the firm-specific labor supply elasticity appears in the expression capturing "type 2" rigidity; the *lower* the firm-specific labor supply elasticity, the steeper a firm's marginal cost curve and the less a firm will want to change its own price in response to the change in its marginal cost. This also induces greater real rigidity and a lower Phillips curve slope.

The exact difference in the Phillips curve slopes in the finite and infinite firm-specific labor supply elasticity differ depends greatly on the calibration of the firm-specific labor supply elasticity parameter. The dashed line in Figure 1 shows the slope of the Phillips curve, relative to the perfectly competitive case, as a function of the firm-specific labor supply elasticity (holding the other parameters constant). An elasticity of 1.0—a low estimate, but similar to the estimates from Webber (2015)—yields a Phillips curve slope that is 25% that of the competitive case. On the higher end of estimates, an elasticity of 20 (consistent with the results of stock-based estimations of the labor supply elasticity (see Sokolova and Sorensen, 2020) yields a Phillips curve that is 87% times the competitive case slope.

Comparison with a single-elasticity setup. Note that the relative Phillips curve slopes in Figure 1 are holding the *aggregate* labor supply elasticity constant at $\eta = 0.2$. This is not possible if the household preference structure is modeled with a single elasticity, as in Woodford (2003), Woodford (2005), Matheron (2006), and Carvalho and Nechio (2016). Such a single-elasticity setup can dramatically overstate the real rigidity importance of firm-specific labor as moving to the firm-specific case induces real rigidity once through the firm-specific channel as well as a second time if the aggregate labor supply elasticity increases as a result of calibrating the model to firm-specific labor supply elasticities. To see this, consider a model that is identical except that the representative

Figure 1: Relative Phillips Curve Slope by Firm-Specific Labor Supply Elasticities



Note: Lines denote the slopes of Phillips curves relative to the case where $\eta = 0.2$ and the labor market is perfectly competitive ($\theta = \infty$). The solid line denotes the case where $\eta = 0.2$ as θ varies. The dashed line denotes the case where θ varies and is both the aggregate and firm-specific labor supply elasticity.

household maximizes

$$\max_{\{C_{it}\},\{L_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - L_t \right), \tag{13}$$

where C_t and L_t are consumption and labor indices given by

$$C_t = \left(\int_0^1 C_{it}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \tag{14}$$

$$L_t = \int_0^1 L_{it}^{\frac{1+\theta}{\theta}} di, \tag{15}$$

in which case θ serves as both the firm-specific and the aggregate labor supply elasticity. Under this preference structure, the Phillips curve is:

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\gamma)(1-\beta\gamma)}{\gamma} \frac{\sigma + \frac{\alpha+1/\theta}{1-\alpha}}{1+\epsilon\frac{\alpha+1/\theta}{1-\alpha}} (y_t - y_t^n) \tag{16}$$

In this Phillips curve, θ plays a role in both the "type 1" real rigidity (since it determines the aggregate labor supply elasticity) as well as the "type 2" real rigidity (through the firm-specific labor supply channel) in equation (12).[4]

The solid line in Figure 1 plots the Phillips curve slope of this single-elasticity setup, relative to the $\eta = 0.2, \theta = \infty$ two-elasticity case. Like the two-elasticity case, the Phillips curve is substantially flatter at low levels of θ. However, for higher elasticities, the Phillips curve continues to be much flatter for the single-elasticity setup. This is because at higher elasticities the reduction in the firm-specific labor channel of real rigidity is in large part offset by the increase in the aggregate labor supply elasticity channel.

Model Responses to Monetary Policy Shocks In the two-elasticity model, the real rigidity differences between the competitive case and low levels of the firm-specific labor supply elasticity produces large differences in the models' responses to demand shocks. In Figure 2, I plot the IRFs for

[4] The single-elasticity household preference setup is identical to the two-elasticity household preference where the firm-specific and aggregate labor supply elasticities are identical, since $\int_0^1 L_{it}^{\frac{1+\theta}{\theta}} di = \left[\left(\int_0^1 L_{it}^{\frac{1+\theta}{\theta}} di \right)^{\frac{\theta}{1+\theta}} \right]^{\frac{1+\theta}{\theta}}$.

various macroeconomic variables to monetary policy shocks for the standard New Keynesian model and the model augmented with a firm-specific labor supply elasticity of 1.08 (following Webber, 2018).

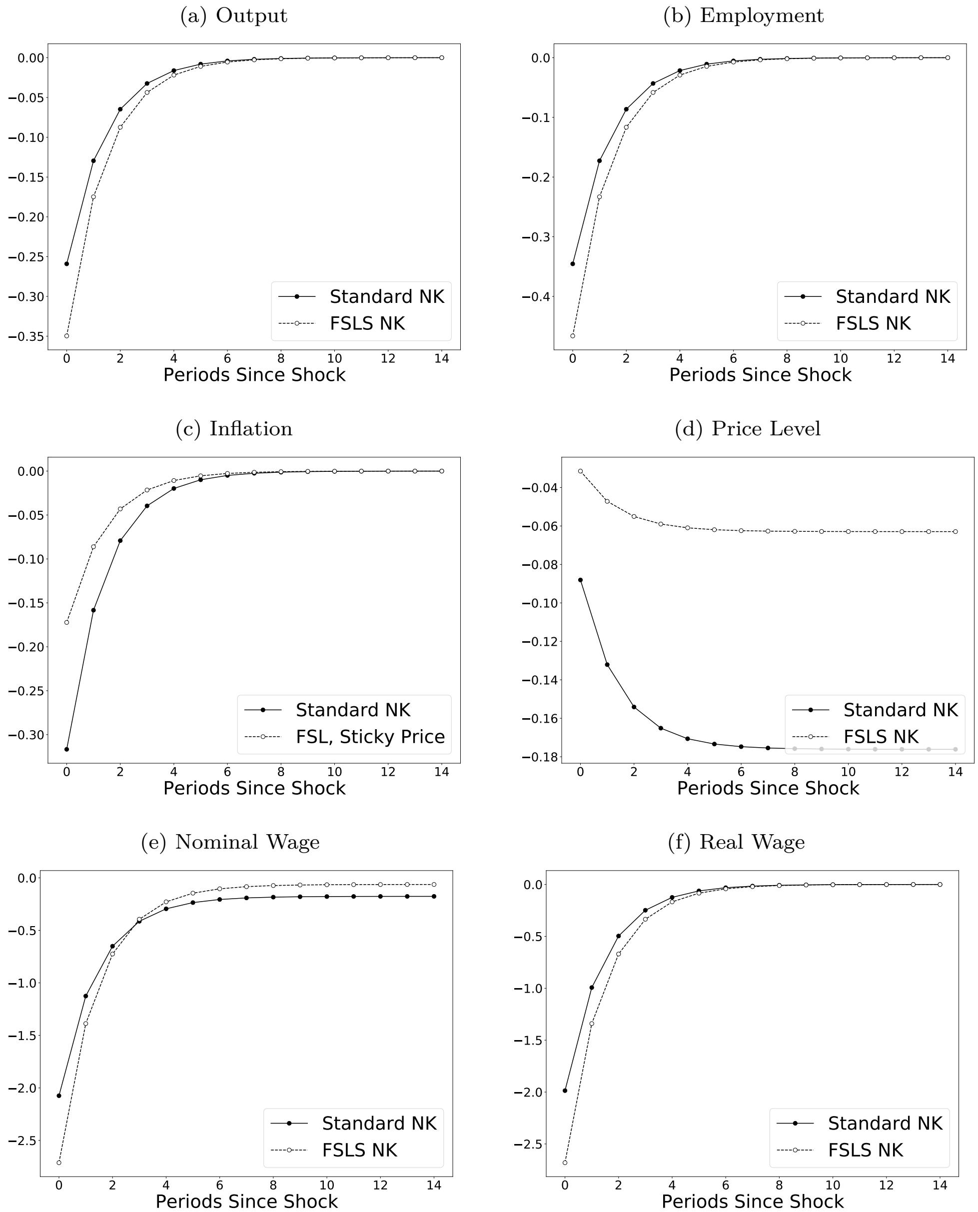
The model with finite firm-specific labor supply elasticity exhibits larger responses of output, employment and wages than that of the model with a competitive labor market. The differences are especially pronounced in the prices, with inflation and price level responses for the competitive model approximately nearly three times as large as the finite elasticity. model. In response to a contractionary monetary policy shock, the on-impact inflation rate in the competitive model is -0.35%, and in the firm-specific labor model it is -0.13%. On-impact, real output falls by 0.26% in the competitive model while it falls by -0.35% in the firm-specific labor model. Similarly, employment and wages fall by more in the firm-specific labor model, because output dictates labor utilization (through the production function). In Figure 3, I plot the responses of the firm-specific model relative to that of the perfectly competitive model. As one would implied from the Phillips curve slope differences, lower firm-specific labor supply elasticity lead to larger responses of output and smaller responses of prices and inflation.

3 Industry Heterogeneity in Firm-Specific Labor Supply Elasticities

In this section, I estimate firm-specific labor supply elasticities in the U.S. economy using a dynamic monopsony approach. With an eye towards the empirical cross-sectional approach, I estimate these elasticities by industry. I begin by describing the theory behind the dynamic monopsony approach to estimating firm-specific labor supply elasticities. The estimation method is from Manning (2013), and is based on the model in Burdett and Mortensen (1998). I then describe the SIPP data, on which I apply the dynamic monopsony estimation and present the estimated firm-specific labor supply elasticities.

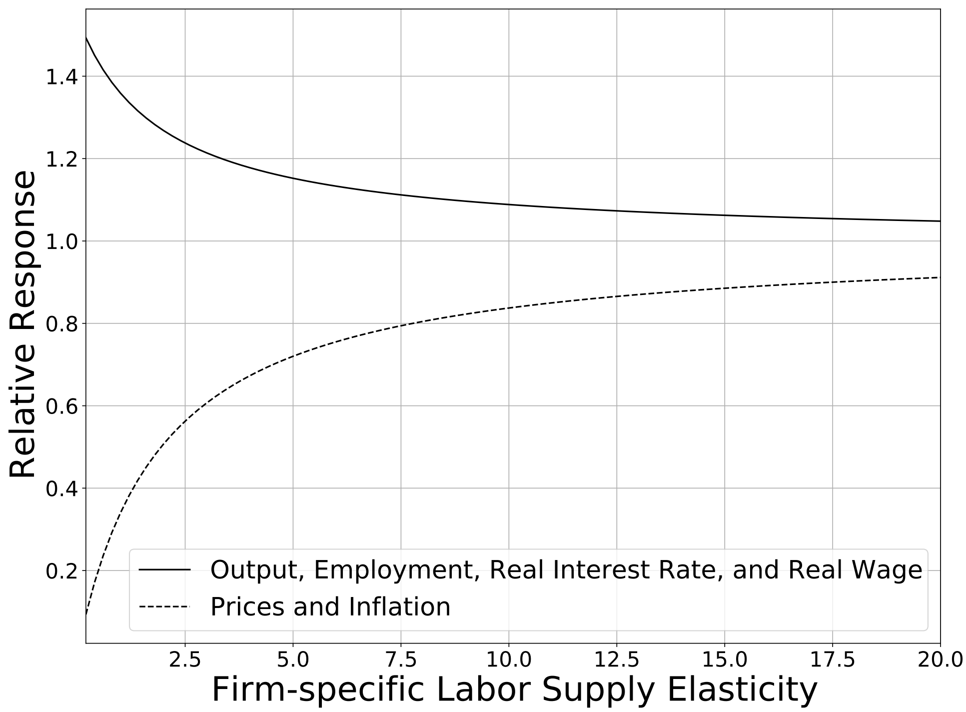
Then, I modify the model presented in Section 2 to include multiple sectors that are heterogeneous in the firm-specific labor supply elasticity parameter. I calibrate this model using the

Figure 2: Impulse-Response Functions to Monetary Policy Innovations



Note: IRFs are in percentage point responses to a 100 basis point (annualized) positive shock to the policy rate. Calibration of the model follows Table 1, with the firm-specific labor supply elasticity calibrated to 1.08.

Figure 3: Relative Impulse-Responses to Monetary Policy Shocks of the Firm-Specific model



Note: IRFs are relative to the IRFs of the perfectly competitive labor market model. A relative IRF of x means that the response of the variable is x times that of the response in the model with a perfectly competitive labor market. The relative IRFs are stable at all horizons. Calibration of the model follows Table 1.

industry-level firm-specific labor supply elasticities to confirm that cross-sectional differences in responses to monetary policy shocks due to differences in firm-specific labor supply elasticities may be informative about the mechanism in general; industries with different firm-specific labor supply elasticities behave qualitatively like one-sector economies with different firm-specific labor supply elasticities.

3.1 Dynamic Monopsony Estimation of the Firm-specific Labor Supply Elasticity

The Manning (2013) approach to estimating the firm-specific labor supply elasticity is based on the Burdett and Mortensen (1998) wage-posting model with on-the-job search. In this wage-posting model, a finite labor supply elasticity arises from search frictions and a finite arrival rate of job offers. When firms post wages, higher wages are associated with a higher arrival rate, since the job is more attractive to on-the-job searchers (relative to that of a lower wage job), as well as a lower separation rate, since a higher-paid worker is less likely to encounter a more attractive job while searching. Here, I outline the estimation procedure of the labor supply elasticity in this model (a complete proof of the methodology is in Manning, 2013).

For a firm paying (and posting) wage w, let $L(w)$ denote the labor employed by the firm, $R(w)$ denote the flow of recruits to the firm, and $S(w)$ denote the separation rate from the firm. In steady state, the labor supply to the firm can be written as

$$L(w) = R(w)/S(w). \tag{17}$$

In elasticity terms, this is

$$\theta_{L,w} = \theta_{R,w} - \theta_{S,w}, \tag{18}$$

where $\theta_{V,w}$ refers to the elasticity of $V \in \{L, R, S\}$ to w. The labor supply elasticity can be broken down into

$$\theta_{L,w} = \sigma_R \theta_{R,w}^{E\to E} + \left(1-\sigma^R\right)\theta_{R,w}^{N\to E} - \sigma_S \theta_{S,w}^{E\to E} - \left(1-\sigma_S\right)\theta_{S,w}^{E\to N}, \tag{19}$$

where σ_R and σ_S denote the fraction of recruits that are from other employers and the fraction of separations that are to other employers, respectively; $\theta_{R,w}^{E\to E}$ and $\theta_{R,w}^{N\to E}$ denote the elasticity of recruits from other employers and non-employed workers, respectively; and $\theta_{S,w}^{E\to E}$ and $\theta_{S,w}^{E\to N}$ denote the elasticity of separations to other employers and non-employment, respectively. The elasticity of recruitment from employment can be written as

$$\theta_{R,w}^{E\to E} = -\frac{\sigma_S}{\sigma_R}\theta_{S,w}^{E\to E}, \tag{20}$$

and that the elasticity of recruitment from non-employment can be written as

$$\theta_{R,w}^{N\to E} = \theta_{R,w}^{E\to E} - w\frac{\sigma_R'(w)(1-\sigma_R(w))}{\sigma_R(w)} \tag{21}$$

where the latter term in (21) can be thought of as the bargaining premium that an employed worker receives while searching while employed. Manning (2013) shows that if one estimates a logistic regression of the probability that a worker is a recruit from employment, when the log wage is included as one of the regressors, the coefficient on the log wage is equivalent to this bargaining premium term. Thus, in order to estimate the elasticity of labor supply to the firm, one needs to estimate the separation elasticities to employment and non-employment, this bargaining premium term, and the shares of separations and recruits from and to other employers.

3.2 Estimation of Elasticities using the Survey of Income and Program Participation

I estimate the firm-specific labor supply elasticity on data from the Survey of Income and Program Participation (SIPP). The SIPP is a household-based survey in the United States comprised of a series of panels. Panels collect information from households in 4-month waves and last between 8 and

16 waves. In this paper, I use the eight survey panels between 1990 and 2008, since the method used to collect information on job spells was collected similarly throughout this time period, significantly changing in 2012 in a way that coarsened the information available.

Households are surveyed every four months at the end of each wave. During the survey, respondents are asked about their employment history over the past four months. For each of the four reference months in the wave, respondents report the hours and wage rate or salary of any jobs they held during the month. Jobs are matched between reference months and waves using a unique employer ID number that is constant over the survey panel, as well as a reported job start and end month.[5] For the purposes of estimating separations and recruitment elasticities, I designate someone as employed at a job in a given month if they reported positive earnings at the job in the reference month. Non-employed are those who did not report any earnings at a job in the reference month.

Following Manning (2013), I estimate the separations elasticities $\theta_{S,w}^{E\to E}$ and $\theta_{S,w}^{E\to N}$ by modeling the instantaneous separation rate independently as $S^{ee}(x) = \exp(\beta^{ee}x)$ and $S^{en}(x) = \exp(\beta^{en}x)$, where x is a vector of controls and a log wage variable. The elasticity of separations is the coefficient on the log wage variable. I estimate these using maximum likelihood. The individual log-likelihood contribution is

$$\begin{aligned}\log L = {} & y^{E\to E}\ln\left[1-\exp(-S^{E\to N}(x))\right] + (1-y^{E\to E})\ln\left[\exp(-S^{E\to N}(x))\right] \\ & + (1-y^{E\to N})\left[y^{E\to E}\ln[1-\exp(-S^{E\to E}(x))] + (1-y^{E\to E})\ln[\exp(-S^{E\to E}(x))]\right],\end{aligned} \tag{22}$$

where $y^{E\to E}$ and $y^{E\to N}$ are dummies indicating separations to employment or non-employment, respectively. I define separations as those that are not employed at the same job in the next month. To allow for short breaks between employment spells, I define separations to non-employment as not being employed at any job in the next four months, while separations to employments are defined as separations in which the respondent is employed at some other job at any point in the next four months. Similarly, for the logistic regression used to estimate the bargaining premium term in (21), I define a recruit from employment as an observation where the worker is employed at a job, not

[5] For the earlier 1990-1993 panels, I apply the fix to the erroneous job id coding described in Stinson (2003).

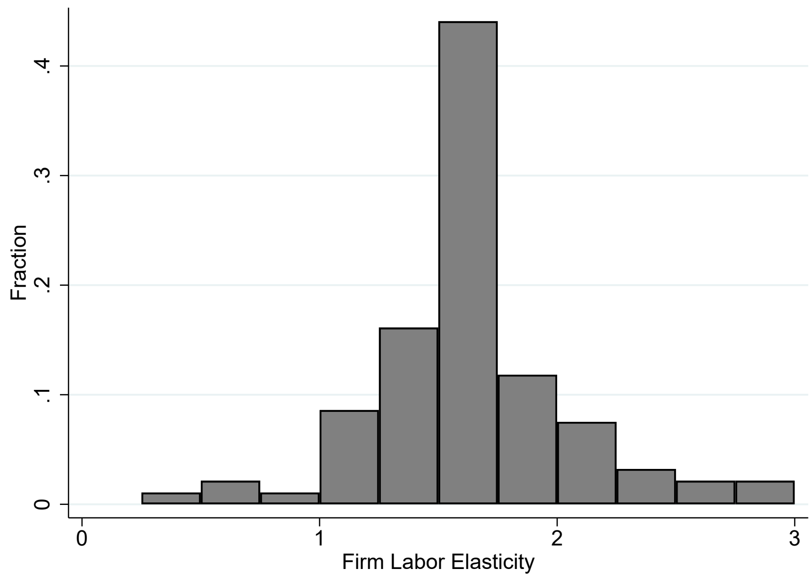
employed at that same job in the previous month, but employed in some job in the previous four months.

I only include observations (defined as a person in a month) during which the surveyed participant only holds a single job. I drop any spell in which the wage is top-coded or if the wage is under the federal minimum wage at the time. I also drop any reported employment spells if the hours are top-coded (above 98) or if hours are below 10 a week. Finally, I drop employment spells that are indicated as self-employed business, self-employed, or the armed forces. If I drop an employment spell for a given month, I do not treat the individual as non-employed during the month; I drop the observation entirely from the estimation sample. I have 7,248,517 observations used in the separations likelihood estimation. Of these, 92,423 are separations to other employment, and 110,437 are separations to non-employment. The recruitment from non-employment likelihood estimation is estimated on the sample of newly employed workers; that is, observations that report employment, meet the sample criteria above, and were observed as not employed in the same job during the preceding month. Recruits are defined as those who are employed in a job that were not employed in the same job in the previous month; there are 231,501 recruits observed, 99,394 of which are from other employment, and 110,437 of which are from non-employment.[6]

I use the same log wage variable and the same set of controls in the estimation of the separations elasticities and the recruitment from non-employment elasticity. I construct the wage variable using a combination of the reported hourly wage and salary variables. When there is an hourly wage reported, I use the hourly wage. For jobs in which there is only a reported salary, I impute an hourly wage using the reported monthly earnings divided by the number of weeks in the month multiplied by the reported hours worked per week. For controls, I include gender, marriage status, race, a set of education dummies (high school degree, some college, and college), year dummies, and a dummy indicating which reference month (1 - 4) the observation takes place in as controls. It is important to include the reference month as a control because there is a well-known "seam effect" in the SIPP, where respondents are more likely to report job changes between waves rather than within waves.

[6]There is a risk that this overstates the number of recruits from non-employment, if there are recruits from other employers that take more than a month off between jobs.

Figure 4: Distribution of Firm-specific Labor Supply Elasticities across Industries



To obtain sector-specific estimates of the elasticities of separation and recruitment, the log wage term is interacted with NAICS 3-digit industry dummies. Jobs in SIPP are encoded using Census industry codes, which are typically the equivalent of NAICS 4-, 5-, and 6-digit codes. I concord these to 3-digit NAICS codes. Because the concordance between the Census industry codes and NAICS 3-digit industries is not unique, I group some NAICS 3-digit codes and estimate their elasticities as if they were one industry. The grouped industries are listed in Appendix Table B.1.

Elasticity Estimates

In Figure 4, I plot a histogram of the sector-level firm-specific labor elasticity estimates. Notably, the estimates imply a significant degree of monopsony power in the labor market. The median industry has a firm-specific labor supply elasticity of 1.59, and the range of estimates is from 0.47 to 2.93. In Appendix Table B.1, I report the estimated firm-specific labor supply elasticities for each industry, as well as the estimated components of the elasticity (the elasticities of separation to other employment and non-employment, the search premium term, and the shares of separations and recruits to and from other employment).

These estimates are low, but not relative to other work that has estimated firm-specific labor elasticities using dynamic monopsony methods. Webber (2015), using LEHD data, finds an average labor supply elasticity of 1.08 among U.S. firms. Sánchez et al. (2020) find average elasticities of 0.61 and 0.36 for men and women, respectively, using matched firm-worker data from Chile. Barth and Dale-Olsen (2009) find average elasticities between 0.84 and 1.71 depending on the gender and specification using Norwegian establishment data.

3.3 Multi-Sector New Keynesian Model

I now extend the model to include multiple sectors in order to create testable predictions about how industries with heterogeneous firm-specific labor supply elasticities respond to monetary policy shocks. I briefly summarize the model here and discuss the relevant model differences. Sectors with different labor supply elasticities exhibit differences in business cycle dynamics that are analagous to the differences between one-sector model economies calibrated to different elasticities.

The only modification to the model is that there is now a finite number of industries, indexed by j, within which are a unit mass of firms, indexed by i. Households have two-tiered CES preferences over consumption goods and labor supply to firms. The within-industry elasticities of substitution are ϵ_j and θ_j for consumption and labor, respectively; the intersectoral elasticities are ζ and λ. Industries are also potentially heterogeneous in the returns to scale parameter α_j and the price reset probability γ_j. Firm pricing decisions give rise to a sectoral Phillips curve, the derivation of which is available in Appendix A.2:

$$\begin{aligned}\pi_{jt} = \beta \mathbb{E}_t \pi_{j,t+1} + &\frac{(1-\gamma_j)(1-\beta\gamma_j)}{\gamma_j} \frac{1}{1+\epsilon_j \frac{\alpha_j + 1/\theta_j}{1-\alpha_j}} \times \\ &\left[\left(\frac{\alpha_j}{1-\alpha_j} \right) \check{y}_{jt} - \left(\frac{1+1/\lambda}{1-\alpha_j} \right) \check{z}_{jt} + \sigma \check{y}_t + \frac{1}{\zeta} \left(\check{y}_{jt} - \check{y}_t \right) + \frac{1}{\eta} \check{l}_t + \frac{1}{\lambda} \left(\check{l}_{jt} - \check{l}_t \right) \right].\end{aligned} \tag{23}$$

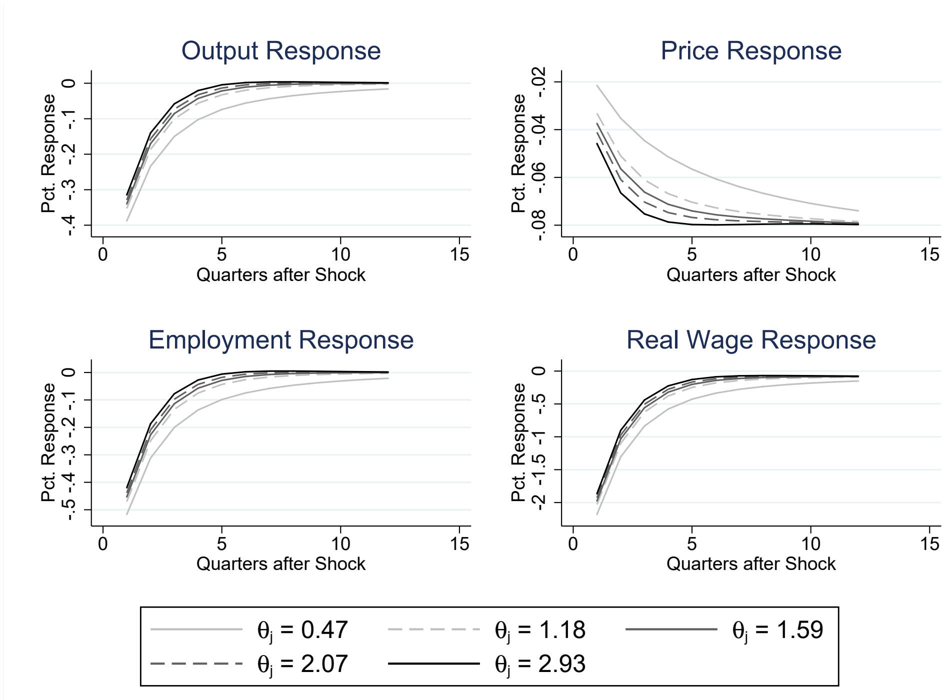
The sectoral Phillips curve in the multi-sector model is analogous to the one-sector Phillips curve. Since firms compete in the product market against other firms in the same sector, what matters for price setting is expectations of sectoral, not aggregate inflation. The term $\frac{1}{1+\epsilon_j \frac{\alpha_j+1/\theta_j}{1-\alpha_j}}$ is a direct analog of the denominator in equation (12); that is, it captures how the firm responds to changes in the marginal cost of its competitors. As in the single-sector model, the firm-specific labor supply elasticity appears in this term, lowering the slope of the sectoral Phillips curves as the elasticity decreases. The bracketed term in equation (23) captures how the marginal cost at the sectoral level evolves. As in the one-sector model, this depends on aggregate output through diminishing marginal utility (σ) and increasing labor disutility. It also depends on sectoral output and labor *relative* to aggregate output and labor, since consumption and labor are imperfect substitutes across sectors.

Calibration I calibrate the multi-sector model using the same parameter values as in 2.2 for the one-sector model, with the exception of the inter- and intra-sectoral demand and and labor supply elasticities. For the intersectoral labor supply elasticity, I follow Berger et al. (2021), who estimate the intersectoral labor supply substitution elasticity using changes in corporate tax rates, and set ζ to 0.31. They define the upper-level labor sector as NAICS 3-digits by commuting zones, so the elasticities at the NAICS 3-digit level are likely to be lower. However, lower upper-level labor elasticities do not qualitatively change the results of the multi-sector model.

I set the intersectoral product demand elasticity λ to 3.0, which Hobijn and Nechio (2017) estimate as the sectoral-level elasticity using long-run changes in relative prices in response to changes in value-added tax rates. This elasticity may be too small for NAICS 3-digit sectors, since their sectoral definitions are somewhat larger than NAICS 3-digit sectors. On the other hand, these are elasticities estimated off of long-run changes, not short-run elasticities, which may be lower and more relevant to sectoral responses within a few quarters. I calibrate the model to 92 sector, each corresponding to a NAICS 3-digit industry for which I have an estimated firm-specific labor supply elasticityfrom Section 3. To isolate the effect of the heterogeneous labor supply elasticity, I keep homogeneous $\alpha_j = 0.25$, $\epsilon_j = 9.0$ and $\gamma_j = 0.75$. I simulate the economy's response to the same 100 basis point (annualized) monetary policy shock as above.

In Figure 5, I plot the sectoral responses of output, prices, labor, and wages for the sectors with the lowest, 10th percentile, median, 90th percentile, and highest firm-specific labor supply elasticities (0.47, 1.18, 1.59, 2.07, and 2.93, respectively). As with the differences between one-sector economies calibrated to different firm-specific labor supply elasticities, monetary policy shocks induce smaller responses of prices and larger responses of output, employment, and wages in sectors with lower elasticities. So, qualitatively speaking, the response of sectors with heterogeneous firm-specific labor supply elasticities mirrors the difference between one-sector economies with different firm-specific labor supply elasticities.

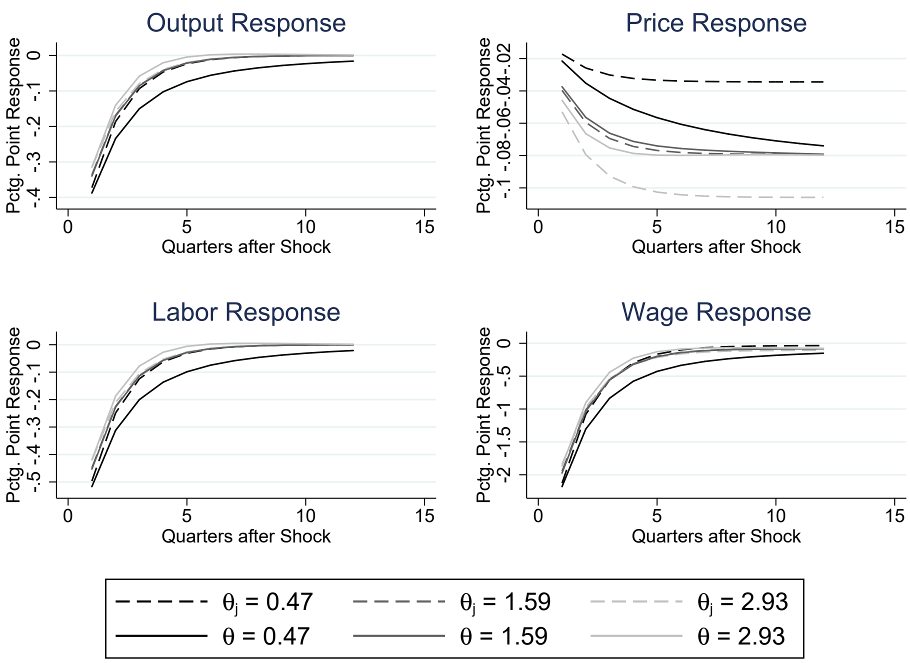
Figure 5: Comparison of Sectoral Responses to Monetary Policy Shocks



Note: IRFs are in percentage point responses to a 100 basis point (annualized) positive shock to the policy rate; each time unit represents one quarter.

There are, however, important quantitative differences in the comparison of sectoral responses and the comparison of one-sector model responses. The differences arise from the presence of intersectoral substitution in the product and labor markets, which is not present when comparing one-sector models with different firm-specific labor supply elasticities. Relative to the one-sector comparisons, this substitution attenuates the difference in price responses and increases the difference in output, employment, and wage responses between low- and high-elasticity sectors. Over time, as the monetary policy shock wears off, the difference in price reponses in the multi-sector model disappear as relative sectoral price return to parity.

Figure 6: Comparison of Multi-sector and Single-sector Responses to Monetary Policy Shocks



Note: IRFs are in percentage point responses to a 100 basis point (annualized) positive shock to the policy rate. Solid lines indicate the impulse response of the variable for a sector in the multi-sector model; the dashed lines refer to responses of the corresponding one-sector models where the firm-specific labor supply elasticity has been calibrated to the corresponding sector. Time periods correspond to quarters. Light grey lines correspond to the sector (in the multi-sector model) or the one-sector model calibrated to the lowest elasticity sector ($\theta_j = 0.47$); grey lines correspond to the sector (in the multi-sector model) or the one-sector model calibrated to the median elasticity sector ($\theta_j = 1.59$); black lines correspond to the sector (in the multi-sector model) or the one-sector model calibrated to the highest elasticity sector ($\theta_j = 2.93$).

4 Empirical Industry Responses to Monetary Policy Shocks

In this section, I test the predictions of firm-specific labor supply in New Keynesian theory in the industry cross-section. I estimate IRFs of industry variables, industry-by-industry, and project those IRFs onto the firm-specific labor supply elasticity estimates as well as other industry characteristics. I find no cross-sectional evidence that firm-specific labor supply generates real rigidities, and do not find any differential effect of monetary policy shocks on industry outcomes due to differences in firm-specific labor supply elasticity. Industries with differing firm-specific labor supply elasticities do not experience differential price responses to monetary policy shocks. Industries with higher elasticities actually face more negative responses of output and employment to contractionary policy shocks, contrary to the real rigidity story. These results are robust to the inclusion of various industry characteristics as controls as well as an alternate one-step estimation strategy.

4.1 Industry Responses to Monetary Policy Shocks

To estimate the differential effect of monetary policy shocks on industries with different firm-specific labor supply elasticities, I estimate IRFs of industry price levels, output, employment, and wages by using a series of Jorda Local Projections. I then project the IRFs at different horizons on industry characteristics.[7] For each industry i and variable y, I estimate a series of local projections:

$$\log y_{i,t+h} - \log y_{i,t-1} = \alpha^{y,h} + \sum_{j=1}^{J} \beta_j^{i,y,h} \Delta \log y_{i,t-j} + \sum_{k=0}^{K} \gamma_k^{i,y,h} shock_{t-k} + \nu_t^{i,y,h} \tag{24}$$

The response of industry variable y in a industry i to the monetary policy shock h periods out is equal to the coefficient $\gamma_0^{i,y,h}$ in Equation (24). I estimate the local projections on monthly data up to $H = 24$ horizons and set $I = J = 12$. Then, for each variable y and each horizon h, I then run a cross-sectional regression of the estimated IRFs on the industry's firm-specific labor supply

[7] This methodology was previously used by Dedola and Lippi (2005) and Henkel (2020), although not to measure the effect of firm-specific labor supply elasticities on industry outcomes.

elasticity and a vector of controls:

$$\hat{\gamma}_0^{i,y,h} = a^{y,h} + b^{y,h} \log(\hat{\theta}_i) + C_i X_i + e_i^{y,h}. \tag{25}$$

The coefficient of interest, $b^{y,h}$, which I will call the "differential IRF", captures how the industry IRFs relate to industry heterogeneity in the firm-specific labor supply elasticity. The monetary policy shock, which is described below, is scaled so that a positive value corresponds to a contractionary monetary policy shock. To recap the predictions from Section 4, the New Keynesian model would predict more negative responses of output, employment, and wages, and less negative responses of prices; that is, one would expect $\hat{b}^{y,h}$ to be negative for prices and positive for output, employment, and wages.

Industry Outcome Variables For prices, I use the monthly Producer Price Index (PPI) data from the Bureau of Labor Statistics (BLS). PPI data is available (for some industries) at the NAICS 3-digit level; I do not attempt to replace or construct NAICS 3-digit level data for industries where it is not available. Most industries are available from 2004 onwards, although a few go back further. Unfortunately, the concordance between the SIC-based (pre-2004) and the later NAICS-based data is insufficiently clean for use.

For output, I construct a monthly output series using data from the Board of Governors of the Federal Reserve System's monthly real industrial production series (G.17) and the Census Bureau's monthly retail and wholesale trade reports. The latter two report nominal sales for retail and wholesale trade industries, which I deflate using the corresponding PPI.[8]

For labor market variables, I use the Current Employment Statistics (CES) from the BLS. For both employment and wages, there are several choices; I use production employment and average weekly real production earnings as employment and wage measures, respectively, although results using other series are similar. These data are available on a monthly basis from 1990 onwards.

Monetary Policy Shocks I use the monetary policy shock series from Bu et al. (2021). The

[8]As an alternative, I use the real gross output and real value-added series from the Bureau of Economic Analysis (BEA) Industry Economic Accounts Data. This data is generally available at a NAICS 3-digit level on a quarterly basis from 2000q1 forward. Results are similar between the monthly and quarterly regressions.

shocks are derived using a Fama-Macbeth two-step procedure in which the authors first estimate the sensitivity of interest rates across the maturity spectrum, and then recover the monetary policy shock from a cross-sectional regression of interest rate changes on the sensitivity estimates. Importantly, this shock series does not show any evidence of an information effect à la Nakamura and Steinsson (2018) and produces conventionally signed impulse-response functions of production and prices. The shock series is available at a monthly basis from 2004 onwards.

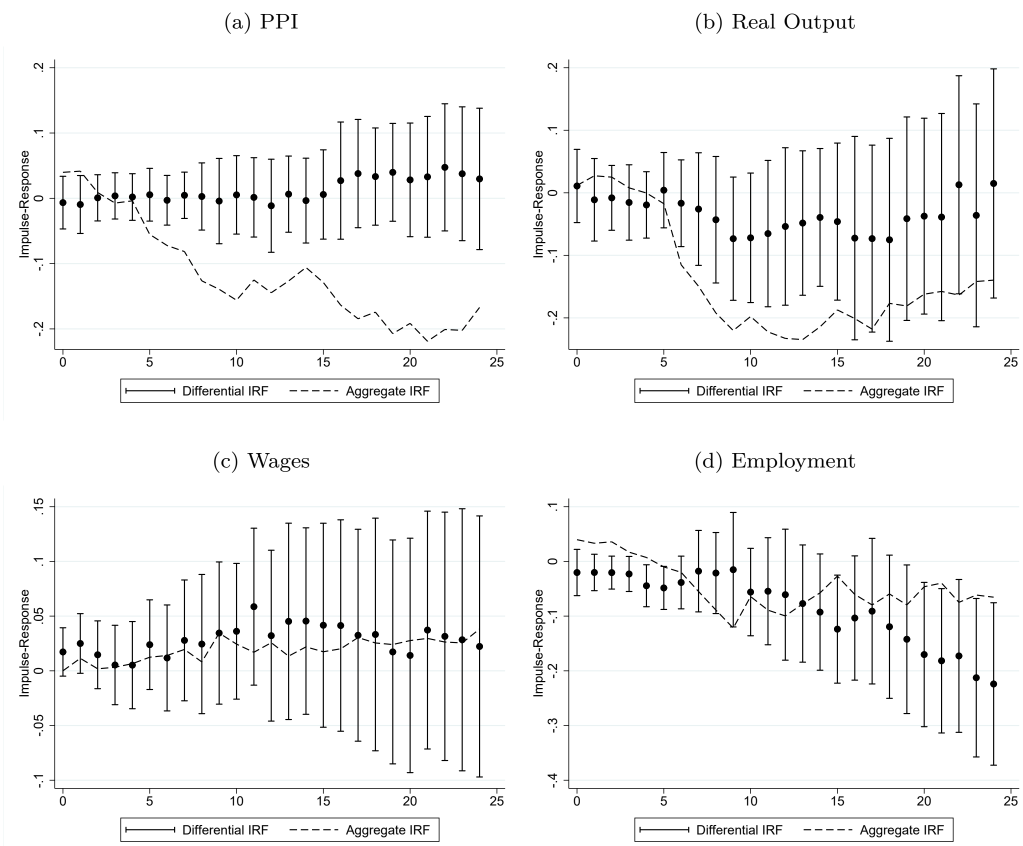
4.2 Industry Outcomes and Firm-Specific Labor Supply Elasticities

In Figure 7, I plot the differential IRFs estimated in Section 4.1. To begin with, I present the results without the use of controls in the estimation. To reiterate, the estimate of $b^{y,h}$ is the coefficient on the firm-specific labor supply elasticity in Equation (24), and measures how different the IRFs are due to differences in firm-specific labor supply elasticities. According to the model, industries with higher firm-specific labor supply elasticities should see negative differential IRFs for prices, but positive differential IRFs for output, wages, and employment. I also plot the IRFs of the aggregate counterparts of the industry variables in Figure 7

Contrary to the real rigidity prediction, I find no significant effect of firm-specific labor supply elasticity on responses of industry prices. Industries with higher firm-specific labor supply elasticites do not appear to experience significantly different responses of prices to the monetary policy shock. Neither do I find any evidence for the real rigidity predictions in the responses of real output or wages, although the standard errors on the former are quite large and the latter measure is not composition-adjusted.

The only industry outcome which appears to be affected by the firm-specific labor supply elasticity is production employment. Here, the effect of the firm-specific labor supply elasticity is the opposite of that predicted by the New Keynesian model, which predicted larger employment falls in low-elasticity industries, not high-elasticity industries. The empirical industry responses find the opposite, with employment falling more in higher-elasticity industries, with the difference significantly different (at the 90% level) from zero starting at 20 months from the monetary policy shock. Relative to the aggregate response of production employment, the difference in employment

Figure 7: Differential Effects of Monetary Policy Shocks on Industry Variables (No Controls)



Note: Each point represents the estmate of $\hat{b}^{y,h}$ from estimating equation (24), with no controls. Error bars represent 90% confidence intervals. The wage measure is average weekly real production employee earnings and the employment measure is production employees.

is substantial.

4.3 Controlling for Other Industry Characteristics

A potential concern is that the firm-specific labor supply elasticity is not randomly assigned between industries. This poses a threat to identification if there are industry characteristic that affects industry responses to monetary policy shocks that is also correlated with the firm-specific labor supply elasticity. For example, it may be the case that industries vary in firm size, which could affect both the firm-specific labor supply elasticty as well as the borrowing capacities of those firms. This could lead to omitted variable bias if monetary policy is stronger in industries with firms that are more financially constrained (as Dedola and Lippi, 2005, finds); in this particular case, the differential IRF would be biased downwards. To address the issue of omitted variable bias, I estimate equation (24) with a set of industry controls.

Description of Controls

First, I control for the frequency of price adjustment. Previous work (Bils, Klenow and Kryvstov, 2003; Henkel, 2020) have found differential responses between goods and industries with respect to the frequency of price adjustment. I use the frequency of price adjustment data reported by Nakamura and Steinsson (2008), who report rates price adjustment derived from the BLS data underlying the PPI and CPI. For their PPI data (Table 23 of their online supplement), I manually concord each item to a NAICS 3-digit manufacturing code to cover NAICS codes beginning with 31, 32, and 33. In addition, I supplement this data with their CPI-based frequency of price adjustment data for retail trade and services (Table 20). For both data sources, I use the price change frequency with substitutions as a measure of the frequency of price adjustment.

For the manufacturing NAICS sectors (NAICS codes beginning in 31, 32, and 33), I use the PPI-based frequency of price adjustment data, matching PPI product codes to NAICS manufacturing sectors. For the retail trade sectors, I draw on frequency of price change data from the CPI, matching CPI Entry Level Items (ELIs) to the appropriate NAICS retail sector. For example, "Girl's Dresses" is matched to the NAICS 3-digit code 448 ("Clothing and Clothing Accessory Stores)." For a number of non-manufacturing and non-trade sectors, I am also able to obtain a measure of the frequency of price change using the reported CPI data. For example, I use the frequency of price change of the "Airline Fare" item in the CPI data as the measure of the frequency of price change for NAICS 481 ("Air Transportation"). Overall, I am able to map the frequency of price adjustment data to 49 of the NAICS sectors. In the case where I have multiple items mapped to a NAICS sub-sector, I take the median frequency of price adjustment of all items matched to that NAICS sub-sector.

A second set of controls includes other industry characteristics that, while not present in the canonical New Keynesian model, may affect industry responses to monetary policy shocks and also be related to industry variation in labor market monopsony. First, I construct a measure of interest rate exposure using data from Compustat. For each industry, I compute measures of the interest rate burden (interest expenses over sales), the leverage ratio (total debt over assets), and the short-term debt ratio (short term debt over assets). These measures are computed annually and then averaged over years 2004 through 2019. Second, I construct a measure of the fraction of establishments with under fifty employees in each industry using the Quarterly Census of Employment and Wages from the QCEW. Finally, I include a dummy variable for industries producing durable goods.[9]

A final set of controls is related to the other determinants of real rigidity in the canonical New Keynesian model explored earlier in this paper, returns to scale in the production function and the elasticity of product demand. Real rigidities are theoretically increasing in the product demand elasticity and decreasing in the returns to scale parameter. In particular, it is plausible that sectors that are monopsonistic in the labor market may also be monopolistic in the product market (it may be the case that these are related to firm concentration, which could appear in both the product and labor market; or, search frictions in the labor market may be correlated with similar search frictions in the product market). Normally, these might be controlled for by using the profit share and the labor share, respectively; however, if monopsony power allows firms to set wages below the marginal revenue product of labor level, the profit share and labor share are controls that are outcomes variables of the firm-specific labor supply elasticity, thus making them "bad controls."

In the absence of better controls for the returns to scale and the elasticity of product demand,

[9]NAICS codes starting with 33, and codes 321, 327, and 423.

I estimate Equation (24) with and without the labor share and profit shares in the set of controls X_i. For the labor share, I use the industry's average compensation over value added and for the labor share I use the average net operating surplus over value added, as reported in the BEA's GDP by Industry statistics. The results are robust to the inclusion or exclusion of the labor and profit shares as controls. In the main text, I report the results without these controls. In Appendix Table B.3 - B.6, I compare the results with and without these labor and profit shares as controls; the estimates are very similar.

Differential IRFs with Controls

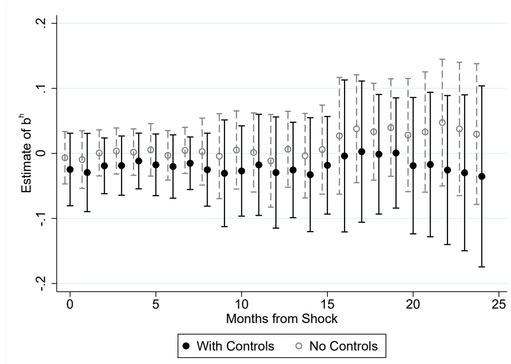
I present the differential IRFs, estimated with controls, in Figure 8, along with the differential IRFs estimated without controls from Section 4.2 for comparison. I also report the estimated differential IRFs, with and without controls, in Appendix Table B.2 at 3-month intervals. As before, the results with controls provide no evidence for the real rigidity mechanism. Industries with different firm-specific labor supply elasticities do not exhibit significantly different responses of prices to monetary policy shocks. The differential IRFs for output become more negative, contrary to that predicted by the New Keynesian model (which would have predicted positive differential IRFs), although again the standard errors for those estimates are large. Real wages also continue to show no evidence of differential effects of monetary policy. The results for employment become even more negative, further contradicting the notion that firm-specific labor supply generates real rigidity.

4.4 Alternative One-Step Specification

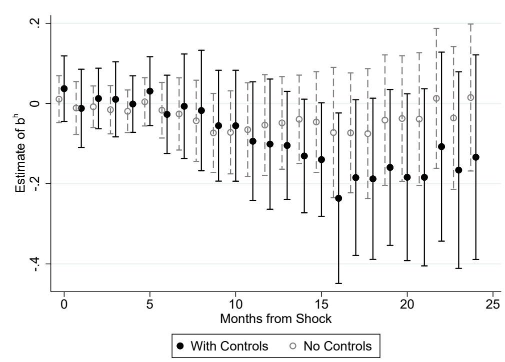
For robustness, I estimate the differential IRFs using a one-step estimation procedure. To estimate the differential effect of monetary policy shocks on industries with different firm-specific labor supply elasticities, I again estimate a series of local projections, but instead of estimating the local projections industry-by-industry, for each variable I estimate a single projection using all industries, and interact the monetary policy shocks with industry characteristics. For each industry variable

Figure 8: Differential Effects of Monetary Policy Shocks on Industry Variables (with Controls)

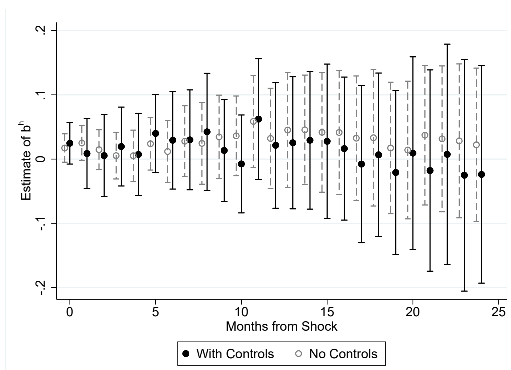
(a) PPI



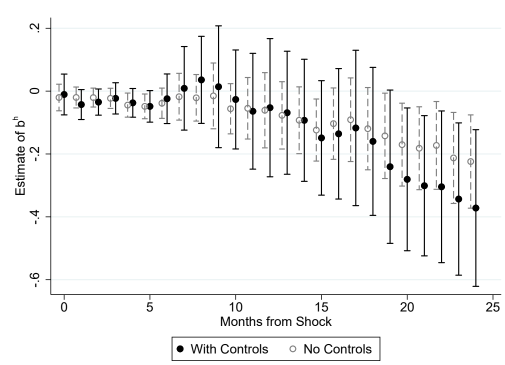
(b) Real Output



(c) Wages



(d) Employment



Note: Each point represents the estimated differential impulse response function at the indicated horizon, ($\hat{b}_0^{y,h}$ from estimating equation (24), using the frequency of price adjustment, durables, and financial constraint variables as controls). Error bars represent 90% confidence intervals using robust standard errors. The wage measure is average weekly real production employee earnings and the employment measure is production employees.

y and for each horizon in $h = 0, \dots, H$, I estimate:

$$\log y_{i,t+h} - \log y_{i,t-1} = \alpha^{y,h} + \sum_{j=1}^{J} \beta_j^{y,h} \Delta \log y_{i,t-j} + \sum_{k=0}^{K} \gamma_k^{y,h} shock_{t-k} \tag{26}$$

$$+ \sum_{k=0}^{K} \delta_k^{y,h} \left(shock_{t-k} \times \log \hat{\theta}_i \right) + \sum_{k=0}^{K} \left(shock_{t-k} \times X_i \right) Z^{y,h} + \nu_{i,t}^{y,h} \tag{27}$$

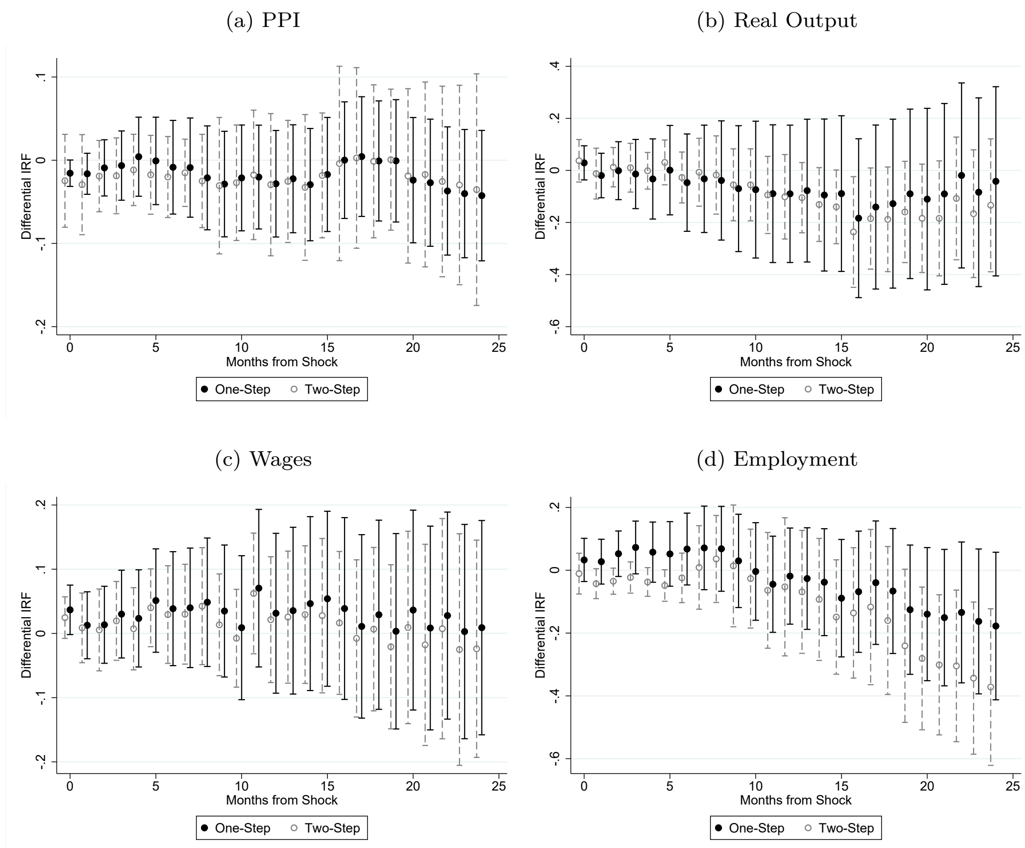
where X_i is the vector of industry controls. The coefficient of interest is $\hat{\delta}_0^{y,h}$, which gives the differential impulse-response of a an industry variable y to a monetary policy shock h periods out as the firm-specific labor supply elasticity of the industry changes. I estimate the local projections on monthly data up to $H = 24$ horizons and set $I = J = 12$. To recap the predictions from Section 4, the New Keynesian model would predict more negative responses of output, employment, and wages, and less negative responses of prices; that is, one would expect $\hat{\delta}_0^{y,h}$ to be negative for prices and positive for output, employment, and wages. In Figure 9, I plot the estimated coefficients $\hat{b}^{y,h}$ from this one-step procedure alongside the differential IRF estimates from the two-step procedure in the previous section for comparison.

As with the two-step estimation, I do not find any evidence that low firm-specific labor supply elasticities are associated with stronger real rigidities. Prices do not fall by appreciably less, and output, wages and employment do not fall by more, in low-elasticity industries. Similar to the previous results, I find, if anything, that employment falls by more in the higher-elasticity industries, contrary to the predictions of the model.

5 Discussion

My results cast doubt on the notion that firm-specific labor generates real rigidities. I consistently fail to find any evidence that industries with higher firm-specific labor supply elasticities experience more negative price responses in response to contractionary monetary policy shocks; rather, the firm-specific labor supply elasticity appears to have no effect on industry price responses. When it comes to other industry variables, I find evidence in the opposite direction that the real rigidity story

Figure 9: Comparing One-Step vs. Two-Step Specifications



Note: This Figure plots the estimated differential IRFs from the one-step and the two-step specifications. The two-step plot uses the estimates of $b^{y,h}$ from estimating Equation (24); the one-step plot uses the estimates of $\delta_0^{y,h}$ from estimating Equation (27). Both estimates are with the same set of controls (durables dummy, frequency of price adjustment, interest expense over sales, short-term debt ratio, and total debt over assets) as described in Section 4.3. Error bars indicate 90% confidence intervals, using robust standard errors in the one-step procedure.

would suggest. Industries with higher firm-specific labor supply elasticities actually experience more negative employment responses to monetary policy shocks, as opposed to less negative responses as the model from Section 3 predicted. This difference in employment responses is large, relative to the aggregate response of employment. These results are consistent across the two empirical specifications, as well as the inclusion or exclusion of control variables.

There are some statistical caveats to these results. The first is the estimated firm-specific labor supply elasticities are themselves subject to measurement error. This measurement error biases the estimated differential IRFs towards zero, and may make it difficult to detect any differential effects of monetary policy shocks on the price level. Monetary policy shocks, especially during this period, may simply lack the power to detect the differential effects of monetary policy. Finally, if the intersectoral elasticities of demand and labor supply are large, one might not expect large difference in industry price responses, even if firm-specific labor causes real rigidity in general. If firm-specific labor does indeed induce real rigidity, these are reasons why a cross-sectional approach may fail to detect any differences.

One consistent result is that industries with higher firm-specific labor supply elasticities tend to experience sharper declines in employment that those with lower elasticities. This is contrary to the prediction of the New Keynesian model. However, it is important to note that, in the model, firms compete for workers with other firms in the same industry, since the firm-specific labor supply elasticity parameter θ_j arises from the household's elasticity of substitution of labor supply between sectors. Therefore, in the model, differences in sectoral responses of employment arise because differential sectoral responses of prices lead to differential responses of output, which then pass through to differential responses of labor demand. The firm-specific labor supply elasticity affects indirectly through its affect on firm's pricing decisions. However, in reality, firms compete with firms outside their industry as well as non-employment. In this case, it could be the case that during a negative demand shock, firms with high labor supply elasticities lose workers to firms with low labor supply elasticities, or lose more workers to non-employment than firms with low labor supply elasticities.

6 Conclusion

Coming

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A Theoretical Appendix

A.1 The Phillips curve with Firm-Specific Labor

Here I derive the Phillips curve of the single-sector New Keynesian model with firm-specific labor supply in Subsection 2.1.

Firm Pricing Decision

Let P_t^* be the optimal reset price of a firm that resets their price in time t. Then, the pricing decision follows

$$\max_{P_t^*} \mathbb{E}_t \sum_{s=t}^{\infty} \gamma^s \left[Q_{t,s} \left(P_t^* Y_{s|t} - \Sigma_s(Y_{s|t}) \right) \right] \tag{28}$$

where $Q_{t,s}$ is the S.D.F. between t and s, and Σ_s is the nominal total cost function in time s, as a function of output. For a firm that sets their price in t, demand for the firm's output $Y_{s|t}$ is given by $Y_{s|t} = Y_s \left(\frac{P_t^*}{P_s}\right)^{-\theta_p}$, implying $\frac{\partial Y_{s|t}}{\partial P_t^*} = -\epsilon \frac{Y_{s|t}}{P_t^*}$. The firm's optimal pricing condition is given by

$$\mathbb{E}_t \sum_{s=t}^{\infty} \gamma^k \left[Q_{t,s} Y_{s|t} \left(P_t^* - \frac{\epsilon}{\epsilon - 1} \Sigma'(Y_{s|t}) \right) \right] = 0 \tag{29}$$

so on average (weighted) deviations from the steady state markup are zero. A first-order Taylor expansion of (29) yields

$$p_t^* - p_{t-1} = (1 - \beta\gamma) \sum_{s=t}^{\infty} (\beta\gamma)^k \mathbb{E}_t \left[mc_{s|t} + p_s - p_{t-1} \right] \tag{30}$$

where $mc_{s|t}$ is the log deviation of the firm's real marginal cost (deflated by the sectoral price index) from steady state.

The Firm's Marginal Cost Function

The firm-specific nominal marginal cost function is comprised of labor costs:

$$\Sigma_{s|t} = W_{s|t} L_{s|t} \tag{31}$$

and the marginal cost function takes into account the increase in the firm's wages necessary to increase labor supply at the firm level:

$$\frac{\partial \Sigma_{s|t}}{\partial Y_{s|t}} = \frac{\partial W_{s|t}}{\partial L_{s|t}} \frac{\partial L_{s|t}}{\partial Y_{s|t}} L_{s|t} + W_{s|t} \frac{\partial L_{s|t}}{\partial Y_{s|t}} \tag{32}$$

$$= \left(\frac{\partial W_{s|t}}{\partial L_{s|t}} L_{s|t} + W_{s|t} \right) \frac{\partial L_{s|t}}{\partial Y_{s|t}} \tag{33}$$

$$= \frac{1+\theta}{\theta} W_{s|t} \frac{\partial L_{s|t}}{\partial Y_{s|t}} \tag{34}$$

where the substition $\frac{\partial W_{s|t}}{\partial L_{s|t}} L_{s|t} = \frac{1+\theta}{\theta} W_{s|t}$ in equation (34) arises from the household's labor supply to the firm, $W_{s|t} = \left(\frac{L_{s|t}}{L_s} \right)^{1/\theta} W_s$. In log deviations, equation 34 can be written as

$$mc_{s|t} = w_{s|t} - mpl_{s|t} - p_t \tag{35}$$

$$= w_{s|t} - mpl_{s|t} - p_t \tag{36}$$

where $mpl_{s|t}$ is the (log) marginal cost of the resting firm in period s. In log deviations, labor supply to the firm is

$$w_{s|t} = w_s + \frac{1}{\theta} \left(l_{s|t} - l_s \right) \tag{37}$$

and labor demand at the firm level is determined by output, which is determined by the firm's relative price and aggregate output:

$$l_{s|t} = \frac{1}{1-\alpha} \left(y_{s|t} - z_s \right) \tag{38}$$

$$= \frac{1}{1-\alpha} \left[-\epsilon(p_t^* - p_s) + y_s - z_s \right] \tag{39}$$

and aggregate labor demand l_s is, up to a first-order approximation, given by

$$l_s = \frac{1}{1-\alpha} \left(y_s - z_s \right) \tag{40}$$

plugging this into equation (37), the firm's wages are given by

$$w_{s|t} = w_s - \epsilon \frac{1/\theta}{1-\alpha} \left(p_t^* - p_s\right). \tag{41}$$

The marginal product of labor of the firm is given by

$$\begin{aligned} mpl_{s|t} &= z_s - \alpha l_{s|t} && (42)\\ &= z_s - \frac{\alpha}{1-\alpha} \left[-\epsilon(p_t^* - p_s) + y_s - z_s\right] && (43) \end{aligned}$$

where the substitution for $l_{s|t}$ is from (39). So, substituting in the expressions for $w_{s|t}$ and $mpl_{s|t}$ into (36), the firm's real marginal cost is

$$\begin{aligned} mc_{s|t} &= w_s - \epsilon \frac{\alpha + 1/\theta}{1-\alpha} \left(p_t^* - p_s\right) - z_s - \frac{\alpha}{1-\alpha} \left[y_s - z_s\right] && (44)\\ &= mc_s - \epsilon \frac{\alpha + 1/\theta}{1-\alpha} \left(p_t^* - p_s\right) && (45) \end{aligned}$$

where mc_s is the aggregate average marginal cost analog $mc_s = w_s - z_s - \alpha l_s$. Substituting (45) into (30) and rearranging terms yields

$$p_t^* = (1-\beta\gamma) \sum_{s=t}^{\infty} (\beta\gamma)^k \mathbb{E}_t \left[p_s - \Omega mc_s\right] \tag{46}$$

where $\Omega = \frac{1}{1+\epsilon \frac{\alpha+1/\theta}{1-\alpha}}$. Following Galí (2008), this can be written recursively and in terms of the output gap to yield the Phillips curve,

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{(1-\gamma)(1-\beta\gamma)}{\gamma} \frac{\sigma + \frac{1/\eta + \alpha}{1-\alpha}}{1 + \epsilon \frac{\alpha + 1/\theta}{1-\alpha}} (y_t - y_t^n) \tag{47}$$

A.2 Sectoral Phillips Curves with Firm-specific Labor

In this section, I derive the sector-specific Phillips curves in Section 3.3.

Let $P_{j,t}^*$ be the optimal reset price of a firm in sector j that resets their price in time t. Then, the pricing decision follows

$$\max_{P^*_{j,t}} \mathbb{E}_t \sum_{s=t}^{\infty} \gamma_j^s \left[Q_{t,s} \left(P^*_{j,t} Y_{j,s|t} - \Sigma_{j,s}(Y_{j,s|t}) \right) \right] \tag{48}$$

from here on, the derivation follows the single-sector Phillips curve derivation in Appendix Subsection A.1 from equations (29) through (46), except that sector-specific aggregates take the place of economy-wide aggregates; e.g. $Y_{j,s}$ instead of Y_s. Doing so yields the firm's pricing choice

$$p^*_{j,t} = (1-\beta\gamma_j) \sum_{s=t}^{\infty} (\beta\gamma_j)^k \mathbb{E}_t \left[p_{j,s} - \Omega_j mc_{j,s} \right] \tag{49}$$

where $p_{j,s}$ is the log deviation of the sector's price index, $mc_{j,s}$ is the sector real marginal cost analog $mc_{j,s} = w_{j,s} - z_{j,s} - \alpha l_{j,s}$, and $\Omega = \frac{1}{1+\epsilon_j \frac{\alpha_j + 1/\theta_j}{1-\alpha_j}}$.

The sectoral real marginal cost analog, $rmc_{j,t}$, can be written as

$$\begin{aligned}
rmc_{j,t} &= w_{j,t} - p_{j,t} + y_{jt} - l_{jt} && (50)\\
&= w_{j,t} - p_{j,t} - \frac{1}{1-\alpha_j}\left(z_{j,t} - \alpha_j y_{j,t}\right) && (51)\\
&= \frac{1}{\lambda}\left(l_{j,t} - l_t\right) + w_t + \frac{1}{\eta}\left(y_{j,t} - y_t\right) - p_t - \frac{1}{1-\alpha_j}\left(z_{j,t} - \alpha_j y_{j,t}\right) && (52)\\
&= \frac{1}{\lambda}\left(\frac{y_{jt} - z_{jt}}{1-\alpha_j} - l_t\right) + w_t + \frac{1}{\eta}\left(y_{j,t} - y_t\right) - p_t - \frac{1}{1-\alpha_j}\left(z_{j,t} - \alpha_j y_{j,t}\right) && (53)\\
&= \left(\frac{1/\lambda + \alpha_j}{(1-\alpha_j)} + \frac{1}{\eta}\right) y_{jt} - \left(\frac{\lambda+1}{\lambda(1-\alpha_j)}\right) z_{jt} + \left(\sigma - \frac{1}{\eta}\right) y_t + \left(\frac{1}{\eta} - \frac{1}{\lambda}\right) l_t && (54)
\end{aligned}$$

where $l_{j,t}$ has been substituted out for $\frac{1}{1-\alpha_j}(y_{jt} - z_{jt})$ using a first-order approximation. So, the sectoral Phillips curve is:

$$\begin{aligned}
\pi_{jt} &= \beta\mathbb{E}_t \pi_{j,t+1} + \frac{(1-\gamma_j)(1-\beta\gamma_j)}{\gamma_j} \frac{1}{1+\epsilon_j \frac{\alpha_j + 1/\theta_j}{1-\alpha_j}} \times && (55)\\
&\left[\left(\frac{1/\lambda + \alpha_j}{(1-\alpha_j)} + \frac{1}{\eta}\right) \check{y}_{jt} - \left(\frac{\lambda+1}{\lambda(1-\alpha_j)}\right) \check{z}_{jt} + \left(\sigma - \frac{1}{\eta}\right) \check{y}_t + \left(\frac{1}{\eta_t} - \frac{1}{\lambda}\right) \check{l}_t\right] && (56)
\end{aligned}$$

B Empirical Appendix

Table B.1: Estimation of Firm-specific Labor Supply Elasticities

NAICS Code(s)	EE Sep. Elasticity	EN Sep. Elasticity	Search Premium	Recruits Share EE	Separations Share EE	FSLS Elasticity
111	-0.937	-1.348	1.012	0.592	0.629	1.672
	(0.114)	(0.168)	(0.195)			
112	-1.243	-1.697	1.336	0.656	0.663	2.192
	(0.204)	(0.305)	(0.327)			
113	-0.875	-1.073	0.386	0.650	0.697	1.738
	(0.202)	(0.273)	(0.294)			
114	-1.318	-3.115	0.954	0.725	0.729	2.867
	(0.496)	(1.135)	(1.126)			
212	-0.479	-0.434	0.933	0.717	0.673	0.650
	(0.241)	(0.360)	(0.467)			
211	-0.310	-0.387	0.469	0.770	0.739	0.520
	(0.165)	(0.267)	(0.317)			
23	-0.486	-0.633	0.500	0.716	0.710	0.868
	(0.027)	(0.044)	(0.048)			
311	-1.095	-1.273	0.871	0.680	0.678	1.966
	(0.077)	(0.113)	(0.135)			
312	-0.811	-0.727	1.296	0.774	0.724	1.253
	(0.204)	(0.325)	(0.471)			
314	-1.048	-1.208	-0.534	0.743	0.750	2.284
	(0.386)	(0.761)	(0.754)			
313, 315	-1.047	-1.057	0.550	0.706	0.676	1.891
	(0.104)	(0.155)	(0.189)			
322	-1.137	-1.193	0.821	0.727	0.698	2.023
	(0.137)	(0.201)	(0.261)			
325	-1.066	-0.971	0.799	0.763	0.719	1.853
	(0.100)	(0.156)	(0.184)			
324	-0.920	-1.549	0.845	0.726	0.709	1.769
	(0.254)	(0.385)	(0.423)			
326	-1.165	-1.340	0.775	0.727	0.741	2.187
	(0.119)	(0.213)	(0.211)			
316	-0.459	-1.805	2.818	0.696	0.692	0.472
	(0.437)	(0.645)	(0.837)			
321	-1.156	-1.240	1.019	0.714	0.730	2.069
	(0.145)	(0.242)	(0.276)			
337	-0.793	-0.508	0.275	0.722	0.704	1.405
	(0.145)	(0.223)	(0.260)			
327	-0.943	-0.734	0.646	0.733	0.695	1.601
	(0.142)	(0.226)	(0.256)			

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Estimation of Firm-specific Labor Supply Elasticities (ctd)

NAICS Code(s)	EE Sep. Elasticity	EN Sep. Elasticity	Search Premium	Recruits Share EE	Separations Share EE	FSLS Elasticity
331	-1.182	-0.797	0.234	0.778	0.705	2.087
	(0.128)	(0.201)	(0.244)			
332	-0.957	-0.988	0.403	0.747	0.736	1.806
	(0.086)	(0.149)	(0.165)			
333	-0.893	-0.987	0.636	0.748	0.718	1.618
	(0.082)	(0.132)	(0.156)			
334, 335	-0.731	-0.660	0.485	0.758	0.724	1.291
	(0.078)	(0.120)	(0.137)			
336	-0.812	-0.876	0.372	0.771	0.721	1.504
	(0.063)	(0.103)	(0.121)			
339	-0.681	-1.097	0.833	0.720	0.700	1.235
	(0.117)	(0.187)	(0.217)			
482	-0.987	-1.211	1.280	0.756	0.724	1.681
	(0.278)	(0.432)	(0.506)			
485, 487	-0.947	-1.100	1.151	0.756	0.733	1.625
	(0.120)	(0.203)	(0.252)			
484, 492	-0.854	-1.148	0.827	0.736	0.728	1.560
	(0.076)	(0.126)	(0.145)			
493	-1.160	-1.026	1.056	0.695	0.720	2.003
	(0.219)	(0.375)	(0.338)			
491	-1.670	-1.668	1.055	0.717	0.669	2.930
	(0.150)	(0.227)	(0.263)			
483	-0.767	-1.335	1.925	0.713	0.689	1.132
	(0.246)	(0.385)	(0.561)			
481	-0.946	-0.610	0.325	0.747	0.716	1.675
	(0.110)	(0.180)	(0.197)			
488	-0.760	-0.841	0.668	0.705	0.698	1.339
	(0.141)	(0.221)	(0.268)			
515	-0.860	-1.329	-0.040	0.729	0.764	1.883
	(0.176)	(0.298)	(0.314)			
517	-1.092	-0.587	0.375	0.747	0.717	1.901
	(0.107)	(0.169)	(0.199)			
221, 562	-0.894	-0.820	0.686	0.760	0.715	1.549
	(0.102)	(0.161)	(0.186)			
423	-0.927	-1.251	0.862	0.737	0.714	1.691
	(0.082)	(0.131)	(0.148)			
424	-1.025	-1.314	0.976	0.716	0.701	1.837
	(0.077)	(0.117)	(0.139)			
444	-1.155	-1.221	0.897	0.678	0.688	2.058
	(0.099)	(0.145)	(0.169)			
452	-0.968	-1.201	0.944	0.639	0.685	1.738
	(0.060)	(0.090)	(0.108)			
445	-1.063	-1.533	1.208	0.620	0.680	1.921
	(0.048)	(0.077)	(0.091)			
441	-0.879	-0.847	0.796	0.734	0.735	1.539
	(0.085)	(0.136)	(0.153)			
447	-0.845	-1.175	0.579	0.669	0.706	1.643
	(0.142)	(0.224)	(0.252)			
442, 722	-0.642	-1.306	0.613	0.666	0.684	1.306
	(0.164)	(0.257)	(0.277)			
443, 446, 451, 453	-0.751	-1.365	0.886	0.663	0.684	1.422
	(0.052)	(0.083)	(0.094)			

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Estimation of Firm-specific Labor Supply Elasticities (ctd)

NAICS Code(s)	EE Sep. Elasticity	EN Sep. Elasticity	Search Premium	Recruits Share EE	Separations Share EE	FSLS Elasticity
448, 454	-0.876	-1.131	0.847	0.637	0.671	1.576
	(0.086)	(0.128)	(0.149)			
521, 522	-0.884	-0.978	0.828	0.769	0.735	1.563
	(0.091)	(0.143)	(0.171)			
523, 525	-1.392	-0.725	-0.241	0.767	0.756	2.659
	(0.208)	(0.330)	(0.320)			
524	-0.872	-0.799	0.886	0.741	0.723	1.473
	(0.105)	(0.165)	(0.184)			
531	-0.986	-0.924	0.805	0.701	0.711	1.728
	(0.091)	(0.136)	(0.161)			
814	-0.721	-0.607	0.572	0.569	0.568	1.145
	(0.157)	(0.204)	(0.255)			
721	-0.839	-1.192	1.128	0.642	0.671	1.428
	(0.080)	(0.124)	(0.137)			
812	-0.814	-0.906	0.979	0.647	0.659	1.330
	(0.111)	(0.166)	(0.186)			
115, 323, 511, 512, 518, 519,	-0.829	-1.053	0.496	0.697	0.714	1.592
532, 533, 541, 561, 811	(0.024)	(0.039)	(0.042)			
711, 713	-0.885	-1.463	1.296	0.565	0.619	1.512
	(0.077)	(0.102)	(0.129)			
621	-0.612	-0.941	0.688	0.720	0.716	1.122
	(0.046)	(0.077)	(0.084)			
622	-0.559	-0.992	0.751	0.750	0.746	1.037
	(0.039)	(0.069)	(0.076)			
611	-0.838	-1.361	0.978	0.778	0.771	1.571
	(0.037)	(0.066)	(0.067)			
623, 624	-0.629	-1.180	0.821	0.675	0.696	1.179
	(0.042)	(0.072)	(0.076)			
712	-1.001	-1.162	0.983	0.583	0.597	1.681
	(0.197)	(0.243)	(0.304)			
813	-0.934	-0.810	0.593	0.666	0.640	1.589
	(0.131)	(0.173)	(0.205)			
921, 922	-0.869	-1.308	1.034	0.742	0.710	1.561
	(0.068)	(0.101)	(0.124)			
923	-0.970	-1.081	0.881	0.710	0.720	1.728
	(0.142)	(0.226)	(0.243)			
924, 925	-1.280	-1.563	0.667	0.715	0.722	2.460
	(0.217)	(0.290)	(0.334)			
926, 927	-0.789	-1.543	1.610	0.705	0.708	1.327
	(0.158)	(0.222)	(0.268)			
928	-1.206	-1.038	1.518	0.747	0.726	1.948
	(0.148)	(0.255)	(0.327)			

Notes here XXX

Table B.2: Regression of IRFs on Firm-specific Labor Supply Elasticities

IRF Horizon	Price Level	Price Level	Real Output	Real Output	Employment	Employment	Wages	Wages
0 months	-0.007	-0.025	0.011	0.037	-0.020	-0.011	0.017	0.025
	(0.025)	(0.034)	(0.036)	(0.050)	(0.026)	(0.039)	(0.013)	(0.020)
3 months	0.004	-0.019	-0.015	0.010	-0.023	-0.023	0.005	0.020
	(0.022)	(0.028)	(0.037)	(0.057)	(0.019)	(0.030)	(0.022)	(0.037)
6 months	-0.003	-0.020	-0.017	-0.027	-0.039	-0.024	0.012	0.029
	(0.023)	(0.030)	(0.042)	(0.059)	(0.029)	(0.048)	(0.029)	(0.046)
9 months	-0.004	-0.031	-0.073	-0.055	-0.015	0.014	0.035	0.013
	(0.040)	(0.050)	(0.060)	(0.084)	(0.064)	(0.118)	(0.040)	(0.048)
12 months	-0.011	-0.029	-0.054	-0.101	-0.061	-0.053	0.032	0.021
	(0.043)	(0.052)	(0.077)	(0.099)	(0.073)	(0.134)	(0.047)	(0.060)
15 months	0.006	-0.018	-0.046	-0.140	-0.124**	-0.149	0.042	0.028
	(0.042)	(0.046)	(0.076)	(0.086)	(0.060)	(0.111)	(0.057)	(0.073)
18 months	0.033	-0.001	-0.075	-0.188	-0.119	-0.160	0.033	0.007
	(0.045)	(0.056)	(0.099)	(0.122)	(0.080)	(0.143)	(0.065)	(0.077)
21 months	0.033	-0.017	-0.039	-0.184	-0.182**	-0.301**	0.037	-0.018
	(0.056)	(0.068)	(0.101)	(0.134)	(0.080)	(0.136)	(0.066)	(0.095)
24 months	0.030	-0.035	0.015	-0.134	-0.224**	-0.372**	0.022	-0.024
	(0.066)	(0.085)	(0.111)	(0.155)	(0.090)	(0.152)	(0.073)	(0.103)
Controls	Yes	No	Yes	No	Yes	No	Yes	No

Standard errors in parentheses. The differential IRFs are the estimates of $b^{y,h}$ in (24). Controls included were the log frequency of price adjustment, durables dummy, industry interest expenses over sales, leverage ratio, and short-term debt ratio as described in subsection 4.3. Coefficients are significantly different from zero at the 1% (***), 5% (**), and 10% (*).

Table B.3: Robustness to Controls: Price Level

Industry Characteristic	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Labor Supply Elasticity	0.030	-0.000	0.036	0.030	0.013	-0.035	-0.026
	(0.066)	(0.078)	(0.072)	(0.067)	(0.064)	(0.085)	(0.090)
Log Freq. Price Adj.		-0.038				-0.037	-0.050
		(0.032)				(0.037)	(0.041)
Interest Rate Burden			-0.506			0.676	-0.146
			(0.935)			(2.143)	(2.419)
Leverage Ratio			0.072			0.226	0.305
			(0.231)			(0.356)	(0.377)
Short-term Debt Ratio			-0.024			-0.161	-0.265
			(0.642)			(0.768)	(0.795)
Durable Dummy				-0.009		-0.015	-0.002
				(0.048)		(0.053)	(0.057)
Frac. Small Estabs.					-0.340*	-0.435	-0.459
					(0.164)	(0.237)	(0.255)
Log Labor Share							-0.132
							(0.145)
Log Profit Share							-0.023
							(0.046)
N	49	40	49	49	49	40	40
R^2	0.00	0.04	0.02	0.01	0.09	0.15	0.18

The estimates reported are $\hat{b}^{y,h}$ from Equation (24), the coefficient on the log firm-specific labor supply elasticity ,for $h = 24$. The construction of the control variables are described in subsection 4.3. Standard errors in parentheses; coefficients are significantly different from zero at the 1% (***), 5% (**), and 10% (*) levels.

Table B.4: Robustness to Controls: Real Output

Industry Characteristic	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Labor Supply Elasticity	0.015	0.057	-0.114	0.021	0.009	-0.134	-0.102
	(0.111)	(0.132)	(0.144)	(0.107)	(0.114)	(0.155)	(0.129)
Log Freq. Price Adj.		0.016				0.077	-0.070
		(0.080)				(0.087)	(0.084)
Interest Rate Burden			-0.774			5.212	-1.815
			(4.869)			(8.504)	(7.294)
Leverage Ratio			1.167			0.889	0.698
			(0.812)			(0.896)	(0.773)
Short-term Debt Ratio			-0.811			-0.909	-1.116
			(1.311)			(1.257)	(1.053)
Durable Dummy				-0.135		-0.130	-0.118
				(0.072)		(0.084)	(0.073)
Frac. Small Estabs.					0.141	-0.444	0.075
					(0.376)	(0.491)	(0.447)
Log Labor Share							-0.136
							(0.231)
Log Profit Share							0.182*
							(0.085)
N	33	28	33	33	33	28	28
R^2	0.00	0.01	0.10	0.11	0.01	0.27	0.55

The estimates reported are $\hat{b}^{y,h}$ from Equation (24), the coefficient on the log firm-specific labor supply elasticity ,for $h = 24$. The construction of the control variables are described in subsection 4.3. Standard errors in parentheses; coefficients are significantly different from zero at the 1% (***), 5% (**), and 10% (*) levels.

Table B.5: Robustness to Controls: Production Employment

Industry Characteristic	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Labor Supply Elasticity	-0.224*	-0.325*	-0.215*	-0.220*	-0.223*	-0.372*	-0.369*
	(0.090)	(0.154)	(0.091)	(0.087)	(0.091)	(0.152)	(0.158)
Log Freq. Price Adj.		0.039				0.020	-0.004
		(0.047)				(0.047)	(0.048)
Interest Rate Burden			0.756			3.393	1.419
			(0.502)			(2.789)	(3.011)
Leverage Ratio			0.002			-0.643	-0.371
			(0.187)			(0.418)	(0.444)
Short-term Debt Ratio			-0.629			-0.199	-0.472
			(0.849)			(0.991)	(0.991)
Durable Dummy				-0.113*		-0.144*	-0.128
				(0.046)		(0.060)	(0.063)
Frac. Small Estabs.					-0.051	0.218	0.266
					(0.165)	(0.261)	(0.278)
Log Labor Share							-0.226
							(0.169)
Log Profit Share							0.009
							(0.053)
N	60	34	60	60	60	34	34
R^2	0.10	0.13	0.14	0.18	0.10	0.31	0.39

The estimates reported are $\hat{b}^{y,h}$ from Equation (24), the coefficient on the log firm-specific labor supply elasticity ,for $h = 24$. The construction of the control variables are described in subsection 4.3. Standard errors in parentheses; coefficients are significantly different from zero at the 1% (***), 5% (**), and 10% (*) levels.

Table B.6: Robustness to Controls: Average Real Weekly Production Earnings

Industry Characteristic	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Labor Supply Elasticity	0.022	0.029	0.037	0.025	0.023	-0.024	0.044
	(0.073)	(0.122)	(0.067)	(0.071)	(0.073)	(0.103)	(0.094)
Log Freq. Price Adj.		-0.018				0.002	-0.023
		(0.037)				(0.032)	(0.029)
Interest Rate Burden			-0.107			0.751	-0.577
			(0.371)			(1.893)	(1.793)
Leverage Ratio			0.468**			0.663*	0.877**
			(0.138)			(0.284)	(0.264)
Short-term Debt Ratio			-0.087			-0.170	-0.371
			(0.628)			(0.673)	(0.590)
Durable Dummy				-0.076*		-0.057	-0.016
				(0.037)		(0.041)	(0.038)
Frac. Small Estabs.					-0.024	-0.439*	-0.530**
					(0.132)	(0.177)	(0.166)
Log Labor Share							-0.328**
							(0.100)
Log Profit Share							-0.060
							(0.031)
N	60	34	60	60	60	34	34
R^2	0.00	0.01	0.19	0.07	0.00	0.42	0.60

The estimates reported are $\hat{b}^{y,h}$ from Equation (24), the coefficient on the log firm-specific labor supply elasticity ,for $h = 24$. The construction of the control variables are described in subsection 4.3. Standard errors in parentheses; coefficients are significantly different from zero at the 1% (***), 5% (**), and 10% (*) levels.