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## Abstract

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# THE LINK BETWEEN MONETARY POLICY AND THE LABOR SHARE—NEW EMPIRICAL EVIDENCE AND THEORETICAL CONSIDERATIONS

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Abstract. Using a structural VAR with a relatively agnostic identification based on narrative sign restrictions, this paper, in line with recent empirical evidence, documents an increase in the labor share following restrictive monetary policy in the euro area. We then complement the empirical analysis with a theoretical investigation that provides mechanisms linking monetary policy and the labor share—a connection that has so far been regarded as lacking an explanation. Specifically, we show that the observed responses of the labor share, real wages, and productivity to a monetary policy shock can be reconciled within an otherwise standard New Keynesian framework once capital accumulation is introduced and both nominal and real frictions—in particular, labor adjustment costs—are incorporated.

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Key words: Monetary policy, labor share, euro area, structural VAR, New-Keynesian model, labor market frictions

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## 1. INTRODUCTION

In the wake of a sharp increase in inflation, the European Central Bank (ECB) has tightened its monetary policy at an unprecedented pace and scale, raising its policy rate by 4.5 percentage points within just 14 months from mid-2022 onward. A striking empirical observation following this monetary tightening is that the labor share in national income and real wages have increased, while labor productivity has declined or, at best, remained flat (see Appendix A). These stylized facts are noteworthy because all three variables—the labor share, real wages, and labor productivity—moved in exactly the opposite direction from what the textbook New-Keynesian (NK) model would predict (Galí, 2015, Chapter 3).

Clearly, wages, productivity and the labor share were affected by many other macroeconomic developments and shocks. But even if the effects of monetary policy on labor market variables have been masked by other factors, the question remains as how monetary policy impacts the labor market given these remarkable developments.

The tension between the canonical macroeconomic framework and the broader empirical evidence has been highlighted prominently by Cantore et al. (2021) for the U.S., the euro area, the U.K., Australia, and Canada. Using a structural vector autoregression (VAR) and two alternative identification strategies (external instruments and recursive ordering) they document an increase in the labor share following a restrictive monetary policy shock and conclude that "*either NK models are unable to separate the dynamics of the labor market from the markup, or markups do not respond in the way NK models predict.*"

Given the lack of a clear consensus on how monetary policy affects the labor share—and the limited empirical evidence available—the distributional implications of monetary policy remain an open and policy-relevant question that warrants further investigation. This paper seeks to advance the analysis of the transmission of monetary policy to labor-market outcomes from both an empirical and a theoretical perspective. In doing so, it contributes to a relatively young strand of the literature on the labor share that emphasizes its cyclical behavior, with Cantore et al. (2021) representing the seminal contribution.[1] Our line of investigation builds directly on their work and aims to provide the missing link identified therein. Thereby, our analysis proceeds in two stages.

In our empirical analysis, we reassess the findings of Cantore et al. (2021) for the euro area, its (founding) member states, and its various economic sectors, using an alternative, more agnostic identification strategy. Providing such supplementary evidence seems warranted since the structural VARs have to be estimated using quarterly data, given that labor share series are not available at a higher frequency. This makes identification schemes that are based on timing assumptions (recursive ordering of variables) or high-frequency instruments potentially problematic.

Our empirical strategy builds on Badinger and Schiman (2023) and exploits a small set of large monetary policy shocks, i.e., surprising interest rate decisions by the ECB, which are identified at the monthly frequency and subsequently aggregated to the quarterly level. To achieve strong identification and avoid aggregation issues (from which the classical high-frequency approach may suffer), we select the largest surprises from those quarters only, in which all monthly surprises (if more than one) point in the same direction and therefore do not offset one another. A supplementary narrative analysis ensures that these interest rate surprises constitute conventional monetary policy shocks rather than central bank information effects.

The directions of these monetary policy shocks—restrictive or expansionary—inform the sign restrictions placed on the corresponding structural residuals in the monetary policy equation of our structural VAR. In doing so, we advance the relatively young, but rapidly growing literature on so-called “narrative identification” or “narrative VARs” (cf. Antolín-Díaz and Rubio-Ramírez, 2018, for the seminal paper in this regard). Narrative restrictions to identify monetary policy shocks in the euro area have been used not only by Badinger

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[1] In contrast, a large body of literature has long examined the structural determinants and long-term evolution of the labor share. Prominent historical contributions include those of Keynes (1939), Kaldor (1955) and Solow (1958), which revolve around whether the (U.S.) labor share had been stable over time or not. More recent contributions, meanwhile, investigate its secular decline. This decline, however, is not ubiquitous but rather confined to the United States and a few other economies. For an overview see Karabarbounis (2024) and the literature cited therein.

and Schiman (2023), who use them as the sole source of identification, but also by Neri (2023) and Reichlin et al. (2023), who use narrative restrictions in conjunction with traditional sign restrictions on impulse responses to sharpen inference.

Apart from the textbook effects—a decline in real output and prices and an appreciation of the euro—we find that a monetary tightening reduces total hours worked by less than real output, generating a fall in labor productivity. At the same time, it raises real hourly wages because nominal wages decline only marginally—if at all—while prices fall more markedly. Taken together, the increase in real wages and the decline in labor productivity lead to a temporary rise in the labor share, corroborating the findings of Cantore et al. (2021) for the euro area. We further show that these patterns hold across all founding members of the euro area and are particularly pronounced in the manufacturing sector.

We then develop a theoretical framework that rationalizes the empirical responses of the labor share, real wages, and productivity to a monetary policy shock within an otherwise standard New-Keynesian (NK) model. The fundamental challenge is the tight link, embedded in textbook formulations, between the labor share and real marginal costs: when labor is the sole input to production and the production function exhibits diminishing returns, the labor share is, up to a constant of proportionality, simply equal to marginal costs (or equivalently, to the inverse of the price markup). A monetary contraction lowers marginal costs and raises the markup, so the labor share must fall, in direct contradiction with the data. Breaking this mechanical link is the central modeling task. We achieve it through two complementary departures from the canonical model: the introduction of capital accumulation as a second factor of production, and a parsimonious set of frictions in which real labor-adjustment costs play the leading role.

The first departure is motivated by an analytical decomposition that we derive. For any homogeneous production function of degree one with capital ($k$) and labor ($h$) as inputs, Euler's theorem implies that the labor share equals real marginal costs scaled by the wedge which is made up of the marginal product of capital and its average product. A fall in marginal costs no longer translates one-for-one into a fall in the labor share. Adding capital therefore opens a margin through which a monetary shock can move the labor share independently of marginal costs.

The second and decisive ingredient is the set of frictions that govern factor adjustment. Our framework embeds three of them: price stickiness in product markets, wage stickiness in labor supply, and a real friction in the form of convex employment adjustment costs. The first two are standard nominal rigidities in the New-Keynesian tradition (Rotemberg, 1982; Erceg et al., 2000; Christiano et al., 2005; Smets and Wouters, 2003, 2007). The third—an employment adjustment cost—is the central novelty of our framework relative to the workhorse NK model. It gives rise to a wedge between the real wage and the marginal product of labor that is distinct from the price-markup wedge. When all three frictions are switched off and only capital is retained, our framework collapses to a standard Real Business Cycle model, providing a clean benchmark against which to assess the role of each ingredient (King and Rebelo, 1999).

This combination of ingredients resolves the labor-share puzzle through a specific mechanism. Following a contractionary monetary shock, employment adjustment costs lead firms to smooth the path of employment rather than dismiss workers immediately—reflecting either labor hoarding or institutional rigidities. Real marginal costs of production decline, as in the standard NK model, putting downward pressure on prices and raising markups; yet real hourly wages rise because nominal wages adjust only mildly while prices fall by more. Because hours worked adjust more slowly than output, labor productivity declines temporarily. The wedge between marginal costs and the real wage, opened by the employment-adjustment friction, is precisely what allows these otherwise conflicting movements to coexist with a rise in the labor share. We document that, even when wage stickiness is calibrated to be substantially larger than price stickiness, the absence of an employment-adjustment friction prevents the model from generating a positive response of the labor share.

The friction therefore identifies a margin that the canonical NK framework, however refined in its nominal block, structurally lacks.

Our theoretical contribution thus speaks to three strands of literature. It complements the recent debate on the cyclicality of the labor share—where Cantore et al. (2021) document the aggregate puzzle and Steininger and Fritsche (2025) provide firm-level evidence—by supplying the structural mechanism that the canonical NK framework had so far been missing. It enriches the New-Keynesian literature on the transmission of monetary policy to factor markets by elevating a real friction—the cost of adjusting employment—to a role comparable in importance to that of nominal rigidities in prices and wages (Galí and Gertler, 1999; Christiano et al., 2005; Erceg et al., 2000). And by stressing the institutional features of (European) labor markets as a key amplifier of monetary transmission, it dovetails with the work of Boeck and Glocker (2025) and feeds into the broader debate on the distributional consequences of monetary tightening (Coibion et al., 2017).

The remainder of the paper is organized as follows. Section 2 sets up the empirical model, motivates our identification strategy, and presents the estimation results for the euro area; country- and sector-specific results are relegated to the appendix. Section 3 develops the theoretical model. It first explores analytically how introducing capital as a second factor of production can decouple the labor share from marginal costs, before laying out a New-Keynesian framework with nominal rigidities, capital accumulation, and labor-adjustment frictions. The model is calibrated to standard values and then used to dissect the role of each friction, the elasticity of substitution between capital and labor, and the source of wage-setting power in the labor market. Section 3 closes by estimating the structural parameters through impulse-response matching, which quantifies the contribution of each friction and discriminates between the monopolistic and monopsonistic specifications. Section 4 concludes.

## 2. EMPIRICAL EVIDENCE FOR THE EURO AREA

This section outlines our econometric framework and identification strategy, based on residual sign restrictions, and presents the estimation results for the euro area as a whole. Country- and sector-specific results are given in Appendices B and C, along with a discussion and comparison of the results using alternative identification strategies.

### 2.1. Econometric Framework.

To examine the empirical relationship between monetary policy and the labor share, we employ a standard VAR augmented with labor-market variables, the structural form of which is given by

$$\boldsymbol{B}\boldsymbol{y}_t = \boldsymbol{B}\boldsymbol{c} + \sum_{i=1}^{L} \boldsymbol{B}\boldsymbol{A}_i\boldsymbol{y}_{t-i} + \boldsymbol{B}\boldsymbol{u}_t, \tag{1}$$

where $\boldsymbol{y_t}$ is the $K \times 1$ vector of observations on the endogenous variables in time period (quarter) $t$. The right-hand side includes a $K \times 1$ vector of constants, $\boldsymbol{c}$, and $i = 1, \dots, L$ time lags of the vector of endogenous variables, $\boldsymbol{y}_{t-i}$, with corresponding $K \times K$ parameter matrices $\boldsymbol{A}_i$, and $\boldsymbol{u}_t$ is a $K \times 1$ vector of errors, which are assumed to be independently and normally distributed, $\boldsymbol{u}_t \sim \mathcal{N}(\boldsymbol{0}, \boldsymbol{V})$. We set the lag length to $L = 4$ quarters.

The matrix $\boldsymbol{B}$ is the structural parameter matrix that governs the instantaneous relationships between the model variables. It is chosen such that $\boldsymbol{B}\boldsymbol{u}_t = \boldsymbol{w}_t \sim \mathcal{N}(\boldsymbol{0}, \boldsymbol{I})$ and some identifying restrictions (discussed in subsection 2.3) are satisfied.

### 2.2. Variables and Data.

Our baseline VAR includes eight variables: the 1-week Euribor, real GDP, the GDP deflator, a corporate bond spread, M1 (narrow money), the euro–dollar exchange rate, total labor income, and total hours worked. All variables are in natural log form, with the exception of the interest rate and the corporate bond spread. For reasons of data availability—specifically, the labor share, which is central to our analysis—our VAR is estimated using quarterly data.[2]

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[2] The data were retrieved from Macrobond and FRED. Primary data sources are: European Money Markets Institute (interest rate, GDP), the ECB (M1, exchange rate) and ICE Data Indices (corporate bond spread, defined spread between euro-denominated bonds below investment grade and the Treasury rate). Financial market variables (the corporate bond spread, interest rates and the exchange rate) are available at higher frequencies and measured as quarterly averages.

We regard our specification as sufficiently broad to capture the key macroeconomic variables and relationships needed to assess the effects of monetary policy, particularly on the labor market. Thereby, we opt for including the constituent components of the labor share—labor income and nominal GDP—separately rather than relying solely on an aggregate labor-share measure itself. This allows to more clearly distinguish the transmission channels through which monetary policy affects factor payments and output. In addition, it offers a more nuanced and differentiated input for the theoretical framework that will be developed in Section 3, where we explore potential extensions to the standard NK model required to reconcile it with the empirical evidence. We emphasize that results are robust to including the labor share directly in the specification, which we show in Appendix D.

Having estimated the model, we can readily infer the implied impulse responses for the variables that constitute the main focus of this paper (expressed in natural logs): (i) the labor share, defined as labor income minus nominal GDP (itself given by the sum of real GDP and the GDP deflator); (ii) labor productivity, given by real GDP minus hours worked; and (iii) real wages, defined as labor income minus the GDP deflator and hours worked.

The baseline sample covers the period from 1999-Q1 to 2019-Q4, comprising 84 quarters. We cut the sample before 2020-Q1 to avoid the effective-lower-bound period that the ECB faced during the Covid pandemic, and to prevent the strong monetary tightening as of 2022 to dominate the results. In Appendix E, we consider an extended sample, running from 1999-Q1 to 2025-Q3.

2.3. **Identification.** Our methodological approach follows Antolín-Díaz and Rubio-Ramírez (2018), who apply 'narrative' sign restrictions to selected structural VAR residuals at dates associated with exogenous shocks. For our application to euro area data, we draw on Badinger and Schiman (2023). They identify monetary policy shocks (on a monthly basis) through unusually large movements in EONIA swap rates within narrow windows around ECB policy announcements. Their complementary narrative analysis determines the direction of each shock (restrictive or expansionary) and its nature (conventional monetary policy or central bank information shock). For the period

1999–2019, they identify 15 major interest-rate surprises, 14 of which turn out the be conventional monetary policy shocks.

Mapping their monthly shocks to a quarterly frequency is, in principle, straightforward (see, e.g., Eichenbaum et al., 2022; Ottonello and Winberry, 2020 for U.S. applications). However, identification may be weakened, when multiple large shocks, offsetting each other, occur within the same quarter. Hence, for a quarterly-frequency interest rate surprise to unambiguously qualify as a large, conventional monetary policy shock, we impose two conditions that must be satisfied:

1. At least one month in the quarter must feature a 'large' shock, as classified by Badinger and Schiman (2023).
2. If multiple large shocks occur within the same quarter, they must all reflect conventional monetary policy and be of the same direction (restrictive or expansionary).

Application of this procedure yields six "quarterly large shocks", each (coincidentally) stemming from a single monthly large shock within that quarter. Table 1 summarizes these quarterly large shocks, together with a brief narrative analysis.

These shocks form the basis for identification of our structural VAR given by equation (1). Specifically, we impose three positive and three negative sign restrictions on the structural residuals $\omega_{1,t}$ of the first equation.[3] In addition, we impose the innocuous, essentially definitional restriction that the impulse response of the interest rate to a restrictive shock is positive. While this is not material to our main findings, it improves computational efficiency and enhances the precision of the estimates (i.e., it narrows down the credible sets of the impulse responses).

The key advantage of this identification strategy is its deliberately agnostic nature: It avoids imposing theory-based structural relationships a priori and instead exploits clear (quantitative and narrative) information on the timing and direction of major monetary policy shocks. In Appendix H, we show that two other widely used identification approaches—instrumental variables based

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[3] The choise of the first as monetary policy equation is without loss of generality.

Table 1. Quarterly large interest rate surprises in the euro area, 1999-2019

| Date | Sign | Description |
|---|---|---|
| 2003-Q1 | + | Mar. 6, 2003: In the run-up to this meeting, President Duisenberg pointed to rising uncertainty, a weaker outlook and easing inflationary pressures. The markets read these and similar comments as foreshadowing a sizeable cut after two months on hold. When the ECB cut rates by only 25bps, investors expecting 50bps were disappointed. |
| 2003-Q2 | − | Jun. 5, 2003: A substantial rate cut was widely urged by economists and market participants, and it was delivered with a 50bp move. However, the market reaction revealed lingering doubts about the ECB's willingness to act: Given its record of caution, many had feared a smaller move, so the implementation still took investors by surprise. |
| 2009-Q2 | + | Apr. 2, 2009: The ECB cut its main rate by 25 bps to 1.25%, disappointing markets that had largely expected a 50 bps move; only a handful of surveyed economists foresaw the smaller step. Observers argued the ECB hesitated to approach a zero-interest policy, effectively postponing what seemed inevitable. |
| 2012-Q3 | − | Jul. 5, 2012: The ECB cut all three rates by 25 bps, bringing the deposit rate to zero. While the easing was expected, the across-the-board cuts—especially to zero on deposits—surprised markets and signaled experimentation. Draghi's pledge later that month to "do whatever it takes to preserve the euro" did not move the monthly average of EONIA. |
| 2014-Q3 | − | Sep. 4, 2014: After signaling in August 2014 that rates would remain unchanged for an extended period, the ECB surprised analysts by cutting all key rates by 10 basis points. Earlier, in June, after pushing the deposit rate below zero, the bank had indicated that it was at the effective lower bound. September's decision was not unanimous. |
| 2015-Q4 | + | Dec. 3, 2015: Markets were disappointed when the ECB delivered less easing than expected, cutting the deposit rate only from -0.20% to -0.30% despite persistent undershooting of inflation and prior signals of strong action. Some observers said Draghi had deliberately raised expectations to pressure a divided Governing Council, and many investors had expected a larger rate cut. |

Note: A negative sign denotes an expansionary shock, a positive sign a restrictive shock. Source of the monthly shocks and narrative analysis is Badinger and Schiman (2023), online Appendix C.

on high-frequency data and recursive identification schemes—deliver inconclusive results with quarterly data for the euro area. By contrast, our findings can be closely replicated when one is willing to impose a limited set of largely standard sign restrictions on the impulse responses of interest rates, prices, the money stock, and the exchange rate.

2.4. **Estimation.** We estimate the SVAR in Equ. (1) with standard Bayesian techniques, employing an independent Normal-Wishart prior with Minnesota-style shrinkage of the prior parameter variance-covariance matrix $\boldsymbol{V_A}$. $\boldsymbol{A} = (\boldsymbol{c}, \boldsymbol{A}_1, \ldots, \boldsymbol{A}_L)$ is of dimension $K \times (KL+1)$ and $\boldsymbol{V_A}$ is assumed diagonal, implying independent parameters. With regard to the $K^2L + K$ diagonal elements $v_{ii,\boldsymbol{A}}$, we set a flat prior variance on intercepts, $v_{ii,\boldsymbol{A}} = 100$, and decreasing prior variances on lag parameters, $v_{ii,\boldsymbol{A}} = \kappa_1 \cdot l^{-2}$ for own lag $l$ and $v_{ii,\boldsymbol{A}} = \kappa_2 \cdot l^{-2} \cdot \hat{\sigma}^2_{ii}/\hat{\sigma}^2_{jj}$ for lags of other variables, where the scaling parameter $\hat{\sigma}^2_{ii}/\hat{\sigma}^2_{jj}$ is the ratio of estimated error variances of univariate AR($L$) models for variables $i$ and $j$. The hyperparameters are set to $\kappa_1 = 0.1$ and $\kappa_2 = 0.5 \cdot \kappa_1$ to achieve sufficient shrinkage.

The prior mean of AR(1) parameters in the VAR is set to one, while all other slope parameters, including the constant, are set to zero. Hence, the model estimates are shrunk towards a multivariate random walk. This is a reasonable assumption given the non-stationary nature of the variables at hand, but the results are virtually unchanged if the prior mean of the AR(1) parameters is set to zero, i.e., the estimated model is shrunk towards a multivariate white noise process.

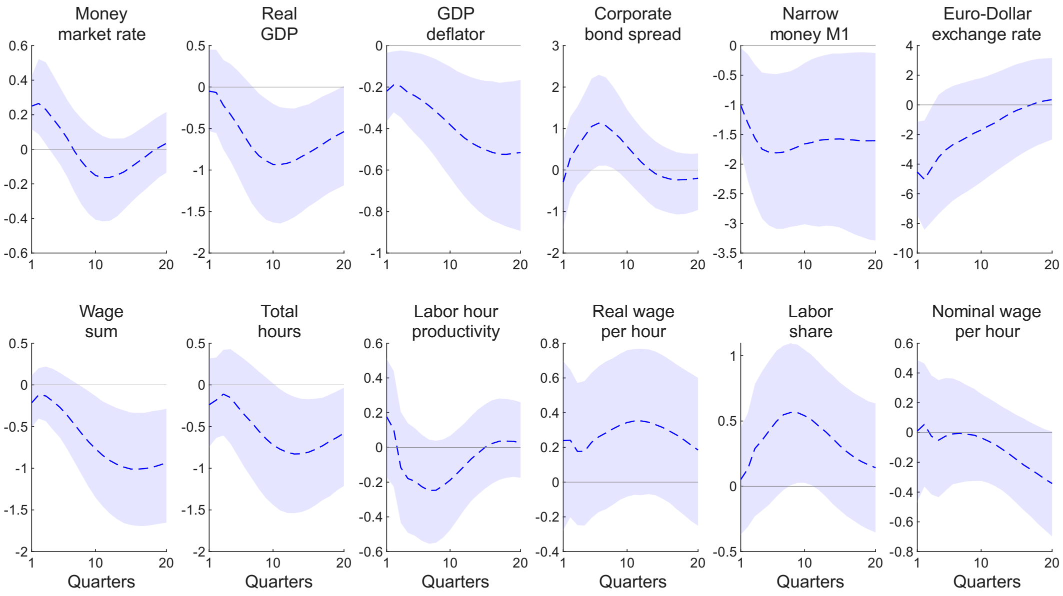
In selecting structural parameter matrices $\boldsymbol{B}$ that satisfy the sign and magnitude restrictions we apply the well-established procedure proposed by Rubio-Ramírez et al. (2010) for set-identified models (see also Kilian and Lütkepohl, 2017). Specifically, we randomly draw a square orthogonal matrix from a multivariate Normal distribution and multiply it with the Cholesky factor of $\boldsymbol{V}$ to obtain independent shocks. If a candidate draw does not satisfy the sign and magnitude restrictions on the structural residuals, it is discarded, otherwise it is retained. In line with the recommendation by Giacomini et al. (2021) we use the unconditional likelihood to construct the posterior, i.e., we abstain from importance sampling. Sampling stops when 5,000 valid draws are collected.

2.5. **Results.** Estimation results for our baseline specification—based on sign restrictions on six structural residuals and one impulse-response sign restriction, as described in Section 2.3—are reported in Figure 1. The dashed blue line and the shaded blue area depict the posterior median and the 68% credible region of the impulse responses of the eight model variables to a restrictive monetary policy shock over a five-year horizon.

Focusing on the core macroeconomic variables, we find a dampening but delayed effect on real GDP. On average, the maximum output response occurs approximately two and a half to three years after the shock and corresponds to a decline of about three-quarters of a percent, when the impact response of the money market rate is normalized to 25 basis points. When considering the 90% credible region, the estimated output response ranges from zero to -2 percent. The GDP deflator also declines following the shock, with the effect gradually intensifying over time. The corporate bond spread does not respond immediately but increases with a delay before gradually reverting to its pre-shock level, consistent with the evidence reported by Jarociński and Karadi (2020) for the euro area. Finally, narrow money contracts following a conventional monetary policy tightening, while the exchange rate declines, corresponding to an appreciation.

Turning to the labor market variables, we find that an unanticipated monetary policy tightening leads to a decline in both total labor income and total hours worked, with effects materializing after a delay of several quarters. Because total hours adjust more gradually than real GDP, labor productivity temporarily deteriorates. Over the first three years following the shock, total labor income and total hours worked follow similar downward trajectories, leaving nominal hourly wages broadly unchanged. Subsequently, nominal hourly wages begin to decline as total hours recover, while total labor income remains depressed for a longer period. Since prices fall more rapidly and by a larger magnitude than wages, real hourly wages increase.

Figure 1. Impulse responses to a restrictive monetary policy shock



Note: Dashed lines are median impulse responses, shaded areas correspond to 68% credible sets.

It is reassuring that our results are robust both at the country and the sectoral level. Appendix B reports estimates for individual euro area countries. While some variation in the identified effects naturally emerges, the qualitative conclusions remain consistent with our baseline euro area results. The sectoral analysis presented in Appendix C further corroborates our findings at the macro-level, with the manufacturing sector contributing most strongly to the aggregate responses.

It should be mentioned that recent firm-level evidence points to a decline in the labor share following restrictive monetary policy shocks (Steininger and Fritsche, 2025), whereas we document an increase at the aggregate level. Such differences may reflect variation in identification strategies and measurement, which can affect the estimated transmission of monetary policy, but do not necessarily imply a contradiction. The labor share is not an additive object, and its aggregate response reflects both within-firm adjustments and changes in the composition of activity across firms. Accordingly, firm-level declines can coexist with aggregate increases once one accounts for heterogeneous adjustment margins and endogenous aggregation. While micro-level responses primarily operate through cost adjustments, our results emphasize nominal rigidities and differential adjustment speeds of wages and hours, giving rise to rising real wages and declining productivity.

## 3. The theoretical model

Our empirical results imply that, following a restrictive monetary policy shock, the real wage tends to rise while labor productivity declines, both of which give rise to an increase in the labor share. Such findings stand in contrast to the canonical three-equation New Keynesian (NK) model, according to which a monetary contraction raises the real interest rate, causing households to postpone consumption (due to an intertemporal substitution effect) which reduces current demand and in turn output and inflation (Galí, 2015). Lower output reduces labor demand and, subsequently, the real wage. Additionally, under the assumption of a declining marginal product of labor, output is predicted to drop by less than employment, pushing up labor productivity. The drop in the real wage and the rise in labor productivity induce a unique fall in the labor share, all of which conflict with our empirical evidence.

To rationalize these empirical results, we begin by focusing on the labor share ($s_L$), defined as

$$s_L = \frac{Wh}{Py} = \frac{w}{y/h} \tag{2}$$

where $W$ is the nominal wage, $h$ is employment (total hours worked), $P$ is the price level, $w = W/P$ is the real wage and $y$ is output. To resolve this inconsistency, it is instructive to revisit a key element in the New Keynesian model, that is, the equation for firms' labor demand, given by

$$mc = \frac{w}{mpl}, \tag{3}$$

where $mc$ denotes real marginal costs and $mpl$ is the marginal product of labor. Consider, for example, a decreasing-returns-to-scale Cobb-Douglas production function $f(h)$ where $mpl \propto y/h$. It follows that

$$s_L \propto mc \tag{4}$$

and the labor share responds in tandem with marginal costs.[4] Given that a decline in marginal costs is a central initial effect of a monetary contraction (equivalently, the price markup $\mu^p = 1/mc$ rises), this mechanism straightforwardly translates into a fall in the labor share. Consequently, reconciling an increase in the labor share in response to a monetary contraction requires enriching the theoretical framework to relax the implied, somewhat mechanical link between wages, productivity, and the labor share.

For a more general homogeneous production function with two input factors—labor ($h$) and physical capital ($k$)—and a degree of homogeneity equal to one, Euler's theorem implies, via equation (3), that

$$s_L = mc \left(1 - \frac{mpk}{y/k}\right) \tag{5}$$

where $mpk$ is the marginal product of capital and the term $\frac{mpk}{y/k}$ is the ratio of the marginal product of capital to the average product of capital, which is less than one if the production function has diminishing returns to capital. Consequently, a fall in marginal costs, ceteris paribus, raises the labor share if $\frac{mpk}{y/k}$ decreases, that is, the marginal product of capital must fall relative to its average product. For example, if lower marginal costs encourage significant capital accumulation, but diminishing returns to capital set in quickly, $mpk$ could fall faster than $y/k$ rises, causing the ratio $\frac{mpk}{y/k}$ to decrease.

This discussion leads to two important conclusions for reconciling the empirical finding that the labor share rises after a restrictive monetary policy shock. First, the production function must include an additional input factor, for instance, capital ($k$), alongside labor ($h$). Second, the productivity of this additional factor must decrease sufficiently to enable an increase in the labor share. Even more important than capital as a second input, however, are labor market frictions, which will be discussed in more detail when the theoretical model is introduced.

3.1. **General model outline.** We formalize the central insight from the preceding discussion within a theoretical model. For the remaining elements,

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[4] In the simple case of a production function with a labor elasticity in output of $1-\alpha$, we have that $mpl = (1-\alpha)y/h$ and the proportionality factor is hence $1-\alpha$ implying that $s_L = (1-\alpha)mc$.

we adhere to Ockham's razor (Ariew, 1976), also known as the Principle of Parsimony, which favors theoretical simplicity. Consequently, our modeling framework is intentionally designed to introduce only the minimal set of frictions necessary to account for the empirical evidence. The core elements of the model consist of profit-maximizing firms utilizing capital and labor as input factors, utility-maximizing households, and a public authority responsible for policy. Within this structure, we incorporate three frictions: (i) market power in price-setting, (ii) market power in wage-setting, and (iii) adjustment costs to employment. The first two constitute nominal frictions, whereas the third represents a real friction motivated specifically by the sector-specific empirical findings (see Section C in the Appendix).

We then investigate the implications of the three frictions and the importance of the degree of substitutability between capital and labor. Furthermore, we examine in detail the role of the source of market power in wage-setting (monopolistic labor supply vs. monopsonistic labor demand). The latter allows us to investigate how the locus of wage-setting power—whether it resides with households or firms—affects labor market dynamics and, by extension, the consequences for the labor share.

### 3.2. Households as monopolistic wage setters.

We assume a continuum of infinitely-lived households indexed by $j \in [0,1]$, each of which derives utility from consuming goods $(c_t(j))$ and dis-utility from working $(h_t(j)$, hours worked). They can invest their savings in one-period (nominal) bonds $(B_t(j))$ or in the physical capital stock $(k_t(j))$, which they own. Investment in the latter requires the purchase of capital/investment goods $(\iota_t(j))$. They rent out the capital stock to firms at the price $P_{k,t}$. The capital stock depreciates at the rate $\delta$ and evolves according to

$$k_t(j) = (1-\delta)k_{t-1}(j) + \iota_t(j) \tag{6}$$

Households receive (nominal) labor income equal to $W_t(j)(1 - S_t^w(j))h_t(j)$. We follow Erceg et al. (2000) and introduce market power in wage-setting by assuming that each household supplies a distinct type of labor. We assume that households, as the monopolistic suppliers of differentiated labor services, face adjustment costs when changing wages à la Rotemberg (1982), given by $S_t^w(j) = \frac{\phi_w}{2}\left(\frac{W_t(j)}{W_{t-1}(j)} - 1\right)^2$, where $\phi_w \geq 0$ measures the extent of wage stickiness.

Households supply their differentiated labor to the labor packers under monopolistic competition, who then aggregate the imperfectly substitutable labor services of households to establish the homogeneous labor services $h_t$, and supply them to firms under the perfectly competitive wage $W_t$. The production function for the labor packers is given by $h_t = \left(\int_0^1 h_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$, where $\varepsilon > 1$ is the price elasticity of labor demand. The demand for labor of type $j$ is then given by

$$h_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\varepsilon} h_t \tag{7}$$

and the aggregate wage is given by $W_t = \left(\int_0^1 W_t(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$. Apart from the income on labor and from renting out the physical capital stock, households receive gross interest payments on their bond holdings $R_t B_{t-1}(j)$. This gives rise to the following budget constraint (ignoring dividend receipts)

$$P_t(c_t(j)+\iota_t(j))+B_t(j) = R_{t-1}B_{t-1}(j)+W_t(j)(1-S_t^w(j))h_t(j)+P_{k,t}k_{t-1}(j) \tag{8}$$

Households discount instant utility $u(c_t, h_t)$ with $\beta$. They maximize their expected lifetime utility $E_0 \sum_{t\geq 0} \beta^t u(c_t, h_t)$, where $E_t$ is the expectation conditional on the information available up to and including time $t$, subject to the budget constraint (8), the law of motion of the capital stock (6) and the demand for the type-$j$ labor service (7). Under symmetry across households, this gives rise to the following optimality conditions

$$1 = E_t\left[\Lambda_{t,t+1}\frac{R_t}{\Pi_{t+1}}\right] \tag{9}$$

$$1 = E_t\left[\Lambda_{t,t+1}\left(1-\delta+p_{k,t+1}\right)\right] \tag{10}$$

$$w_t = \mu_t^w \, mrs_t \tag{11}$$

where the wage markup is given by

$$\frac{1}{\mu_t^w} = (1-S_t^w)\frac{\varepsilon-1}{\varepsilon} + \frac{\phi_w}{\varepsilon}\left((\Omega_t - 1)\Omega_t - E_t\Lambda_{t,t+1}(\Omega_{t+1}-1)\frac{\Omega_{t+1}^2}{\Pi_{t+1}}\frac{h_{t+1}}{h_t}\right) \tag{12}$$

Equation (9) determines the optimal (intertemporal) consumption-saving decisions (Euler equation, consumption demand), equation (10) the rate of return on the physical capital stock and equation (11) the optimal intratemporal allocation between consumption and labor (labor supply). The stochastic discount factor is given by $\Lambda_{t,t+k} = \beta^k \frac{u_c(c_{t+k},h_{t+k})}{u_c(c_t,h_t)}$, $\Pi_t = P_t/P_{t-1}$ is the gross price inflation rate, $p_{k,t} = \frac{P_{k,t}}{P_t}$ is the real rental price of the physical capital stock, $mrs_t = -u_{h,t}/u_{c,t}$ is the marginal rate of substitution between labor and consumption, $w_t = W_t/P_t$ is the real wage, and $\Omega_t = W_t/W_{t-1}$ is the gross wage inflation rate.

The steady-state form of equation (11) yields $w = \mu^w \, mrs$, where $\mu^w = \frac{\varepsilon}{\varepsilon-1} > 1$ denotes the wage markup. This markup implies that the real wage rate exceeds the marginal rate of substitution, thereby capturing the degree of market power exercised by households in wage setting.

3.3. **Firms as monopolistic price setters.** We assume a continuum of firms indexed by $i \in [0,1]$, each of which maximizes profits. Firms operate in perfectly competitive input markets and in monopolistically competitive output markets. A typical firm $i$ rents the physical capital stock $k_t(i)$ from households at the price $P_{k,t}$ and employs labor $h_t(i)$ at the price $W_t$ to produce a differentiated output good $y_t(i)$ which is sold at the price $P_t(i)$ in a monopolistically competitive market. The individual goods are aggregated to a composite aggregate final good according to $y_t = \left(\int_0^1 y_t(i)^{(\eta-1)/\eta} di\right)^{\eta/(\eta-1)}$, with the associated price index given by $P_t = \left(\int_0^1 P_t(i)^{1-\eta} di\right)^{1/(1-\eta)}$, and $\eta > 1$ is the elasticity of substitution among different goods (and it is also the absolute value of the price elasticity of demand for good $i$). From this, the following demand function for good $i$ can be established

$$y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\eta} y_t \tag{13}$$

Each firm is able to set its own price, $P_t(i)$, however, price adjustment is subject to menu costs, specified by

$$S_t^p = \frac{\phi_p}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 P_t y_t,$$

where $\phi_p \geq 0$ denotes the degree of price stickiness. In addition to price adjustment costs, firms also incur costs when adjusting employment. Such costs may arise, for example, from search and hiring processes, labor hoarding, firing costs, or other frictions associated with changing employment levels. We capture these costs by

$$S_t^h = \frac{\phi_h}{2}\left(\frac{h_t(j)}{h_{t-1}(j)} - 1\right)^2 W_t h_t, \tag{14}$$

where $\phi_h \geq 0$ measures the stickiness of adjusting employment.

Firm $i$ produces output according to the following technology

$$y_t(i) = f(k_{t-1}(i), h_t(i)) \tag{15}$$

The optimization problem of firm $i$ is to choose the price of its product $(P_t(i))$, employment $(h_t(i))$ and the capital stock $(k_{t-1}(i))$ to maximize the present discounted value of profits (expressed in nominal terms)

(16)
$$E_s \sum_{t\geq s} \Lambda_{s,s+t}\left(P_t(i)y_t(i) - W_t h_t(i) - P_{k,t}k_{t-1}(i) - S_t^p(i)P_t y_t - S_t^h(i)W_t h_t\right)$$

subject to the demand function for its good (13) and the production function (15). Under symmetry across firms, the first-order conditions are

$$\begin{aligned}
&(17) & \eta(1-mc_t) &= 1 - \phi_p\left((\Pi_t - 1)\Pi_t - E_t\Lambda_{t,t+1}(\Pi_{t+1}-1)\Pi_{t+1}\frac{y_{t+1}}{y_t}\right)\\
&(18) & mc_t &= \frac{p_{k,t}}{f_{k,t-1}}\\
&(19) & mc_t &= (1+\Psi(h_t))\frac{w_t}{f_{h,t}}
\end{aligned}$$

where the one with respect to labor (equation (19)) is extended by a wedge $\Psi(h_t)$ given by

$$\Psi(h_t) = \phi_h\left(\frac{h_t}{h_{t-1}} - 1\right)\frac{h_t}{h_{t-1}} - \phi_h E_t\Lambda_{t,t+1}\left(\frac{h_{t+1}}{h_t} - 1\right)\left(\frac{h_{t+1}}{h_t}\right)^2\Omega_{t+1}. \tag{20}$$

$mc_t$ is real marginal cost and $f_k$ and $f_h$ denote the marginal products of capital and labor. Equation (17) determines optimal price setting and equations (18)-(19) the demand for capital and labor. The steady state version of equation (17) implies the following price markup: $\mu^p = 1/mc = \frac{\eta}{\eta-1} > 1$. Hence the wedge $\Psi(h_t)$ measures the gap between the real wage and the marginal product of labor beyond the price markup $1/mc_t$. It is a marginal object and zero in the steady state, though not within the dynamic adjustment to an exogenous shock.

3.4. **Equilibrium and monetary policy.** Assuming symmetry across households and firms in equilibrium, equation (15) expresses output of the production account. Taking the total differential $dy_t = f_{k,t-1}dk_{t-1} + f_{h,t}dh_t$, and substituting the partial derivatives according to equations (18) and (19), and integrating on both sides, yields

$$y_t = \mu_t^p \left(p_{k,t}k_{t-1} + (1 + \Psi(h_t))w_t h_t\right) \tag{21}$$

This equation expresses output of the income account. Since $\mu^p > 1$, it illustrates that the total real income generated by the use of capital ($k_{t-1}$) and labor ($h_t$) in production exceeds the direct payments to households for supplying these inputs ($p_{k,t}k_{t-1}$ and $w_t h_t$). This discrepancy reflects the presence of firms' market power. However, as firms are ultimately owned by households, the resulting profits are distributed to households as dividends.

Using equation (21) in the household budget constraint (equation (8)) and noting that in equilibrium, bonds ($B_t$) are in zero net supply, results in the following expression for market clearing in the final goods market (ignoring adjustment costs $S_t^p$, etc. as they vanish in a log-linearized equilibrium)

$$y_t = \mu_t^p \left(c_t + \iota_t + \Psi(h_t)w_t h_t\right) \tag{22}$$

which expresses output of the expenditure account, and $\Psi(h_t)w_t h_t$ captures the real resource cost associated with adjusting employment.

Finally, we assume that the central bank sets the nominal interest rate $i_t = \log(R_t)$ according to the following interest rate rule

$$i_t - \bar{\imath} = \phi_i \left(i_{t-1} - \bar{\imath}\right) + \phi_\pi \pi_t + \phi_y \hat{y}_t + v_t \tag{23}$$

where $v_t$ is a discretionary monetary policy shock, $\pi = \log(\Pi_t)$, $\hat{y}$ is the log-deviation of output from its steady state, $\bar{\imath}$ is the steady state level of $i_t$ (=

$\log(R)$) and $\phi_\pi > 1$ so that the Taylor principle (Chatelain and Ralf, 2022) is satisfied. This equation closes the model.

The three equations capturing the frictions—price, wage and employment stickiness are given by equations (11), (17) and (19)—read as follows in log-linearized form

$$\omega_t = \beta E_t \omega_{t+1} + \frac{\varepsilon - 1}{\phi_w}\left(\hat{mrs}_t - \hat{w}_t\right) \tag{24}$$

$$\pi_t = \beta E_t \pi_{t+1} + \frac{\eta - 1}{\phi_p}\hat{mc}_t \tag{25}$$

$$\Delta\hat{h}_t = \beta E_t \Delta\hat{h}_{t+1} + \frac{1}{\phi_h}\left(\hat{mc}_t + \hat{f}_{h,t} - \hat{w}_t\right) \tag{26}$$

where $\omega_t = \log(\Omega_t)$, $\pi_t = \log(\Pi_t)$, $\Delta$ is the difference operator ($\Delta\hat{h}_t = \hat{h}_t - \hat{h}_{t-1}$) and $\hat{mc}_t$ and $\hat{f}_{h,t}$ denote the log-deviation of marginal costs and the marginal product of labor from their respective steady state values.

3.5. **Model solution and calibration.** We solve the model under the assumption of rational expectations. To this purpose we log-linearize the model's equations. We assume the following functional forms for the utility function[5] and the production function

$$u(c_t, h_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{h_t^{1+\varphi}}{1+\varphi} - \chi c_t^{1-\sigma} h_t^{1+\varphi} \tag{27}$$

$$f(k_{t-1}, h_t) = \bar{A}\left(\alpha k_{t-1}(i)^{\frac{\nu-1}{\nu}} + (1-\alpha) h_t(i)^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}} \tag{28}$$

where $\sigma$ is the coefficient of relative risk aversion, $\varphi$ is the inverse of the Frisch labor supply elasticity, $\chi$ is a leveling parameter, $\bar{A}$ is the general level of technological attainment, $\alpha$ is the capital share in production and $\nu$ is the elasticity of substitution between capital and labor.

We calibrate the model to a quarterly frequency and provide the values for each parameter in Table 2. The discount factor implies an annual nominal interest rate of three percent ($R = 1.03$) and an annual depreciation rate of the physical capital stock of ten percent. The price and wage markups imply that $\eta = 11$ and $\varepsilon = 9$. We consider Laxton et al. (2010); Freedman et al. (2010) for calibrating the parameters for the price, wage and employment adjustment

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[5] This specification is taken from Hall and Milgrom (2008).

TABLE 2. Calibration (Baseline)

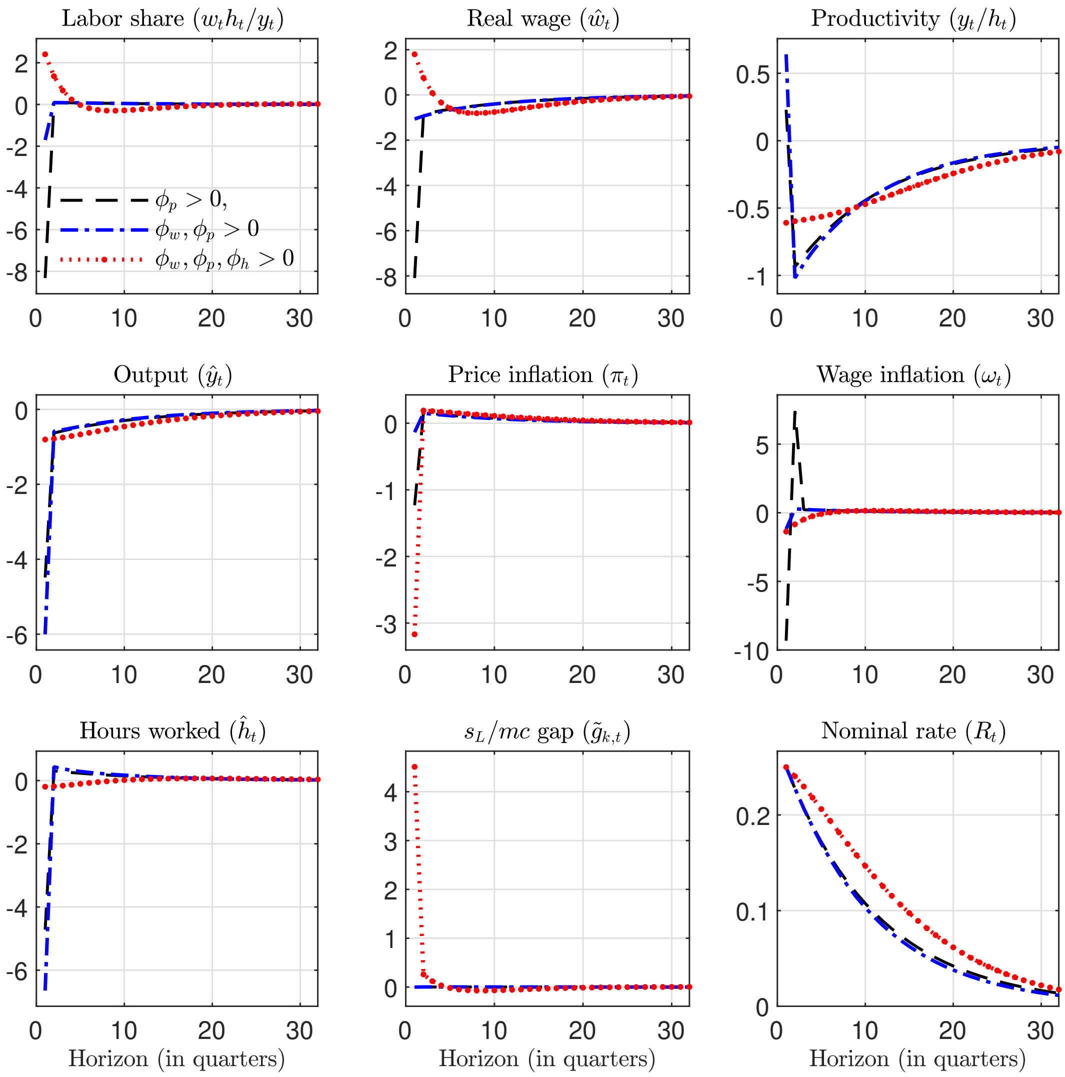
| Ident. | Value | Description |
|---:|---:|---|
| $\beta$ | 0.99 | Discount factor |
| $\sigma$ | 2 | Coefficient of relative risk aversion |
| $\varphi$ | 3 | Inverse of the Frisch labor supply elasticity |
| $\chi$ | 0.1 | Complementarity parameter for consumption and working (leisure) |
| $\delta$ | 0.03 | Depreciation rate of the physical capital stock |
| $\alpha$ | 0.25 | Capital share in production |
| $\nu$ | 1 | Elasticity of substitution between capital and labor |
| $\mu_p$ | 1.1 | Price markup |
| $\mu_p$ | 1.1 | Wage markup |
| $\phi_p$ | 60 | Degree of price adjustment stickiness |
| $\phi_w$ | 66 | Degree of wage adjustment stickiness |
| $\phi_h$ | 110 | Degree of employment adjustment stickiness |
| $\phi_i$ | 0.6 | Extent of interest rate smoothing |
| $\phi_\pi$ | 1.5 | Reaction of monetary policy to inflation |
| $\phi_y$ | 0.25 | Reaction of monetary policy to output |

costs ($\phi_p$, $\phi_w$ and $\phi_h$). The values for $\eta$ and $\phi_p$ imply a value for a Calvo-style parameter for the price stickiness of 0.67. We chose a value for the policy reaction to inflation equal to 1.5. This value guarantees that the Blanchard and Kahn (1980) conditions are satisfied over a wide parameter range.

We compute the steady state of the model by solving a system of non-linear equations. This gives rise to a consumption-output ratio equal to 0.73 and a labor share equal to 0.68. Further technical details are provided in the Appendix.

3.6. **Baseline results.** We analyze the effects of a restrictive monetary policy shock by computing impulse response functions, which are illustrated in Figure 2. The red dotted lines correspond to results based on the calibration detailed in Table 2. As shown in the figure, a 25 basis point increase in the policy interest rate reduces both price and wage inflation. Hence the real interest rate rises, inducing households to defer consumption which causes an immediate decline in current consumption. Additionally, the higher interest rate raises the cost of capital, increasing firms' borrowing costs. This contracts investment, which exacerbates the demand contraction from the consumption decline.

Figure 2. Restrictive MP shock: the contribution of the three frictions



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Note: The figure shows the impulse response functions based on the calibration of Table 2. The black dashed lines are the IRFs from a model with price stickiness only ($\phi_p > 0$, $\phi_w = \phi_h = 0$), the blue dotted lines are the IRFs from a model with price and wage stickiness only ($\phi_p > 0$, $\phi_w > 0$, $\phi_h = 0$), and the red dotted lines are the IRFs from a model with price, wage and employment adjustment stickiness ($\phi_p > 0$, $\phi_w > 0$, $\phi_h > 0$). As regards the $s_L/mc$-gap, it is given by $g_{k,t} := s_L/mc = \frac{1}{1+\Psi(h)}\left(1 - \frac{mpk}{y/k}\right)$ as of equation (29).

Most significantly, the real wage rises while labor productivity falls, both contributing to a pronounced increase in the labor share. In this regard, our model qualitatively replicates the empirical patterns documented in Section 2. 535

3.7. **Inspecting the mechanisms.** We now investigate the sensitivity of the labor share to monetary policy shocks in detail. All subsequent simulations employ the baseline calibration parameters from Table 2. Throughout our analysis, we systematically vary one parameter at a time while maintaining all other parameters at their baseline values, thereby isolating the effects of individual parameter changes.

3.7.1. *The role of the frictions.* Figure 2 displays the impulse response functions for multiple friction-specific calibrations. The baseline model, which incorporates all frictions, is represented by the red dotted lines. To disentangle the contribution of each friction, we also present results for model variants in which specific frictions are deactivated. For example, the black dashed lines correspond to a setting where only price stickiness is present ($\phi_p > 0$, $\phi_w = \phi_h = 0$). In this scenario, the standard result documented by Cantore et al. (2021) is recovered: a restrictive monetary shock leads to declines in output and inflation, accompanied by increased productivity and decreased real wages, culminating in a reduction in the labor share.

Furthermore, Cantore et al. (2021) highlight that the decline in the labor share is lessened when wage stickiness is introduced. Our model corroborates this finding. The blue dash-dotted lines illustrate the case where wage stickiness accompanies price stickiness ($\phi_w > 0$, $\phi_p > 0$, $\phi_h = 0$). Here, wage stickiness dampens both the fall in real wages and the rise in productivity, thereby attenuating the reduction in the labor share. Importantly, even when wage stickiness is substantially greater than price stickiness, the qualitative behavior of the model remains unchanged. The critical friction required for a positive response in the labor share is stickiness in employment adjustment, as captured by the parameter $\phi_h$. To see this, note that while equation (5) holds with equality in the steady state, in the short-run (i.e. dynamic) equilibrium we have (ignoring time subscripts)

$$s_L = \frac{mc}{1 + \Psi(h)} \left(1 - \frac{mpk}{y/k}\right) \tag{29}$$

and $\Psi(h) = 0$ only holds in the steady state. Key to understanding the response of the labor share to a monetary contraction is the labor adjustment-cost wedge $\Psi(h_t)$, which in log-linearized form reads[6]

$$\Psi(h_t) = \varphi_h \left[\Delta\hat{h}_t - \beta E_t \Delta\hat{h}_{t+1}\right] \tag{30}$$

The wedge combines the current marginal adjustment cost, $\Delta\hat{h}_t$, and the discounted expected future marginal adjustment cost, $\beta E_t \Delta\hat{h}_{t+1}$. After a restrictive monetary policy shock at time $t$, employment falls. With convex adjustment costs, firms smooth the labor adjustment, implying $\Delta\hat{h}_t = \hat{h}_t - \hat{h}_{t-1} < 0$ (with $\hat{h}_{t-1}$ predetermined). If firms expect further reductions, $E_t\Delta\hat{h}_{t+1} = E_t(\hat{h}_{t+1} - \hat{h}_t) < 0$, so the expectation term raises $\Psi_t(h_t)$, however, its partial effect is muted by discounting. Hence overall $\Psi_t(h_t)$ turns negative. This has two important implications. First, for the marginal cost of labor (see equation (26)): When $\Psi(h_t) < 0$, we have $(1 + \Psi(h_t))w_t < w_t$, so the effective marginal labor cost is below the wage. This moderates the decline in employment in response to the monetary contraction, hence smoothing the adjustment in employment as stated previously. Second, and most importantly for us, the drop in $\Psi(h_t)$ exerts upward pressure on the labor share (see equation (29)), counteracting the downward pressure from declining marginal costs. This is most clear once $\nu = 1$ is assumed as in this case, the log-linearized version of equation (29) reads (ignoring time subscripts)

$$\hat{s}_L = \hat{mc} - \Psi(h) \tag{31}$$

As shown in Figure 2 (second panel, third row; $s_L/mc$), the pronounced increase in the red dotted lines ($\phi_h > 0$) contrasts sharply with the cases where $\phi_h = 0$ (blue dash-dotted and black dashed lines). This demonstrates that employment adjustment frictions drive both the wedge between the labor share and marginal costs (equivalently the price markup, $\hat{mc}_t = -\hat{\mu}_t^p$) and consequently, the overall increase in the labor share. Although a concurrent decline

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[6] Consider also equation (26) and note that $\Psi(h_t) = 0$ in the steady state. Hence, for some variable $x_t$, the change $dx_t$ can be proxied by the (absolute) deviation from the steady state ($\bar{x}$): $dx_t \approx x_t - \bar{x}$, which then implies $\hat{x}_t \approx (x_t - \bar{x})/\bar{x}$ for the log-deviation; and when the steady state value of $x = 0$, we then have $dx_t = x_t - \bar{x} = x_t$, which was used in equation (30).

in capital productivity mildly amplifies this effect, its magnitude is small relative to the employment adjustment cost channel. Nevertheless, the presence of capital as a second input factor to production is essential in obtaining a drop in labor productivity in response to the monetary contraction.[7] We discuss this more formally in the Appendix.

Price and wage adjustment frictions play essential complementary roles. To show this, we quantify relative wage versus price stickiness through the parameter $\kappa = \phi_w/\phi_p$, where higher $\kappa$ values indicate greater wage stickiness relative to price stickiness. Holding $\phi_p$ fixed at its baseline value (Table 2), we vary $\phi_w$ across an extensive range to examine $\kappa$'s impact. The upper panels of Figure 3 present the resulting impulse responses, from which two conclusions emerge:

1. Even when wage stickiness substantially exceeds price stickiness ($\kappa \gg 1$), the absence of employment adjustment frictions ($\phi_h = 0$) prevents positive responses in both real wages and the labor share.
2. When employment adjustment frictions are present ($\phi_h > 0$), positive real wage and labor share responses materialize even under price-stickiness dominance ($\kappa < 1$).

These results demonstrate that the concurrent operation of all three frictions is necessary for the theoretical model to replicate the empirical responses documented in the data: declining productivity, (slightly) rising real wages, increasing labor share, alongside reductions in output, price and wage inflation, hours worked, and capital.

3.7.2. *The role of the elasticity of substitution.* An additional dimension warrants consideration. While the presence of at least two production inputs is essential, as shown and discussed in equation (5), equally important is the degree of substitutability between these inputs. As highlighted by Cantore et al. (2021), the CES production function introduces a wedge between the labor

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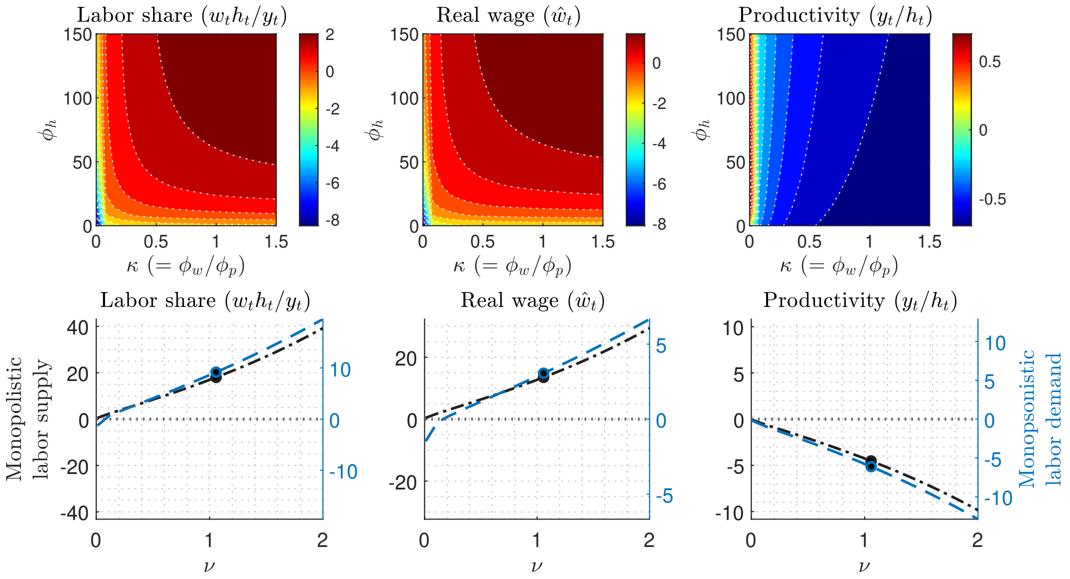
[7] This is also pertinent when considering the profit share which is often interpreted as a proxy for the (price) markup. Colonna et al. (2023) demonstrate that, in the context of a production function with two inputs—labor and intermediates—the profit share may rise even if markups remain constant or decline. This emerges when the cost of intermediate inputs increases more rapidly than labor costs, especially in situations where input substitutability is limited, as is often the case with energy and labor in the short run (see also Nikiforos et al., 2024).

Figure 3. Restrictive monetary policy shock: Sensitivity



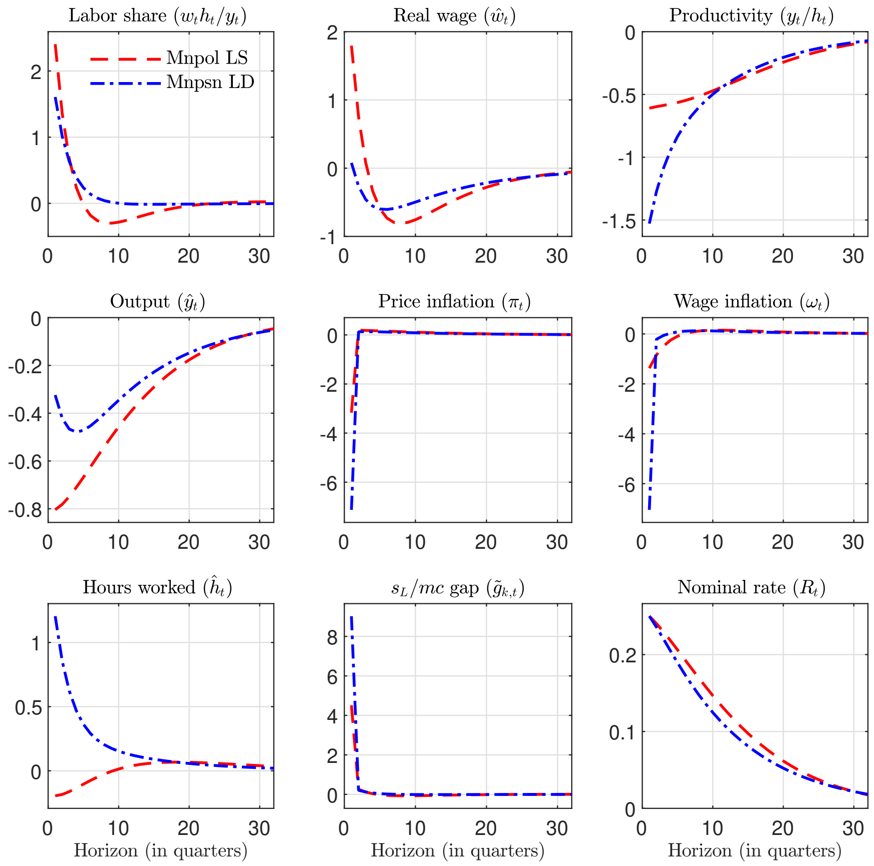
Note: The figure shows the impact effect, i.e. the impulse response functions at horizon one, based on a model with monopolistic labor supply and a model based on monopsonistic labor demand.

share and marginal costs that depends on labor productivity and the elasticity of capital–labor substitution.

The lower panels of Figure 3 depict the immediate effects of a monetary contraction on the labor share, the real wage, and productivity as the elasticity of substitution ($\nu$) between capital and labor varies. It is evident that $\nu$ influences not only the magnitude but also the sign of the impact responses. When $\nu$ approaches zero, indicating low substitutability, adjustment channels are limited. By contrast, higher values of $\nu$ allow for greater substitutability between capital and labor. In this case, stickiness in employment adjustment interacts with relatively flexible capital adjustment, inducing a pronounced decline in productivity and, ultimately, an increase in the labor share.

3.7.3. *The role of market power over the wage.* Our analysis relies on a crucial modeling assumption, namely, that market power in the labor market resides with households. However, a series of recent empirical studies have presented evidence in favor of firms holding market power in the labor market (see, among others, Popp, 2021; Jha and Rodriguez-Lopez, 2021; Ashenfelter et al.,

FIGURE 4. Restrictive MP shock: market power in the labor market



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Note: The figure shows the impulse response functions based on a model with monopolistic labor supply (calibration as outlined in Table 2) and a model based on monopsonistic labor demand (calibration as outlined in Table 2 but with $\phi_h = 0$). The IRFs for the model with monopolistic labor supply (red lines) are the same as those in Figure 2.

2022; Manning, 2003). In light of this evidence, we alter our baseline model by considering an alternative specification in which firms exercise monopsonistic wage setting power in the labor market. We provide a detailed description of this model in the Appendix.

The primary distinction of the monopsonistic labor market model (i.e., monopsonistic labor demand) relative to the baseline model with monopolistic labor supply pertains to the wage inflation equation. In the baseline model, wage inflation is governed by equations (11)/(24). In contrast, with monopsonistic labor demand, wage inflation follows the alternative expression

$$\omega_t = \beta E_t \omega_{t+1} + \frac{1+\varepsilon}{\phi_w} \left( \hat{mc}_t + \hat{f}_{h,t} - \hat{w}_t \right) \tag{32}$$

Building on this alternative framework, we revisit the implication of a monetary contraction on the labor share. We continue to use the structural parameter values specified in Table 2, subject to two important changes. First, whereas the baseline model assumes a wage markup ($\mu_w = 1.1$), we now introduce a wage markdown by setting $\mu_w = 0.9$ to quantify the extent of monopsonistic power. Second, we focus exclusively on price and wage rigidities, adopting the values for $\phi_p$ and $\phi_w$ provided in Table 2, while omitting rigidities in employment adjustment by setting $\phi_h = 0$.

The impulse response functions under monopsonistic labor demand are illustrated in Figure 4 with blue dash-dotted lines. The results show that the model with monopsonistic labor demand predicts declines in output, price inflation, and wage inflation in response to a restrictive monetary policy shock, all of which aligns fully with our empirical findings.

For most variables, the qualitative responses to the policy shock exhibit similarities between the two frameworks—the baseline model with monopolistic labor supply (red lines in Figure 4 are the same as in Figure 2) and the alternative model with monopsonistic labor demand—showing only moderate quantitative differences. However, a significant divergence emerges in the adjustment of hours worked.

Under monopolistic labor supply, hours worked decline following a monetary contraction, partially mitigating the effect of reduced output on labor productivity. Conversely, in the monopsonistic labor demand framework, hours worked increase in response to the restrictive policy shock. This results from household responses to higher real wages. According to the log-linearized form of equation (11)

$$\hat{h}_t = \frac{1}{\phi} \hat{w}_t - \frac{\sigma}{\phi} \hat{c}_t \tag{33}$$

where a hat denotes log-deviation from steady state and the wage markup is now absent in this equation, an increase in the real wage induces greater labor supply. When wage stickiness exceeds price stickiness, a restrictive monetary policy shock elevates the real wage. This increase is partially offset by the corresponding rise in hours worked, which moderates the overall output decline.

While both frameworks theoretically support the empirical findings, the monopsonistic labor demand model replicates the documented empirical patterns—decreased productivity, increased real wages, and rising labor share—using only nominal frictions (sticky prices and wages), without requiring additional frictions such as employment adjustment costs.

To illustrate this, consider equation (5), which under monopsonistic labor demand becomes

$$s_L = \frac{mc}{\tilde{\Psi}(\omega)}\left(1 - \frac{mpk}{y/k}\right) \tag{34}$$

where $\tilde{\Psi}(\omega) = \frac{1}{\mu^w}$ in steady state. The monetary contraction reduces $\tilde{\Psi}(\omega)$, raising the labor share despite declining marginal costs. This mechanism parallels the monopolistic labor supply model, but now the gap between labor share and marginal costs stems from firms' wage adjustment costs. Although a concurrent decline in capital productivity amplifies this effect by further reducing $\tilde{\Psi}(\omega)$, its quantitative contribution is again small.

A limitation of this framework is the counterfactual increase in hours worked following a restrictive shock, which contradicts empirical observations. This anomaly could be mitigated by reintroducing employment adjustment frictions ($\phi_h > 0$).

### 3.8. **Quantifying the frictions' role: Matching impulse responses.**

Our results demonstrate that a relatively small-scale model can readily reproduce the empirical responses of the labor share and the real wage to monetary policy shocks once employment adjustment frictions are introduced (in a setting with price and wage adjustment costs and monopolistic labor supply). An even simpler framework with only price and wage adjustment costs accounts for the same empirical regularities when firms act as monopsonists in the labor market (monopsonistic labor demand). These findings challenge the conclusions of Cantore et al. (2021): using the medium-scale DSGE model of Christiano et

Table 3. Matching impulse responses: Estimates

| | | Model version | | | |
|---|---|---|---|---|---|
| | Range | Baseline (Mnpol LS) | | Alternative (Mnpsn LD) | |
| $\phi_p$ | [0,1000] | 121.07 | 75.23 | 126.80 | 134.03 |
| $\phi_w$ | [0,1000] | 3.18 | 0.27 | 48.36 | 50.75 |
| $\phi_h$ | [0,1000] | 50.72 | - | 5.02 | - |
| $\phi_i$ | [-0.9,0.9] | 0.08 | 0.08 | 0.07 | 0.09 |
| $\phi_\pi$ | [0.5,10] | 1.21 | 1.19 | 1.18 | 1.21 |
| $\phi_y$ | [-1,1] | -0.19 | -0.22 | -0.16 | -0.19 |
| $M(\hat{\boldsymbol{\theta}})$ | - | 51.60 | 195.73 | 63.89 | 65.01 |

Notes: The table provides the point estimates of the structural parameters in $\boldsymbol{\theta}$ as of equation (36). The baseline model refers assumes monopolistic labor supply (Mnpol LS), the alternative one assumes monopsonistic labor demand (Mnpsn LD).

al. (2016), they argue that only a small but non-zero subset of the parameter space can match the signs of the impulse responses of the labor share and real wages (their model contains investment/capital adjustment costs next to various other frictions, however, no employment adjustment frictions). To assess this discrepancy, we next quantify the role of employment adjustment frictions by aligning the impulse response functions (IRFs) generated by our theoretical model with those estimated from the data (see, e.g., Rotemberg and Woodford, 1997; Guerron et al., 2017). This methodology facilitates a systematic assessment of the relative significance of various frictions in explaining the observed empirical dynamics.

The estimation is restricted to those parameters that do not influence the steady state, specifically $\phi_p$, $\phi_w$, $\phi_h$, $\phi_i$, $\phi_\pi$, and $\phi_y$. These parameters are collected in the vector $\boldsymbol{\theta}$. Let the theoretical IRFs be represented by the $nh \times 1$ vector $\mathbf{x}(\boldsymbol{\theta})$, which depends on these parameters. Here, $n$ denotes the number of variables included in the estimation, and $h$ is the horizon of the impulse responses of each of the $n$ variables. The empirical IRFs are denoted by $\hat{\mathbf{x}}$, which is of dimension $nh \times 1$ too. Estimation proceeds by minimizing a matching function, $M(\boldsymbol{\theta})$, which quantifies the weighted squared distance between the theoretical and empirical IRFs for the following variables: labor share, real wage, output, prices, and the nominal interest rate. Thus, $n = 5$, and we use a horizon of $h = 24$ periods. The matching function is defined as

$$M(\boldsymbol{\theta}) = (\hat{\mathbf{x}} - \mathbf{x}(\boldsymbol{\theta}))' \, \mathbf{W} \, (\hat{\mathbf{x}} - \mathbf{x}(\boldsymbol{\theta})) \,, \tag{35}$$

where $\mathbf{W}$ is a diagonal weighting matrix of dimension $nh \times nh$. In our estimation, $\mathbf{W}$ is set equal to the inverse of the standard deviation of the empirical IRFs, thereby assigning greater weight to variables with lower empirical estimation uncertainty. The optimal parameter vector is then given by

$$\hat{\boldsymbol{\theta}} = \arg\min_{\boldsymbol{\theta}} M(\boldsymbol{\theta}). \tag{36}$$

We examine two model specifications for the theoretical IRFs: (i) the baseline model with monopolistic labor supply (Mnpol LS), and (ii) the alternative model featuring monopsonistic labor demand (Mnpsn LD) instead. To allow for a fair comparison between the two models, we introduce labor adjustment cost also in the alternative model (see the Appendix). The minimum value of the matching function, together with the estimated parameters, provides a basis for discriminating between these two models.

We utilize a non-linear estimation algorithm that searches for parameter values minimizing (36) within predetermined bounds for each parameter, as reported in the first numerical column of Table 3. The estimation results are also presented in Table 3. For the baseline model, the estimated price stickiness parameter ($\phi_\pi$) implies a Calvo-style parameter value of approximately 0.74, aligning well with commonly reported values in the literature.[8] The estimates further highlight the significance of wage stickiness ($\phi_w$) and employment adjustment rigidities ($\phi_h$), as both parameters are found to be relatively large, though lower than the degree of price stickiness. In addition, the results indicate a moderate level of interest rate smoothing ($\phi_i$), an inflation coefficient in the interest rate rule ($\phi_\pi$) close to two, and a small, but negative output coefficient ($\phi_y$) in the Taylor rule.

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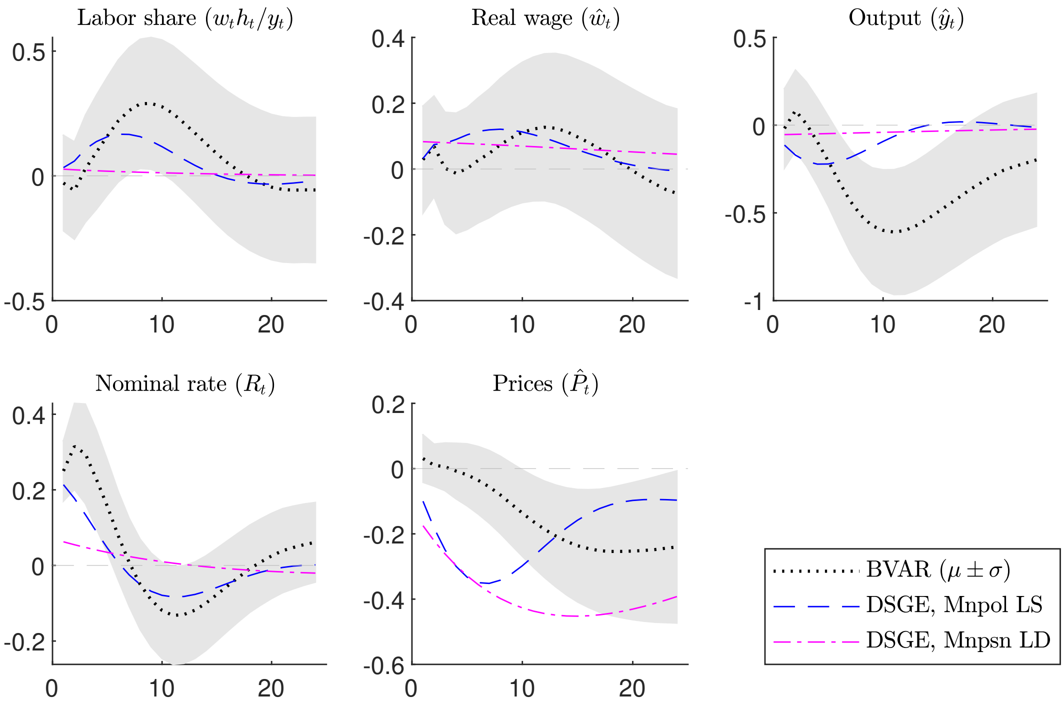
[8] The reduced form coefficients to be compared with for this purpose are $\frac{\varepsilon-1}{\phi_p}$ as of the Rotemberg approach and $\frac{(1-\theta)(1-\beta\theta)}{\theta}$ as of the Calvo approach, where $\theta$ measures the probability of not adjusting prices.

FIGURE 5. Matching impulse responses: Examining the fit



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Note: The figure displays the quality of the matching exercise by comparing the IRFs of the BVAR model (black lines) to those of the baseline theoretical model (monopolistic labor supply; blue dashed lines) and the alternative model (monopsonistic labor demand; magenta dash-dotted lines). Gray bands indicate 68 percent confidence intervals around the empirical IRFs.

3.8.1. *The role of market power in the labor market.* A comparison between the baseline model and the alternative specification provides insight into the role of the source of market power within the labor market. In the alternative model characterized by monopsonistic labor demand (Mnpsn LD), the estimated parameters associated with the three principal frictions differ markedly from those in the baseline model. Specifically, the price and wage stickiness parameters are estimated to be higher, whereas the parameter for labor adjustment friction is lower. By contrast, the coefficients governing the Taylor rule remain remarkably similar across both model variants. Notably, the minimal value of $M(\boldsymbol{\theta})$ for the alternative model is 63.9, which is higher than that of the baseline model (51.6). These results indicate, first, that the specific locus of market power in the labor market is of importance and, second, that the empirically preferred specification allocates this market power to households rather than firms.

This conclusion is further substantiated by a visual comparison of the fit of the IRFs resulting from the matching exercise, as illustrated in Figure 5. The figure displays the IRFs derived from the BVAR model (black dotted lines), the baseline theoretical model (blue dashed lines), and the alternative theoretical model (magenta dash-dotted lines). The baseline model successfully reproduces the empirical IRFs for most variables. In contrast, the alternative model exhibits an inferior fit especially in the case of hours worked and productivity.

3.8.2. *The role of the employment adjustment friction.* For the baseline model, the minimum value of $M(\boldsymbol{\theta})$ is 51.6. When the employment adjustment friction is excluded ($\phi_h = 0$), this value rises significantly, highlighting the critical role of this model feature in capturing the observed dynamics (third numerical column in Table 3). Furthermore, this model specification encounters substantial difficulties in replicating the empirical IRFs, as evidenced by several implausible parameter estimates. Interestingly, the employment adjustment friction is nearly irrelevant in the alternative model. The minimum value of $M(\boldsymbol{\theta})$ rises from 63.9 to 65.0 when the employment adjustment friction is omitted. This underscores the role of nominal wage stickiness captured by $\tilde{\Psi}(\omega)$ for explaining the reaction of the labor share to a monetary contraction as highlighted by equation (34).

Against this background, the estimation exercise clearly favors the baseline specification, which incorporates all three frictions and assumes monopolistic labor supply. The results confirm the importance of each friction, thereby substantiating the assumptions made in the previous section. While the alternative model with monopsonistic labor demand provides a qualitatively valid framework, it performs worse in matching the empirical IRFs relative to the baseline model.

3.9. **General discussion: the employment adjustment friction.** The importance of the employment adjustment friction in the baseline model stands out and warrants a deeper discussion. While the presence of price and (nominal) wage adjustment costs are standard (nominal) frictions in the New Keynesian literature, employment adjustment costs ($\phi_h$) are not. Employment adjustment costs are a real friction as opposed to the nominal frictions arising from price and wage adjustment costs. They represent the obstacles firms face in modifying employment levels in response to external shocks, such as changes in monetary policy. These impediments can arise from various institutional and behavioral sources, including employment protection legislation that increases firing costs, collective bargaining agreements, or regulatory constraints that render workforce reductions administratively burdensome (see Da-Rocha et al., 2019; Siena and Zago, 2022; Fanfani, 2023; Cahuc and Palladino, 2024, among others). Additionally, search-and-matching frictions play a crucial role, as the process of finding, hiring, and training suitable employees entails significant time and financial investments for firms. Importantly, such frictions often lead firms to engage in labor hoarding during downturns (Radlińska et al., 2020), retaining staff even as output falls in order to avoid the adjustment costs associated with future re-hiring and training. This behavior slows the adjustment of total hours worked relative to output (see Figure 2), thereby giving rise to the empirical patterns observed following external shocks: a muted movement in employment and a temporary decoupling of labor input dynamics from output dynamics (see Figure 1). By incorporating $\phi_h$, the model better captures these real-world institutional and behavioral features, thereby enhancing its ability to replicate observed labor market responses to monetary policy (and possibly other macroeconomic) shocks. Importantly, this aligns our findings with those of, for instance, Boeck and Glocker (2025), who emphasize the role of structural labor market characteristics in shaping the transmission of monetary policy.

## 4. Conclusion

This paper analyzes how monetary policy affects labor-market outcomes in the euro area, focusing on the response of the labor share to restrictive monetary policy shocks. It combines empirical evidence with a theoretical model that rationalizes the observed dynamics.

The empirical analysis, based on sign restrictions on structural residuals identified from high-frequency monetary policy surprises, shows that a restrictive monetary policy shock temporarily raises the labor share in the euro area. This procyclical response operates through two complementary channels: real wages tend to increase because nominal wages adjust only mildly while prices fall more strongly, and labor productivity declines because employment responds more sluggishly than output.

These results conflict with the predictions of the canonical New Keynesian model, which implies an increase in the labor share after a monetary contraction. To reconcile theory with the data, the paper develops an extended New Keynesian framework with capital accumulation, nominal rigidities in prices and wages, and—crucially—real frictions in the form of labor adjustment costs. The adjustment friction drives a wedge between marginal costs and real wages, so that a monetary contraction lowers marginal costs but raises real wages, generating an increase in the labor share. Sensitivity exercises indicate that this mechanism is robust across different degrees of capital–labor substitutability and outperforms alternative models based on monopsonistic wage setting.

From a policy perspective, the findings highlight the distributional implications of monetary tightening. The increase in the labor share suggests that restrictive monetary policy, at least in the short to medium term, need not systematically worsen labor's income position relative to capital. Instead, the interaction of wage stickiness and labor-market frictions temporarily shifts factor income toward labor during monetary contractions, underscoring the importance of institutional labor-market features and sectoral heterogeneity when assessing the broader effects of monetary policy.

Our study also points to several directions for future research. First, incorporating heterogeneous agents and intra-labor-income distributional dynamics would yield a more detailed assessment of the welfare consequences of monetary policy. Second, examining whether the documented patterns persist in the post-pandemic environment of high inflation and rapid tightening would test their robustness across regimes. Third, extending the theoretical framework to distinguish explicitly between skill groups and sectoral labor markets would sharpen policy conclusions on the distributional effects of monetary interventions.

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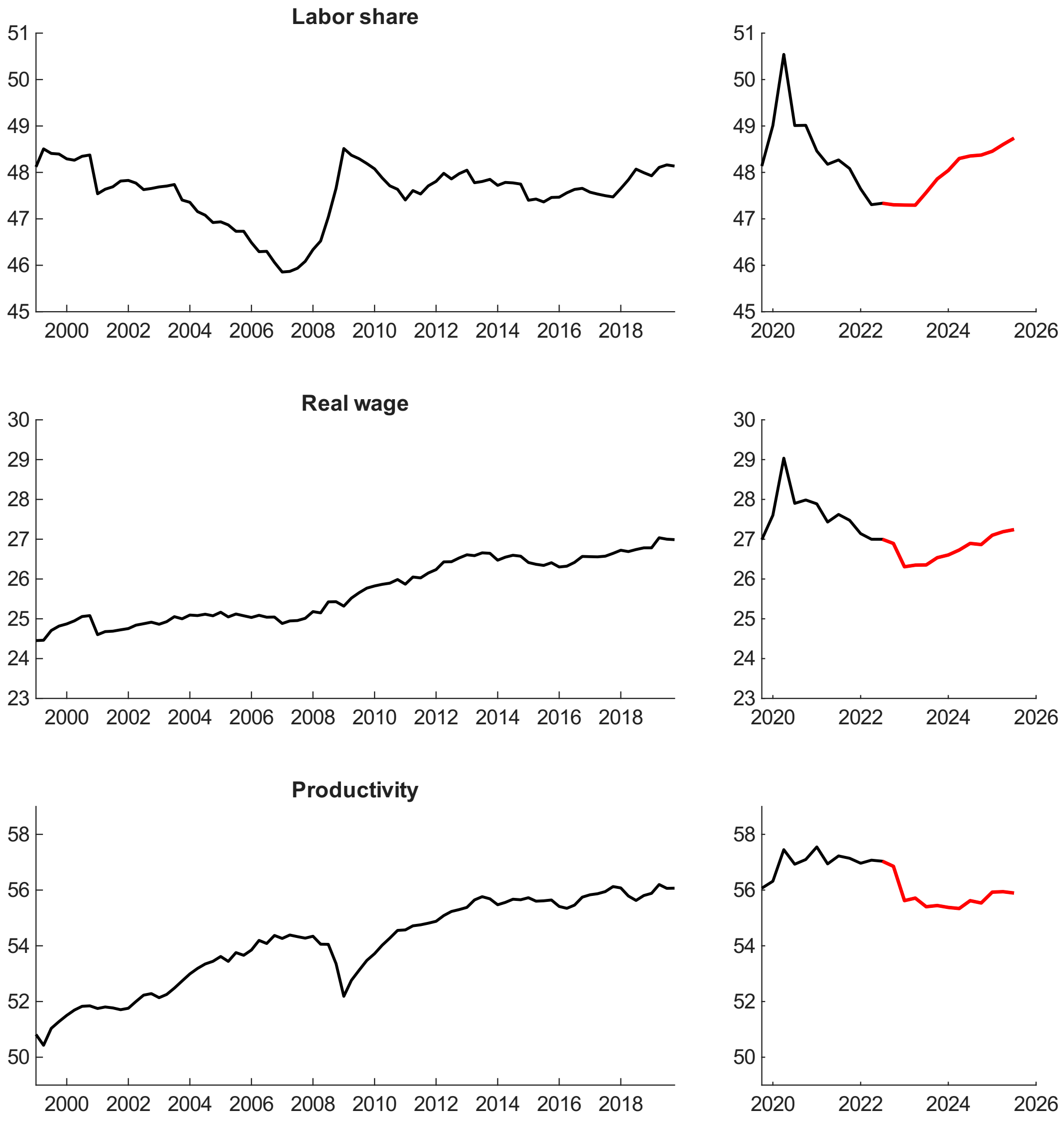
## Appendix A. Main data

Figure 6 shows the time series of the labor share in per cent, real hourly wages in euro and labor productivity per hour worked in the euro area. The left-handside graphs run from 1999-Q1 through 2019-Q4, the time period over which the baseline model is estimated. The right-handside graphs show the data from 2019-Q4 through 2025-Q3. The period affected by the most recent monetary tightening cycle from 2022-Q3 onward is colored red.

Figure 6. Main data



## Appendix B. Country-specific results

To provide a differentiated perspective of the euro-area wide results at the country level, we estimate block-exogenous VARs consisting of a euro area block and a country-specific block. The euro area block includes variables of the baseline model: the 1-week Euribor, real GDP, the GDP deflator, the corporate bond spread, M1, the euro-dollar exchange rate, total labor income, und total hours worked. The country block includes real GDP, the GDP deflator, total labor income, and total hours worked. This allows us to calculate country-specific labor shares.

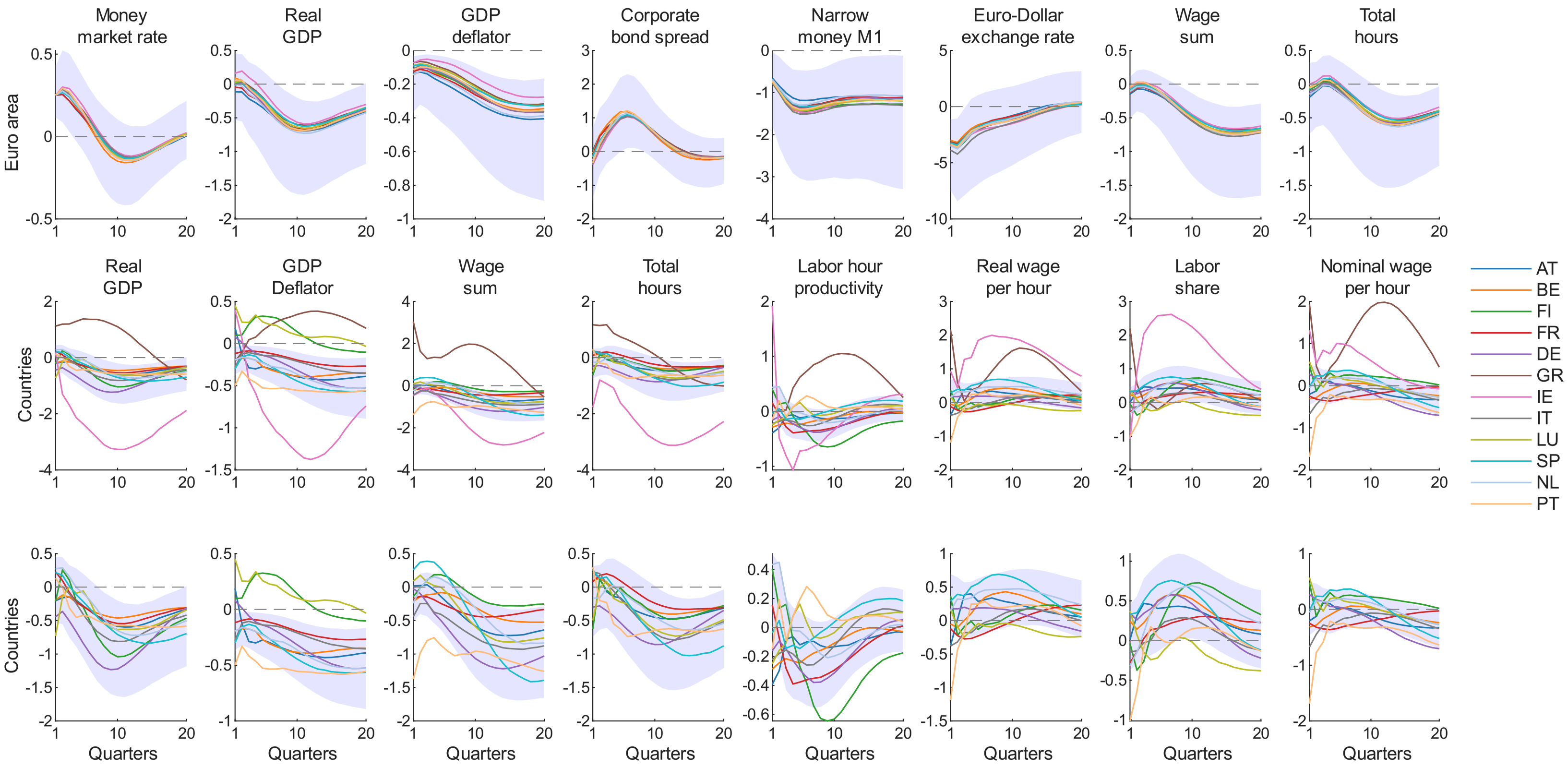
Table 4. Country-specific labor shares, 1999-Q1–2019-Q4

| Country | Average | SD | Maximum | Minimum |
|---|---|---|---|---|
| Austria | 47.6 | 1.0 | 49.9 (1999-Q4) | 45.4 (2007-Q4) |
| Belgium | 50.5 | 1.0 | 52.7 (2009-Q1) | 48.6 (2019-Q4) |
| Finland | 47.7 | 1.4 | 50.3 (2012-Q2) | 45.7 (2007-Q2) |
| France | 51.5 | 0.7 | 52.5 (2007-Q1) | 50.0 (2008-Q1) |
| Germany | 51.3 | 1.4 | 53.9 (2019-Q3) | 48.0 (2007-Q4) |
| Greece | 34.7 | 1.9 | 37.6 (2012-Q4) | 30.6 (2001-Q4) |
| Ireland | 37.5 | 4.6 | 45.1 (2009-Q1) | 28.7 (2019-Q3) |
| Italy | 38.4 | 1.0 | 40.0 (2009-Q4) | 36.5 (2001-Q1) |
| Luxembourg | 47.6 | 1.5 | 50.7 (2002-Q4) | 44.9 (2007-Q2) |
| Netherlands | 48.5 | 1.2 | 50.7 (2000-Q1) | 46.3 (2007-Q1) |
| Portugal | 46.3 | 1.6 | 48.6 (2000-Q4) | 43.3 (2015-Q4) |
| Spain | 47.2 | 1.4 | 49.6 (2009-Q1) | 45.0 (2017-Q4) |

We examine the effects in the twelve founding countries of the euro area: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Throughout the sample period, the country-specific labor shares remained within a narrow, stable range of 43% to 54% of GDP (Table 4).

Three countries are below this range: Ireland, Italy, and Greece. Many international companies are based in Ireland for tax reasons. This means that profits are generated there, but not the work, which depresses the labor share. There has been a particular downward shift since 2015, when many companies moved their headquarters to Ireland. This also explains the high standard

Figure 7. Impulse responses to a restrictive monetary policy shock, countries



Note: Lines are median impulse responses, shaded areas correspond to 68% credible sets of the baseline (euro-area) model. The first row of diagrams shows the results within the euro-area block, the second and the third rows show the results within country blocks. The second and the third row of diagrams are identical except that in the third row the ‘outlier countries’ Ireland and Greece are excluded.

deviation of the labor share in Ireland. In Italy and Greece, the low labor share is due to a larger proportion of the workforce being self-employed. This is probably the result of larger agricultural sectors and shadow economies.

Two of these countries also stand out with respect to the macroeconomic effects of ECB monetary policy (second row of diagrams in Figure 7). In Ireland, the effects are particularly pronounced (and perhaps spurious due to the limited usefulness of Irish GDP data). Corsetti et al. (2021) also find large effects of monetary policy for Ireland. For Greece, on the other hand, many effects are in contrast to those of the other countries and the euro area as a whole. The policy of the ECB seems to have procyclical effects in Greece—a result that has also been recovered by Geiger et al. (2023) and Hafemann and Tillmann (2020) for Greek unemployment.

Ignoring these outlier countries, we see in the third row of diagrams in Figure 7 that the remaining country-specific effects are well within the euro area wide ranges, with the only exception of Finnish and Luxembourgian prices. Most importantly, labor shares tend to temporarily increase following a monetary policy shock caused by an overly restrictive ECB interest rate decision.

## APPENDIX C. SECTOR-SPECIFIC RESULTS

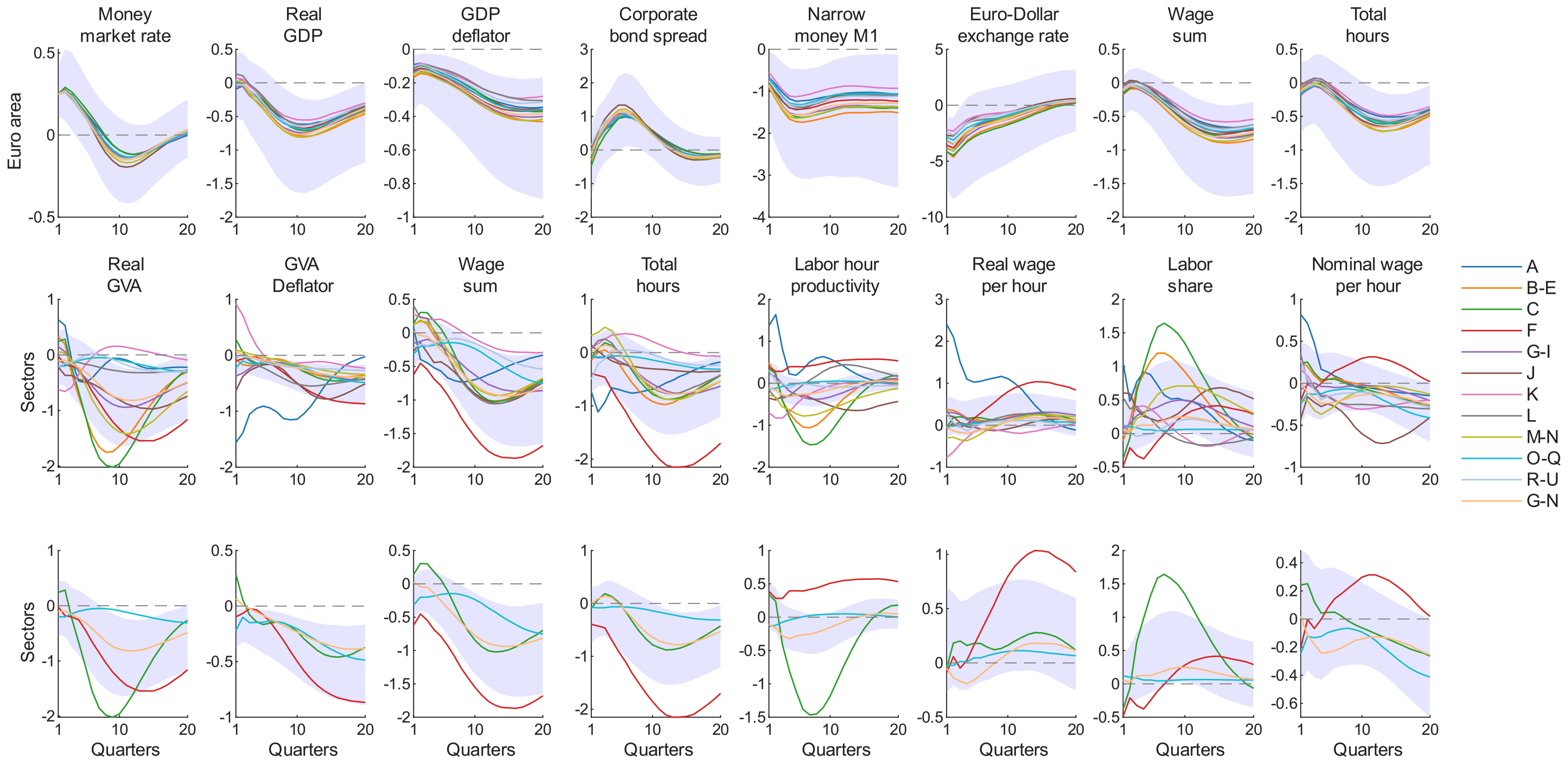
Elsby et al. (2013) demonstrate that sectoral developments have substantially shaped the aggregate labor share in the U.S., showing that one must not neglect the former when analyzing the latter. In doing so, we utilize a block-exogenous framework as in the country-specific analysis in Appendix B. Examining the raw data (Table 5) reveals that there is significantly more variation in the labor share across sectors than in the economy-wide labor shares across countries. Three sectors stand out: public services (high), agriculture (low), and real estate (low). The high labor share in public services reflects the sector's high labor intensity. The low labor share in agriculture reflects the fact that farmers are predominantly self-employed. Real estate (housing) exhibits an ultra-low labor share. It is the most capital-intensive sector (dwellings) and consists mostly of rents. There is a separate strand of literature that deals with the special role of housing in the economy-wide labor share (Kerspien et al., 2026; Gutiérrez and Piton, 2020; Rognlie, 2015).

TABLE 5. Sector-specific labor shares, 1999-Q1–2019-Q4

| Sector | Average | SD | Maximum | Minimum |
|---|---|---|---|---|
| Agriculture (A) | 23.5 | 2.2 | 27.0 (2009-Q3) | 19.3 (2001-Q3) |
| Industry (B–E) | 55.7 | 1.6 | 60.2 (2009-Q1) | 53.0 (2017-Q4) |
| Manufacturing (C) | 58.8 | 2.1 | 65.7 (2009-Q1) | 54.8 (2017-Q4) |
| Construction (F) | 57.4 | 2.3 | 64.0 (2000-Q1) | 54.3 (2006-Q4) |
| Market services (G–N) | 43.2 | 1.1 | 45.4 (2018-Q3) | 41.4 (2007-Q2) |
| Trade,Transp.,Accom.(G–I) | 56.0 | 1.3 | 58.0 (2012-Q4) | 53.7 (2001-Q2) |
| Inform.,Communication (J) | 50.0 | 2.8 | 54.1 (2018-Q3) | 46.1 (2004-Q1) |
| Finance,Insurance (K) | 53.5 | 2.7 | 61.3 (2000-Q4) | 49.9 (2015-Q1) |
| Real Estate (L) | 4.5 | 0.2 | 5.0 (1999-Q3) | 4.2 (2013-Q4) |
| Prof. Services (M–N) | 53.1 | 4.2 | 59.1 (2019-Q2) | 45.7 (1999-Q1) |
| Public Services (O–Q) | 76.8 | 0.7 | 78.7 (1999-Q4) | 75.6 (2012-Q4) |
| Other Services (R–U) | 61.2 | 0.9 | 63.5 (2019-Q4) | 59.4 (2006-Q2) |

Our focus will be on four main economic sectors, which are assembled from the ten aggregate NACE sections shown in Table 5: manufacturing (NACE section C), construction (NACE section F), public services (NACE sections O-Q), and market services (NACE sections G-N).

Figure 8. Impulse responses to a restrictive monetary policy shock, sectors



Note: Lines are median impulse responses, shaded areas correspond to 68% credible sets of the baseline (economy-wide) model. The first row of diagrams shows the results within the economy-wide block, the second and the third rows show the results within sector blocks. The second and the third row of diagrams are identical except that the third row shows only four sectors: sector C (manufacturing), sector F (construction), sectors O-Q (public services), and sectors G-N (market services).

Figure 8 illustrates the sectoral responses to a restrictive monetary policy shock. The labor share in the industrial sector exhibits the most pronounced reaction. In fact, it drives the response of the economy-wide labor share, as the labor share responses in the other sectors – construction, market services, and public services – are much more muted.

More specifically, there is essentially no response of the labor share in the construction and in the public sector. The latter is not surprising given the acyclicality of the public sector. The insignificant response of the labor share in the constructions sector results from a simultaneous medium-term increase in productivity and real wages, which contrasts with the economy-wide response. The construction sector's productivity increase stems from a combination of an above-average decline in gross value added (which it shares with the manufacturing sector) and an even stronger decline in total hours worked (in contrast to manufacturing). In the manufacturing sector, gross value added and total hours also decline, but the latter by a smaller amount than the former. One possible explanation is that labor hoarding may be more pronounced in the manufacturing sector, as retaining better-qualified staff is more valuable. In contrast, layoffs of less-qualified, lower-paid construction workers may raise average productivity and real wages in this sector.

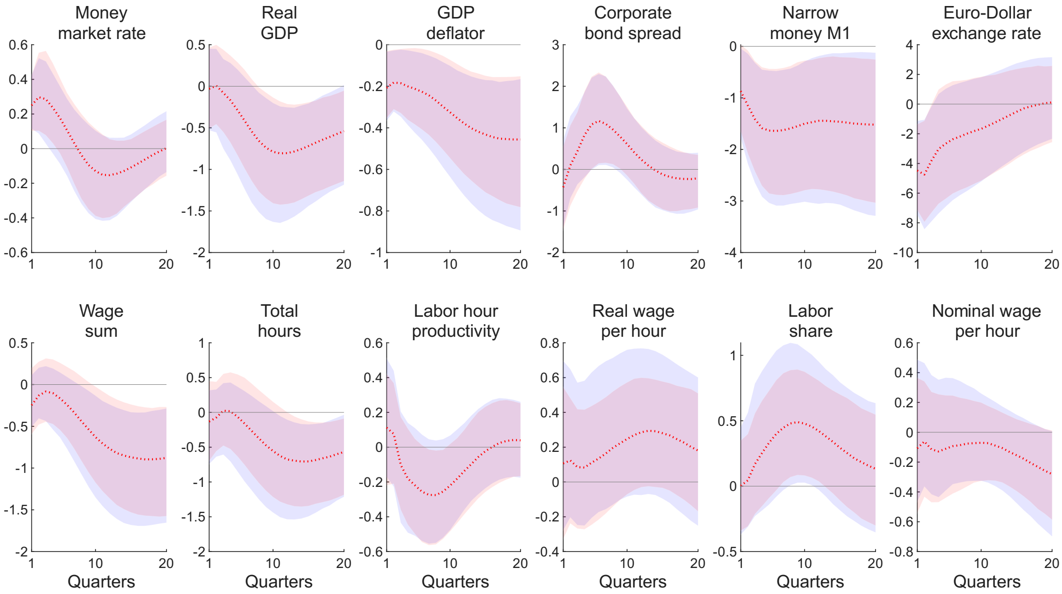
The labor share response in market services resembles the pattern in the manufacturing sector, but it is much more muted. More generally, the impulse responses of market services resemble those of the overall economy, not least because market services constitute the largest part of it.

The sectoral analysis shows that an increase in the labor share in response to a monetary tightening is to a large extent due to the effect in the manufacturing sector. This sector is more exposed to interest rate changes than market, let alone public services. In terms of human capital, manufacturing is more 'vulnerable' than construction, which experiences a similar output loss.

## Appendix D. Direct inclusion of the labor share

1090 Using the labor share and real hourly wages as endogenous variables and deriving the impulse responses of the wage sum and total hours ex post leaves the results unchanged compared to the baseline specification in which the latter variables are included directly and the responses of the former are derived ex-post (Figure 9).

Figure 9. Labor share directly included



Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with a specification which includes the labor share and real wages per hour instead of the wage sum and total hours; dotted lines are median impulse responses, shaded areas correspond to 68% credible sets.

# Appendix E. Extended Sample (1999-Q1-2025-Q3)

We estimate our baseline specification over the period from 1999-Q1 to 2019-Q4 because the euro area-wide monetary policy was established in 1999, and large fluctuations occurred in the years after 2019 due to the effects of the pandemic (during which the ECB was effectively restricted by the lower bound) and the commodity price shock.

Figure 10. Estimation period 1999-Q1–2025-Q3

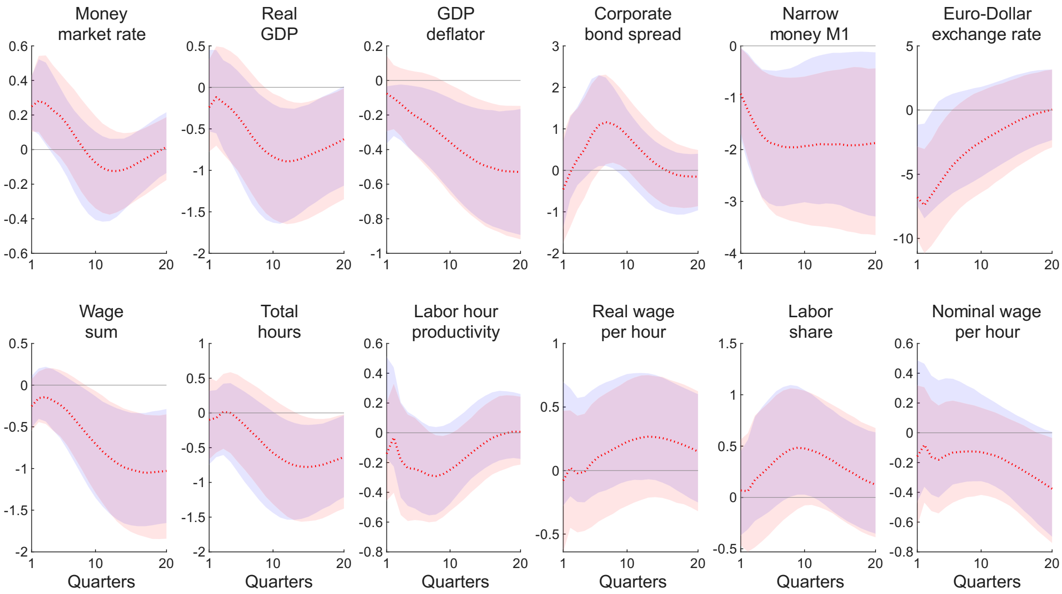
Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with the estimation period extended to 2025-Q3 and 2020-Q1 observations dropped; dotted lines are median impulse responses, shaded areas correspond to 68% credible sets.

Before estimating the model up to the most recent observations, we drop the data of 2020-Q1 to adjust for the most obvious distortions related to the pandemic (Lenza and Primiceri, 2022). Figure 10 shows that, quantitatively, the results differ from those of the baseline specifications in some aspects, but qualitatively, they remain intact.

## Appendix F. Alternative shock timing specification

When a monetary policy shock occurs late within a quarter, its effects are unlikely to be fully realized within the same period. This timing issue arises for four of the six identified shocks. To assess robustness, we therefore adopt an alternative timing specification that reassigns these shocks to the subsequent quarter.

Figure 11. Identification with 'shifted quarters'



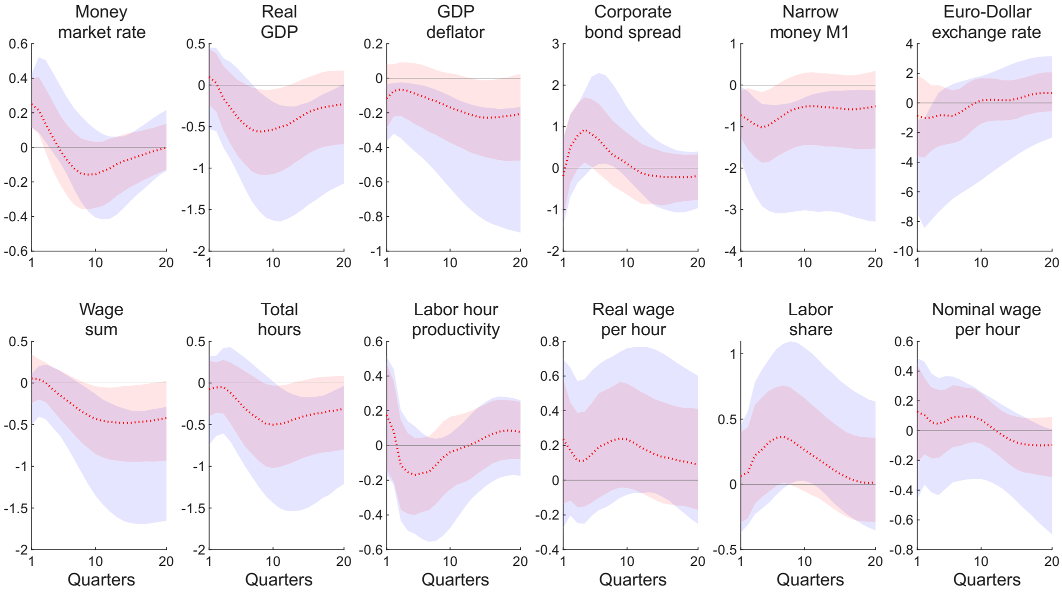
Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with the identifying quarters shifted forward when the monetary policy shock occurred in the last month of the respective quarter (2003-Q1→2003-Q2, 2003-Q2→2003-Q3, 2009-Q2, 2012-Q3, 2013-Q3→2014-Q4, 2015-Q4→2016-Q1); dotted lines are median impulse responses, shaded areas correspond to 68% credible sets.

Note that this procedure reverses the restriction for 2003-Q2. While the baseline setting for this quarter is characterized by expansionary monetary policy due to the expansionary shock in June 2003, this robustness exercise characterizes it as having restrictive monetary policy due to the restrictive shock in March 2003. However, this does not affect the results, which remain virtually unchanged compared to the baseline (Figure 11).

## Appendix G. Many lags

Montiel Olea et al. (2025) and De Graeve and Westermark (2025) make a strong case for using as many lags as possible in a VAR in order to reduce both bias and variance. We are able to increase the lag length to $p = 16$ quarters. A longer lag length is not feasible in this setup, since the sample starts in 1999-Q1 and the first narrative restriction is placed on the structural residual of 2003-Q1.

Figure 12. Estimation with many lags



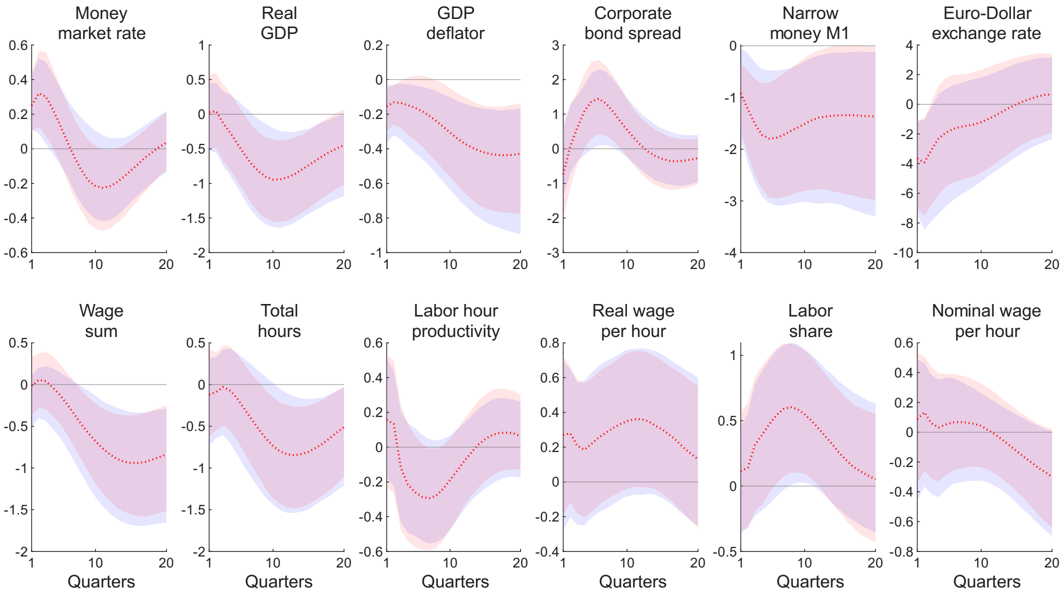
Note: Blue shaded areas correspond to 68% credible sets of the baseline specification. Red are results with $p = 16$; dotted lines are median impulse responses, shaded areas correspond to 68% credible sets.

Figure 12 shows that the results are robust to using many lags in the estimation. The impact on the exchange rate becomes less clear in the early quarters and the price response is more muted.

## Appendix H. Other identification schemes

H.1. **Sign restrictions on impulse responses.** Restricting the signs of the impulse responses means to predetermine some (initial) effects of monetary policy. We base these restrictions on our own empirical evidence which shows that restrictive monetary policy shocks tend to have positive initial effects on short-term interest rates and negative initial effects on prices, the stock of narrow money and the exchange rate. Beyond this empirical basis, the restrictions on interest rates, prices and the money stock form the foundation of this vast body of empirical literature (Uhlig, 2005). The exchange rate effect has been documented with high-frequency data (Rüth, 2020).

Figure 13. Sign restrictions on impulse responses

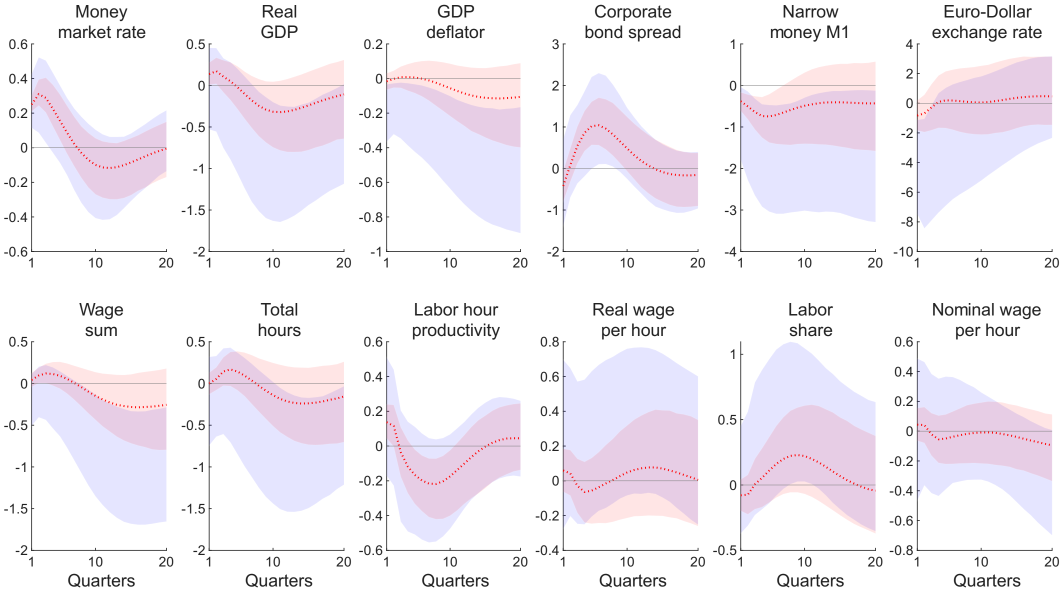


Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with identification via impulse responses; dotted lines are median impulse responses, shaded areas correspond to 68% credible sets.

Figure 13 shows that these traditional sign restrictions on impulse responses yield essentially the same results as our baseline identification based on narrative sign restrictions on the structural residuals. Apart from the predefined initial effects on the interest rate, the GDP deflator, M1, and the exchange rate, the medium-term effects and the effects on all other variables are closely matched with this kind of identification.

H.2. **Recursive identification.** The triangular approach is perhaps the most popular identification scheme in monetary policy. However, it relies on timing assumptions that become more critical as the frequency of observations decreases. The ordering of the variables implies that a variable either is not observed when monetary policy is set, yet is potentially affected by it, or is observed, yet not affected when monetary policy is set. These assumptions may be practical for daily data. They are more difficult to justify for monthly data and are even more questionable for quarterly data. Nevertheless, researchers apply recursive identification to models with quarterly data. Therefore, we test the robustness of our results to this type of identification.

FIGURE 14. Recursive identification, interest rate ordered first



Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with recursive identification and the interest rate ordered first; dotted lines are median impulse responses, shaded areas correspond to 95% credible sets.

On one end of the spectrum, none of the data is observed by the ECB when setting monetary policy, yet it is potentially affected by it (interest rate ordered first, Figure 14). In this case, some ´puzzles' emerge, such as the initial increase in GDP and the wage sum. However, the main results of the baseline identification remain largely intact. At the other extreme, when all data are observed by the ECB but not affected by it (interest rate ordered last,

Figure 15), the results differ more and are unconvincing, as are the identifying assumptions.

FIGURE 15. Recursive identification, interest rate ordered last

Note: Blue shaded areas correspond to 68% credible sets of the baseline identification. Red are results with recursive identification and the interest rate ordered last; dotted lines are median impulse responses, shaded areas correspond to 95% credible sets.

H.3. **Instrumental variables.** Instrumental variables have become the standard identification tool for monetary policy in recent years. They can be used as external or internal instruments. In the latter case, which we use, the instrument is incorporated directly in the VAR, ordered first in the vector of endogenous variables and a Cholesky decomposition is applied to the variance-covariance matrix. The external and internal instruments approach yield equivalent results (Plagborg-Møller and Wolf, 2021).

We employ four different instruments of monetary policy in the euro area: the pure monetary policy instrument of Jarociński and Karadi (2020), the so-called poor man's proxy of it, the target shock of Andrade and Ferroni (2021), and the monetary policy instrument of Boeck and Glocker (2025), which is based on data compiled by Altavilla et al. (2019). In principle, they should all describe the same object, that is a target shock in conventional monetary (i.e., interest rate) policy. However, Table 6 of cross correlations

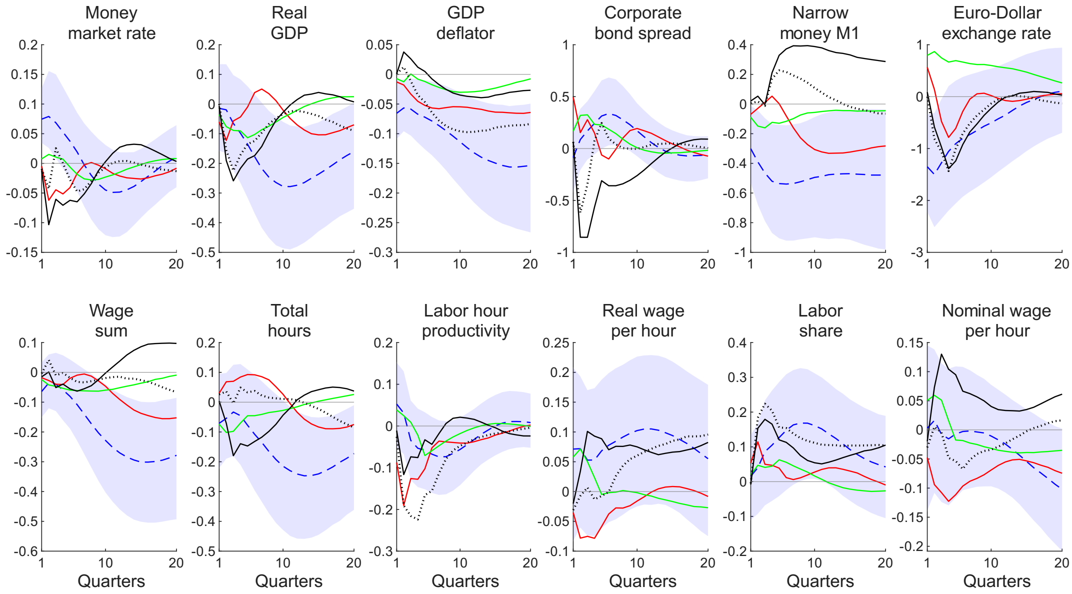
Table 6. Cross correlations among monetary policy instruments

| monthly | JK | JKpm | AF | BG | |
|---|---|---|---|---|---|
| BG | 0,07 | 0,16 | 0,18 | 1 | BG |
| AF | 0,60 | 0,74 | 1 | -0,11 | AF |
| JKpm | 0,83 | 1 | 0,66 | 0,03 | JKpm |
| JK | 1 | 0,85 | 0,58 | -0,06 | JK |
| | JK | JKpm | AF | BG | quarterly |

Note: "JK" and "JKpm": Jarociński and Karadi (2020), "AF": Andrade and Ferroni (2021), "BG": Boeck and Glocker (2025)

shows considerable differences, both for the original monthly frequency as well as for the aggregated quarterly frequency.

Figure 16. Instrumental variables



Note: Lines are median impulse responses, blue shaded areas correspond to 68% credible sets of the baseline identification

black solid: Jarociński and Karadi (2020) pure monetary policy instrument for the euro area

black dotted: Jarociński and Karadi (2020) poor man's pure monetary policy proxy

red solid: Andrade and Ferroni (2021) target shocks for the euro area, 2004-Q3–2015-Q4

green solid: Boeck and Glocker (2025) monetary policy instrument for the euro area

This carries over to the supposed effects of monetary policy (Figure 16). There is considerable variation among the instruments used, and the results are generally questionable. Most notably, the supposed restrictive monetary policy shock does not result in an obvious initial increase in the short-term interest rate for any of the instruments used (therefore, we do not normalize the shock to a 25-basis-point increase). Furthermore, each instrument exhibits peculiar effects or falls outside the credible set spanned by the baseline model for at least one variable.

Too much information seems to be lost when instrumental variables, collected at daily or intra-day frequencies, are aggregated excessively. It therefore holds the same for monetary policy instruments as for recursive identification: In our setting, using them with quarterly data yields inconclusive results.

## APPENDIX I. EQUILIBRIUM AND THE STEADY STATE

The equilibrium of the baseline model (monopolistic labor supply) is composed of the following equations

$$1 = E_t \left[ \Lambda_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right] \tag{37}$$

$$1 = E_t \left[ \Lambda_{t,t+1} \left( 1 - \delta + p_{k,t+1} \right) \right] \tag{38}$$

$$\begin{aligned} \frac{mrs_t}{w_t} &= (1 - S_t^w) \frac{\varepsilon - 1}{\varepsilon} + \\ &\quad \frac{\phi_w}{\varepsilon} \left( (\Omega_t - 1)\Omega_t - E_t \Lambda_{t,t+1} (\Omega_{t+1} - 1) \frac{\Omega_{t+1}^2}{\Pi_{t+1}} \frac{h_{t+1}}{h_t} \right) \end{aligned} \tag{39}$$

$$\eta(1 - mc_t) = 1 - \phi_p \left( (\Pi_t - 1)\Pi_t - E_t \Lambda_{t,t+1} (\Pi_{t+1} - 1) \Pi_{t+1} \frac{y_{t+1}}{y_t} \right) \tag{40}$$

$$mc_t = \frac{p_{k,t}}{f_{k,t-1}} \tag{41}$$

$$mc_t = \left( 1 + \Psi(h_t) \right) \frac{w_t}{f_{h,t}} \tag{42}$$

$$y_t = \bar{A} \left( \alpha k_{t-1}(i)^{\frac{\nu-1}{\nu}} + (1 - \alpha) h_t(i)^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}} \tag{43}$$

$$k_t = (1 - \delta) k_{t-1} + \iota_t \tag{44}$$

$$y_t mc_t = c_t + \iota_t + \Psi(h_t) w_t h_t \tag{45}$$

$$i_t - \bar{\imath} = \phi_i \left( i_{t-1} - \bar{\imath} \right) + \phi_\pi \pi_t + \phi_y \hat{y}_t + v_t \tag{46}$$

where $\Psi(h_t) = \phi_h \left( \frac{h_t}{h_{t-1}} - 1 \right) \frac{h_t}{h_{t-1}} - \phi_h E_t \Lambda_{t,t+1} \left( \frac{h_{t+1}}{h_t} - 1 \right) \left( \frac{h_{t+1}}{h_t} \right)^2 \Omega_{t+1}$, $i_t = \log(R_t)$, $f_k$ and $f_h$ denote the marginal products of capital and labor and $w_t / w_{t-1} = \Omega_t / \Pi_t$ determines nominal wage inflation $\Omega_t = 1 + \omega_t$. The utility function is specified by $u(c_t, h_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{h_t^{1+\varphi}}{1+\varphi} - \chi c_t^{1-\sigma} h_t^{1+\varphi}$, with $mrs_t = -u_{h,t}/u_{c,t}$ and $\Lambda_{t,t+1} = \beta \frac{u_c(c_{t+1}, h_{t+1})}{u_c(c_t, h_t)}$. This comprises a set of ten equations and ten variables $(y_t, c_t, \iota_t, h_t, k_{t-1}, \pi_t, w_t, p_{k,t}, R_t, mc_t)$.

The steady state of the model is obtained by solving a system of non-linear equations that summarize the equilibrium relationships. Given values for the structural parameters ($\chi$, $\phi$, $\sigma$, $\alpha$, $\nu$, $\delta$, $\beta$, $\mu^p$, $\mu^w$, $\bar{A}$), we solve for the steady state as follows. First, the steady-state relationships for the (gross) real interest rate ($R$), the real rental rate of capital ($p_k$) and the marginal product of capital ($f_k$) are computed as follows: $\beta = 1/R$, $p_k = R - 1 + \delta$, and $f_k = \mu^p p_k$. Then, we compute the steady state values for the remaining endogenous variables which are output ($y$), the capital stock ($k$), labor ($h$), real wage ($w$), marginal product of labor ($f_h$), consumption ($c$) and investment ($\iota$). The system of equations to be solved is as follows

$$
\begin{aligned}
&f_h = \mu^p w \\
&w = \mu^w \chi h^\phi c^\sigma \\
&f_k = \alpha \bar{A}^{1-1/\nu} \left(\frac{y}{k}\right)^{1/\nu} \\
&f_h = (1-\alpha) \bar{A}^{1-1/\nu} \left(\frac{y}{h}\right)^{1/\nu} \\
&y = \bar{A} \left(\alpha k^{\frac{\nu-1}{\nu}} + (1-\alpha) h^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}} \\
&y = \mu^p (c + \iota) \\
&\iota = \delta k
\end{aligned}
$$

which are firms' first-order condition for labor, households' intratemporal optimality condition, firms' marginal product of capital, firms' marginal product of labor, the production function, the aggregate resource constraint and the capital accumulation equation.

Noting that $\mu^p = 1/mc$, this system of (seven) non-linear equations in (seven) unknowns ($f_h$, $w$, $h$, $c$, $y$, $\iota$, $k$) is solved numerically. This ensures that all optimality conditions of the model are satisfied, among others, equation (5).

## APPENDIX J. THE BASELINE MODEL WITHOUT CAPITAL

We examine the role of physical capital as a secondary input factor in production by excluding it from the baseline model. Specifically, we remove the capital stock ($k_{t-1}$), investment ($\iota_t$), and rental price of capital ($p_{k,t}$) variables. This reduction yields a simplified system of seven equations in seven variables ($y_t, c_t, h_t, \pi_t, w_t, R_t, mc_t$).

Considering Section I, the modified model comprises equations (37), (39), (40), (42), and (46), while equations (43) and (45) are reformulated as

$$y_t = \bar{A} h_t^{1-\alpha},$$

$$y_t mc_t = c_t + \Psi(h_t) w_t h_t$$

We compute the steady state in the same form as outlined in Section I and use the values put forth in Table 2 to calibrate the model. We again simulate a monetary contraction and examine the implications of the three frictions.

Figure 17 presents the key results. When only price stickiness is present (black dashed lines), the real wage declines while labor productivity rises, generating a substantial decrease in the labor share. This qualitative pattern persists when nominal wage stickiness is introduced (blue dash-dotted lines). The results change only moderately with the inclusion of employment adjustment costs. Under this specification, both the real wage and labor productivity rise resulting in a moderate (initial) increase in the labor share.

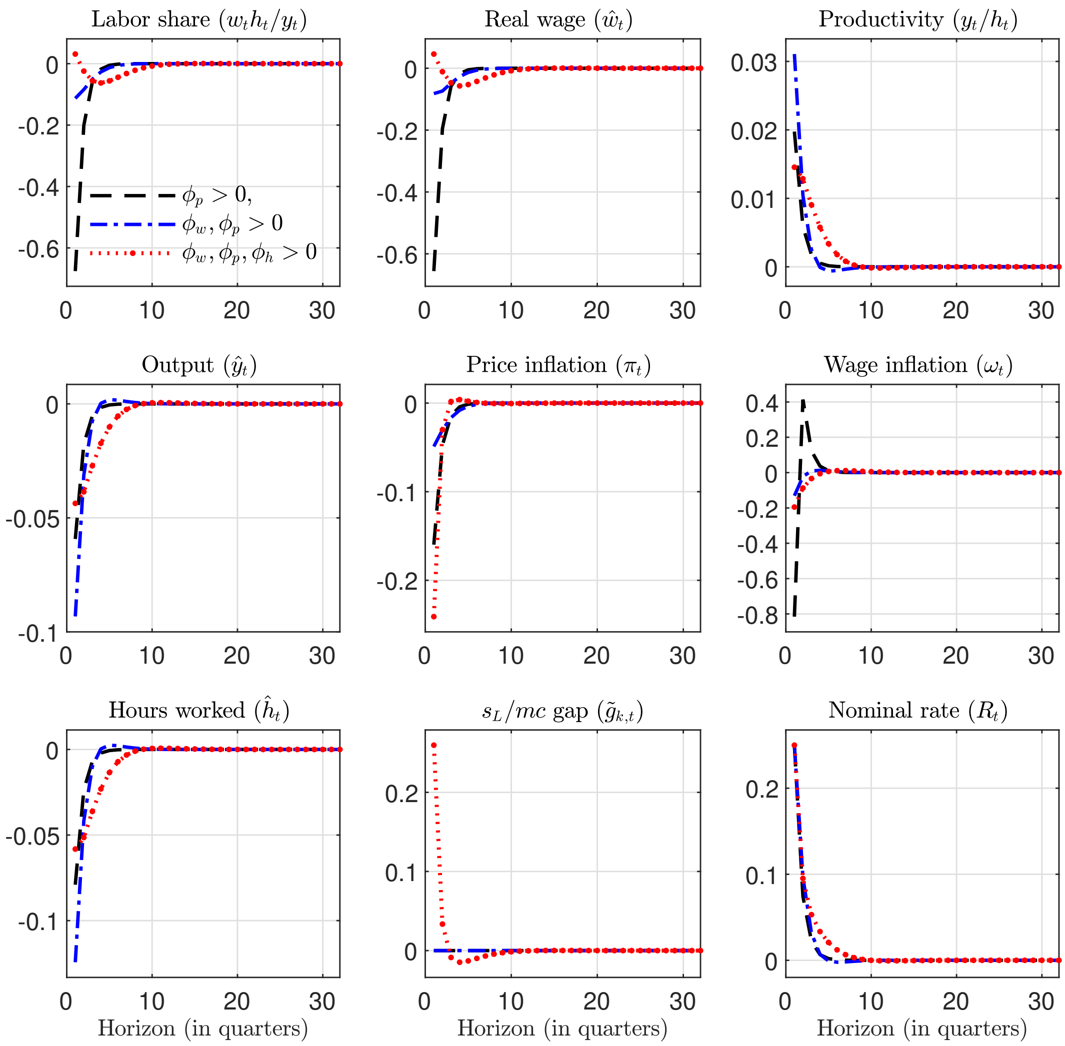
The rise in the labor share is explained by the modified form of equation (5):

$$s_L = (1-\alpha)\frac{mc}{1+\Psi(h)}, \tag{47}$$

which implies that the term $1 - \frac{mpk}{y/k}$ in equation (29) simplifies to $1-\alpha$. The increase in the labor share occurs because the decline in $\Psi(h)$ dominates the reduction in marginal costs ($mc$). From a different point of view of the labor share ($s_L = \frac{w}{y/h}$), this effect stems solely from the real wage increase and is moderated by the concurrent rise in labor productivity.

This outcome contrasts sharply with the baseline model including capital: whereas decreasing capital supports labor share increases through declining

FIGURE 17. Restrictive MP shock: the contribution of the three frictions (baseline model without capital)



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Note: The figure shows the impulse response functions based on the calibration of Table 2 for the baseline model though without capital. The black dashed lines are the IRFs from a model with price stickiness only ($\phi_p > 0$, $\phi_w = \phi_h = 0$), the blue dotted lines are the IRFs from a model with price and wage stickiness only ($\phi_p > 0$, $\phi_w > 0$, $\phi_h = 0$), and the red dotted lines are the IRFs from a model with price, wage and employment adjustment stickiness ($\phi_p > 0$, $\phi_w > 0$, $\phi_h > 0$).

labor productivity in the baseline model, the opposite mechanism operates in the capital-free specification. This result, replicating findings in Cantore et al. (2021), underscores the critical role of capital as a production input. The intuition follows from the single-factor production function: a monetary contraction reduces both output and labor, but diminishing marginal returns cause labor to decline more sharply than output. Consequently, labor productivity necessarily increases—an unambiguous outcome that cannot be altered without additional production factors. In log-linearized terms labor productivity is given by $\widehat{y/h} = -\alpha\hat{h}$; hence, the drop in labor in response to the monetary contraction necessarily leads to a rise in labor productivity.

The attenuation effect arising from rising labor productivity can be mitigated through two alternative specifications: (i) setting $\alpha = 0$ to create a linear production function in the single-input case, or (ii) implementing a Leontief production function when both labor and capital serve as production inputs (perfect complementarities). Under either specification, labor and output decline proportionally, leaving labor productivity unchanged. Consequently, changes in the real wage transmit directly to the labor share without distortion from productivity changes.

## Appendix K. A model with monopsonistic labor demand

We now consider the same model as in the main part of the analysis; however, we alter the source of market power in wage setting. In the baseline model, market power resides with households, resulting in a monopolistically competitive labor market. In this framework, a continuum of households supplies differentiated labor services to firms and, owing to their market power, is able to charge a wage markup over the competitive wage. This markup reflects the households' ability to influence the terms at which they supply their specialized labor.

By contrast, in the present setup, we assume that market power in wage setting is held by firms rather than households. Specifically, we analyze a monopsonistically competitive labor market in which a continuum of firms demands labor services from households. Under this configuration, firms leverage their market power to set wages below the competitive level, thereby imposing a wage markdown on households. This markdown stems from the firms' capacity to influence the wage paid for labor services in the presence of limited competition among employers.

In what follows we only provide a detailed description of those elements and equations which are now different compared to the baseline model.

K.1. **Households.** The setup of the household sector is as outlined in Section 3.2 except that we assume now that households are price takers with respect to both (final) goods prices and nominal wages. The baseline model considers rigidities in adjusting employment on the side of firms. We do so now on the side of households. We assume that households face costs when adjusting their labor supply. These costs accrue to, for instance, search costs when extending the labor supply, or alternatively, rigidities in adjusting labor supply could also arise from elements related to search costs or to household preferences, for instance, due to habit formation. We assume that households face adjustment costs when changing labor supply, given by $S_t^h(j) = \frac{\phi_h}{2}\left(\frac{h_t(j)}{h_{t-1}(j)} - 1\right)^2$, where $\phi_h \geq 0$ measures the extent of stickiness in adjusting labor supply. By supplying labor, households receive (nominal) labor income $(1 - S_t^h(j))W_t(j)h_t(j)$

modified for employment adjustment costs. They also receive gross interest payments on their bond holdings $R_tB_{t-1}(j)$. This gives rise to the following budget constraint (ignoring dividend receipts)

$$P_t(c_t(j)+\iota_t(j))+B_t(j)=R_{t-1}B_{t-1}(j)+W_t(j)(1-S_t^h(j))h_t(j)+P_{k,t}k_{t-1}(j) \tag{48}$$

Under symmetry across households, this leads to the following optimality condition for labor supply

$$\frac{mrs_t}{w_t}=1-\Psi_H(h_t) \tag{49}$$

where $\Psi_H(h_t)=S_t^h+\phi_h\left(\left(\frac{h_t}{h_{t-1}}-1\right)\frac{h_t}{h_{t-1}}-\Lambda_{t,t+1}\left(\frac{h_{t+1}}{h_t}-1\right)\left(\frac{h_{t+1}}{h_t}\right)^2\Omega_t\right)$. The notation of the remaining variables is as outlined in Section 3.2. The two intertemporal first order conditions are the same as in Section 3.2, given by equations (9) and (10).

K.2. **Firms–monopolistic price setters and monopsonistic wage setters.** We assume a continuum of firms indexed by $i\in[0,1]$, each of which maximizes profits. Firms operate in perfectly competitive input markets for the physical capital goods, in monopsonistically competitive input markets for labor and in monopolistically competitive output markets. A typical firm $i$ rents the physical capital stock $k_{t-1}(i)$ from households at the price $P_{k,t}$ and employs labor $h_t(i)$ at the price $W_t(i)$ to produce output $y_t(i)$ which is sold at the price $P_t(i)$. Each firm produces a differentiated good $y_t(i)$ which is supplied in a monopolistically competitive market as described in detail in Section 3.3. The new element here concerns the labor market in which firms now have market power in wage setting.

We assume that there is now a demand from firms for specific labor services which are supplied by households according to the following household labor supply equation

$$h_t(i)=\left(\frac{W_t(i)}{W_t}\right)^{\varepsilon}h_t \tag{50}$$

where $\varepsilon>0$.

When adjusting wages, firms face costs according to $S_t^w(i)=\frac{\phi_w}{2}\left(\frac{W_t(i)}{W_{t-1}(i)}-1\right)^2$.

The optimization problem of firm $i$ is to choose the price of its product $P_t(i)$, the wage $W_t(i)$ and the capital stock $k_{t-1}(i)$ to maximize the present discounted value of profits (in nominal terms)

$$E_s \sum_{t \geq s} \Lambda_{s,s+t} \Big( P_t(i) y_t(i) - W_t(i) h_t(i) - P_{k,t} k_{t-1}(i) \\ - S_t^p(i) P_t y_t - S_t^w(i) W_t h_t \Big) \tag{51}$$

subject to the demand function for its good (13), the labor supply function for its labor demand (50) and the production function (15). Under symmetry across firms, the first-order necessary conditions are

$$\eta(1 - mc_t) = 1 - \phi_p \left( (\Pi_t - 1)\Pi_t - E_t \Lambda_{t,t+1} (\Pi_{t+1} - 1) \Pi_{t+1} \frac{y_{t+1}}{y_t} \right) \tag{52}$$

$$mc_t f_{k,t-1} = p_{k,t} \tag{53}$$

$$mc_t f_{h,t} = w_t \tilde{\Psi}(\omega_t) \tag{54}$$

where $\tilde{\Psi}(\omega_t) = \frac{1+\varepsilon}{\varepsilon} + \frac{\phi_w}{\varepsilon} \left( (\Omega_1 - 1)\Omega_t - E_t \Lambda_{t,t+1} (\Omega_{t+1} - 1) \frac{h_{t+1}}{h_t} \frac{\Omega_{t+1}^2}{\Pi_{t+1}} \right)$ and we have $\tilde{\Psi}(\omega) = \frac{1+\varepsilon}{\varepsilon}$ in the steady state. The steady states of equations (52) and (54) imply the following price markup $\mu^p = 1/mc = \frac{\eta}{\eta - 1} > 1$ and the following wage markdown $\mu^w = \frac{\varepsilon}{1+\varepsilon} < 1$ with the following labor demand function function in the steady state

$$w = \frac{\mu^w}{\mu^p} f_h \tag{55}$$

where $\mu^w/\mu^p < 1$ since $\mu^w < 1$ and $\mu^p > 1$. This highlights that both the price markup and the wage markdown shape the wedge between the marginal product of labor and the real wage in favor of firms' profits.

K.3. **Equilibrium and monetary policy.** Using the production function and computing its total differential yields $dy_t = f_{k,t-1} dk_{t-1} + f_{h,t} dh_t$; substituting the partial derivatives by the expressions from equations (53) and (54), and integrating on both sides, yields the following

$$y_t = \frac{\mu_t^p}{\mu_t^w} \left( p_{k,t} k_{t-1} + \tilde{\Psi}(\omega_t) w_t h_t \right) \tag{56}$$

This expression captures output as of the income account. Since $\mu^p/\mu^w > 1$, it highlights that the real income generated by the use of capital $k_{t-1}$ and labor $h_t$ in production exceeds the respective income accruing to households by supplying these elements to firms ($p_{k,t}k_{t-1}$ and $\tilde{\Psi}(\omega_t)w_th_t$). This arises from firms' market power. As firms are owned by households, the resulting dividends still accrue to households.

Using equation (56) in the household budget constraint (equation (48)) and noting that in equilibrium, bonds ($B_t$) are in zero net supply, results in the following expression for market clearing in the final goods market (ignoring adjustment costs $S_t^p$ and $S_t^w$ as they vanish in a log-linearized equilibrium)

$$y_t = \frac{\mu_t^p}{\mu_t^w}\left(c_t + \iota_t + \left(\tilde{\Psi}(\omega_t) - 1\right) w_th_t\right) \tag{57}$$

This expression captures output as of the expenditure account while equation (15) captures output as of the production account.

Finally, the model is closed with an interest rate rule given by equation (23).

We solve the model under the assumption of rational expectations. To this purpose, we log-linearize the model's equations. The three key equations capturing the frictions— price, wage and (household) employment adjustment rigidities are given by equations (49), (52) and (54)—read as follows in log-linearized form

$$\omega_t = \beta E_t\omega_{t+1} + \frac{1+\varepsilon}{\phi_w}\left(\hat{mc}_t + \hat{f}_{h,t} - \hat{w}_t\right) \tag{58}$$

$$\pi_t = \beta E_t\pi_{t+1} + \frac{\eta - 1}{\phi_p}\hat{mc}_t \tag{59}$$

$$\Delta\hat{h}_t = \beta E_t\Delta\hat{h}_{t+1} + \frac{1}{\phi_h}\left(\hat{w}_t - \hat{mrs}_t\right) \tag{60}$$

where $\omega_t = \log(\Omega_t)$, $\pi_t = \log(\Pi_t)$, and $\hat{mc}_t$ and $\hat{f}_{h,t}$ denote the log-deviation of marginal costs and the marginal product of labor from their respective steady state values.

K.4. **Equilibrium equations.** The equilibrium of the model with monopsonistic labor demand is composed of the following equations

$$1 = E_t\left[\Lambda_{t,t+1}\frac{R_t}{\Pi_{t+1}}\right] \tag{61}$$

$$1 = E_t\left[\Lambda_{t,t+1}\left(1-\delta+p_{k,t+1}\right)\right] \tag{62}$$

$$\frac{mrs_t}{w_t} = 1 - \Psi_H(h_t) \tag{63}$$

$$\eta(1-mc_t) = 1 - \phi_p\left((\Pi_t - 1)\Pi_t - E_t\Lambda_{t,t+1}(\Pi_{t+1}-1)\Pi_{t+1}\frac{y_{t+1}}{y_t}\right) \tag{64}$$

$$mc_t = \frac{p_{k,t}}{f_{k,t-1}} \tag{65}$$

$$mc_t\frac{f_{h,t}}{w_t} = \tilde{\Psi}(\omega_t) \tag{66}$$

$$y_t = \bar{A}\left(\alpha k_{t-1}(i)^{\frac{\nu-1}{\nu}} + (1-\alpha)h_t(i)^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}} \tag{67}$$

$$k_t = (1-\delta)k_{t-1} + \iota_t \tag{68}$$

$$y_t mc_t = \frac{1}{\mu^w}\left(c_t + \iota_t + \left(\tilde{\Psi}(\omega_t) - 1\right)w_t h_t\right) \tag{69}$$

$$i_t - \bar{\imath} = \phi_i\left(i_{t-1} - \bar{\imath}\right) + \phi_\pi \pi_t + \phi_y \hat{y}_t + v_t \tag{70}$$

where $\Psi_H(h_t) = S_t^h + \phi_h\left(\left(\frac{h_t}{h_{t-1}} - 1\right)\frac{h_t}{h_{t-1}} - \Lambda_{t,t+1}\left(\frac{h_{t+1}}{h_t} - 1\right)\left(\frac{h_{t+1}}{h_t}\right)^2\Omega_t\right)$, $\tilde{\Psi}(\omega_t) = \frac{1+\varepsilon}{\varepsilon} + \frac{\phi_w}{\varepsilon}\left((\Omega_1 - 1)\Omega_t - E_t\Lambda_{t,t+1}(\Omega_{t+1} - 1)\frac{h_{t+1}}{h_t}\frac{\Omega_{t+1}^2}{\Pi_{t+1}}\right)$, $i_t = \log(R_t)$, $f_k$ and $f_h$ denote the marginal products of capital and labor and $w_t/w_{t-1} = \Omega_t/\Pi_t$ determines nominal wage inflation $\Omega_t = 1 + \omega_t$. The utility function is specified by $u(c_t, h_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{h_t^{1+\varphi}}{1+\varphi} - \chi c_t^{1-\sigma} h_t^{1+\varphi}$, with $mrs_t = -u_{h,t}/u_{c,t}$ and $\Lambda_{t,t+1} = \beta\frac{u_c(c_{t+1},h_{t+1})}{u_c(c_t,h_t)}$. This comprises a set of ten equations and ten variables $(y_t, c_t, \iota_t, h_t, k_{t-1}, \pi_t, w_t, p_{k,t}, R_t, mc_t)$.

The steady state is computed in the same form as outlined in Section I.

## Appendix L. Fixed costs in production as an alternative mechanism

We consider a model variant in which the steady-state markup wedge is absorbed by a fixed cost $F > 0$ in production rather than by quadratic labor adjustment costs ($\phi_h > 0$), following an approach used by Melitz (2003); Smets and Wouters (2003). All household equations and the monetary policy rule remain identical to the baseline. The three equations that differ are the following.

**Production and net output.** Gross output $y_t^g$ is produced by the same CES technology as in equation (43), and the good supplied to the market is net output

$$y_t = y_t^g - F, \qquad y_t^g = \bar{A}\left(\alpha k_{t-1}^{\frac{\nu-1}{\nu}} + (1-\alpha) h_t^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}}. \tag{71}$$

The fixed cost is calibrated so that steady-state profits equal zero, which requires $F = (\mu^p - 1)\bar{y}$ and implies $y_g^{ss} = \mu^p \bar{y}$.

**Resource constraint.** Under the zero-profit calibration, equation (45) simplifies to

$$y_t = c_t + \iota_t, \tag{72}$$

i.e., net output is fully absorbed by consumption and investment without a markup wedge—in contrast to the baseline where $y_t mc_t = c_t + \iota_t + \Psi(h_t) w_t h_t$.

**Labor demand.** With $\phi_h = 0$, the adjustment wedge $\Psi(h_t)$ vanishes and equation (42) simplifies to

$$w_t = mc_t\, f_{h,t}^g, \tag{73}$$

where $f_{h,t}^g = (1-\alpha)\bar{A}^{1-1/\nu}(y_t^g/h_t)^{1/\nu}$ is the marginal product of labor evaluated at gross output.

**Labor share.** Combining equation (73) with the definition $s_{L,t} = w_t h_t / y_t$ yields

$$s_{L,t} = \frac{mc_t\, f_{h,t}^g\, h_t}{y_t^g - F}. \tag{74}$$

Log-linearizing around the steady state for $\nu = 1$ (Cobb-Douglas) gives

$$\hat{s}_{L,t} = \hat{mc}_t - \frac{\mu^p - 1}{\mu^p}\,\hat{y}_t. \tag{75}$$

The first term $\hat{mc}_t$ is the standard channel: a monetary contraction lowers marginal costs and, all else equal, compresses the labor share. The second term, $-\frac{\mu^p-1}{\mu^p}\hat{y}_t$, is the fixed-cost channel: as net output falls ($\hat{y}_t < 0$), overhead costs are spread over fewer units, which exerts upward pressure on the labor share. Whether a contraction raises or lowers the labor share therefore depends on which term dominates.

For the baseline calibration with $\mu^p = 1.10$, the coefficient $(\mu^p-1)/\mu^p \approx 0.09$ is small, so the decline in marginal costs dominates and the labor share falls. In principle, a sufficiently large markup would make the fixed-cost term dominant and could generate a rising labor share. Numerical simulations confirm this: the labor share begins to rise only once $\mu^p$ is raised substantially above its baseline value. However, such values imply a price markup far outside the conventional range (see De Loecker et al., 2020, among others). Moreover, within the subset of parameterizations that still deliver a determinate equilibrium and a conventional positive response of the nominal interest rate to the shock, the implied labor-share increase is an order of magnitude significantly smaller than that generated by the employment adjustment friction. Fixed costs in production hence constitute an inferior alternative mechanism; employment adjustment frictions remain the key driver of the positive labor-share response to a monetary contraction.

## APPENDIX M. A HOUSEHOLD-SIDE VIEW OF THE LABOR SHARE

The discussion in the main part was confined to firms' optimality condition (for labor demand) and its implication for the labor share. We now derive household-side counterparts to that, in particular, to equation (29). The derivations below start from the definition of the labor share and substitute out the real wage using households' optimality condition for labor supply. This provides a complementary perspective on the determinants of the labor share and clarifies how restrictive monetary policy affects it through the household sector. We do so both for the model based on monopolistic labor supply and the one based on monopsonistic labor demand.

M.1. **Monopolistic labor supply.** In the baseline model with monopolistic labor supply, households are wage setters. Their intratemporal optimality condition is given by equation (11) where $\mu_t^w$ is the (time-varying) wage markup. It states that monopolistic wage setting drives a wedge between the real wage and the marginal rate of substitution. In the steady state, wage adjustment costs vanish (by construction) and $\frac{\varepsilon-1}{\varepsilon} = 1/\mu^w < 1$, so that $w = \mu_w \, mrs$.

Substituting equation (11) into equation (29) yields the household-side analogue to equation (29)

$$s_{L,t} = \mu_t^w \frac{mrs_t}{y_t/h_t} \tag{76}$$

Equation (76) expresses the labor share as the marginal rate of substitution scaled by the wage markup $\mu_t^w$ and normalized by (average) labor productivity $y_t/h_t$. Using the utility function (27), then under the simplification of $\chi = 0$ and noting that $mrs = h^\phi c^\sigma$, we obtain

$$s_{L,t} = \mu_t^w \frac{h_t^{1+\phi} c_t^\sigma}{y_t} \tag{77}$$

Finally, using the goods market equilibrium (see equation (22)) and assuming $\iota_t = 0$ for simplicity,[9] the household related labor share is given by (in log-linearized form)

$$\hat{s}_{L,t} = \hat{\mu}_t^w - \hat{\mu}_t^p + (1+\phi)\hat{h}_t + (\sigma-1)\hat{c}_t \tag{78}$$

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[9] In the baseline model, the resource constraint is $y_t \, mc_t = c_t + \iota_t + \Psi(h_t) w_t h_t$ and $mct = 1/\mu_t^p$ in the monopolistically competitive steady state. Assuming $\iota_t = 0$ is a special case without investment (or, equivalently, when $c_t$ is interpreted as aggregate absorption).

This equation decomposes fluctuations in the labor share into economically meaningful components:

(i) Wage-setting wedge. An increase in the wage markup $\mu_t^w$ giving a rise to a higher real wage relative to the MRS increases the labor share one-for-one.

(ii) Price markup. A rise in the price markup $\mu_t^p$ decreases the labor share. Intuitively, when firms' markups increase, a smaller fraction of output is paid out as wages.

(iii) Hours worked. The coefficient $(1 + \phi)$ captures the sensitivity of the MRS to hours under $\chi = 0$. Since $(1 + \phi) > 1$, movements in hours affect the labor share strongly: lower hours reduce the MRS (and hence the real wage required for households to supply labor), decreasing the labor share.

(iv) Consumption (or output). The role of $\hat{c}_t$ depends on risk aversion $\sigma$. If $\sigma > 1$, a decline in consumption after a monetary contraction reduces the labor share while the opposite applies once $\sigma < 1$.

Taken together, equation (78) suggests that a restrictive monetary policy shock may raise the labor share if the increase in the wage markup $\mu_t^w$ dominates the counteracting effects operating through lower consumption, lower employment and a higher price markup. Hence, from a mere household perspective, wage stickiness sufficies to enable an increase in the labor share in response to a monetary contraction; however, wage stickiness alone is insufficient for this once the firm side is considered. The latter hence requires the labor adjustment costs.

M.2. **Monopsonistic labor demand.** We finally consider the alternative labor-market set-up with monopsonistic labor demand, in which firms (rather than households) possess wage-setting power. Households are wage takers and choose hours subject to labor-supply adjustment costs. Their intratemporal optimality condition is given by equation (49) where $\Psi_H(h_t)$ summarizes the (time-varying) wedge induced by labor-supply adjustment costs. It states that the adjustment friction drives a wedge between the real wage and the marginal rate of substitution. In the steady state, adjustment costs vanish (by construction) and $\Psi_H(h) = 0$, so that $w = mrs$.

Substituting equation (49) into the definition of the labor share yields the household-side analogue to equation (29):

$$s_{L,t} = \frac{mrs_t}{(1 - \Psi_H(h_t))} \frac{h_t}{y_t} \tag{79}$$

Equation (79) expresses the labor share as the marginal rate of substitution, scaled by the labor-supply adjustment wedge $1/(1 - \Psi_H(h_t))$, and normalized by (average) labor productivity $y_t/h_t$. Using the utility function (27), then under the simplification of $\chi = 0$ and noting that $mrs_t = h_t^{\phi} c_t^{\sigma}$, we obtain

$$s_{L,t} = \frac{1}{1 - \Psi_H(h_t)} \frac{h_t^{1+\phi} c_t^{\sigma}}{y_t}. \tag{80}$$

Finally, using again the goods market equilibrium (see equation (22)) and assuming $\iota_t = 0$ for simplicity,[10] the household-related labor share is given by (in log-linearized form)

$$\hat{s}_{L,t} = \Psi_H(h_t) \; - \hat{\mu}_t^p + \hat{\mu}_t^w + (1+\phi)\hat{h}_t + (\sigma - 1)\hat{c}_t. \tag{81}$$

To obtain (81), note that $\Psi_H(h_t) = 0$ in the steady state.

This equation decomposes fluctuations in the labor share into economically meaningful components:

(i) Labor-supply adjustment wedge. An increase in $\Psi_H(h_t)$ raises the labor share. Economically, if the adjustment friction makes it locally attractive for households to smooth hours over time, then $\Psi_H(h_t)$ may become positive along the adjustment path, implying $1/(1-\Psi_H(h_t)) < 1$; in this case, the wedge dampens the response of $s_L$. Conversely, if $\Psi_H(h_t) > 0$, then $1 - \Psi_H(h_t) < 1$ and the wedge amplifies the labor share.

(ii) Price markup. A rise in the price markup $\mu_t^p$ decreases the labor share. Intuitively, when firms' markups increase, a smaller fraction of output is paid out as wages.

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[10] In the baseline model, the resource constraint is $y_t\, mc_t = \frac{1}{\mu_t^w}(c_t + \iota_t + \tilde{\Psi}(\omega_t) w_t h_t)$ and $mc_t = 1/\mu_t^p$ in the monopolistically competitive steady state. Assuming $\iota_t = 0$ is a special case without investment (or, equivalently, when $c_t$ is interpreted as aggregate absorption).

(iii) Hours worked. The coefficient $(1+\phi)$ captures the sensitivity of the MRS to hours under $\chi = 0$. Since $(1+\phi) > 1$, movements in hours affect the labor share strongly: lower hours reduce the MRS (and hence the real wage required for households to supply labor), decreasing the labor share.

(iv) Consumption (or output). The role of $\hat{c}_t$ depends on risk aversion $\sigma$. If $\sigma > 1$, a decline in consumption after a monetary contraction reduces the labor share while the opposite applies once $\sigma < 1$.

Taken together, equation (81) suggests that a restrictive monetary policy shock may raise the labor share if the labor-supply adjustment wedge (embedded in $\Psi_H(h_t)$) rises sufficiently, and/or if the decline in labor productivity (captured by relatively muted movements in $h_t$ compared to $y_t$) is strong enough to dominate the counteracting effects operating through lower consumption and a higher price markup.