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# Monetary Policy and the Cost of Wage Rigidity: Evidence from the Stock Market

SAFE Working Paper No. 242

**SAFE | Sustainable Architecture for Finance in Europe**

A cooperation of the Center for Financial Studies and Goethe University Frankfurt

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## Non-Technical Summary

In a 2015 speech, the President of the ECB Mario Draghi claimed: “For a larger sample of countries, firms with flexibility at the plant-level have reduced employment less during the crisis than those bound by centralized wage bargaining agreements, partly because they have been more able to adjust wages to economic conditions.”<sup>1</sup>

Draghi was citing research conducted at the ECB, comparing the effects of the Great Recession in different European countries where workers are subject to heterogeneous labor market regulations.<sup>2</sup> While this argument is intuitively appealing, testing whether rigidly centralized wage bargaining agreements can cause firms’ inability to react to aggregate shocks is not an easy task. For example, European countries may differ in a number of institutional factors that could contaminate causal inference.

In the work we present here, we chose to focus on a single, fairly integrated labor market, that of Italy. We do so for two reasons. First, in Italy wage setting is still fairly centralized and firm-level bargaining plays a relatively minor role, contrary to most European countries where recent reforms have increased contract negotiation flexibility. Hence, our results may serve as a useful benchmark. Second, we can make use of a unique employee-employer dataset comprising the universe of the workers employed in the Italian private sector, which we access through the project “VisitINPS Scholars Program” at the Italian Institute of Social Security. We combine this dataset with intraday data on stock returns, as well as hand-collected information on renewals of collective agreements.

We then test, using high-frequency identification, whether wage rigidity induced by collective bargaining amplifies the effects of monetary policy. We focus on monetary policy because of the intense debate, among researchers and policymakers, regarding its effectiveness since the onset of the Great Recession.

The intuition we exploit is straightforward and relies on the fact that a firm may be hit by a shock at different stages of the “life” of its workers’ collective agreement. If the monetary policy shock occurs when the agreement is close to the renewal, any change in firm profitability due to a macroeconomic shock will be taken into account in the new contract. On the other hand, if there is a long time left before the renewal, workers and managers will be “stuck” with the

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<sup>1</sup> Introductory speech at the ECB Forum on Central Banking, Sintra, 22 May 2015.

<sup>2</sup> Ronchi, Maddalena & di Mauro, Filippo, 2017. “Wage bargaining regimes and firms’ adjustments to the Great Recession,” Working Paper Series 2051, European Central Bank.

same wage despite the fact that the firm's profitability might have drastically changed. Hence, in this case, the impact of a change in the Central Bank's monetary policy will have stronger effects on firm outcomes.

Exploiting high-frequency identification of monetary policy shocks, we find results consistent with our hypothesis. More specifically, we find that stock market valuations and employment levels react more when the average time left before the renewal of the employees' collective agreement is large. In further tests, we find that this amplification channel is stronger in firms that experience low profitability and at time of low economic growth. The effects are quantitatively important and are consistent with the predictions of a rigorous general equilibrium model we develop to interpret the results.

Overall, our findings show that the response to monetary policy shocks is heterogeneous and depends on the degree of nominal rigidities, as well as on firms' characteristics, suggesting that monetary policy can have important distributional consequences.

# Monetary Policy and the Cost of Wage Rigidity: Evidence from the Stock Market\*

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Current draft: January 2018.

## Abstract

Using a unique confidential contract level dataset merged with firm-level asset price data, we find robust evidence that firms' stock market valuations and employment levels respond more to monetary policy announcements the higher the degree of wage rigidity. Data on the renegotiations of collective bargaining agreements allow us to construct an exogenous measure of wage rigidity. We also find that the amplification induced by wage rigidity is stronger for firms with high labor intensity and low profitability, providing evidence of distributional consequences of monetary policy. We rationalize the evidence through a model in which firms in different sectors feature different degrees of wage rigidity due to staggered renegotiations vis-a-vis unions.

JEL:

Keywords: *heterogeneous monetary policy response, distributional consequences of monetary policy, employer-employee level dataset, monetary policy surprise shocks, heterogeneous wage rigidity.*

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\*We gratefully acknowledge financial support from SAFE LOEWE center and data access from the Istituto Nazionale della Previdenza Sociale (INPS) through the VisitINPS Scholars Program. We thank Edoardo Di Porto, Marcin Kacperczyk, Leonid Kogan, Matthias Meier (discussant), Marco Pagano, Paolo Naticchioni, Michael Weber and seminar participants at the Goethe University Finance Brown Bag Seminar at Goethe University, INPS, the SAFE Annual Conference on Sustainable Architecture for Finance for helpful comments, and Nan Hu and Sören Karau for excellent data research assistance on the data. We thank Tito Boeri, Pietro Garibaldi, Massimo Antichi, Maria Cozzolino, and Elio Bellucci for making the social security data available. Correspondence to: Ester Faia, Chair in Monetary and Fiscal Policy, Goethe University Frankfurt, Theodor W. Adorno Platz 3, 60323, Frankfurt am Main, Germany. E-mail: faia@wiwi.uni-frankfurt.de. Webpage: <http://www.wiwi.uni-frankfurt.de/profs/faia/>.

# 1 Introduction

The heterogeneity of agents and firms has characterized the recent macro literature quite fervently. The importance of the distributional consequences of monetary policy has taken a central role in both academic and policy debates. Much discussion has been centered around heterogeneity in price stickiness, given its striking micro evidence<sup>1</sup>, and many authors have built theoretical models to explore the macro consequences of these facts<sup>2</sup>. Others have assessed the impact on firms' stock market valuations of different degrees of price rigidity. Until now, fewer works have considered heterogeneity in wage stickiness and its consequences for monetary policy. The latter is crucial also because, given that bargaining arrangements between workers and employers depend crucially on institutional factors, and are at least in part outside of managers' control, there is scope for constructing a truly exogenous measure of the nominal rigidities.

To take a step forward into this research agenda, we merge a unique micro level dataset on collective bargaining agreements, which comprises the entire Italian industrial landscape, with high frequency data on stock prices for individual firms. We use the dataset to study how staggered wage adjustment affects the heterogeneous response of firms' stock returns to monetary policy shocks. The Italian labor market has contracting rules that provide a unique environment for such a research question. More specifically, in Italy, virtually all workers are covered by collective bargaining agreements. Contract renegotiations occur at predetermined schedules, with a typical contract length of about 2 years, and firms in different sectors have different renegotiations dates. This staggering structure provides useful variation in nominal rigidities, which are captured by the heterogeneous distance of firms' wage adjustment to the monetary policy shock, and, as such, it easily lends itself to study the heterogeneous effects of monetary policy.

We identify monetary policy shocks at high frequencies via changes in swap rates on money market rates, namely the main ECB policy rate, shortly after and before the time an ECB meeting

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<sup>1</sup>See Nakamura and Steinsson (2008).

<sup>2</sup>See Carvalho (2006).

takes place<sup>3</sup>. The key novelty of our analysis lies in the construction of a measure of wage rigidity, which is based on the time left before the expiration of the contract in force at the time of a shock. Importantly, this measure depends on the timing of collective agreements, which are largely outside of an individual firm's control. Precisely this reason makes it a truly exogenous measure of nominal rigidities, also in comparison with others based on firms' price level data. We find robust evidence that firms with high wage rigidity exhibit higher volatility of asset prices in response to monetary policy announcements. We further exploit the variation in our firms' sample and also show that sensitivity to monetary policy shocks is higher for firms with high labor intensity, with low profitability, and during times of economic downturn.

We also test whether such shocks have real effects, by looking at the effects on employment outcomes. Our results closely resemble those on stock market valuations. Thanks to the detailed information available in our comprehensive matched employer-employee dataset, we also show that long-term workers are fairly unaffected by the combined effects of monetary policy shocks and wage rigidity, suggesting that most of the burden of such adjustments is borne by short-term workers.

We rationalize this evidence by constructing a novel macro model featuring different sectors, whereby firms experience different degrees of wage rigidity due to union-based collective contract re-negotiations. We model wage rigidity through simple staggered contracts in the spirit of Taylor (1979). We have chosen this structure as it matches more closely the realm of the Italian industrial sectors, as well as that of other Western European countries (Ronchi and di Mauro (2017)), whereby contracts are renegotiated at fixed length, but staggering occurs among firms in different sectors. We populate our model with firms from 8 different sectors, again for reasons of realism. By simulating our model, we repeat the same regression exercise performed in the data. Like-wise in the empirical analysis we show that firms with a higher degree of wage rigidity exhibit higher volatility of stock returns and of employment changes as a result of monetary policy shocks.

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<sup>3</sup>Early work on high frequency identification of monetary policy shocks includes Gürkaynak, Sack, and Swanson (2005) and Barakchian and Crowe (2013). Following a recent approach by Corsetti, Duarte, and Mann (2018) we employ swap rates to compute the surprise component.

The underlying intuition is simple and straightforward: firms with larger distance between contract renegotiation and the monetary policy shock are bound to tolerate larger fluctuations in marginal costs, hence mark-ups. Thus, the range in which the discounted present value of cash flows can fluctuate is wider. This, in turn, raises the volatility of firms' stock market values.

Our paper makes three contributions. First, we construct a truly exogenous measure of nominal rigidity at the firm level, based on the timing of wage contract renewals. Second, we use this proxy to estimate the costs of wage rigidity by showing how the inability of firms to quickly adjust wages amplifies the effects of monetary policy shocks, a channel often posited in modern New-Keynesian models that had, however, not been formally tested. Third, we construct a dynamic general equilibrium model that accommodates quite well our reduced-form results.

The rest of the paper proceeds as follows. Section 2 compares our work to past literature. Section 3 presents a simple model to assess the role of monetary policy in the presence of rigid wages. The model also serves the purpose of providing guidance to subsequent econometric specification. Section 4 provides some institutional background and describes our data. Section 5 presents our empirical evidence. Section 6 develops a fully dynamic multi-sector general equilibrium model that can rationalize and replicate the evidence. Section 7 concludes. Tables and figures follow.

## 2 Comparison to the Literature

Questions centered around nominal rigidities and their macro consequences, mostly in response to monetary policy, date far back into the past. More recent work, however, has emphasized the importance of firms' heterogeneity. If firms exhibit different degrees of nominal rigidities they are likely to be differentially affected by changes in monetary policy. Our research question places itself into a lively debate on the costs of nominal rigidities and their differences across sectors and firms. A distinctive feature of our work is its focus on wage rigidity, in contrast to most of the recent literature which tends to concentrate on price rigidity.

The closest work to ours is that of Gorodnichenko and Weber (2016). They merge confidential

micro-level data underlying the producer price index (PPI) from the Bureau of Labor Statistics (BLS) with stock price data of individual firms from NYSE Trade and Quote (TAQ), and study how stock returns of firms with different frequencies of price adjustment respond to monetary shocks, the latter measured through high frequency identification procedures. They find significant effects of monetary policy on stock price volatility, and more so for firms that experience higher degrees of wage rigidity.

Our approach differs in two important ways. First, our measure of nominal rigidity is based on wages, rather than prices. Second, while the frequency of price adjustment might be, in some respects, a choice variable for a firm's managers, the factors affecting the timing of the wage renegotiations in our context are largely outside of a firm's control. Hence, our strategy exploits arguably exogenous variation in nominal rigidities.

Evidence on the importance of price stickiness and of its heterogeneity, mostly captured by menu costs and using micro data, existed before. Zbaracki, Ritson, Levy, Dutta, and Bergen (2004), along with others, measure menu costs directly by keeping records of costs associated with every stage of price adjustments at the firm level. Anderson, Jaimovich, and Simester (2015) use data on wholesale costs and price changes of a large retailer. Blinder (1991) elicits information about the costs and mechanisms of price adjustments from survey responses of managers. A large number of papers has assessed the macro consequences of nominal rigidities through DSGE calibrated models<sup>4</sup>.

Our paper also relates more directly to all the literature measuring wage rigidity. For the US, early evidence on wage rigidity is included in McLaughlin (1994), who looks at historical data from the Panel Study of Income Dynamics (hereafter, PSID) between 1976 and 1986. He finds that wage cuts or raises are often compressed by the power of unions, and that wage changes do not fully reflect inflation. Later on, Kahn (1997), using the same data source, but in a different sample period and adopting a different methodology, also finds evidence of nominal wage rigidity. To address the possible measurement errors in previous survey-based studies, Card and Hyslop (1997)

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<sup>4</sup>See Nakamura and Steinsson (2013) for a review of the literature.



consider individual-level wage changes using data from both CPS and PSID. They adopt a fully non-parametric analysis that examines the whole distribution of wage changes<sup>5</sup>. The authors find that 6% to 15% of workers experience no change in the nominal wage from one year to the next. Most of those studies are based on survey data and, hence, are possibly subject to measurement errors.

In contrast, Groshen and Schweitzer (1999) use an employer data source, namely the Community Salary Survey, which spans the period 1956–1996. Their study, however, focuses on the link between changes in wages and expected changes in inflation. A pioneering approach is the one in Bewley (1998), who conducted interviews himself. His questions were mostly geared toward discovering the incentives for wage cuts or raises. As for Europe, there are several studies at the country level, such as Smith (2000) for the UK and Smith (2000) for Switzerland. All are surveyed by Kramarz (2001). Again, most of the studies are based on survey data<sup>6</sup>.

A distinctive feature of our wage data is that they come from a matched employer-employee dataset, hence we can observe directly all contract-level related information. This provides a unique opportunity for an exact measurement of wage changes. Furthermore, none of the above studies focusing on the wage rigidity measurement have addressed the questions of the distributional consequences of monetary policy for firms experiencing different degrees of wage rigidity<sup>7</sup>.

Work related to ours, and on similar research questions, has been conducted without the aid of micro data. Olivei and Tenreyro (2007) show, for instance, using VAR evidence, that the response of inflation to changes in official interest rates is likely to be faster and larger when these changes take place at the moment in which most workers are renegotiating their wages. Our results share a

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<sup>5</sup>A fully parametric specification of the wage change process is instead used in Altonji and Devereux (2000). Indeed, they use a well-specified statistical model of nominal wage rigidity together with a measurement error model.

<sup>6</sup>Further recent comprehensive evidence can be found in the work by a European consortium of researchers belonging to the International Wage Flexibility Project (IWFP). Results for this are summarized in Dickens, Goette, Groshen, Holden, Messina, Schweitzer, Turunen, and Ward (2007). They analyze individuals' earnings in 31 different data sets from sixteen countries. They find that wage distributions are tightly clustered around the median and also exhibit extreme values.

<sup>7</sup>There are, however, important studies that use employer-employee matched datasets to assess the behavior of firms subject to rigid wages in terms of employment adjustment. See for instance Abowd, Corbel, and Kramarz (1999).

similar intuition. However, thanks to the cross-sectional variation present in our data, our evidence is essentially model-free.

This paper is also related to a growing literature in Corporate Finance linking managerial actions to labor market frictions. For example, Serfling (2016) and Simintzi, Vig, and Volpin (2014) hypothesize that firms reduce leverage in the presence of higher firing costs, and provide supporting evidence from the US and from a cross-section of countries, respectively. Unlike these papers, our paper analyzes the effects of rigidities in the wage setting, not in the firing process. Others have studied the strategic interactions between management and unions (Matsa (2010) and DeAngelo and DeAngelo (1991), among others). We differ from this earlier work by focusing on a different aspect, namely how a relatively rigid bargaining protocol between unions and industry leaders can affect firms' sensitivity to aggregate shocks.

### **3 A Simple Model to Guide Intuition**

In this section we present a simple dynamic model in the spirit of Fischer (1977) to highlight the link between wage rigidity and the effects of monetary policy. This framework will also guide us to the empirical specification that we use in our empirical analysis. The main goal is to establish a link between shocks to profitability and changes in firms' market values, and to show how this connection can be amplified by wage rigidity. We impose at this stage a minimal set of assumptions, so that the resulting testable implications from the model can be subject to an agnostic test. We postpone to Section 6 the presentation of a more rigorous model that, under some parameter calibrations, can produce results that are not too far from our reduced-form estimates.

Consider a firm whose expected per-period cash flow is equal to  $\mathbb{E}[\pi_t] = \pi$ . The firm's horizon is infinite, and discounts each period at a rate  $\delta$ . Every two periods, the trade union representing the workforce bargains with firms' managers on behalf of workers. The firm's total surplus, represented by its cash flow, is then split with bargaining weights  $\beta$  and  $1 - \beta$  between workers and managers, respectively.

More precisely, suppose that, at the beginning of period  $t$ , all players learn the value of  $\pi_t$ . After having learned its value, but before it is actually realized, the trade union and the managers of the firm agree on the total wage bill  $w$  that will accrue to workers in period  $t$  and  $t + 1$ . Given that the value of  $\pi_{t+1}$  is unknown at time  $t$ , we assume that workers and managers simply set  $w_{t+1} = \beta\pi$ . Hence, shareholders get  $(1 - \beta)\pi_t$  in periods  $t$  and  $\pi_{t+1} - \beta\pi$  in period  $t + 1$ .

Now consider a shock, such as a monetary policy announcement, that temporarily changes the cash flow of the firm by an amount  $\Delta$ , but only in period  $\tau$ , so that  $\pi_\tau = \pi + \Delta$ . The impact of this change on the firm's value depends upon the timing of the contract's renewal. If  $t = \tau$ , meaning that the renegotiation of the wage contract occurs immediately after the shock is realized, the firm value is as follows:

$$V_{\tau,\tau=t} = (1 - \beta) \left( \frac{\pi}{1 - \delta} + \Delta \right) \quad (1)$$

On the other hand, if the shock occurs *after* the renegotiation has taken place, hence if  $\tau = t + 1$ , the previously bargained share of the surplus between workers and managers does not reflect the changed profitability of the firm. Hence, in this case, firm value reads as follows:

$$V_{\tau,\tau=t+1} = (1 - \beta) \frac{\pi}{1 - \delta} + \Delta \quad (2)$$

The difference between these two values is  $V_{\tau,\tau=t+1} - V_{\tau,\tau=t} = \beta\Delta$ . This simple framework has two immediate implications that we will test in the data. First, the distance from the contract renegotiation magnifies the effect of a temporary shock on firm value. Second, this impact is larger when  $\beta$  is larger, as in firms characterized by high labor intensity. While this model is stylized enough to accommodate any kind of temporary shocks to a firm's profitability, in our empirical analysis we will focus on monetary policy announcements.

Two comments are important to make. First, the effects of wage stickiness could be completely undone if state contingent contracts were available. As we will discuss later, however, in Italy wages reflect in a very limited way changes in profitability, whereas indexation to the broad consumer price

index has been repealed in 1994 (see Manacorda (2004) for details). In addition, as Fischer (1977) notices, the type of indexing needed to restore money neutrality would be much more complicated than those seen in practice, and require the knowledge of a number of real world parameters that are typically unobserved.

Second, Gorodnichenko and Weber (2016) show that, without making strong assumptions about a firm's profit function and its optimal price level, it is generally impossible to tell whether a monetary policy announcement will have a positive or negative effect on its profit (namely, whether  $\Delta > 0$  or  $\Delta < 0$ ). Intuitively, and for the case examined by Gorodnichenko and Weber (2016), if product prices are sticky, a firm that enjoys some rents due to monopolistic competition may have prices that are either too low or too high at the time of an announcement. An example is shown in Figure 1. Suppose that an expansionary monetary policy shock increases a firm's optimal price level from  $p_1^*$  to  $p_2^*$ . If a firm cannot adjust prices immediately in the short run, this may be either good news or bad news, depending on its price level before the occurrence of the shock. If the initial price level is too low ( $p_L$ ), the shock moves the firm further away from the optimal pricing policy; on the other hand, if the initial price level is very high ( $p_H$ ), the shock will increase the firm's profit. To account for those possible non-linearities, Gorodnichenko and Weber (2016) include the square of both the monetary policy shock and the firm's stock return in their econometric specification. Similarly, we are agnostic regarding the direction of the effect of monetary policy announcements on firm value; all we need is that larger shocks cause larger changes in valuations. For this reason, we employ a similar specification in our empirical section.

## 4 Institutional Background and Data

### 4.1 Institutional Background

Italy has a fairly centralized wage bargaining process, similar to other developed economies in Western Europe, such as France and Spain (Ronchi and di Mauro (2017)). For each job category, collective bargaining agreements regulate salary conditions, days of vacation, the compensation

for extra hours, and a number of other aspects of the employee-employer relationship. Categories include, for example, *metal workers, bankers or textile workers*. In other cases, collective agreements may regulate the labor conditions of workers with different positions within the same sector. For example, different collective agreements are in force for *banking employees* and *banking managers*.

Collective agreements are agreed upon by union leaders and industry representatives, and are generally valid for two years although, in some cases, they may last up to four years. Importantly, by law such contracts are valid *erga omnes*, meaning that every worker is subject to the provisions of a collective agreement, independent of whether she is enrolled in a union.<sup>8</sup> Because Italy does not have minimum wages set by law, such collective agreements are, essentially, equivalent to law and, in case of a labor lawsuit, an employer will be sanctioned if provisions of the collective agreement in force for a given job category are violated.

Recent empirical work has shown that collective bargaining is a major determinant of compensation policies. Boeri, Ichino, Moretti, and Posch (2017) show that the gap in nominal wages between Northern and Southern Italy is about 4%, despite a gap in the productivity in the order of 30%. Because the cost of living is higher in the North, real wages end up being substantially higher in the South, where productivity is lower, generating unemployment as a result. They show theoretically that these findings are consistent with a model in which collective agreements prevent wages from clearing local labor markets.

A similar argument is put forward by Belloc, Naticchioni, and Vittori (2018), who argue that the centralized wage setting causes a large real urban wage premia. Given that nominal wages do not vary much across firms or areas, real wages are on average lower in urban areas, where house prices tend to be higher. Devicienti, Fanfani, and Maida (2016) reach similar conclusions, showing that the increase in pay dispersion has been quite limited in recent years, as opposed, for example, to what has occurred in Germany over the same period (Card, Heining, and Kline (2013)), and

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<sup>8</sup>From Article 39 of the Italian Constitution: *Registered trade unions (...) may, through a unified representation that is proportional to their membership, enter into collective labor agreements that have a mandatory effect for all persons belonging to the categories referred to in the agreement.*

suggest that nationwide sectorial bargaining has determined, to a large extent, such rigidity.

An institutional feature that gives further relevance to collective agreements is the dominance of “two-tier” compensation schemes (Dell’Aringa (2017)). Individual wages are typically determined as the sum of two components: (i) the minimum wage, as prescribed by the relevant collective agreement, plus (ii) a firm-specific top-up. This implies that a change in the minimum wage is going to affect even high-earning workers, and not just the marginal ones. In other words, as long as firms do not immediately adjust individual top-ups, changes in sectorial minimum wages are going to shift the entire distribution of earnings. Indeed, Boeri (2015) shows that this kind of arrangement, which fairly common in Western Europe, fails to align pay and firm-productivity.

## 4.2 Data

For our empirical analysis, we combine several datasets. We use a unique dataset on the universe of all the Italian individuals working in the private sector through restricted, on-site access to a confidential database made available by *Istituto Nazionale della Previdenza Sociale* (INPS), the Italian national institute of social security. The data was made available to selected researchers through the project “VisitINPS”. INPS has a number of tasks, such as delivering retirement or disability pensions, as well as unemployment benefits. Hence, its administrative data are of the highest quality.

Starting from January 2005, the dataset records income and other information of each worker at a monthly rate. More precisely, the unit of observation is a contract-month, meaning that an individual worker may be employed under multiple contracts, possibly with the same firm, and therefore may appear in the dataset more than once in a given month.

Crucially for our analysis, the dataset also has a variable called *contract code*, which identifies the job category each individual worker’s job belongs to. As explained in the previous section, collective agreements are, *de facto*, equivalent to legislative provisions in case of a labor lawsuit. Thus, such a variable is recorded with a high degree of accuracy.

We retrieve information on each collective agreement from the web archive of *Consiglio Nazionale dell'Economia e del Lavoro* (CNEL), a council provided for by the Italian Constitution that advises the executive and legislative branches of the public administration. For each of the over 2,000 contracts available in the archive, we code the dates in which the contract was signed and expired, as well as possible vacancy periods. We use a crosswalk provided to us by INPS to match the contracts with the contract code variable in the INPS dataset.

The panel of individual workers also records the fiscal identifier of the company that each individual works for. We merge the INPS data with the Bureau Van Dijk (BvD) “Amadeus” database through this variable, which corresponds to the BvD firm identifier. We further merge the combined dataset with Compustat Global through ISIN or firm name to obtain the accounting information of the listed companies. We purchase intraday data on stock prices of all the companies listed on the Milan Stock Exchange between 2005 and 2016 from Tick Data, LLC, a private vendor of tick-by-tick stock market data. The data are then merged with Compustat Global, again using either the ISIN or the company name. This overall merging of firm-level data allows us to link the contract-based variables with information on the firms’ values.

Finally, we use intraday data on EONIA swap rates, kindly shared with us by Corsetti et al. (2018). We refer to Section 4.4 for details about how we use swap rates to construct our monetary policy shocks.

### 4.3 The Wage Rigidity Proxy

The main contribution of our paper is the construction of a proper firm-level proxy for wage stickiness. For this purpose, we need to aggregate, at the firm-month level, information on the time that individual workers have left prior to their contract renewal.

For any given job category  $c$  and day  $t$ , we know the date on which the agreement in force was signed, its date of expiration  $\tau_t$  and the date on which the agreement that replaced the one in force on date  $t$  was signed. A significant complication arises due to the fact that the latter and

the date of expiration typically do not coincide because of “vacancy periods” during which, as long as employers’ representatives and trade unions cannot find an agreement and sign a new contract, the expired contract is assumed to be in force.

Hence, for any given date and job category, we could, in principle, construct the variable “time to renewal” of each agreement simply by subtracting  $t$  from the date on which the contract that replaces the one currently in force is signed. This would introduce, however, a forward-looking bias because, on day  $t$ , agents are not aware of the date of the next renewal - i.e., they do not know if there are going to be any delays in the bargaining process. They foresee, however, when the agreement is going to expire. Thus, we adjust our “time to renewal” variable by subtracting the current date from the *expiration* date. We truncate this variable to zero to avoid negative values which would not be meaningful for economic purposes and which would otherwise arise during vacancy periods. Intuitively, we realistically conjecture that investors form their expectations assuming that, after the expiration of an agreement, the next agreement will be signed any time soon.

Any firm typically hires workers in several job categories, and are hence subject to different collective agreements. Based on this, we construct a firm level measure of wage rigidity  $WR$  as follows:

$$WR_{i,t} \equiv \log \left( 1 + \frac{\sum_j w_{i,j,c} \times \max \{0, t - \tau_r\}}{\sum_j w_{i,j,c}} \right) \quad (3)$$

where  $j$ ,  $t$ ,  $c$  index workers, firms and job categories, respectively. We use the max operator to truncate the difference  $t - \tau_t$  at 0 for each worker, and take its average at the firm level using the wage earned in the previous month as weight. This choice is preferable to that of assigning an equal weight to each worker, as it more appropriately reflects the actual labor cost associated with each individual. Because of the truncation at zero, the measure is right-skewed. Hence, we take the logarithm of 1 plus the measure to normalize its distribution.



## 4.4 Monetary Policy Shocks

Our approach to construct monetary policy shocks has become fairly standard in recent empirical work. Because market valuations will react only to new information, we need to extract the *unexpected* component of monetary policy decisions.

First, we obtain the list of announcements of the ECB target rates from the ECB website. We match these dates with the corresponding changes in the 1-year Euro Overnight Index Average (EONIA) swap rate. The 1-year rate strikes the best balance between being highly sensitive to monetary policy announcements, while remaining relatively unaffected by term premia.<sup>9</sup>

Intraday data on the EONIA swap rates are not available prior to 2008, but we follow Corsetti et al. (2018), who choose a 6-hour window from 13:00 to 19:00 CET, which match the closing times of the Tokyo and London stock exchanges, respectively. Hence, this window can be constructed by simply using daily series from these two stock exchanges, without the need for intraday data.

This approach of measuring monetary policy shocks based on high-frequency data has been used, for the US, by Gertler and Karadi (2015) and Gorodnichenko and Weber (2016), among others. These studies tend to focus on tighter windows, of 30 or 60 minutes surrounding the announcement of the FED fund rate. Our choice for a 6-hours window depends not only on data availability, but also on the institutional context on which we focus. The ECB target rates are announced at 13:45 CET. However, unlike in the US, investors learn much about the future course of action of the ECB during the press conference, followed by a Q&A with the president, which starts 45 minutes later, at 14:30 CET. Thus, a wider window is appropriate.

## 5 Empirical Evidence

### 5.1 Econometric Strategy

Our main econometric specification aims at testing the two main implications highlighted in the simple model of Section 3. Specifically, we wish to test first whether the impact of a monetary

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<sup>9</sup>We will see in Section 5.3 that our results are not sensitive to this particular choice.

policy shock is larger when the distance from contract renegotiation, hence wage rigidity, is higher. Second, to assess the distributional consequences of monetary policy, we examine how the impact varies depending on firms' labor intensity.

Based on the above our main econometric specification reads as follows:

$$R_{i,t}^2 = \alpha MP_t^2 + \beta WR_{i,t} + \gamma MP_t^2 \times WR_{i,t} + \delta' X_{i,t} + \theta' X_{i,t} \times MP_t^2 + \eta_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

where:

$$MP_t = S_t^+ - S_t^- \quad (5)$$

and where  $WR$  is defined in equation 3.

The variable  $R_{i,t}$  indicates the return of firm  $i$  on day  $t$  between 13:00 CET and 19:00 CET. As explained in Section 3, we square this variable as we do not have enough information on the direction of the change in firms' profits (upward or downward). This implies that we will be measuring the effects of monetary policy shocks on the volatility of firms' returns.

The variable  $MP_t^2$  captures our monetary policy shock and is based on high frequency identification. Specifically, the index  $t$  in  $S$  indicates the date of an ECB meeting, when ECB target rates are announced, and  $S_t^+$  and  $S_t^-$  are the 1-year Euro Overnight Index Average (EONIA) swap rates, shortly after and before the time of the announcement, respectively. While expectations about future policy rate changes should be already priced in, unexpected policy shocks will cause the swap to appreciate or depreciate instantly. This variable is also squared as our econometric specification is non-linear. Following Corsetti et al. (2018), we take swap changes within a 6-hour window from the press conference in which the ECB announces the policy rate. As explained in Section 4.4, while the press release made in the 30 minutes after the policy decision contains significant amount of information for the Fed announcements, things are different for the ECB. The release of the monetary policy decision at 13:45 CET only contains a limited amount of information on the latest policy actions. A significant amount of information is disseminated to the market at a later stage, via the press conference. For this reason, it is advisable to extend the window around the policy

announcement.

The wage rigidity measure proxies for the average time left before the renewal of the workers' collective agreement, as discussed in Section 4.3. This allows us to capture the staggering structure present in collective bargaining agreements, which are typical of the Italian industrial landscape. At last, we include an interaction term between the monetary policy shocks and the wage rigidity measure. Based on the discussion of the simple model presented in Section 3, our key prediction is related to the sign of the coefficient  $\gamma$ , which we expect to be positive.

We also include a vector  $X$  of control variables, described below, that could be potentially related to firm volatility on announcement days. Importantly, we also include the same vector interacted with the monetary policy shock, accounting for the possibility that our proxy  $WR$  is simply capturing some other firm characteristic. Finally, in most specifications we also include two vectors of firm and day dummies  $\eta_i$  and  $\mu_t$ , respectively. (The time-fixed effects, whenever included, will absorb the coefficient on  $MP^2$  but not our main coefficient of interest.)

## 5.2 Descriptive Statistics

Descriptive statistics for the main variable used in the paper are in Table 1. The dependent variable  $Return^2$  is, as explained in Section 5.1, the square of the firm's stock return on an announcement day, defined as the price of the stock at 19:00 CET minus the price at 13:00 CET, all divided by the latter. The monetary shock  $MP^2$  is the squared difference between the swap rate on the target policy rate at 19:00 CET and 13:00 CET.  $WR$  is our measure of wage stickiness, based on the distance to renegotiation of the collective bargaining agreement. We also add a number of control variables in our estimation. Size is the logarithm of total assets. Leverage is defined as the sum of debt in current liabilities plus long-term debt, all divided by total assets. ROA is earnings before interest, debt and amortization divided by total assets. All these variables are measured at the beginning of the fiscal year in which the announcement is made. Labor Intensity is defined as the total wage expenses in the month preceding the announcement, divided by total assets at

the beginning of the fiscal year. Our final sample has 25,529 observations and comprises all the monetary policy announcements occurred between 2004 and 2016.

### 5.3 Results

The results from the estimation of model 4 are contained in Table 2. We present results for six different variations over the baseline equation, going from the least to the most conservative specification. For ease of interpretation, we divide all variables (before taking interactions) by their sample standard deviations after subtracting their means. In column 1 we include only  $WR$  and  $MP^2$ , as well as the interaction between the two, which is our coefficient of interest. Consistent with Gorodnichenko and Weber (2016), the coefficient on  $MP^2$  has a positive sign, and is significant at the 1% level. The standalone coefficient on  $WR$ , that does not have an obvious economic interpretation, is instead insignificant.

Crucially, the coefficient on the interaction term  $MP^2 \times WR$  is positive, and equal to 0.017, significant at the 1% level. Note that the positive sign on this term is in line with the analytics of the simple model described above, but also with the regression of the extended dynamic model discussed further below. Given that the coefficient on  $MP^2$  is equal to 0.040, the two coefficients are in the same order of magnitude. In column 2 we add a number of control variables, measured at the end of the fiscal year that precedes each monetary policy announcement. We include size, leverage ROA and labor intensity. We find that firms with higher debt levels and lower profitability exhibit higher volatility during announcement dates. The coefficient of interest is essentially unaffected.

In column 3, we interact  $MP^2$  with the control variables. In this way we take into account the possibility that  $WR$  is simply proxying for, or strongly correlated with, some firm's characteristics. The volatility of smaller firms appear to respond less to the shocks, as shown by the fact that the coefficient on the interaction term  $MP^2 \times \text{Size}$  is negative. Remarkably, our coefficient of interest remains unaffected in magnitude and is significant at the 5% level. Hence, the influence of our measure of wage rigidity on firms' sensitivity to monetary policy shocks appear largely orthogonal

to that of the most plausible firms' characteristics.

In columns 4 through 6, we replicate the specifications of columns 1 through 3, except that we include both firm and announcement date dummies. Hence, the coefficient on  $MP^2$  is not separately identifiable, but its interaction with the wage rigidity proxy still is. The inclusion of firm fixed effects, instead, allows us to control for time-invariant firm characteristics that may determine stock volatility during announcement dates.

Including these two vectors of fixed effects has solely the effect of slightly increasing the size of the coefficient of interest, which varies now between 0.021 and 0.022, significant at the 1% level. Among the control variables, the only one that remains significant is the interaction term  $MP^2 \times \text{Size}$ .

In Table 3, we propose two robustness tests. First, we show that our results are unchanged when we use changes in swap rates at different horizons to measure the monetary policy shocks. In columns 1 through 3 we find that results are essentially identical, whether we use changes in 1-year, 6-month or 3-month swap rates.

Although workers in a given firm may be subject to different collective agreements, in practice they tend to cluster across industries. Hence, one concern may be that we are capturing an "industry effect". An attractive feature of our econometric strategy, however, is that within industry our stickiness measure changes over time. Thus, in our second robustness test we can control non-parametrically for this possibility by interacting the monetary policy shock with industry dummies. Industry are defined using the 1, 2 or 3-digit *NACE* industry classification, which is standard in the European Union. As columns 4 through 6 of Table 3 show, the coefficient of interest remains similar in magnitude, and significant at the 1% level. Hence, we can safely conclude that our measure is not simply capturing time-invariant industry characteristics.

## 5.4 Cross-Sectional Heterogeneity

To further validate the economic channel we posit, we analyze the cross-sectional heterogeneity of our results. Remember from the simple model of Section 3 that if the workforce is entitled to receive a high fraction of the cash flow of the firm (i.e., if the  $\beta$  of our model is large), then wage rigidity should play a more important role in amplifying the stock market response to monetary policy shocks.

We test this straightforward prediction of our model by sorting firms according to their degree of labor intensity, measured in two different ways. First, as in Table 2, we use the ratio of wage expenses divided by total assets. Second, we use the total number of days worked, again divided by total assets. Hence, in the first case the labor intensity proxy is based on actual labor costs, while in the second case it is based on the workforce employed. As usual, both numerators are measured in the month predating the announcement, and are scaled by total assets at the beginning of the fiscal year.<sup>10</sup>

Table 4 shows regression coefficients obtained after estimating equation 4 in the sub-samples of firms characterized by labor intensity in the bottom or top 50%, respectively. For brevity, we report only estimates from our most conservative specification, which includes firm and date-fixed effects, as well as the control variables, both, as standalone regressors and interacted with the monetary policy shock.

Results are consistent with our prediction. In column 1, the coefficient on  $MP^2 \times WR$  is small (0.009) and insignificant. On the other hand, in column 2, namely the case of high labor intensity firms, it is large (0.025) and significant at the 1% level. Columns 3 and 4 display similar results, with the coefficient of interest rising from an insignificant 0.009 to 0.023, significant at the 5% level. This test represents an important validation of our hypothesis, as it shows that the labor demand

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<sup>10</sup>Total sales would perhaps be more coherent with the model presented in Section 3 as denominator of the proxy for labor intensity. We chose total assets because the variable sales is missing in about 20% of the observations; nevertheless, we have re-run our analysis using labor expenses over revenues as sorting variable and, in this smaller sample, found very similar results.

channel is the crucial one in our narrative.

Another important test consists in assessing to what extent cyclical movements affect the responsiveness to monetary policy shocks under different degrees of wage rigidity. To this purpose in Table 5, we verify whether firms' conditions or the business cycle affect the importance of wage stickiness in determining the stock market response to monetary policy shocks. Although we did not elaborate on this additional, potential level of heterogeneity in our simple model, it is reasonable to expect that firms whose profits are lower will be less able to shelter the impact of the shock. Similarly, during economic downturns, we also expect that the rigidity induced by collective bargaining hampers the ability of firms to adjust labor costs. For this reasons their profits should react more strongly to the monetary policy shock. In columns 1 and 2 we use firm's ROA as a sorting variable, to distinguish between highly and non-highly profitable ones. As expected, we find that the wage rigidity channel appears stronger for firms with low profitability. The coefficient for this group of firms is highly significant and equal to 0.028. The coefficient drops to 0.010 and is insignificant in highly profitable firms, instead. In columns 3 and 4, we use an alternative sorting variable, namely the quarterly GDP growth. Again, the results appear to be driven by shocks occurring at times of (relative) economic distress. In column 3 the coefficient is 0.020, significant at the 5% level, while in column 4 the coefficient drops to -0.03 and is insignificant.

The two robustness tests proposed above also strengthen our argument on the distributional consequences of monetary policy shocks. Changes in the interest rate more strongly affect firms that face higher difficulties to adjust their costs. Hence the impact of the shock is stronger for firms with high wage rigidity, and more so when those firms rely highly on labor inputs and have low profitability. Our results complement also other recent evidence on the effects of monetary policy with heterogenous firms. Bahaj, Foulis, Pinter, and Surico (2017), using a panel of UK firms, examine the impact of monetary policy on employment dynamics for small and large firms, pointing at the role of different financial frictions.<sup>11</sup> Other works (see, for example, Rodnyansky

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<sup>11</sup>Past works along the same lines include Gertler and Gilchrist (1994), Moscarini and Postel-Vinay (2012), Kudlyak and Sanchez Kudlyak and Sanchez (2017) and Mehrotra and Crouzet (2017), among others.

(2018)) examine the differential impact of monetary policy for exporting and non-exporting firms.

Before moving to the next section, we propose an additional robustness test, aimed at testing for the presence of any pre-trend in stock market returns that could anticipate the monetary policy shocks. More specifically, we replace our dependent variable with the stock return between 1pm and 7pm on the day *prior to* each monetary policy announcement. If the correlations found so far were spurious, we could in principle obtain similar estimates even in days in which monetary policy announcements do not take place. On the other hand, a small and insignificant coefficient on the interaction term of interest would suggest that our results are indeed driven by heterogeneity in the response to monetary policy shocks.

In Table 6 we first replicate our baseline test of Table 2, focusing for brevity on the most conservative specification. In column 1 we find a coefficient on the interaction term that is small and insignificant, equal to -0.003 ( $t$ -statistic=0.38). We also replicate our analysis of Table 4, where we sort firms according to their degree of labor intensity. This test is crucial because it provides strong evidence that the labor channel is indeed the driving force of our results. As columns 2 through 5 show, the coefficient of interest remains small and insignificant in all the subsamples and, if anything, is more negative in the high labor intensity subgroups.

## 5.5 Real Effects

Our detailed data also allow us to test whether the strong stock market responses we have observed are reflected in changes in employment levels. First, we aggregate our monetary policy shocks at the quarterly level, following the procedure recommended by Gertler and Karadi (2015). We first define  $\hat{e}_t$  as:

$$\hat{e}_t \equiv \sum_{-92}^0 e_t \quad (6)$$

and then cumulate the  $\hat{e}_t$ s over each quarter  $Q$  to obtain a quarterly shock  $\hat{e}_Q$ :

$$\hat{e}_Q = \sum_{t \in Q} \hat{e}_t \quad (7)$$



Intuitively, this procedure assigns higher weight to shocks that occur early in the quarter, and that therefore have more time to display their effects. Our dependent variables are the squared symmetric growth rates of four different objects. “Pay” is the total compensation, given by the sum of all wages paid to a firm’s employees. “Days worked” is defined as the total of workers employed times days worked. “Employees” is the total number of workers (i.e., “bodies”) employed. Finally, “full-time employees” are those who are employed for at least 20 days per month. Results are displayed in Table 7. (As usual, all the variables are demeaned and divided by their standard deviation.) Unfortunately, we do not have plant-level information of the firms’ workforce. Hence, we are not able to identify and exclude changes in employment due to divestitures or acquisitions and, as a result, our outcome variables are prone to exhibit outliers. As a partial remedy, we winsorize the dependent variables at the 5% level.

We find significant and economically large effects on each of the first three outcome variables. In particular, we find that the coefficients of interest are significant at the 5% or 1% level, with estimates between 0.029 and 0.037. Interestingly, only in the last column, where we focus on long-term employees, we find an insignificant coefficient. Its magnitude, 0.015, is much smaller than the one found in column 3 (equal to 0.037), where the change in total employment is used as dependent variable. This suggests that managers respond to aggregate shocks by primarily adjusting the number of short-term employees.

We also run a “placebo test”, in which we use the one quarter-lags of those used in our main tests as dependent variables, along the lines of what described in Section 5.4 and shown in Table 6. Intuitively, we should not find any relationship between changes in employment and shocks occurring in the following quarters. Indeed, in Table 8, we find that to be the case: all the coefficients are now small and insignificant.

## 6 A Multi-Sector Model with Sectorial Wage Rigidity

Our empirical analysis was guided by the simple predictions provided by adapting the Fischer (1977) model, but, through it, we have provided a further narrative on the channels underlying the effects of monetary policy shocks. We are therefore now bound to verify the consistency of our narrative through a full-fledged dynamic general equilibrium model. In addition to that, the practice of assessing the effects of policy shocks through models is now well established, whereby households and firms' decisions are fully micro-founded and expectations for the future course of actions play a role. We do so by constructing a fully dynamic general equilibrium model with micro-founded decisions and with heterogeneous wage rigidity at the sectorial level. We use the model as a laboratory economy and show that it is capable, through simulated data, of replicating the regression results obtained in the empirical analysis.

The production side of the economy is composed of a discrete number of sectors, indexed by  $s = \{1, \dots, S\}$ . In each sector there is a continuum of firms producing different varieties, indexed by  $i$ . The variety heterogeneity serves the purpose of assigning monopolistic power to firms, so that we can associate firms' stock values to the sum of future discounted mark-ups. In the symmetric equilibrium, monopolistic competition implies that firms will all choose the same price. *Ex ante*, each firm  $i$  demands differentiated labor services from a placement agency. The differentiated labor services in each sector are then bundled for each sector into a composite labor input by the competitive representative placement agency. In each sector, wages are set by a labor union in staggered fashion.<sup>12</sup> This implies that firms operating in different sectors feature different marginal cost dynamics. More specifically, the sectorial labor input is supplied by the households to the sectorial labor union, which takes its members' utility into account and acts as a monopoly supplier of differentiated labor services to all the variety-producing firms in the sector. We introduce wage rigidity through a staggered structure à la Taylor (1979), such that each union can re-set wages only

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<sup>12</sup>The assumption through which labor unions hold the monopoly power and hence set wages is realistic and has been advanced before by Schmitt-Grohé and Uribe (2005).

at specific time intervals, which are different across sectors. Heterogeneous wage stickiness implies heterogeneity in firms' marginal cost dynamics, and hence different responses to any aggregate shocks. We will focus on monetary policy shocks.

In the general equilibrium there is a continuum of households which consume, invest in Arrow-Debreu securities and supply labor services to different sectors and to different variety-producing firms within each sector. Hence total labor supply comes from aggregating firm level labor services, upon which unions have monopolistic power, and then sectorial labor services. Importantly, despite the fact that individual household members supply labor services to different firms and sectors, heterogeneity does not affect their consumption-saving decisions.<sup>13</sup> The possibility of investing in an Arrow-Debreu security gives household members insurance against idiosyncratic risk so that the consumption-saving problem is solved only at the level of the representative household.

## 6.1 Households

The household has a lifetime utility function:

$$W_t = \mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \beta^k U \left( C_{t+k}, \sum_{s=1}^S (f^s) \int_0^1 N_{si,t+k} di \right) \right\}, \quad (8)$$

where  $\beta$  is the discount factor,  $\mathbb{E}_t$  is the conditional expectation operator with respect to information at time  $t$ ,  $C_t$  is a consumption aggregate and  $N$  denotes labor services. The sum of the households in the economy supplies labor services to all sectors,  $\sum_{s=1}^S (f^s) N_{s,t+k}$ , where  $N_{s,t+k} = \int_0^1 N_{si,t+k} di$ . In each sector, unions will only represent the portion of households whose labor services are supplied there. Labor supply in each sector is then an aggregate of labor services to the continuum of firms producing varieties,  $i$ . We specify the per-period utility function as  $\frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \psi \frac{(N_{s,t})^{1+\eta}}{1+\eta}$ , where  $\sigma$  the elasticity of intertemporal substitution,  $\eta^{-1}$  is the Frisch elasticity of labor supply, and  $h$  is an internal habit parameter.

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<sup>13</sup>Each household consists of a large number of individuals, each individual supplies one unit of labor inelastically and shares all income with the other household members through an insurance scheme. This specification is along the lines of Schmitt-Grohé and Uribe (2005) and Galí (2015).

The representative household maximizes its utility subject to the budget constraint:

$$C_t P_t + \sum_{h^{t+1}} \nu_{t+1,t} B_{t+1} = \sum_{s=1}^S (f^s) W_{s,t} \int_0^1 N_{si,t+k} di + B_t - \tau_t + \int_0^1 \Gamma_t(i) di, \quad (9)$$

where the household earns income from differentiated labor  $N_{si,t}$  at the nominal wage rate  $W_{si,t}$  through the labor services supplied by the union. Note once more that the sectorial union will eventually choose one wage for all firms  $i$  operating in sector  $s$ . The final good can be used for either saving in the Arrow-Debreu security or consumption, and sells at the nominal price  $P_t$ . Households also face a lump-sum tax  $\tau$ . To insure their consumption pattern against random shocks at time  $t$  households spend  $\nu_{t+1,t} B_{t+1}$  in nominal state contingent securities, where  $\nu_{t,t+1} \equiv \nu(h^{t+1}|h^t)$  is the period  $t$  price of a claim to one unit of domestic currency in state  $h^{t+1}$ , divided by the probability of occurrence of that state. Each asset in the portfolio  $B_{t+1}$  pays one unit of domestic currency at time  $t + 1$  and in state  $h^{t+1}$ . Finally,  $\Gamma_t(i)$  is the profit of monopolistic firm  $i$ , whose shares are owned by households.

The representative household chooses processes  $\{C_t\}_{t=0}^\infty$  and bonds  $\{B_{t+1}\}_{t=0}^\infty$ , taking as given the set of processes  $\{P_t, \nu_{t+1,t}\}_{t=0}^\infty$  and the initial wealth  $B_0$  so as to maximize (8) subject to (9). For any given state of the world, the following set of efficiency conditions must hold:

$$\lambda_t = (C_t - hC_{t,-1})^{-\sigma} - \beta h(C_{t+1} - hC_t)^{-\sigma} \quad (10)$$

$$\beta \frac{P_t}{P_{t+1}} \frac{\lambda_{t+1}}{\lambda_t} = \nu_{t,t+1} \quad (11)$$

$$\lim_{k \rightarrow \infty} \mathbb{E}_t \{ \nu_{t,t+k} B_{t+k} \} = 0 \quad (12)$$

where  $\lambda_t$  is the Lagrange multiplier on the budget constraint, equation (11) is the Euler condition on the state-contingent bond holding for each state of the world, and equation (12) is a condition on terminal wealth.

## 6.2 The Final Good Sector

Households consume a homogeneous good, which results from summing up the output produced in each sector, with the latter resulting from bundling the continuum of varieties produced by firms, indexed by  $i$ , in each sector through a Dixit and Stiglitz (1977) aggregator. Note that, in each sector, a representative competitive firm bundles together a Dixit-Stiglitz composite of varieties produced by monopolistically competitive firms. At the aggregate level a representative competitive firm bundles together a Dixit-Stiglitz composite of the sectorial outputs. The optimization problems solved by each of those firm-level and sectorial-level output bundlers will deliver the optimal demand for each variety  $i$ , which in turn will depend upon the optimal demand of the sectorial product  $s$ . The optimal demand for each sectorial variety will represent the constraint of the monopolistically competitive firm  $i$ , choosing prices in sector  $s$ . Note for sake of clarity that monopolistic firms operating in each sector will have to be indexed both by the sectorial index,  $s$ , and by their individual variety index  $i \in [0, 1]$ . Each sector size is given by  $f_s > 0$ , with  $\sum_{s=1}^S f_s = 1$ .

Given the above, the sectorial output is given by  $Y_{s,t} = \left[ (f^s)^{\frac{\epsilon_p-1}{\epsilon_p}} \int_0^1 Y_{si,t}^{\frac{\epsilon_p-1}{\epsilon_p}} di \right]^{\frac{\epsilon_p}{\epsilon_p-1}}$ , where  $Y_{s,i,t}$  is the variety produced by firm  $i$  in sector  $s$ . The parameter  $\epsilon_p \geq 0$  is the elasticity of substitution within as well as across sectors, which for simplicity we assume to be equal. The aggregate output is given by  $Y_t = \left[ \sum_{s=1}^S (f^s)^{\frac{1}{\epsilon_p}} Y_{s,t}^{\frac{\epsilon_p-1}{\epsilon_p}} \right]^{\frac{\epsilon_p}{\epsilon_p-1}}$ . The output-bundlers solve an optimization problem<sup>14</sup> to obtain the downward-sloping demand for sectorial varieties  $s = \{1, \dots, S\}$ , which reads as:  $Y_{s,t} = f^s \left( \frac{P_{s,t}}{P_t} \right)^{-\epsilon_p} Y_t$ . Similarly, the representative firm that bundles individual varieties into sectorial

<sup>14</sup>The problem is rather standard and reads as follow:

$$\max_{Y_t} \left[ P_t Y_t - \sum_{s=1}^S P_{s,t} Y_{s,t} \right]$$

subject to  $Y_t = \left[ \sum_{s=1}^S (f^s)^{\frac{1}{\epsilon_p}} Y_{s,t}^{\frac{\epsilon_p-1}{\epsilon_p}} \right]^{\frac{\epsilon_p}{\epsilon_p-1}}$ .

goods solves an optimization problem<sup>15</sup> to obtain the downward-sloping demand for individual varieties  $i \in [0, 1]$ , which reads as:  $Y_{si,t} = (f^s)^{-1} \left( \frac{P_{si,t}}{P_{s,t}} \right)^{-\epsilon_p} Y_{s,t}$ . Given the optimal demands for varieties and sectorial output, we can derive the price index  $P_t = \left[ \sum_{s=1}^S (f^s) P_{s,t}^{1-\epsilon_p} \right]^{\frac{1}{1-\epsilon_p}}$ , and the sectorial price aggregator is  $P_{s,t} = \left[ \int_0^1 P_{si,t}^{1-\epsilon_p} di \right]^{\frac{1}{1-\epsilon_p}}$ .

### 6.2.1 Intermediate Goods in each Sector

Each variety  $Y_{s,i,t}$  is produced by a single firm in a monopolistically competitive environment. Each firm  $i \in [0, 1]$  produces output using labor services  $N_{s,i,t}$  as factor inputs. The production technology reads as follows:  $Y_{si,t} = N_{si,t}$ . In some specifications, we assume that hiring labor comes with convex costs, such that minimization of discounted future labor costs  $W_{s,t}N_{s,t} + \frac{\xi}{2}N_{s,t} \left[ \frac{N_{s,t}}{N_{s,t-1}} - 1 \right]^2$ , subject to  $Y_{si,t} = N_{si,t}$  and the demand for individual varieties yields:

$$mc_{s,t} = \left[ W_{s,t} + \frac{\xi}{2} \left( \frac{N_{s,t}}{N_{s,t-1}} - 1 \right)^2 + \left( \xi \frac{N_{s,t}}{N_{s,t-1}} - 1 \right) - \beta \xi \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \left( \frac{N_{s,t+1}}{N_{s,t}} - 1 \right) \frac{N_{s,t+1}^2}{N_{s,t}^2} \right] / P_t, \quad (13)$$

Here the real marginal cost  $mc_{s,t}$  (the Lagrange multiplier deflated by the price level) is given by the sector's real wage plus an adjustment cost term that reflects hiring costs. Wages in turn are determined in a staggered fashion in the spirit of Taylor (1979), as discussed in section 6.2.4. Firms then maximize the stream of real profits,  $\Pi_{si,t} = \frac{P_{si,t}}{P_t} Y_{si,t} - \frac{W_{s,t}}{P_t} N_{si,t}$ , subject to (13),  $Y_{si,t} = N_{si,t}$  and the demand for individual varieties. The optimality condition then reads

$$P_{si,t} = \frac{\epsilon_p}{\epsilon_p - 1} mc_{si,t} P_t, \quad (14)$$

which is the monopolistic pricing condition upon which prices are set equal to a mark-up on nominal marginal costs. Finally, in a symmetric equilibrium we can impose  $P_{si,t} = P_{s,t}$ ,  $N_{si,t} = N_{s,t}$  and  $mc_{si,t} = mc_{s,t}$ .

<sup>15</sup>The optimization problem reads as follows:

$$\max_{Y_{si,t}} \left[ P_{s,t} Y_{s,t} - f^s \int_0^1 P_{si,t} Y_{si,t} di \right],$$

subject to  $Y_{s,t} = \left[ (f^s)^{\frac{\epsilon_p-1}{\epsilon_p}} \int_0^1 Y_{si,t}^{\frac{\epsilon_p-1}{\epsilon_p}} di \right]^{\frac{\epsilon_p}{\epsilon_p-1}}$ .

### 6.2.2 Firm's Value

As explained earlier, upon solving the model, we will also run a regression using artificial data to assess the impact of monetary policy shocks on firms' returns. Responses shall differ across sectors due to the differential degree of wage rigidity. To this purpose, we shall define a recursive formulation for firm's values. Imposing symmetry across firms  $i$  within sector  $s$ , we define the value of a firm in sector  $s$  as:

$$V_{s,t} = \Pi_{s,t} + \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} V_{s,t+1} \right\}. \quad (15)$$

We then define sectorial returns as the percentage change in the sectorial value:

$$R_{s,t} = \log(V_{s,t}) - \log(V_{s,t-1}) \quad (16)$$

### 6.2.3 Labor Services Aggregator

Wages are set by monopolistic unions, each operating within the sectors. Unions have monopoly power over the individual labor services that household members supply to the continuum of firms, indexed by  $i$ . Hence, to define the monopolistic labor union wage optimization problem, we shall first derive the demand for each labor service,  $i$ .

The optimal demand for each labor service at firm and sectorial levels are obtained as solutions to the optimization problem of competitive labor agencies. Specifically, we assume that in each sector a competitive labor agent bundles together the labor services demanded by each firm  $i$ . The Dixit-Stiglitz aggregator for the sectorial labor demand is  $N_{s,t} = \left[ (f^s)^{\frac{\epsilon_w - 1}{\epsilon_w}} \int_0^1 (N_{si,t})^{\frac{1 - \epsilon_w}{\epsilon_w}} di \right]^{\frac{\epsilon_w}{\epsilon_w - 1}}$ , where  $\epsilon_w$  is the elasticity of substitution between labor varieties within sectors. Similarly, at the aggregate level a competitive labor-placement agent bundles together the labor services supplied at the sectorial level. The Dixit-Stiglitz aggregator for economy-wide labor demand is  $N_t = \left[ \sum_{s=1}^S (f^s)^{\frac{1}{\epsilon_w}} N_{s,t}^{\frac{\epsilon_w}{\epsilon_w - 1}} \right]^{\frac{\epsilon_w}{\epsilon_w - 1}}$ , where  $\epsilon_w$  is also the elasticity of substitution between labor varieties across sectors. The competitive labor-placement agent in each sector solves an optimization

problem<sup>16</sup> yielding the downward-sloping demand curve for labor variety  $i$  in sector  $s$ , namely  $N_{si,t} = (f^s)^{-1} \left( \frac{W_{si,t}}{W_{s,t}} \right)^{-\epsilon_w} N_{s,t}$ . Similarly, the competitive placement agent at the aggregate level chooses the optimal labor demand<sup>17</sup>, which results in  $N_{s,t} = f^s \left( \frac{W_{s,t}}{W_t} \right)^{-\epsilon_w} N_t$ .

#### 6.2.4 Labor Unions and Wage Stickiness

Wage setting is staggered in the spirit of Taylor (1979). In each sector labor unions set the wage at a specific date and keep it fixed for  $S$  periods. In each sector the wage setting date is different. This creates the staggered structure. This also implies that in each period  $t$  only a fraction  $1/S$  of all households sees its wage adjusted.

The optimal wage  $W_{s,t}^*$  is then found by maximizing household utility (8), subject to the relevant part of the budget constraint (9) and the downward-sloping demand curve for labor variety  $i$  in sector  $s$ :

$$W_{s,t}^* = \frac{\epsilon_w}{\epsilon_w - 1} \frac{\mathbb{E}_t \left\{ \sum_{\tau=t}^{t+S-1} \beta^{\tau-t} U_{N_s,\tau} W_\tau^{\epsilon_w} N_\tau \right\}}{\mathbb{E}_t \left\{ \sum_{\tau=t}^{t+S-1} \beta^{\tau-t} \lambda_\tau / P_\tau W_\tau^{\epsilon_w} N_\tau \right\}}, \quad (17)$$

where  $U_{N_s}$  is the marginal dis-utility of labor in sector  $s$ . Therefore, the household's optimal wage is given by a markup,  $\frac{\epsilon_w}{\epsilon_w - 1}$ , over the ratio of weighted marginal utilities of leisure to marginal utilities of income within the duration of wage contracts, with the weights given by the normalized demand for its labor services. If the household expects an increase in the marginal utility of leisure or a fall in the marginal utility of income within the next  $S$  periods, the union will respond by setting a higher nominal wage.

<sup>16</sup>It chooses the optimal demand,  $N_{is,t}$ , to maximize:

$$W_{s,t} N_{s,t} - \sum_{s=1}^S W_{si,t} N_{si,t}$$

subject to  $N_{s,t} = \left[ (f^s)^{\frac{\epsilon_w - 1}{\epsilon_w}} \int_0^1 (N_{si,t})^{\frac{1 - \epsilon_w}{\epsilon_w}} di \right]^{\frac{\epsilon_w}{\epsilon_w - 1}}$ .

<sup>17</sup>The placement agent maximizes  $W_t N_t - W_{s,t} N_{s,t}$  subject to the demand constraint  $N_t = \left[ \sum_{s=1}^S (f^s)^{\frac{1}{\epsilon_w}} N_{s,t}^{\frac{\epsilon_w}{\epsilon_w - 1}} \right]^{\frac{\epsilon_w - 1}{\epsilon_w}}$ .



### 6.2.5 Firm Wage Heterogeneity

Given that wages are set at different dates in each sector and are kept constant for a fixed interval  $S$ , firms operating in each sector experience different marginal costs. They will thereby react differently to shocks.

In each sector wages are set according to the general functional form given by (17) but, operationally, we stagger the sectorial wages in time. Specifically, the wage for sector  $s = 1$  is set in  $t = \tau$ , the wage for sector  $s = 2$  in  $t = \tau - 1$ , ..., the wage for sector  $s = S$  in  $t = \tau - S + 1$ . Hence, in each period  $t$  a firm in sector  $s$  pays nominal wages  $W_s^*$  that have been set either in the current or in one of the past periods. This way of staggering the wage contracts over time allows us to tie firms' marginal costs, hence profits, to the timing in which the monetary policy shock hits the economy. To fix ideas, consider a monetary policy shock that occurs at the current period. Firms belonging to a sector whose renegotiation took place in the previous period are able to adjust their wage bill only  $S - 1$  periods from now. In other words, their marginal costs are tied to nominal wages  $W_{s,t-1}^*$  until then. On the other extreme, firms belonging to a sector whose renegotiation takes place in the current period will experience an immediate change in their marginal costs, and hence in their profits. This also implies that these firms are affected by wage stickiness only through general equilibrium effects, which they take into account when setting their prices.

### 6.2.6 Market clearing, Monetary Policy and Calibration

The model requires also a market clearing condition,  $Y_t = C_t$ , and an operational rule for monetary policy, which reads as follows:  $1 + i_t = (1 - \rho_i)(1 + i) + \rho_i(1 + i_{t-1} + b_W(W_t/W - 1)) + \epsilon_t^i$ , wherein  $W$  represents the steady-state value of the nominal wage index.

To replicate our empirical results we solve the model numerically. We calibrate the model to quarterly data using standard values in the literature, given in Table 9. Notably, we choose  $S = 8$  sectors in order to roughly match the approximate time span of wage contracts in the data. More specifically, a value of  $S = 8$  implies that the median renegotiation time is 3.5 quarters, i.e. roughly

315 days, which is very close to the median of 318 days in the data. In the specifications with hiring costs,  $\xi$  is set to 2.015, which is the average of the values estimated in Cooper and Willis (2009) for positive and negative employment changes.

### 6.3 Results

We simulate the model in response to a monetary policy shock active for 2,000 periods. With 1,200 periods used as burn-in, the remaining  $T = 800$  periods are used to obtain artificial data and to sample across sectorial firms' returns so as to run the following regression:

$$R_{s,t}^2 = \alpha \epsilon_t^{i2} + \beta WR_{s,t} + \gamma \epsilon_t^{i2} \times WR_{s,t} + u_{s,t}, \quad (18)$$

Note that the model-based regression reproduces the empirical one, namely equation (4), without control variables. Indeed we again label with  $R_{s,t}^2$  the returns of the firms producing intermediate goods in each sector, with  $WR_{s,t}$  the time (in quarters) it takes for the sector's wage contract to be renewed in period  $t$ . Table 10 reports the coefficient estimates. As in the empirical section, all coefficients are standardized, and coefficients are shown with standard errors in parentheses. In the simplest version of the model, with neither habit nor hiring costs, we obtain coefficient estimates of 0.132 and 0.084, that are higher than the reduced-form estimates presented in Section 5, but are in the same order of magnitude. Recall that our estimates were in the ranges 0.016-0.022 and 0.029-0.037 for stock returns and employment changes, respectively. This result already points to the fact that the qualitative channels embedded in the baseline version of our model can rationalize the empirical evidence quite well. Intuitively, consider an increase in the interest rate. As the common monetary policy shock hits the economy at time  $t$ , the firms that can adjust wages will be able to reduce their marginal costs so as to absorb the negative impact of the shocks on the future sum of discounted profits. The cohort of firms which cannot adjust wages will experience a larger change in profits, which is then reflected in stock returns.

To gain more in terms of quantitative insights, we extend our model along two dimensions. Naturally the full transmission mechanism of monetary policy in the real world is guided by further

channels that are not embedded in the baseline version of our laboratory economy. First, we introduce habit persistence in consumption and hiring costs. The first modification, beyond being well established in the dynamic general equilibrium literature for its ability to match a number of business cycle facts, allows us to fine tune the response of the stochastic discount factor of firms, which is used in the model to discount future profits. Specifically, introducing habit in consumption smooths the marginal weight that investors, and hence firms' owners, attach to fluctuations in future profits. This implies that all cohorts of firms will adjust their marginal costs by less in response to the common monetary policy shock. Hiring costs, instead, beyond being a realistic feature of the labor market, also delay the employment response. Given this background, and as expected, the regression coefficients become lower, and closer to the "true" ones, in the second row, once we introduce habit and hiring costs, and are now equal to 0.033 and 0.071. A further dimension which can affect the response of stock values is clearly the degree of risk aversion. Once more, this affects the stochastic discount factor that investors attach to future firms' profit changes. Raising the coefficient of relative risk aversion  $\sigma$  from 2 to 2.15 further improves the fit, bringing down the coefficients to 0.025 and 0.056, which are not too far from the higher ends of our sample coefficients. An increase in risk-aversion implies that investors attach a higher price of risk to future contingencies and this translates into a reduction of the stochastic discount factor.

## 7 Conclusion

The question of the effects of monetary policy in face of nominal rigidities is old, but still highly debated. With recent emphasis, in the macro literature, placed on the role of firms' and agents' heterogeneity, the question has taken yet a further twist, namely that of the distributional consequences of monetary policy in the face of heterogeneous nominal rigidities.

One of the biggest challenges in answering this question lies in the quest of an exogenous measure of nominal rigidities. Recent literature has relied more increasingly on the use of micro-level data to provide granular metrics of nominal rigidities. Measures of nominal rigidities have

been constructed using price-level data. The latter however are not fully immune to endogeneity concerns. We go one step further in this direction. By relying on a unique confidential contract-level dataset for the Italian economy, we are able to construct a fully exogenous measure of wage rigidity based on a staggered lagged structure of the wage renegotiations. Italy is an excellent case study as, even contrary to most European countries where recent reforms had increased contract negotiation flexibility, collective bargaining is still the main operative mode. Our research question consists in assessing the impact of a monetary policy shock on valuations and employment levels when firms belong to sectors that experience different degrees of rigidity of wages, as set by sectorial labor unions. To this purpose, we also merge our contract-level dataset with stock market returns for the universe of Italian firms in our sample.

We find strong evidence that monetary policy shocks, identified at high frequency, have a significant impact on firms that are subject to wage rigidities. The impact is also more significant and stronger for firms with high labor intensity and low profitability. We rationalize our evidence with a dynamic multi-sector general equilibrium model in which firms face different degrees of wage rigidity as dictated by union bargaining and show that the model can rationalize and replicate the empirical evidence quite well.

We conclude by noticing that our empirical design and our model have a more general validity. Indeed, while we focus on the heterogeneous response of firms to aggregate monetary policy shocks, our basic empirical strategy and our laboratory economy can be adapted to study the response to other common events, such as trade shocks.

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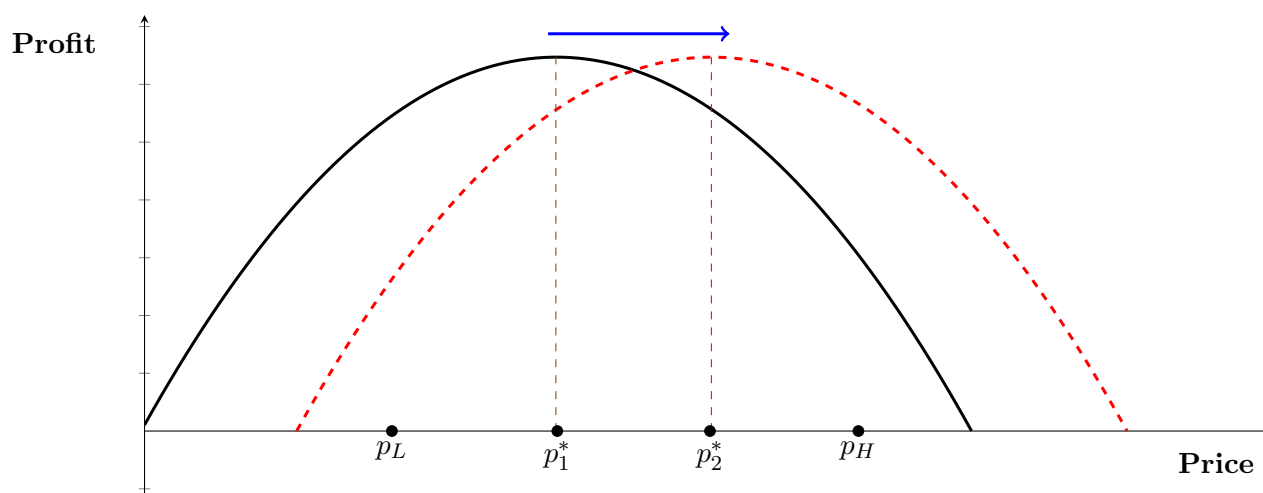
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## 8 Figures and Tables

**Figure 1**

**The Effect of an Expansionary Monetary Policy Shock on Firm Profit: An Example**  
Figure 1 presents the example described in Section 3. The solid black line and the dotted red line plot a firm's profit function before and after an expansionary monetary policy shock, respectively. The optimal price level shifts, accordingly, from  $p_1^*$  to  $p_2^*$ . If prices are rigid in the short run, a firm's profit may benefit or not from the shock, depending on whether its initial price level is too low ( $p_L$ ) or too high ( $p_H$ ). In the first case, the profit will decrease after the shock, in the second it will rise.



**Table 1**  
**Descriptive Statistics**

Table 1 has descriptive statistics for the main variables used in the paper. Return<sup>2</sup> is the squared stock return between 19:00 CET and 13:00 CET on announcement dates of ECB key target rates. MP<sup>2</sup> is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon. WR is a proxy for the average number of days left before the renewal of the relevant collective bargaining agreement. (See Section 4.3 for details.) Size is the logarithm of total assets. Leverage is given by non current liabilities plus current liabilities, all divided by total assets. ROA is earnings before interest and debt divided by total assets. Labor intensity is total monthly wage expenses divided by total assets.

	N	Mean	Median	St. Dev.	Min	Max
Return <sup>2</sup>	25,529	0.03	0.01	0.09	0.00	1.00
MP <sup>2</sup>	25,529	0.36	0.05	1.00	0.00	7.41
MP <sup>2</sup> × WR	25,529	1.63	0.08	5.29	0.00	50.72
WR	25,529	5.04	5.77	2.03	0.00	7.31
Time to Ren.	25,529	376.54	318.65	316.77	0.00	1,489.00
Size	25,529	6.64	6.23	2.08	2.84	12.96
Leverage	25,529	0.29	0.29	0.17	0.00	0.83
ROA	25,529	0.08	0.08	0.08	-0.19	0.31
Lab. Int.	25,529	7.27	7.49	1.60	3.33	10.00

**Table 2**  
**Baseline Results**

Table 2 presents regressions where the dependent variable is the squared firm's stock return between 13:00 CET and 19:00 CET.  $MP^2$  is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses (measured in the month previous to the announcement) over beginning-of-year total assets. Columns 4 through 6 also include firm and announcement date fixed effects. All the accounting control variables are measured at the beginning of the year. Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
$MP^2 \times WR$	0.017*** (0.006)	0.016*** (0.006)	0.016** (0.006)	0.022*** (0.006)	0.021*** (0.006)	0.021*** (0.006)
$MP^2$	0.040*** (0.007)	0.042*** (0.007)	0.045*** (0.007)			
$WR$	0.007 (0.008)	0.008 (0.007)	0.008 (0.007)	-0.001 (0.008)	-0.001 (0.008)	-0.002 (0.008)
Size		-0.020 (0.017)	-0.020 (0.017)		-0.048 (0.060)	-0.058 (0.058)
Leverage		0.033*** (0.012)	0.033*** (0.012)		0.021 (0.017)	0.022 (0.017)
ROA		-0.046*** (0.010)	-0.047*** (0.010)		-0.008 (0.018)	-0.009 (0.018)
Lab. Int.		0.026* (0.014)	0.027* (0.014)		-0.001 (0.030)	-0.001 (0.030)
$MP^2 \times Size$			-0.025*** (0.009)			-0.025*** (0.009)
$MP^2 \times Lev.$			0.005 (0.010)			0.004 (0.010)
$MP^2 \times ROA$			-0.010 (0.008)			-0.007 (0.009)
$MP^2 \times Lab.$			0.002 (0.009)			0.001 (0.009)
Observations	25,529	25,529	25,529	25,529	25,529	25,529
$R^2$	0.002	0.007	0.008	0.125	0.125	0.126
Controls		X	X		X	X
Controls $\times MP$			X			X
Time FE				X	X	X
Firm FE				X	X	X

**Table 3**  
**Robustness Tests**

Table 3 presents regressions where the dependent variable is the squared firm's stock return between 13:00 CET and 19:00 CET.  $MP^2$  is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon, except in columns 2 and 3, where we use the 6-month and the 3-month swap, respectively.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include, as control variables, size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. In columns 4 through 6, regressions also include industry dummies interacted with  $MP^2$ . In columns 4, 5 and 6, industries are defined using the 1, 2 or 3-digit NACE classification, respectively. Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

	Using Different Measures of MP Shocks:			Controlling for Industry FE×Shock:		
	1-Year Swap	6-Mo Swap	3-Mo Swap	1-Digit NACE	2-Digit NACE	3-Digit NACE
$MP^2 \times WR$	0.021*** (0.006)	0.022*** (0.006)	0.023*** (0.009)	0.020*** (0.006)	0.019*** (0.006)	0.020*** (0.006)
$WR$	-0.002 (0.008)	-0.002 (0.008)	-0.002 (0.008)	-0.002 (0.008)	-0.005 (0.008)	-0.008 (0.009)
Observations	25,529	25,529	25,529	25,529	23,089	19,529
$R^2$	0.126	0.126	0.126	0.126	0.130	0.139
Controls	X	X	X	X	X	X
Controls× $MP^2$	X	X	X	X	X	X
Time FE	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X
Ind. FE× $MP^2$				X	X	X

**Table 4**  
**The Effect of Labor Intensity**

Table 4 presents regressions where the dependent variable is the squared firm's stock return between 13:00 CET and 19:00 CET.  $MP^2$  is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include as control variables size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. Columns 1 and 2 include firms that have labor intensity below and above the sample median, respectively. In columns 3 and 4 the proxy for labor intensity is given by total days worked divided by total assets. The numerators of both proxies are measured in the month previous to the announcement date, whereas total assets are measured at the beginning of the year. Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

	<i>Sorting by:</i>			
	Wages / Assets		Days Worked / Assets	
	Low (1)	High (2)	Low (3)	High (4)
$MP^2 \times WR$	0.014 (0.009)	0.029*** (0.010)	0.013 (0.008)	0.027*** (0.010)
$WR$	-0.007 (0.011)	0.000 (0.012)	-0.010 (0.010)	0.006 (0.012)
Observations	12,763	12,752	12,764	12,759
$R^2$	0.178	0.106	0.178	0.109
Controls	X	X	X	X
Controls $\times MP$	X	X	X	X
Time FE	X	X	X	X
Firm FE	X	X	X	X

**Table 5**  
**Firm's Performance and Business Cycle**

Table 5 presents regressions where the dependent variable is the squared firm's stock return between 13:00 CET and 19:00 CET.  $MP^2$  is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include as control variables size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. Columns 1 and 2 include firms that have ROA below and above the sample median, respectively. In columns 3 and 4 the sorting variable is the quarterly GDP growth. Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

	<i>Sorting by:</i>			
	ROA		GDP Growth	
	Low (1)	High (2)	Low (3)	High (4)
$MP^2 \times WR$	0.027*** (0.009)	0.014 (0.010)	0.024*** (0.008)	0.004 (0.010)
$WR$	-0.013 (0.011)	0.003 (0.011)	0.007 (0.011)	-0.012 (0.012)
Observations	12,810	12,710	12,829	12,688
$R^2$	0.135	0.142	0.133	0.135
Controls	X	X	X	X
Controls $\times MP$	X	X	X	X
Time FE	X	X	X	X
Firm FE	X	X	X	X

**Table 6**  
**Placebo Test**

Table 6 presents regressions where the dependent variable is the squared firm's stock return between 13:00 CET and 19:00 CET on the days prior to the monetary policy announcement dates.  $MP^2$  is the square of the change in the 1-year Euro Overnight Index Average (EONIA) swap rate over the same time horizon.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include as control variables size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. Column 1 includes the full sample. Columns 2 and 3 include firms that have labor intensity below and above the sample median, respectively. In columns 4 and 5 the proxy for labor intensity is given by total days worked divided by total assets. The numerators of both proxies are measured in the month previous to the announcement date, whereas total assets are measured at the beginning of the year. Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

	Sorting by:				
	Baseline	Wages / Assets		Days Worked / Assets	
		(1)	Low (2)	High (3)	Low (4)
$MP^2 \times WR$	-0.003 (0.008)	-0.003 (0.010)	-0.008 (0.014)	-0.001 (0.009)	-0.008 (0.011)
$WR$	0.003 (0.007)	0.006 (0.011)	-0.007 (0.011)	0.007 (0.011)	-0.002 (0.010)
Observations	25,043	12,491	12,544	12,487	12,544
$R^2$	0.089	0.102	0.1	0.104	0.098
Controls	X	X	X	X	X
Controls $\times MP$	X	X	X	X	X
Time FE	X	X	X	X	X
Firm FE	X	X	X	X	X

**Table 7**  
**Labor Outcomes**

Table 7 presents regressions where the dependent variables are several employment outcomes, measured at the quarterly horizon.  $MP^2$  is the square of the weighted sum of changes in the 1-year Euro Overnight Index Average (EONIA) swap rate over the quarter.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include as control variables size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. The dependent variables are the symmetric growth rates of: total wage payments (column 1), total days worked (column 2), total number of employees (column 3), total number of employees with at least 20 days worked in the month (column 4). Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

<i>Dep. Var.</i>	$\Delta$ Pay	$\Delta$ Days Worked	$\Delta$ Employees	$\Delta$ Full Time Employees
	(1)	(2)	(3)	(4)
$MP^2 \times WR$	0.033*** (0.013)	0.029** (0.014)	0.037** (0.015)	0.015 (0.013)
$WR$	0.002 (0.009)	0.017 (0.012)	0.019* (0.011)	0.010 (0.012)
Observations	12,495	12,495	12,495	12,495
$R^2$	0.409	0.229	0.216	0.225
Controls	X	X	X	X
Controls $\times MP^2$	X	X	X	X
Time FE	X	X	X	X
Firm FE	X	X	X	X



**Table 8**  
**Labor Outcomes: Placebo test**

Table 8 presents regressions where the dependent variables are several employment outcomes, measured at the quarterly horizon and lagged one quarter.  $MP^2$  is the square of the weighted sum of changes in the 1-year Euro Overnight Index Average (EONIA) swap rate over the quarter.  $WR$  is a measure of wage rigidity. (See Section 4.3 for details.) All regressions include as control variables size, leverage, ROA and labor intensity, both as standalone variables and interacted with  $MP^2$ , all measured at the beginning of the year. Size is the logarithm of total assets. Leverage is the sum of debt in current liabilities and debt in non current liabilities, with all divided by total assets. ROA is the ratio of EBITDA over total assets. Labor intensity is the ratio of wage expenses over total assets. All the regressions include firm and announcement date fixed effects. The dependent variables are the symmetric growth rates of: total wage payments (column 1), total days worked (column 2), total number of employees (column 3), total number of employees with at least 20 days worked in the month (column 4). Standard errors, in parentheses, are clustered at the firm level. \*\*\*, \*\*, and \* indicate statistically different from zero at the 1%, 5%, and 10% level of significance, respectively.

<i>Dep. Var.</i>	$\Delta\text{Pay}_{t-1}$	$\frac{\Delta\text{Days}}{\text{Worked}_{t-1}}$	$\Delta\text{Employees}_{t-1}$	$\frac{\Delta\text{Full Time}}{\text{Employees}_{t-1}}$
	(1)	(2)	(3)	(4)
$MP^2 \times WR$	-0.022 (0.015)	-0.004 (0.018)	-0.017 (0.023)	-0.017 (0.023)
$WR$	0.001 (0.009)	0.007 (0.012)	0.010 (0.012)	0.003 (0.012)
Observations	12,095	12,095	12,095	12,095
$R^2$	0.402	0.229	0.216	0.225
Controls	X	X	X	X
Controls $\times MP^2$	X	X	X	X
Time FE	X	X	X	X
Firm FE	X	X	X	X

**Table 9**  
**Model Calibration**

Table 9 presents, for each parameter of the model presented in Section 6, the value chosen for the calibration with the relevant source.

	<b>Value</b>	<b>Description</b>	<b>Source</b>
$\beta$	0.99	Discount factor	Standard
$b_W$	1.5	Response coefficient in mon. pol. rule	Standard
$\sigma$	2	Coefficient of relative risk aversion	Standard
$\eta$	1.17	Inverse Frisch labor elasticity	Fernández-Villaverde et al. (2010)
$\epsilon_p$	10	Elasticity of substitution of goods	Fernández-Villaverde et al. (2010)
$\epsilon_w$	10	Elasticity of substitution of labor services	Fernández-Villaverde et al. (2010)
$\rho_i$	0.77	Smoothing parameter in mon. pol. rule	Fernández-Villaverde et al. (2010)
$f^s$	1/S	Sector shares	Avg. renegotiation time in data
$S$	8	Number of sectors	Avg. renegotiation time in data
$\sigma^i$	0.0043	Volatility of monetary policy shock	Gorodnichenko and Weber (2016)
$h$	0.815	Internal consumption habit	Gertler and Karadi (2013)
$\xi$	2.015	Hiring cost parameter	Cooper and Willis (2009) (avg.)

**Table 10**  
**Regression Coefficients Estimated on Artificial Data**

Table 10 presents coefficients estimated on an artificial dataset generated by the model described in Section 6, with parameter values calibrated using the values indicated in Table 9. In column 1 the dependent variable is the firm stock return squared. In column 2 it is the symmetric growth rate of employment squared. The regressors are the wage rigidity proxy, the monetary policy shock and an interaction term of the two. Only the coefficients associated to the latter regressor are showed. In the first row the coefficients are estimated on a simplified version of the model that has neither an habit component in the utility function, nor hiring costs. The second row presents data generated from the fully specified model. In the third row the model is identical but the relative risk aversion parameter is increased from 2 to 2.15.

<b>Specification</b>	<b>Stock Return</b>	<b>Employment Growth</b>
Baseline	0.132*** (0.011)	0.084*** (0.012)
...plus habit and hiring costs	0.033*** (0.012)	0.071*** (0.012)
...plus habit and hiring costs, relative risk aversion = 2.15	0.025** (0.012)	0.056*** (0.012)

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