The Labor Share is a Catalyst for Monetary Policy

Two Million Firms' Production Dynamics

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Abstract

We study the role of firm heterogeneity and cost structure in determining the transmission of monetary policy. Using local projections and high dimensional fixed effects, we show that a one standard deviation contractionary monetary policy shock decreases firms' labor share by 0.4 percent, on average. However, reactions are heterogeneous along two dimensions: The labor share is most informative to discriminate firms by their response in payroll expenses, firms' leverage is most informative to discriminate by their response in value added. We interpret these findings by theorizing differential effects of factor input costs. Our results inform the policy debate on transmission and redistribution effects of monetary policy, and suggest that the effectiveness of monetary policy may depend on the labor intensity of production.

JEL classification: D22, E52, D31, E23, E32

Keywords: Monetary policy, firm heterogeneity, labor share, production dynamics, factor input costs.

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1 Introduction

Our study provides firm-level evidence on the response of key economic variables to a monetary policy (MP) shock: value added, wages, and the labor share[1]. Both value added and wages constitute a cornerstone of corporate decision-making. Value added measures a company's contribution to economic output. Wages, on the other hand, are the main component in income for the majority of households, they are central to both investment and consumption behavior. From the perspective of the firm, labor compensation is typically a vital cost component, while at the macro-level, understanding wage-setting is key for understanding inflation dynamics and unemployment (Christiano et al., 2016; Galí et al., 2012).[2] The labor share of value added is not only a key indicator for the distribution of income (Piketty, 2015) but directly linked to the mark-up and, by implication, central to the pricing behavior of firms (Cantore et al., 2020; Nekarda & Ramey, 2020; Galí, 2015). Notwithstanding these factors' centrality[3], empirical or theoretical literature of their response to MP shocks at firm-level is virtually nonexistent.

Our paper is thus first to investigate the change of the labor share at the highest resolution across euro area (EA) member states. Moreover, we dig deeper and propose the hypothesis that firm heterogeneity in factor input cost structure is a decisive factor to consider for the labor share response to MP. We inform the current debate on the evolution of the redistribution channel of MP and firm heterogeneity (Auclert, 2019; Cantore et al., 2020; Ottonello & Winberry, 2020; Kehrig & Vincent, 2021). In order to study the nuances in the labor share, wages and value added we analyze a micro-panel from 1999-2017 covering over 2.1 million firm. We find a significant, highly robust and pronounced negative reaction of labor costs, value added and the labor share after a contractionary MP shock. The literature on transitory effects of firm heterogeneity focuses on fundamentals such as age (Cloyne et al., 2018), size (Gertler & Gilchrist, 1994) or balance sheet related measures (Ottonello & Winberry, 2020; Jeenas, 2019). We find that measures related to factor input costs matter predominantly for determining heterogeneity of cyclical behavior. In particular, while firms with a high labor share are affected most strongly by MP, firms with a low labor share operate more independently. Moreover, firms with high leverage ratios are also relatively more responsive to MP. However, across these two dimensions – labor share and leverage – results appear to be driven by fundamentally different channels.

[1] We follow Autor et al. (2020) and define the firm-level labor share as payroll divided by value added.

[2] Together with price-setting, wage-setting determines the response of the economy to MP shocks (Galí, 2011). Galí (2011) notes that, *'despite the central role of the wage-setting block in the New Keynesian model, the amount of work aimed at assessing its empirical relevance has been surprisingly scant'.*

[3] and despite the fact that the New Keynesian model features clear implications

These are, firms are most meaningfully discriminated according to what constitutes the main component in their factor input cost structure: labor-intensive firms react by making payroll amendments, highly leveraged firms react by altering their production. For the latter, value added drives the results.

We use information-neutral shocks developed by Jarociński & Karadi (2020) for identified changes in MP. These shocks may be interpreted as exogenous with respect to credit conditions insofar as they do not contain any central bank information on the state of the economy. Following Ottonello & Winberry (2020), we break down the euro-area wide MP shocks to the micro-level by employing the firm's idiosyncratic leverage ratio as an exposure measure. In a local projections regression framework, we then estimate the labor share's reaction, controlling for a high dimensional combination of fixed effects.

In order to interpret these empirical findings, we extend on the case put forward in Gorodnichenko & Weber (2016) where firms adjust to demand shocks by changing prices. In particular, a toy model rationalizes the case where firms make adjustments in their factor input cost composition in response to MP shocks when they are faced with the impossibility of price adjustments. By allowing for heterogeneity in a firm-specific production function, the model suggests that firms with large labor shares may adapt to MP primarily by altering payroll expenses.

Results from this research project help design more effective governmental and central bank policies. The paper informs the discussion about fundamental questions in the field of monetary economics, including: how do interest rates affect the distribution of income between wages and capital from the perspective of the firm? How do firm-specific characteristics such as financial constraints, age or balance sheet composition affect the transmission of MP, and what channels are at play?

Related literature. This study contributes to four strands of literature. First, our analysis relates to the literature that studies how the effect of MP varies across firms by showing that firms with different balance sheet compositions have fundamentally different prospects in responding to MP shocks. Other studies suggest that the firm-level response depends on age (Cloyne et al., 2018), liquidity (Jeenas, 2019), default risk (Ottonello & Winberry, 2020), or size (Gertler & Gilchrist, 1994). Our data allows to study different features of business model and balance sheet composition. However, we consider these firm characteristics in our analysis (see Sections 3.4 and 3.5.2 or Figure 3, for instance) and show that our results are robust to controlling for them.

Second, our econometric strategy is related to approaches put forward by Ottonello & Winberry (2020) as well as Jeenas (2019), who deploy financial exposure variables to break MP shocks down to the firm-level.

Notwithstanding, the research questions they tackle are fundamentally different from ours. Our findings complement their reasoning and results.[4] In contrast to these studies, however, we base our analysis on a data set that is not limited to listed firms. In Sections 3.5.1 and 3.5.2 we discuss the particularities of listed firms and liquidity as an alternative measure of firm sensitivity to MP, respectively.

Third, we contribute to a growing strand of literature which argues that the labor share is a relevant metric to scrutinize when it comes to the effectiveness of MP. In particular, Cantore et al. (2020) and Nekarda & Ramey (2020) analyze the cyclical behavior of markups and labor market variables conditional on demand shocks at the macro or industry-level.[5] Our contribution relative to this extant literature is that, on the empirical side, we provide systematic, robust micro-level evidence, but are also able to account for differences to their macro-findings. In Section 3.5 and Subsection 3.5.3 we address and arguably solve this puzzle.

Finally, we contribute to the literature which studies the role of the firm factor input differential effects in determining the heterogeneous firm-level response to MP shocks. Our simple model of firm-level labor intensity in productions extends on the case put forward by Gorodnichenko & Weber (2016), who study the effect of relative price stickiness across firms. The approach we propose in Section 4.1 considers firms that cannot adjust prices when faced with demand shocks and hence resort to making amendments in their factor input cost composition.

Road map. The remainder of the paper is structured as follows. The subsequent Section 2 explains our data set and methodology. Section 3 contains the empirical results and robustness exercises. Section 4 discusses and interprets the findings, explains the theory of our working hypothesis, puts them into context with the existing literature and derives some policy implications. Section 5 concludes.

2 Data and empirical strategy

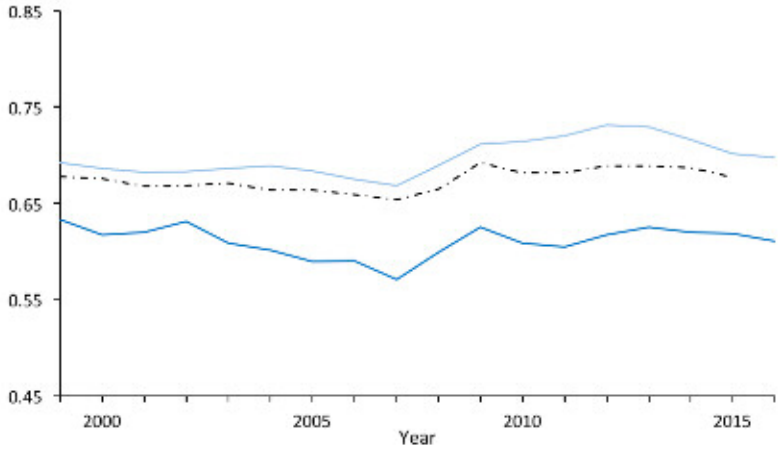
We base our analysis on an annual corporate-sector micro panel of EA companies from 1999 until 2017, and conduct the baseline estimations based on the eleven EA founding members to abstract from a potential sample selection bias at the country dimension. Figure 1 highlights that the EA aggregate labor share, in contrast to the US labor share, is relatively stable (Gutierrez & Piton, 2020) and thus not characterized by a decline described by Autor et al. (2020). Therefore, it serves as an excellent basis for the analysis of cyclical

[4] Especially that the impact of MP is most pronounced after one year is a result that all three studies have in common.

[5] Many others have studied the relationship between the markup, the labor share, and their cyclicality ( ).

labor share components.

Figure 1: Euro Area Labor Shares - BvD Amadeus/EU KLEMS Comparison



Notes: The dark dashed line in the middle displays the wage share according to *EU KLEMS* for EA-11 (defined as ratio of labor compensation to gross value added; data are from July 2018 release). The upper (light blue) line is the *BvD Amadeus* median firm-level wage share for EA-11. The bottom (dark blue) line is the *BvD Amadeus* total sum of costs of employees divided by the total sum of value added for EA-11 (all calculations based on our sample).

While the sample excludes the public sector, freelancers, and financial companies, it is highly representative at the macro-level. Figure 1 demonstrates the representativeness of our data, benchmarked by the EU KLEMS EA-11 labor share[6]. The solid lines (sample mean and median) capture the dynamics as well as the level of well-established statistics (dashed line) very aptly.

2.1 Firm-level data

The data for our main industry-level analysis come from the Bureau van Dijk's (BvD) Amadeus commercial database for European firms, which is a subset of the BvD Orbis dataset for global firms. This rich database comprises employment statistics, detailed balance sheet information and industrial industry affiliation for SMEs and large firms, reported with annual frequency. It covers all EA countries and is thus, despite some noteworthy shortcomings[7], the best publicly available dataset for comparing firm data across Europe over time (Kalemli-Özcan et al., 2019; Gopinath et al., 2017).

[6]EU KLEMS stands for EU level analysis of capital (K), labor (L), energy (E), materials (M) and service (S) inputs.

[7]such as increasing sample size over time and non-uniform national reporting requirements across countries

Crucially, for our purpose, BvD's Amadeus provides firm reporting of total assets, equity, outstanding loans, sales, value added and cost of employees, the latter two of which are the basis to calculate firm-level labor shares[8] over the period from the introduction of the euro in 1999 until 2017. We compute firm-specific leverage ratios as the share of total liabilities[9] over total assets. For the analysis we consider unconsolidated firm statements across the full range of corporate firms and industries. Appendix A.1 describes our sample selection and data cleaning operations which we base on Ottonello & Winberry (2020), Kalemli-Özcan et al. (2019) and Belenzon et al. (2017). Following their suggestions, we drop observations with negative values of total assets, value added, number of employees or sales. In addition, we drop observations where the costs of employees or the labor share is below zero. We winsorize the labor share at the 99.5th and .05th percentile. To assure consistency across estimations, we only consider observations with non-missing labor shares. Our baseline sample includes the eleven EA founding members[10]. Table 1 displays the summary statistics of our data set.

2.2 Industry-level data

In order to extend our analysis to the industry-level, we collapse the micro-data variables to the country-industry[11] level and recompute the labor share.[12] As an exposure variable, in order to break down the EA-wide MP shocks to the industry-level, we employ the well-established external financial dependence ratio as in Rajan & Zingales (1998), recomputed at the two-digit NACE Rev. 2 level using data from Compustat. It is defined as the industry median fraction of capital expenditures financed by external funds for mature Computstat companies over the period 1999-2017.

2.3 Monetary policy shocks

Our employed MP shocks for the EA as a whole are identified by and retrieved from Jarociński & Karadi (2020). These quarterly shocks are relatively new, but at the same time quickly becoming the gold standard for identified EA MP surprises because they can be interpreted as unanticipated changes in credit conditions. Rather than trying to control for confounding variables, these shocks address potential endogeneity of MP

[8] Following Autor et al. (2020) we define the labor share as payroll over value added.

[9] that is, total assets minus equity

[10] These are, Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain.

[11] that is, two-digit NACE Rev. 2 industry classification

[12] We keep only observations for which both payroll expenses and value added are reported.

Table 1: Summary Statistics

Variable	***N***	**Mean** (Std. Dev.)	**p5**	**Median**	**p95**
MP shock$*LR_{t-1}$	13,966,175	0.02 (0.07)	-0.07	0.00	0.15
Cost of Employees/VA	14,453,176	72.63 (23.73)	28.71	75.68	102.98
Cost of Employees	14,453,176	1,310,734.65 (30,167,410.27)	18,539	182,000	3,298,416
Cost of Employees (g)	14,453,176	0.08 (0.23)	-0.22	0.04	0.53
Value added	14,453,176	2,155,078.55 (55,296,745.40)	30,361	259,857.50	5,011,055
Value added (g)	14,453,176	0.08 (0.28)	-0.30	0.04	0.63
TA	14,453,176	9,333,298.15 (361,352,962.85)	58,000	622,832	15,406,928
Equity	14,453,176	3,563,096.65 (14,3336,202.53)	10,067	172,142	5,853,024
LR	14,453,176	0.63 (0.25)	0.16	0.67	0.96
Cash/TA	14,052,516	0.16 (0.19)	0.00	0.09	0.57
Working capital/TA	14,290,750	0.27 (0.27)	-0.10	0.24	0.76
Sales	13,700,288	8,336,940.06 (220,991,484.74)	77,817	773,409.50	17,869,286
Cost of Employees/Sales	13,626,334	29.46 (19.66)	4.91	25.82	67.37
№ Employees	11,218,478	34.92 (562.05)	1.00	6.00	98.00
Age	2,120,040	12.89 (11.36)	2.67	9.52	34.34

Notes: This table presents summary statistics for the variables used in the empirical tests. All statistics are based on annual frequency. The '*MP shock*$*LR_{t-1}$' variable captures the annual sum of ECB monetary shocks provided by Jarociński & Karadi (2020), broken down to the firm-level via the exposure measure, the LR. '*Cost of Employees/VA*' and '*Cost of Employees/Sales*' are the firm level labor shares defined as $\frac{Cost of Employees}{Value Added}$ and $\frac{Cost of Employees}{Sales}$, respectively. Similarly, '*Cost of Employees (g)*'; '*Value Added (g)*' are the growth rates of the name-giving balance sheet items. '*TA*' is the total balance sheet size in euros. '*Equity*' are shareholder's funds. '*LR*' stands for leverage ratio and is defined as $\frac{Total Liabilities}{Total Assets}$. '*Cash/TA*' are firm's cash reserves divided by total assets. '*Working capital/TA*' is a given firm's working capital divided by total assets. '*№ Employees*' are firm's number of employees. '*Sales*' is any given firm's total revenue. '*Age*' is the average firm age in years. All balance sheet items at firm level are provided by Bureau van Dijk's Amadeus database. The sample includes 2,139,347 firms in 79 industries.

by focusing on movements of prices in a narrow window around announcements (Nakamura & Steinsson, 2018). Jarociński & Karadi (2020) provide evidence that it is not uncommon for the stock market to depreciate after markets are surprised with lower than expected policy rates (e.g., a surprisingly strong cut may sends the signal that the economy is in worse condition than previously expected by market participants). Specifically, the authors thus use sign restrictions on the joint high frequency reaction of interest rates and stock market prices, disentangling information conveyed in the shocks about the European Central Bank's (ECB) assessment of the economic outlook as well as its MP decisions. These news about the state of the economy from changes in financing conditions are important for our paper because we specifically study the effect of changing credit conditions rather than the effect of changes in the state of the economy as a whole. We sum up the quarterly shocks[13] in order to obtain annual data along the lines of Holm et al. (2021).

2.4 Identification

We break down EA-wide policy surprises borrowed from Jarociński & Karadi (2020) to the firm-level by employing an exposure variable approach as suggested by Ottonello & Winberry (2020). Since our MP shocks are limited to the measurement of central bank credit conditions and are thus information neutral, firms with more leverage are naturally more exposed to MP. The exposure measure is necessary to identify the shocks at the firm level for several reasons. First, such setup allows for country-time and industry-time fixed effects and hence to control for local or global business and credit cycles (Kiyotaki & Moore, 1997) which influence the transmission of MP. Second, the exposure variable approach prevents spurious correlations, e.g. that any company without outstanding loans is directly affected by changing credit conditions. Third, empirical evidence in Table 2 (see Appendix) shows that our empirical strategy (see Equation 1 below) yields a reasonable response of interest rates at the firm-level: monetary tightening leads to an increase in firm's interest payments for the first three years. In contrast, the shock that is just macro-level identified leads to a very counter-intuitive interest payment response at the firm-level, which reportedly turn strongly and significantly negative in year 1-3 after a tightening shock. In section 3.5.3 we show the puzzling labor share response when shocks are not identified at the firm-level.[14]

[13] we use the MP shocks obtained with Poor Man's sign restrictions. However, results are robust to employing MP shocks obtained with the median rotation that implements the sign restrictions. We choose the former because the latter does not yield point identification and their standard errors might be subject to error.

[14] Notwithstanding, payroll expenses and value added respond qualitatively similar.

2.5 Empirical Strategy

Local projections allow us to estimate how a firm's labor share over horizon $j > 0$ responds to MP shocks conditional on the firm's leverage ratio, and to compute the corresponding impulse responses (Plagborg-Møller & Wolf, 2021). This motivates our baseline local projections framework (Jordà, 2005) as depicted by the following equation:

$$ls_{f,t+h,s,c} = \alpha_{f,h} + \beta_h LR_{f,t-1} MP_t + \Gamma_h' X_{f,t-1} + \delta_{t,h}\zeta_{s,h} + \delta_{t,h}\kappa_{c,h} + \epsilon_{f,t+h,s,c} \quad (1)$$

where $ls_{f,t+h,s,c}$ denotes the labour share of firm f at time t in industry s and country c.[15]. β_h are the coefficients of interest that measure the impact of the EA-wide monetary policy shock MP_{t+h} on the firm-level for every horizon. The shock is broken down to the firm-level by $LR_{f,t-1}$ which denotes the (lagged) firm-specific leverage ratio. $\alpha_{f,h}$, $\delta_{t,h}$, $\zeta_{s,h}$ and $\kappa_{c,h}$ are firm-, time-, industry- and country-fixed effects, respectively. $X_{f,t-1}$ is a vector of firm-specific and macro-economic controls. It contains $LR_{f,t+h-1}$, $LR^2_{f,t+h-1}$, $log(total\ assets)$, $\frac{working\ capital}{total\ assets}$, $\frac{cash}{total\ assets}$, $\frac{loans}{total\ assets}$, and an interaction term between $LR_{f,t+h-1}$ and (lagged) country GDP growth. $\epsilon_{f,t+h,s,c}$ denotes the error term. For above impact horizons ($h > 0$) we also include $\epsilon_{f,t+h-1,s,c}$. To investigate its components, we run the same specification as in Equation 1 on the dependent variables $log(value\ added)$ and $log(costs\ of\ employees)$. This enables us to elaborate the transmission channel through which MP affects the labor share. Finally, we cluster standard errors at the industry and firm-level to account for potential correlation within the unit where the shock takes place: clustering by firm allows to control for error correlation at the most granular level. The additional clustering at industry-level is conservative, given that we already include time-industry fixed effects, but might help to control for potentially correlated shocks across firms in a given industry.

3 Empirical results

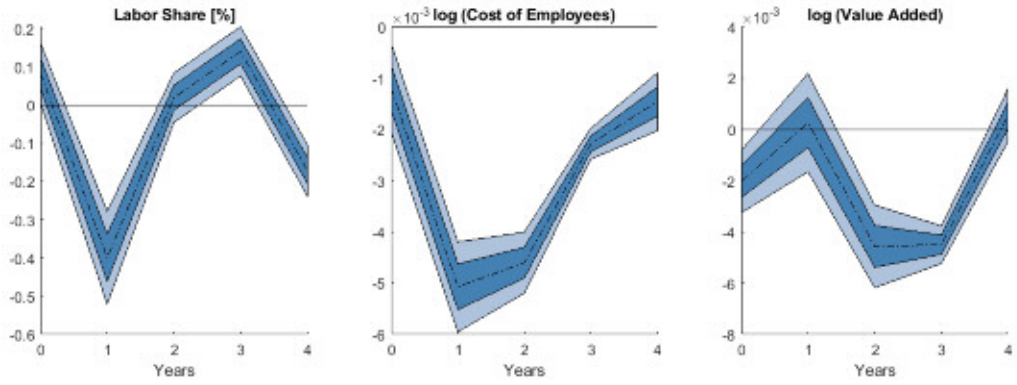
3.1 Results of the baseline specification

Figure 2 displays the results of our baseline specification. We find that a contractionary MP shock results in a significant decline in the labor share, and that this effect is stronger for firms with higher leverage ratios. On average, a one standard deviation MP contraction leads to a .4 percentage points decline in the labor

[15]The labor share is defined as $\frac{Costof Employees}{ValueAdded}$.

share. This decline is driven by decreasing (log) costs of employees, which is small on impact but more pronounced after one year, and is still slightly negative after four years. (Log) value added declines slightly on impact, but react most pronounced after two years - which brings the labor share back to its initial level, after four years.

Figure 2: Labor Share (and Components') Response to Monetary Tightening



Notes: The figure shows the responses to a one standard deviation MP tightening shock in i) the labor share; ii) $log(costs\ of\ employees)$; and iii) $log(value\ added)$ at firm-level. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm-level.

3.2 Ex-ante firm heterogeneity

Our analysis extends beyond the average firm: given that heterogeneity matters for the firm-specific reaction to MP, our research question is tailored around variation in business models, cost structure, and balance sheet composition – which are most meaningfully distinguished along the lines of labor share and leverage heterogeneity (see Section 4.1). As strand of literature also suggests size and age as relevant dimensions (Cloyne et al., 2018; Gertler & Gilchrist, 1994). We address firm heterogeneity empirically by splitting the data into quantile-bins according to size, age, leverage ratio, and labor share, then repeat the set of estimations depicted in Equation 1 on these quantiles of the data.

For each of these four dimensions of interest, data are split by these six quantiles: the lowest 10%, the 10-25%, the 25-50%, the 50-75%, 75-90%, and the top 10 (i.e. the 90-100%).[16] As a next step, we carry out regressions for these six quantiles-bins of firm characteristics. By applying this method, we not only control

[16]Quantiles are calculated based on sample means. For each individual firm we then calculate the sample average of the four dimensions and categorize it by putting it into one of the six quantile-bins.

for *ex-ante* firm heterogeneity, but are also able to provide one estimate conditional on the average leverage ratio of the quantile.[17] [18]

Figure 3 displays this exercise's estimates. Thereby, each line represents a variable and each column represents a quantile-bin. We see that most heterogeneity across estimates is concentrated in the first two lines (that are, leverage ratio and labor share), where, with respect to the labor share sample spilt, we see the strongest reaction in the upper quantile and a less pronounced reaction in lower quantiles. Low labor share companies appear almost non-responsive to MP.[19] However, estimates of leverage-bins are to be taken with a grain of salt: since the leverage ratio is also our exposure variable, this variable features heterogeneity by construction.[20] Across the quantile-bins of size and age in the bottom two rows of Figure 3 we see much less heterogeneity, only very young firms exhibit a pronounced response with wide confidence bands, and very large and very old firms react with a negligible increase in the labor share.

When it comes to the components of the labor share –value added and costs of employees– we find substantially different reactions depending on how we group our firms. Looking at firms grouped from high to low leverage, the reaction of value added varies strongly. However, when we group the same firms according to labor share, the reaction of costs of employees varies more strongly while heterogeneity in value added is mild (see Figure 12 and Figure 13 in Appendix A.4). This finding suggests that indeed both dimensions are crucial to understand heterogeneous responses at firm-level because different frictions are at play.
While the breakdown by leverage ratio has more explanatory power for heterogeneity in the production process and value added, the labor share breakdown is more informative about the developments of labor utilization.[21] The low correlation coefficient of quantile-bins lets us already infer that we are not looking at

[17] Our interpretation of leverage is different from Ottonello & Winberry (2020), who interpret the within-firm variation of leverage as a measure the distance to default – i.e. all else equal, a company taking on more leverage becomes more risky. Our interpretation of leverage, on the other hand, is more related to the business model: the more leverage a company has - and hence the more interest rates and debt-rollovers play a role for the overall costs of a company - the more likely it will make its strategic decision dependent on MP.

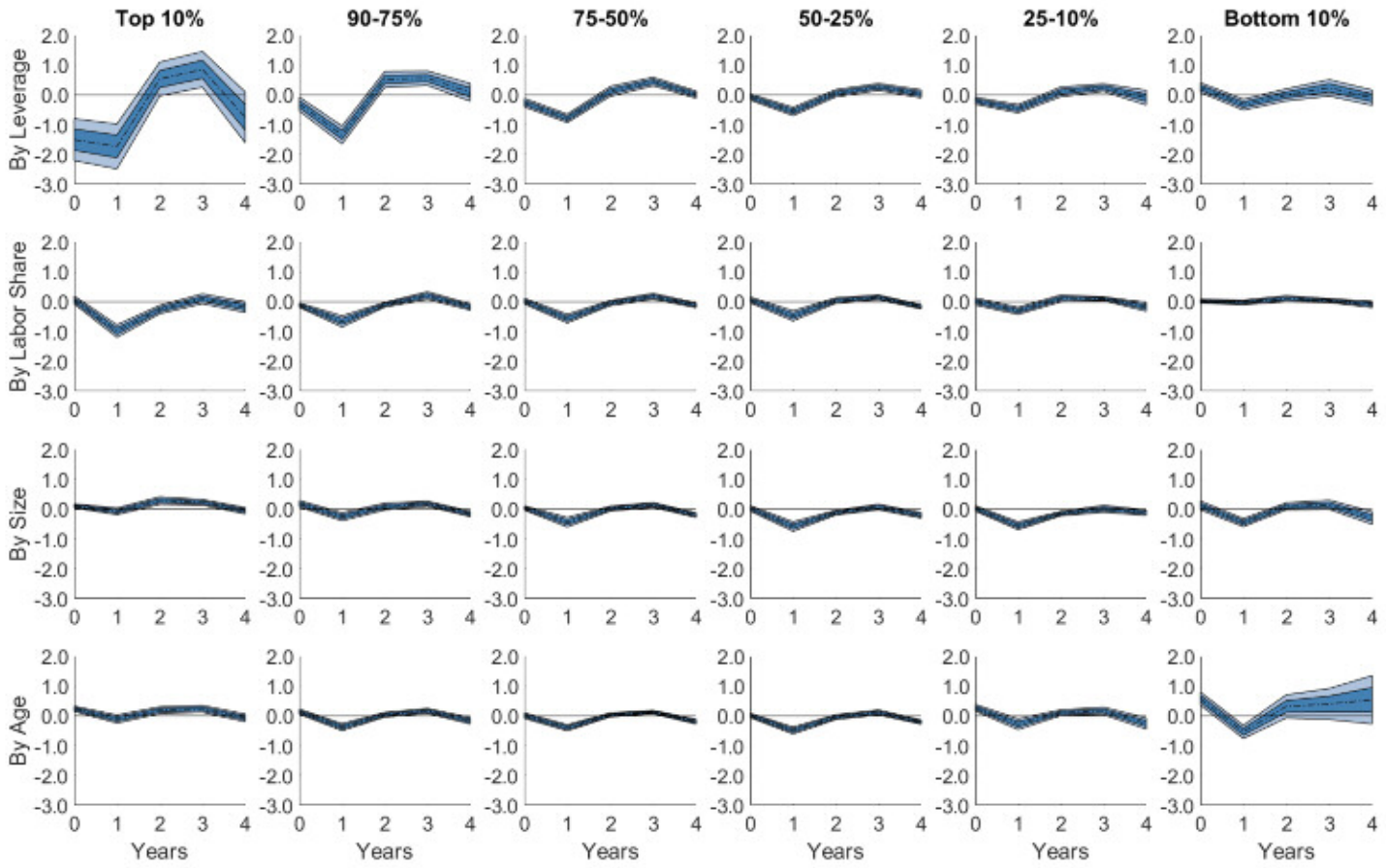
[18] Ottonello & Winberry (2020) show how the fixed effects estimator might yield biased estimates of the coefficient of interest in case of permanent differences in how firms respond to the aggregate shock. They propose to use the within-firm variation of the exposure variable as a measure to break down a macroeconomic shock to the firm-level. We discuss this issue further below in section 3.4, and show that our results remain robust.

[19] Note that the correlation among groups preserves the sample correlation perfectly: while the correlation between leverage and labor share in the sample is 0.13 at the bin-level, the variables exhibit a correlation coefficient of 0.13.

[20] Below we address this issue by conditioning on high and low leverage (Section 3.3), and by taking the first difference of the exposure variable (Section 3.4).

[21] In the top leverage ratio group, for instance, payroll expenses does not react significantly on impact, but log value added

Figure 3: Labor Share Response to Monetary Tightening - Sample Splits



Notes: Figure shows the firm-level labor share response (in percent) to a one standard deviation monetary tightening shock. The sample is split into six quantile-bins for each of the dimensions of firm heterogeneity: leverage ratio, labor share, size, and age. A firm is put into a bin based its sample mean. Quantile-bins of respective groups are depicted from left to right in a descending order. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

two sides of the same coin. In the next section, motivated by the low correlation, we examine firms dominated by either high labor shares *or* high leverage ratios closely to disentangle channels more rigorously.[22]

3.3 Firm heterogeneity: The role of leverage and labor share

Theoretical considerations of Section 4.1 highlight how firms with high labor shares restructure their payroll expenses in response to MP. In addition, it lays out how firms with high leverage adapt to MP by altering their production/value added. This motivates our study of the response of two very distinct types of firms: First, firms with high labor shares that, at the same time, exhibit low leverage ratios and, second, firms that exhibit high leverage ratios with low labor shares.[23]

i) Firms with both high labor share and low leverage ratio. Figure 4 depicts the responses of the labor share, costs of employees, and value added for firms where a high labor share is dominant. The labor share drops to one percent point one year after the shock.[24] This response is driven by a significant and pronounced decrease in costs of employees, which is significant until three years after the shock and reaches its minimum one year after the shock occurs. Value added declines significantly but less pronounced and less swiftly.

ii) Firms with both a low leverage ratio and a high labor share. The lower three impulse responses in Figure 4 depict these firms' reaction to MP. Already on impact, the labor share declines by about 0.6 percentage points. This decline can be decomposed into a strong increase in value added on impact and a small decline in costs of employees. After two years, value added decreases significantly and lets the labor share rebound. Overall, for the highly leveraged group, confidence intervals are much wider.

Note that a low leverage ratio is, by construction, associated with a reduced responsiveness to MP shocks – which corresponds to the credit channel in the literature. Therefore, it is particularly surprising that the high labor share group reacts in such a pronounced and significant way while exhibiting low leverage. Thus,

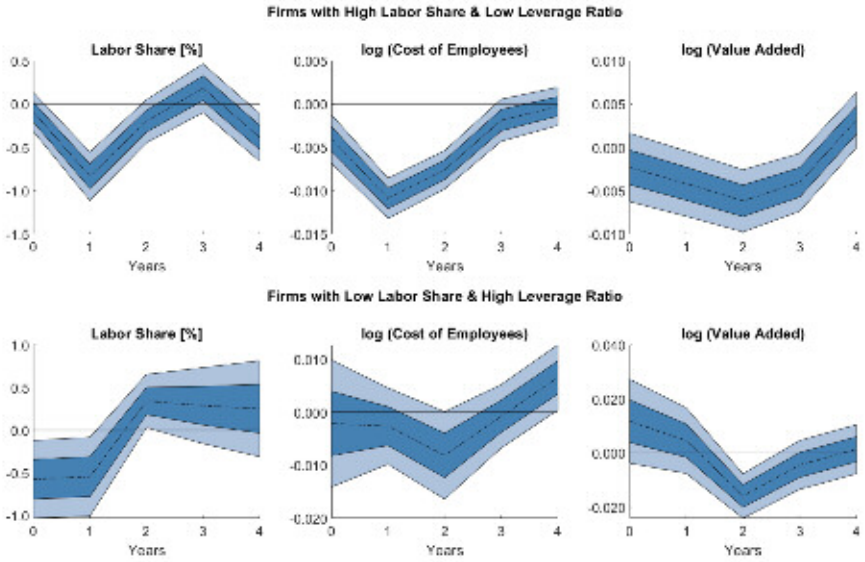
increases significantly. Thus, for highly leveraged firms, the reaction in production is more central than the reaction in payroll expenses. For highest labor share firms, the converse is true: These firms are the only ones to reduce their costs of employees already on impact significantly. They alter their costs easiest by making redundancies, hiring freezes, or amending compensation schemes.

[22] Note, for example, that even the top quantile-bin by leverage ratio contains companies with very high and very low labor share.

[23] In this subsection, we define high and low as the top and bottom 25% quantile of firm averages, respectively

[24] Which is comparable to the reaction of firms in the top 10% leverage or labor share quantile; see figure 3

Figure 4: Labor Share (and Components') Response to Monetary Tightening - Conditional Sample Splits



Notes: The upper row displays the response in the labor share of firms characterized by both a high labor share (top 25% quantile) and low leverage ratio (bottom 25% quantile) to a one standard deviation monetary tightening shock. The bottom row displays the response in the labor share of firms characterized by both a low labor share (bottom 25% quantile) and high leverage ratio (top 25% quantile) to a one standard deviation monetary tightening shock. Firms are put into a quantile-bin based on their sample means. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level

in order to control for possible bias in the results along the leverage-dimension, we employ the leverage ratio's within-firm variation as an exposure measure in the next subsection.

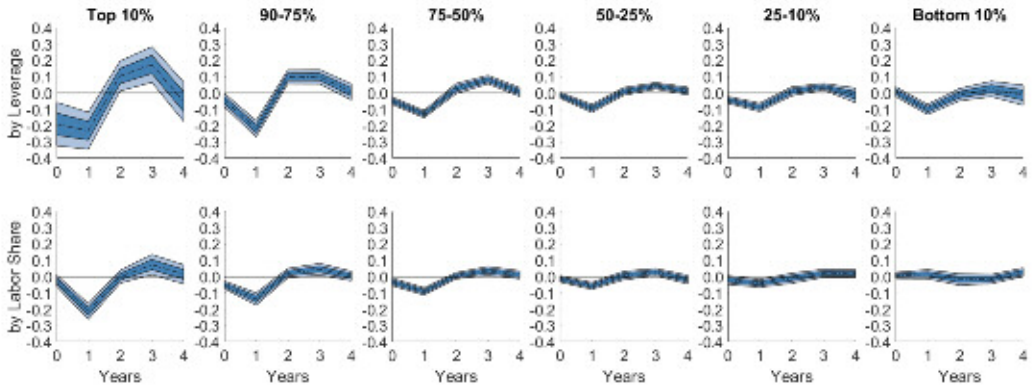
3.4 Alternative Exposure Measure: the Leverage Ratio's Within-firm Variation

Our baseline analysis employs the previous year's (that is, lagged) leverage ratio as an exposure measure to break down MP shocks to the firm-level. Ottonello & Winberry (2020) propose the leverage ratio's within-firm variation[25] as an exposure measure, where this within-firm variation is meant to also control for permanent differences across firms.

Figure 5 displays the results when we carry out the estimation by quantile-bins as described in Section 3.2. We see a very similar pattern as before: The most pronounced labor share reaction is in the top quantiles

[25] i.e. $LR_{t,f} - E_f\{LR_{f,t}\}$

Figure 5: Labor Share Response to Monetary Tightening - Sample Splits & Alternative Exposure



Notes: The figure shows the baseline estimation results (i.e. the response in the firm-level labor share after a one standard deviation monetary policy tightening shock) based on the leverage ratio's within-firm variation as an alternative exposure measure. The sample is split into six quantile-bins by the dimensions labor share and leverage ratio. Firms are put into bins based on the sample mean. Quantile-bins of respective groups are depicted from left to right in a descending order. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

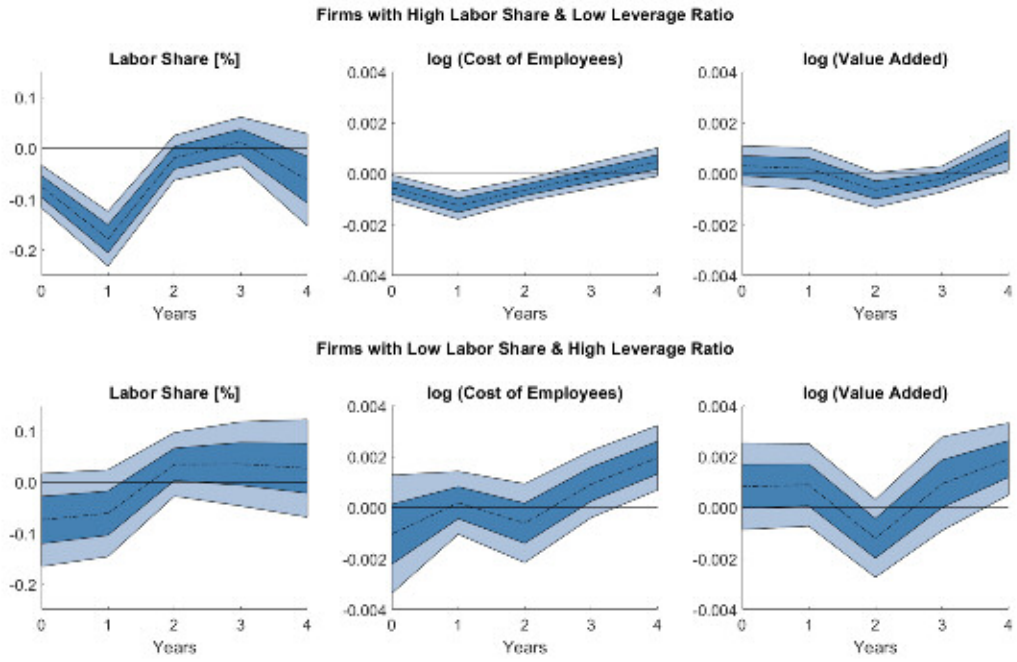
of leverage and labor share.[26] Figure 6 depicts the results when we estimate separately for firms with high labor share (leverage ratio) and a low leverage ratio (labor share). We find that the still highly significant decline in the labor share of labor-intensive firms is again driven by a decline in costs of employees. Highly leveraged firms decrease their labor share while increasing value added. However, in the latter case, results are insignificant.

3.5 Industry-level aggregate estimation

As firm-level research is a relatively young, fast-evolving field in macroeconomic research, there is no established standard approach for measuring firms' financial sensitivity: The choice of exposure measure as well as the efficiency and unbiasedness of resulting estimators hinges on assumptions about the data generating process. At the industry-level, however, external financial dependence is a well-established, mature measure for industries' idiosyncratic financial sensitivity since the seminal work of Rajan & Zingales (1998). Hence, we use their exposure measure to provide industry-level evidence on the robustness of our findings. We do

[26] Figure 14 in Appendix A.5 depicts the sub-components of the labor share. For the responses of log value added, we see most heterogeneity across the quantiles of leverage, whereas the heterogeneity in the response of costs of employees is most pronounced across the quantiles of the labor share.

Figure 6: Labor Share Response to Monetary Tightening - Conditional Sample Splits & Alternative Exposure



Notes: The figure shows estimation results based on the leverage ratio's within-firm variation as an alternative exposure measure. The upper row displays the response in the labor share of firms characterized by both a high labor share (top 25% quantile) and low leverage ratio (bottom 25% quantile) to a one standard deviation monetary tightening shock. The bottom row displays the response in the labor share of firms characterized by both a low labor share (bottom 25% quantile) and high leverage ratio (top 25% quantile) to a one standard deviation monetary tightening shock. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

so by collapsing the firm-level dataset to the industry-level.[27] This step facilitates comparability with other macro-studies such as Cantore et al. (2020). By collapsing the dataset, we also render our estimation more robust to firms entering and exiting the market as well as potential sample-selection bias in our data set. Thus, we estimate the following industry-level equation:

$$ls_{t+h,s,c} = \alpha_{s,h}\kappa_{c,h} + \beta_h EFD_s MP_t + \gamma_h EFD_s \Delta GDP_{t-1,c} + \delta_{t,h}\kappa_{c,h} + \epsilon_{t+h,s,c} \tag{2}$$

where $ls_{t+h,s,c}$ denotes the labor share in industry s at time t and country c for horizon h. EFD_s denotes a time-invariant measure of industry-specific external financial dependence[28]. $\alpha_{s,h}$ are industry-fixed effects,

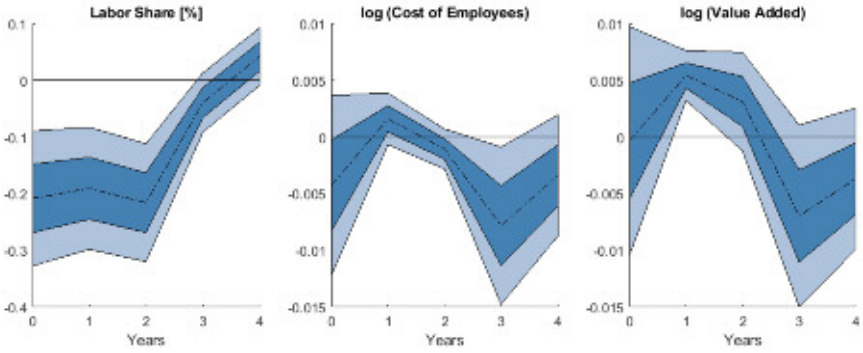
[27] Two-digit NACE Rev. 2 industry classification

[28] which is the industry-median fraction of capital expenditures financed by external funds for mature Compustat companies over the 1999-2017 period, as proposed by Rajan & Zingales (1998).

$\kappa_{c,h}$ are country-fixed effects, $\delta_{t,h}$ are time-fixed effects. β_h are the main coefficients of interest for horizon h, measuring the impact of a EA-wide monetary policy shock MP_t, depending on the extent of reliance on external finance EFD_s of industry s. γ_h aims to control for the effect of real economic activity on the labor share in industries with different external finance dependence. For impact horizons $h > 0$, we also include $\epsilon_{t+h-1,s,c}$. We cluster standard errors at the industry and country-level.

Figure 7 displays the main estimation results. In line with the firm-level findings, we report a significantly negative reaction of the aggregate labor share at the industry-level after a contractionary MP shock. The labor share has a significantly negative reaction on impact and remains negative for the following three years. Payroll expenses have a significantly negative reaction three years after the shock occurs. Value added displays a humped-shaped pattern with a significantly positive reaction after one year, before turning negative, albeit insignificantly.

Figure 7: Labor Share (and Components') Response to Monetary Tightening at Industry-level



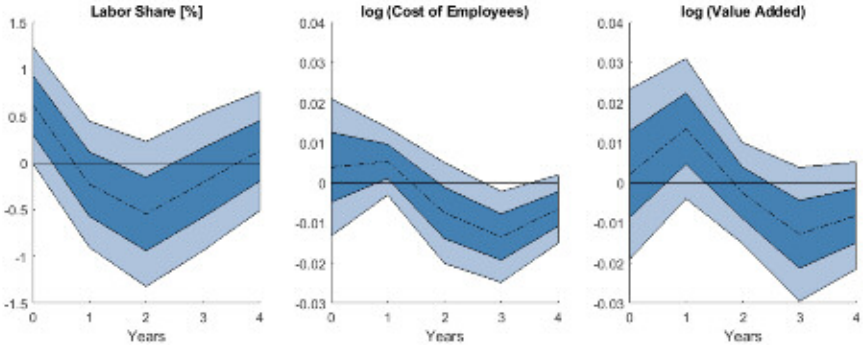
Notes: This figure depicts the industry-level response to a one standard deviation monetary tightening shock in the labor share, log of cost of employees, and log of value added, from left to right. The exposure measure to break down the EA-wide monetary policy shocks is the time-invariant industry-median fraction of capital expenditures financed by external funds for mature Computstat companies over the period 1999-2017. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

3.5.1 Listed firms

Listed firms are regulated fundamentally different compared to non-listed ones, they tend have a more dispersed ownership structure, to operate more globally, and they are in a minority. In our dataset, less than 0.1% of firms are listed. A range of other studies (Jeenas, 2019; Ottonello & Winberry, 2020; Autor et al., 2020) focuses on listed firms when it comes to MP transmission or labor share analysis because of these

firms' unique reporting and ownership characteristics. In order to relate to their research, we repeat the baseline estimation for the sample of listed firms exclusively. Figure 8 displays these results. We find that, on average, listed firms decrease their labor share by about 0.7 percentage points after an MP tightening shock. However, heterogeneity across listed firms is large, rendering the response insignificant. Costs of employees react significantly negative three years after the monetary tightening occurs.[29] The response in value added is insignificant and on impact close to zero. Given that most listed companies in Europe operate globally, are strong exporters, and have ample liquidity Sharpe & Suarez (2015), it is not surprising that they are less sensitive to MP shocks at home – they are more exposed to the global financial and monetary cycle.

Figure 8: Labor Share (and Components') Response to Monetary Tightening - Listed Firms



Notes: The figure depicts the responses to a one standard deviation monetary tightening shock in i) the labor share, ii) $log(costs\ of\ employees)$ and iii) $log(value\ added)$ (from left to right) of listed firms. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

3.5.2 Liquidity vs. Leverage

Sharpe & Suarez (2015) point out that, when it comes to making new investments, listed firms' chief financial officers tend to care more about the liquidity than borrowing costs.[30] Jeenas (2019) builds a model on these arguments. He argues that corporations face fixed treasury costs[31] to motivate his use of liquidity as the firm-level exposure variable. Inspired by his research, we conduct our analysis with two alternative exposure variables related to firms' liquidity conditions. First, gross cash position measured by $\frac{cash}{total\ assets}$ and, second,

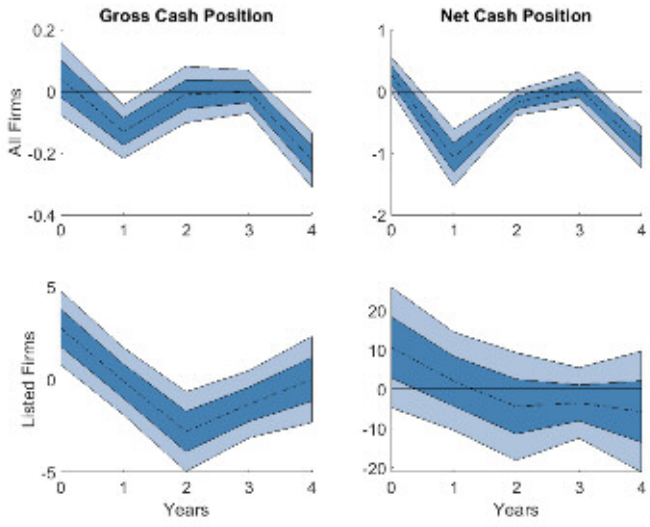
[29] The less timely reaction in costs of employees makes sense because European labor market frictions are comparatively large (Swanson, 2020).

[30] When CFOs were asked why they would not care about changes in their borrowing costs (which only a minority does), they stated that they have ample cash or cash flow to finance investments.

[31] e.g. costs related to issuing debt, changing maturity structure and managing cash reserves

net cash position, measured by $\frac{cash-current\ liabilities}{current\ liabilities}$.[32] Results are displayed in the upper row of Figure 9. For both variables, we find a significant decrease in the wage share. For listed firms (lower row of the same figure), only gross cash position leads to a significant decrease in the labor share.

Figure 9: Labor Share Response to Monetary Tightening - Alternative Exposures with Listed Firms



Notes: The figure shows the baseline estimation result, i.e., the response in the firm-level labor share after a one standard deviation monetary tightening shock. Left-hand side figures are based on *gross* liquidity as an alternative exposure measure. Right-hand side figures are based on *net* liquidity as an alternative exposure measure. The upper row displays the response all firms in the sample. The bottom row displays the response of listed firms. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm levels.

3.5.3 Micro vs. Macro

In Figure 7, we show that our firm-level findings are robust also at the industry-level. These industry results contrast Cantore et al. (2020) and Nekarda & Ramey (2020) who report a puzzling rise in the labor share after a monetary tightening occurs. We can reconstruct this puzzle when we outright regress the labor share on MP shocks without identification at the firm-level[33] by specifying the following:[34]

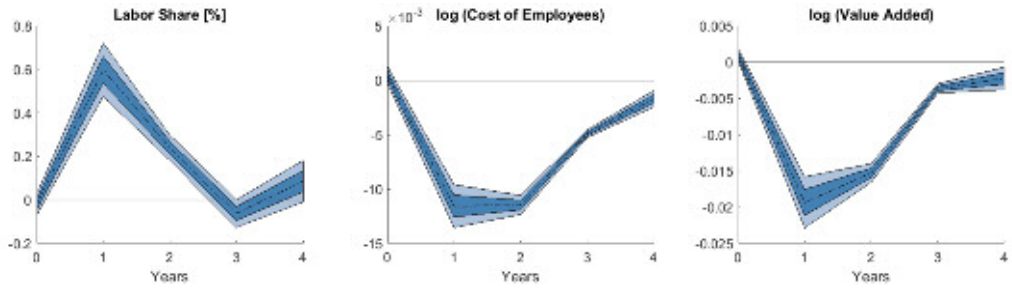
$$ls_{f,t+h,s,c} = \alpha_{f,h} + \beta_h MP_t + \Gamma_h' X_{f,t-1} + \zeta_{s,h} + \kappa_{c,h} + \epsilon_{f,t+h,s,c} \tag{3}$$

[32] We winsorize net liquidity at the 99th and 1th percentile, gross cash position is capped to be on the interval of 0 and 1 based on the sample selection in Appendix A.1.

[33] See Equation 3 for the firm-level specification.

[34] i.e. not employing an exposure variable and not controlling for time-fixed effects at the country- and industry-level.

Figure 10: Labor Share (and Components') Response to Monetary Tightening: Macro-level Identification



Notes: The figure shows the responses to a one standard deviation MP tightening shock in i) the labor share; ii) $log(costs\ of\ employees)$; and iii) $log(value\ added)$ at firm-level without employing the exposure measure approach (and hence under exclusion of time-fixed effects). We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm-level.

Figure 10 displays the results. The puzzle is not driven by large qualitative estimation error in the sub-components (compare figure 2). Both value added and costs of employees decline after monetary tightening - even without firm-level identification. Subtle differences in the relative response of the two components - i.e. the earlier and more pronounced decline of value added together with the less pronounced decline in costs of employees - lead to a reversed sign in response of the labor share.

We express several concerns about equation 3 of both theoretical and empirical nature.[35] First, controlling for local and global credit cycles via time-fixed effects is deemed necessary. Second, firm-level identification is expected to yield better identification compared to macro-level identification (Ottonello & Winberry, 2020), especially given that we employ the less accurate yet point-identified 'Poor Man's' shocks from Jarociński & Karadi (2020), which again is necessary to obtain identified standard errors in our local projections setup (Plagborg-Møller & Wolf, 2021). Third, employing macro-level identification yields strikingly counter-intuitive results with respect to firm's interest payment response (see Table 2), further underscoring the need of more accurate firm-level identification.

[35](see Section 2.4 for greater detail on the discussion

4 Interpretation & formalization

We show empirically that the firm-level labor share functions as a catalyst for monetary policy, and independently so of the leverage ratio of a given company. On average, firms react to a contractionary MP shock with a decline in the labor share. Declines are more pronounced for companies with higher labor shares and for companies with higher leverage. Looking at companies mainly characterized by a high labor share, we see that the labor share decline is driven relatively more by a decrease in costs of employees. In contrast, highly leveraged companies exhibit a pronounced reaction in value added, which drives the response of the labor share (see Section A.4 in the Appendix). Our dataset enables us to control for firm-level dynamics, we deploy identified MP shocks by Jarociński & Karadi (2020) and analyze firms in the EA where no considerable downward trend in the labor share is reportedly present (Gutierrez & Piton, 2020). Therefore, our results are not explained by the rise of superstar firms (Autor et al., 2020) or other trends that affect both mark-up and labor share in the long-run. Our results are in line with a cash-in-advance reasoning for companies with a big payroll and fit in with the main arguments of capital irreversibility (Lanteri, 2018; Ramey & Shapiro, 2001).[36] This section outlines the theoretical underpinning of the empirical findings, proposes a toy model to rationalize as well as relate them to an existing body of economic theory of firm factor differential effects. It furthermore discusses potential policy implications.

4.1 Theorizing firm heterogeneity

MP shocks impact the costs of a company by altering borrowing costs.[37] To investigate the response of a firm to a MP shock, we hence consider it is most informative to look at variables closely related to the company's cost structure. Typically, in the realm of academic macroeconomics, the production process is best characterized via a production function that describes how output is produced as a combination of its factor inputs, capital and labor. Taken together, we consider it reasonable to employ variables that contain information about the composition of and expenses on these factor inputs, in order to discriminate

[36] In addition, our results are in line with the theoretical predictions of the textbook NK model (Galí, 2015; Cantore et al., 2020) — i.e. that monetary tightening leads to a decline in the labor share. The empirical validity of this theoretical prediction, however, is challenged by the findings of Cantore et al. (2020) and Nekarda & Ramey (2020), who report a puzzling positive reaction in the labor share after a monetary tightening. Nekarda & Ramey (2020) discuss the price markup, which they define as the inverse of the labor share.

[37] Some firms may be affected more indirectly, e.g. if they have no or very low borrowing costs.

meaningfully between firms, and to map out their response to MP. These variables are the leverage ratio, and the labor share.

Leverage, on the one hand, is a commonly used measure to approximate the sensitivity of firms to monetary policy (Jeenas, 2019; Ottonello & Winberry, 2020). The labor share, on the other hand, is closely related to the production function of companies, serves as an indicator to distinguish companies between industries and business models, and is highly informative about labor costs a company is faced with. Surprisingly, the degree to which a firm employs labor during production is seldom discussed in macroeconomic literature. Due to the fact that labor has its own regulation, accounting standards and physical limits, the degree to which a company employs it serves as an important dimension to discriminate between firms, both within[38] and between[39] industries.

The literature on firm heterogeneity discusses two other variables used to discriminate firms: size (Gertler & Gilchrist, 1994), and age (Cloyne et al., 2018). Discriminating between firms (or industries) along the lines of (a combination of) age or size, however, does not result in the intuitive description of firms (or industries) that the labor share (often combined with leverage) provides.[40] Therefore, we argue, they are less potent compared to the labor share when it comes to complexity reduction and theoretical abstraction. Complexity reduction is necessary for economic modelling, and an indispensable analytical tool when disentangling the transmission channels of monetary policy.

With this in mind, it is important to note that the labor share and leverage are not two sides of the same coin. The correlation coefficient between leverage and wage share is very low[41], highlighting that both dimensions convey specific information that is not available when looking only at them individually.

To illustrate further, consider two stylized companies with vastly dissimilar business models as an example: First, a consulting agency, characterized by a high labor share. Second, an aerospace plant with planes, airport infrastructure and other tangible assets financed by loans, characterized by high leverage.

[38] Consider, for instance, two companies selling the same good, e.g. translation services: these companies can go about their business either very labor-intensively (by employing a high amount of polyglot workers), or rather labor-unintensively (by using specialized computer software) – pointing toward striking *within*-industry firm heterogeneity in the labor share.

[39] Table 3 provides evidence that the labor share helps discriminate *between* industries, especially when combined with balance sheet indicators. The industry-level correlation coefficient between leverage and wage share is very low - .24 in our sample.

[40] In our data set, an industry-level example with high labor share and low leverage is *'scientific research and development'* and, conversely, *'manufacturing of tobacco products'* (see Table 3 in the Appendix A.3) distinguishes itself as an industry with eminently high leverage and a low labor share. Age or size appear strikingly less handy when it comes to an intuitive distinction between these industries.

[41] .14 in our data set

We hypothesize that when short-term credit conditions tighten, the two types of companies have fundamentally different prospects in reacting to the shock: while both companies face a cash in advance constraint[42], their cost structure and risk management are fundamentally different. As such, we expect that a company with a high labor share and its costs[43] primarily determined by the payroll alters its costs mostly via costs of employees. The consulting firm in our example thus reacts to the shock with large amendments in total costs by making redundancies, imposing hiring freezes or decreasing bonuses. The areospace plant, on the other hand, faces substantial risk of capital irreversibility (Lanteri, 2018).[44] That is to say, this type of company puts more emphasis on managing assets and investments compared to less leveraged ones, because their cost structure is less determined by payroll expenses but by external finance. The considered aerospace plant thus may alter its balance sheet primarily by reducing leverage and covering its capital costs.[45] This can be achieved in different ways e.g. by reducing investments or in case of short-term frictions for investment reduction, the aerospace plant may try to sell more planes - e.g. by offering discounts - to reduce the stock of inventory on its balance sheet.

Based on the considerations laid out above, we deduct the following mechanics in line with empirical findings:
All else equal, ...

- ... a MP tightening shock is followed by a decline in the firm-level labor share, on average.
- ... firms with large labor shares adapt to MP primarily by altering payroll expenses.
- ... firms with high leverage adapt to MP primarily by altering their value added.

4.1.1 Firm factor input differential effects

We may abstract from confounding factors potentially driving empirical findings in a simple, stylized model, and assess whether the estimated results are are quantitatively rationalizable when the only source of heterogeneity across firms is the labor share. Abstracting from taxation, depreciation or leverage, the firm-level

[42] i.e. they have to finance their respective payroll and long-lived capital assets with short-term debt (Carlstrom & Fuerst, 1995; Lucas & Stokey, 1985)

[43] including cost of short-term debt

[44] Ramey & Shapiro (2001) provides evidence from aerospace plant shut-down where capital is sold at large discounts on the secondary market.

[45] this latter transmission mechanism is known as the investment channel of MP (Ottonello & Winberry, 2020).

labor share may be defined as share of labor costs (wL_i) of nominal value-added (P_iY_i). Following Autor et al. (2020), we assume a Cobb-Douglas production function and transform the labor share of value added to

$$LS_i = \left(\frac{wL}{PY}\right)_i = \frac{\alpha^L}{(P/c)_i}, \tag{4}$$

where the ratio of product price P to marginal cost c, or (P/c), is the mark-up.[46] The assumption made by Autor et al. (2020) that factor markets are competitive is lifted in our model. In particular, we assume that labor markets are locally non-competitive, and that firms have some power to alter their labor costs (for instance, by changing their hiring and firing policy, reducing overtime or limiting bonus payments). That is, by extending on the body of work laid out by Gorodnichenko & Weber (2016), we look at the special case that firms cannot change prices and thus have to resort to changing their factor input cost structure. For brevity, we also abstract from a generalized investment channel - such as changes in liquidity or capital - which has been extensively explored by Ottonello & Winberry (2020) and Jeenas (2019). We solely focus on what we call the labor-intensity channel of MP. In a medium-scale New Keynesian macroeconomic model with intermediate goods, the marginal cost of labor is defined as follows:

$$c = \frac{w}{\alpha A(\frac{K}{N_d})^{1-\alpha}} \tag{5}$$

Given our abstraction from changes in capital, prices and technological progress, companies can only alter their costs by reducing the hours N used in production. Substituting c in Equation 4 with its definition stated in Equation 5 yields the following:

$$LS_i = \frac{w_t}{P_i A(\frac{K_t}{N_{d,t}})^{1-\alpha}} \tag{6}$$

Differentiating Equation 6 by hours N yields us the intuitive result that all else equal the labor share of a company is positively proportional to the number of hours worked. Equation 7 is clearly positive.

$$\frac{\partial LS}{\partial N} = \frac{-(\alpha-1)wK^{\alpha-1}N^{-\alpha}}{P_i A} \tag{7}$$

To illustrate how the slope changes across different kinds of companies with different labor intensities, we differentiate Equation 7 by the labor intensity α, which yields the following:

[46] A firm will have a lower labor share if its mark-up is higher for any given value of (α^L, w), as indicated by the firm i subscripts.

$$\frac{\partial LS}{\partial N \partial \alpha} = -\frac{wK^{\alpha-1}N^{-\alpha}((\alpha-1)log(K) - \alpha log(N) + log(N) + 1)}{P_i A} \tag{8}$$

Thereby, Equation 8 is positive if and only if:

$$(1-\alpha)log(N) + 1 < (1-\alpha)log(K), \tag{9}$$

or, put differently, if $0 < N < e^{1/(\alpha-1)}K^{\alpha/(\alpha-1)-1/(\alpha-1)}$ holds.

This, however, is a counter-intuitive result: A model based on the simple Cobb-Douglas production function predicts that for every α there is a fixed numerical point[47] in the relation of labor and capital input factors that determines how (in)sensitive a company's labor share reacts to changes in labor inputs. This is particularly problematic in the light of criticism raised with respect to the *de-facto* heterogeneity of labor and capital inputs encountered in the real world. As expressed by Ackerberg et al. (2015): Empirically speaking, physical units of labor and capital cannot be identified and compared across companies. Accordingly, Equation 9 is rendered non-falsifiable and non-provable in empirical settings.

We are hence inclined to suggest that when investigating industry or firm-level heterogeneity, production functions should be considered that exhibit simpler and more intuitive properties, such as:

$$\frac{\partial LS}{\partial N \partial \alpha} > 0 \tag{10}$$

This would make them them consistent with the empirical finding that more labor-intensive companies reduce their costs of employees stronger after MP tightening compared to less labor-intensive peers. We leave the specification of alternative production functions to a more extensively theoretical follow-up paper as well as to future research. Below we derive some policy implications.

4.2 Policy implications

This study informs policy and academic discussions about the effectiveness and potential redistributive effects of MP as well as about European integration. Through the lens of the NK model, short-term effects of MP on the mark-up and the labor share are a cornerstone of effective policy. We find that the heterogeneity of firms affects the transmission mechanism. Firms with a higher labor share react more strongly to MP, firms

[47] for example in the form $0 < N < 1/3K$

with a lower labor share react significantly less - highlighting that policymakers need to think of ways to transmit MP to firms with low labor shares. This is of particular relevance given that firm structures are heterogeneous not just across countries and regions, but also over time.

Figure 11 illustrates substantial labor share heterogeneity across different jurisdictions, and suggests that regional disparities are strongly correlated within national borders. Given our results, uniform MP in the EA might be more potent at stabilizing business cycles in some member states compared to others.[48] A prioritization and serious consideration of both a banking union and a capital markets union in policy discussion and design is vital, as these will help alleviate heterogeneous effects of MP.

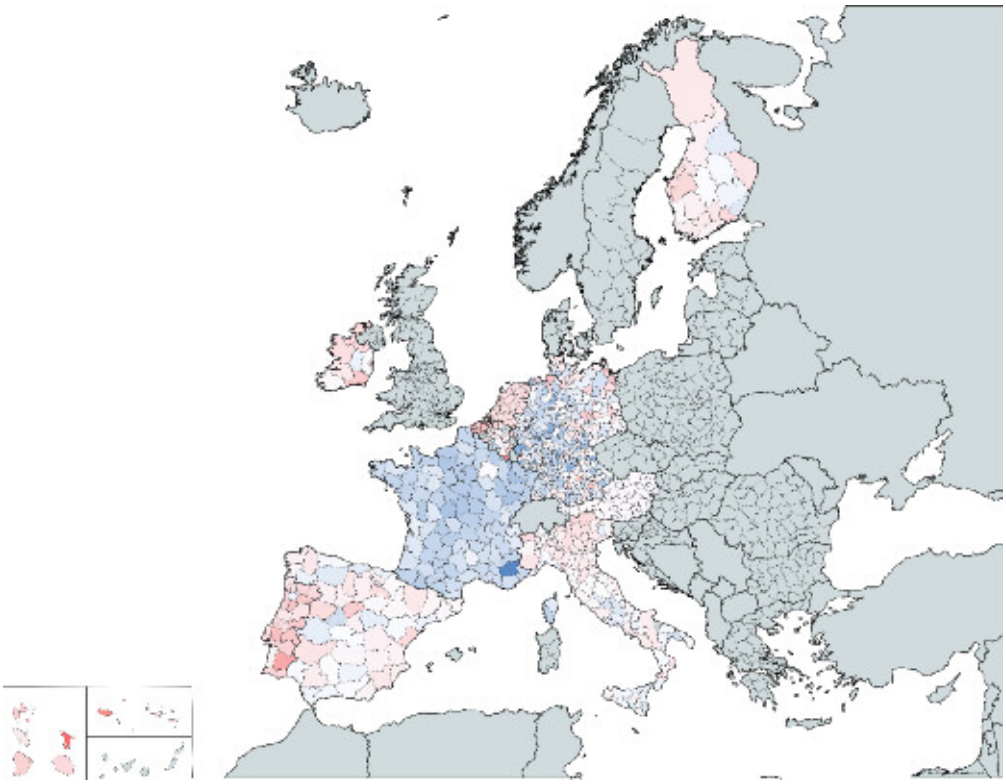
The redistributive effect between capital and labor is an interesting avenue to study at a more granular level, which we leave to future research: as indicated by our results, MP might lead to redistribution in areas that rely more heavily on services and labor-intensive production, such as urban, densely populated spaces. These areas are already prone to valuation effects of MP due to rising real estate and property prices.

The decline of the labor share is the subject of extensive research. Digitalization and the rise of superstar firms are highlighted, among others, as reasons for a decline in the US. If such a decline also materializes in the EA in the future, it is likely that MP will become less effective, according to our research.

From the perspective of a central bank, redistribution might be a promising tool to steer inflation rates closer to target. Apart from MP, fiscal authorities and policymakers can monitor the redistributive effects of MP to determine if they are in line with the political agenda. Potential conflicts between the goals of the institutions can either be addressed by enhancing automatic stabilizers (such as a European unemployment insurance or basic income) or a legislative update of the ECB's toolkit toward transmission channels that are more independent from firm and bank heterogeneity.

[48] For instance, insolvency laws, banking practices, labor rights, and social security schemes differ across member states. Digitalization and the development of digital infrastructure evolves at different speeds across EA countries.

Figure 11: Labor Shares across Euro Area Regions



Notes: The image displays sample averages of aggregated labor shares in EA NUTS-3 regions of eleven founding members (EA-11). (Dark) blue colors mark regions with (very) high labor shares, (dark) red areas mark regions with (very) low labor shares. Teal-colored areas are missing data or not part of the EA at its inception.

5 Conclusion

In this paper, we have shown that heterogeneity in the factor input cost structure matters most for the labor shares' response to MP at firm-level: The higher the labor share, the more firms' costs are driven by the payroll. Consequently, after an MP shock occurs, such firms react by altering the costs of employees. Conversely, firms characterized by a high leverage ratio primarily react by adjusting production and value added to alter their cost structure.

We show a set of highly robust and cohesive findings that we believe should be accommodated in the discussion about firm-level effects of MP generally but especially with respect to their labor share. As demonstrated by their low empirical correlation (.13), the labor share and the leverage ratio are two very distinct dimensions of firm heterogeneity. When borrowing costs change due to MP shocks, however, they are both crucial

for understanding firm-level dynamics and, thus, the labor share of value added. While firms characterized by both low leverage and high labor share are very responsive, the opposite does not hold true: Firms with high leverage yet low labor shares are decisively less responsive. Overall, we find that these dimensions are more informative about firms' response than age and size. Therefore, we emphasize the role of labor share when it comes to MP transmission.

We rationalize the prediction that a contractionary MP shock leads to a decline in the typical firm's labor share of value added in a simple model. Refining this hypothesis, we suggest that a labor-intensity channel of MP may best be accounted for in policy-workhorse macroeconomic models by considering alternative production functions.

Our article complements research that addresses the redistributive effects of MP by providing micro-level evidence, thus enabling us to investigate transmission channels more closely. We yield important policy conclusions and point out that future work needs to incorporate the labor share when analyzing MP transmission.

A Appendix

A.1 Sample Selection

Our sample selection operations are carried out along the lines of Ottonello & Winberry (2020); Kalemli-Özcan et al. (2019), and Belenzon et al. (2017).

- We keep only corporate industry firms (and thus drop banks, financial companies, foundations and research institutes, insurance companies, mutual and pension funds, trusts, private equity firms, public authorities, states, governments and venture capital firms).
- We keep only unconsolidated firm statements (i.e. "U1" and "U2").
- We drop observations with missing dates, missing firm identifiers, and duplicates.
- We drop observations with negative costs of employees, negative value added, negative sales, negative total assets, or negative equity.
- We replace negative values of cash (and cash equivalent) with missing values.
- For each given year, we trim growth variables of value added and cost of employees at the 5 and 95 percentiles.[49] This treatment is helps eliminate outliers unrelated to monetary policy. At the same time, we do not have to eliminate large or small values of the main dependent variables of interest i.e. the wage share, costs of employees, or value added.[50]
- We replace cash to total assets with missing if larger than 1.
- We replace working capital to total assets with missing if larger 1 or smaller -1.
- We compute the labor share by dividing costs of employees by value added, keeping only observations with non-missing labor shares.

[49] Ottonello & Winberry (2020) drop observations with growth rates larger than 1 or smaller than -1, which has numerical advantages but removes values of fast growing firms disproportionately. A growth rate of larger than 1 is just doubling costs, which is not rare among small firms; a growth rate of -1 means going to zero, not an entirely uncommon phenomenon.

[50] Winsorization of the latter two would lead to a disproportionate elimination of very small and very large companies. Extreme growth rates in any direction, however, come in handy to detect outliers, because not only are they unlikely to be related to monetary policy decisions, but they judge observations relative to another observation by the same firm.

A.2 Identification

Table 2: Interest Payment Response to Monetary Tightening

period	incl. time FE	lower	upper	excl. time FE	lower	upper
0	0.0166***	0.0119	0.0134	0.0557***	0.0513	0.0527
1	0.0002	-0.0064	-0.0043	-0.0052***	-0.0154	-0.0121
2	0.0009	-0.0063	-0.0039	-0.0528***	-0.0591	-0.0570
3	-0.0013*	-0.0068	-0.0050	-0.0013***	-0.0048	-0.0037
4	0.0072***	0.0015	0.0034	0.0299***	0.0244	0.0262

Notes: 95% lower and upper bounds reported.

A.3 Labor share and leverage by industry

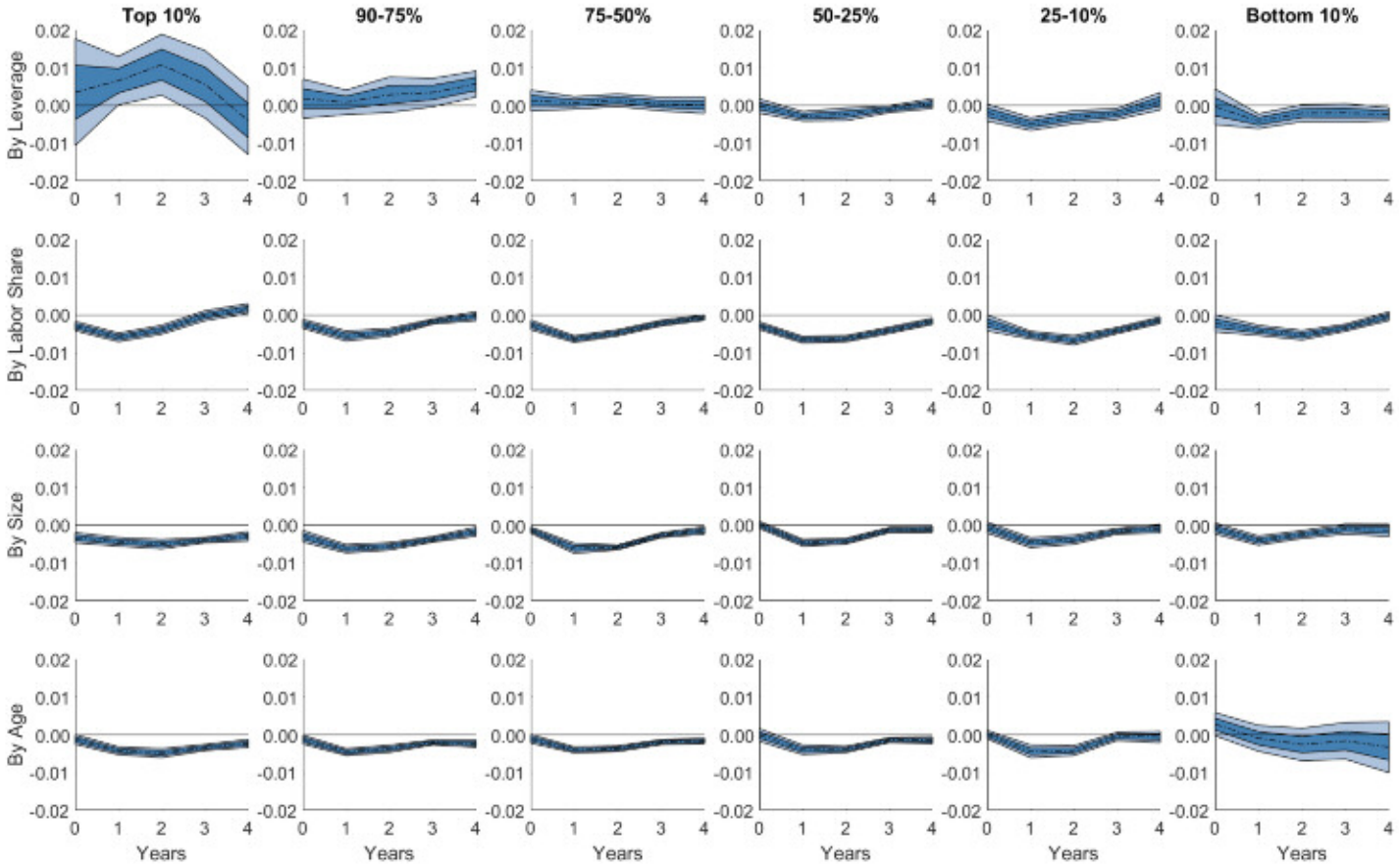
Table 3: Labor Share and Leverage Ratio by two-digit NACE Code

Wage share	Leverage ratio	NACE code	Industry	Wage share	Leverage ratio	NACE code	Industry
0.23	0.38	65	Insurance, reinsurance and pension funding	0.53	0.51	47	Retail trade, except of motor vehicles and motorcycles
0.25	**0.72**	**12**	**Manufacture of tobacco products**	0.54	0.51	23	Manufacture of other non-metallic mineral products
0.25	0.44	19	Manufacture of coke and refined petroleum products	0.54	0.37	16	Manufacture of wood and of products of wood and cork
0.26	0.48	68	Real estate activities	0.54	0.53	56	Food and beverage service activities
0.28	0.44	94	Activities of membership organisations	0.54	0.48	13	Manufacture of textiles
0.31	0.57	6	Extraction of crude petroleum and natural gas	0.54	0.54	66	Activities auxiliary to financial service
0.32	0.56	35	Electricity, gas, steam and air conditioning supply	0.54	0.54	50	Water transport
0.32	0.58	42	Civil engineering	0.55	0.62	71	Architectural and engineering activities
0.32	0.48	60	Programming and broadcasting activities	0.55	0.56	93	Sports activities and amusement
0.33	0.34	64	Financial service activities, except insurance and pension funding	0.55	0.49	25	Manufacture of fabricated metal products
0.36	0.52	49	Land transport and transport via pipelines	0.55	0.51	81	Services to buildings and landscape activities
0.36	0.40	17	Manufacture of paper and paper products	0.55	0.52	18	Printing and reproduction of recorded media
0.37	0.27	43	Specialised construction activities	0.56	0.29	96	Other personal service activities
0.39	0.45	59	Motion picture, video and television programme production	0.56	0.52	28	Manufacture of machinery and equipment n
0.41	0.34	38	Waste collection, treatment and disposal activities	0.56	0.51	32	Other manufacturing
0.42	0.60	7	Mining of metal ores	0.57	0.58	74	Other professional, scientific and technical activities
0.43	0.47	52	Warehousing and support activities for transportation	0.57	0.47	46	Wholesale trade, except of motor vehicles and motorcycles
0.43	0.52	24	Manufacture of basic metals	0.58	0.30	91	Libraries, archives, museums and other cultural activities
0.43	0.66	41	Construction of buildings	0.58	0.50	73	Advertising and market research
0.44	0.50	11	Manufacture of beverages	0.59	0.48	21	Manufacture of basic pharmaceutical products
0.44	0.48	9	Mining support service activities	0.59	0.47	2	Forestry and logging
0.45	0.56	87	Residential care activities	0.59	0.68	39	Remediation activities and other waste management services
0.46	0.69	69	Legal and accounting activities	0.60	0.46	27	Manufacture of electrical equipment
0.46	0.60	1	Crop and animal production, hunting and related service activities	0.60	0.60	70	Activities of head offices; management consultancy activities
0.47	0.59	77	Rental and leasing activities	0.60	0.43	26	Manufacture of computer, electronic and optical products
0.47	0.38	8	Other mining and quarrying	0.61	0.50	86	Human health activities
0.47	0.45	14	Manufacture of wearing apparel	0.64	0.55	79	Travel agency, tour operator
0.48	0.48	22	Manufacture of rubber and plastic products	0.64	0.54	82	Office administrative, office support
0.49	0.46	92	Gambling and betting activities	0.66	0.66	51	Air transport
0.49	0.49	20	Manufacture of chemicals and chemical products	0.66	0.51	55	Accommodation
0.50	0.52	33	Repair and installation of machinery and equipment	0.68	0.54	84	Public administration and defence; compulsory social security
0.50	0.45	45	Wholesale and retail trade and repair of motor vehicles	0.69	0.46	58	Publishing activities
0.51	0.44	15	Manufacture of leather and related products	**0.72**	**0.30**	**72**	**Scientific research and development**
0.51	0.56	30	Manufacture of other transport equipment	0.72	0.46	62	Computer programming, consultancy and related activities
0.51	0.51	61	Telecommunications	0.75	0.56	85	Education
0.52	0.50	10	Manufacture of food products	0.80	0.61	90	Creative, arts and entertainment activities
0.53	0.48	63	Information service activities	0.80	0.63	53	Postal and courier activities
0.53	0.60	29	Manufacture of motor vehicles, trailers and semi-trailers	0.81	0.61	80	Security and investigation activities
0.53	0.63	36	Water collection, treatment and supply	0.87	0.57	78	Employment activities
				0.90	0.59	31	Manufacture of furniture

Notes: The table displays the sample average wage share and leverage ratio by "Statistical Classification of Economic Activities in the European Community" (NACE) Revision 2 for SIC 2-digit industries in percent. It is ordered from low to high wage share industries.

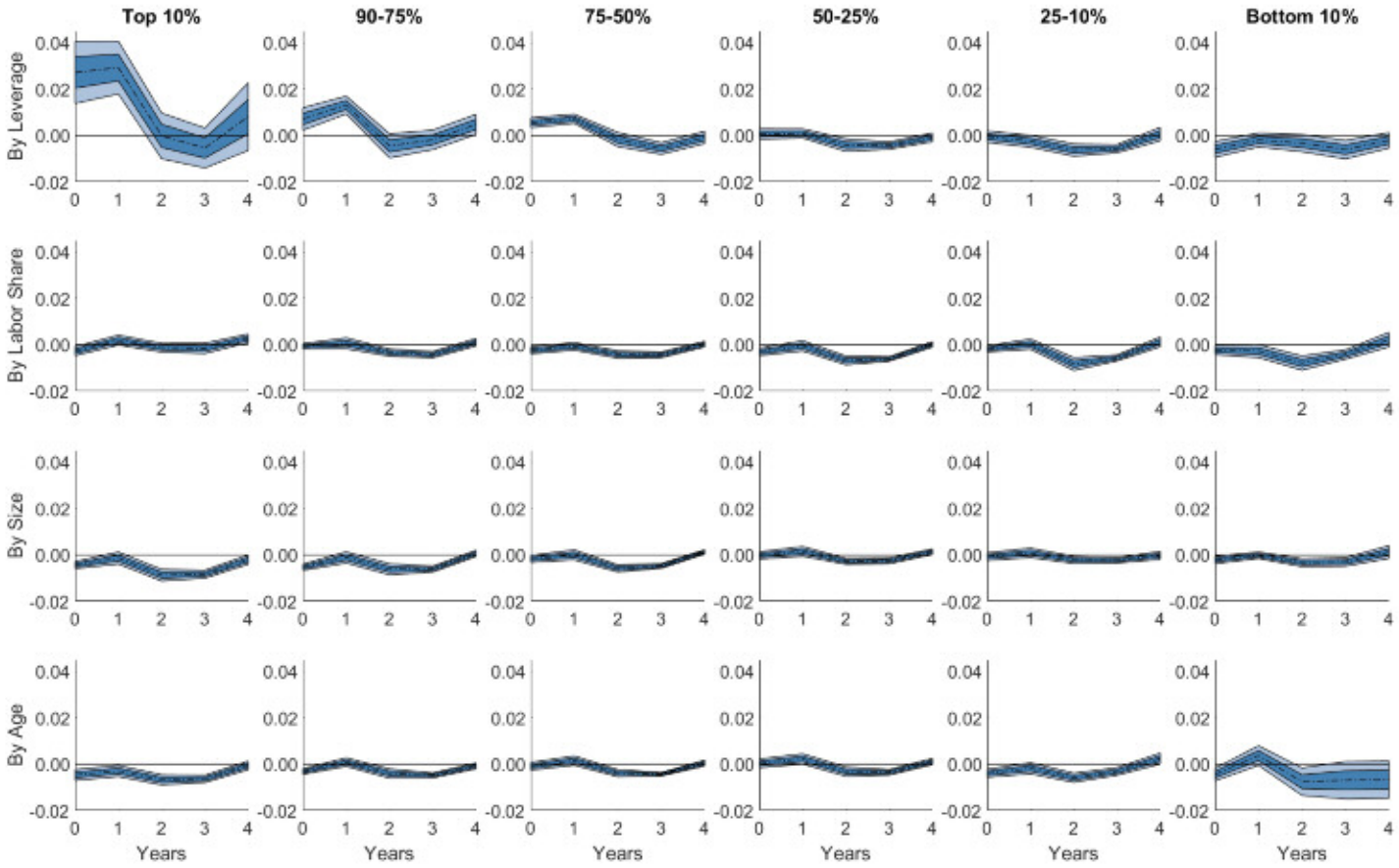
A.4 Responses of the Components of the Labor Share

Figure 12: Payroll Response to Monetary Tightening - Sample Splits



Notes: Figure shows the firm-level response of payroll expenses to a one standard deviation monetary tightening shock. The sample is split into six quantile-bins for each of the dimensions of firm heterogeneity: leverage ratio, labor share, size, and age. A firm is put into a bin based on its sample mean. Quantile-bins of respective groups are depicted from left to right in a descending order. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

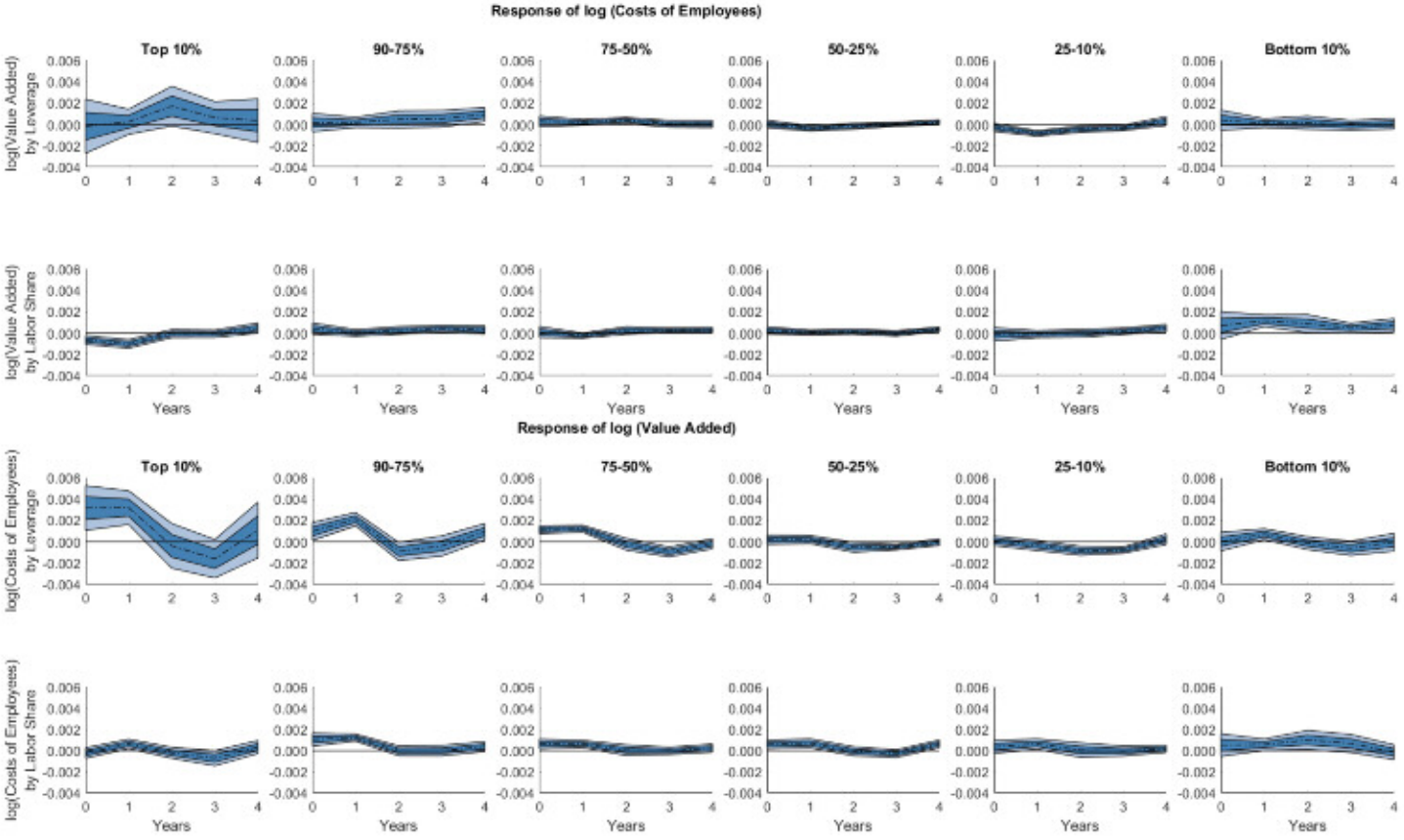
Figure 13: Value Added Response to Monetary Tightening - Sample Splits



Notes: Figure shows the firm-level response of value added to a one standard deviation monetary tightening shock. The sample is split into six quantile-bins for each of the dimensions of firm heterogeneity: leverage ratio, labor share, size, and age. A firm is put into a bin based on its sample mean. Quantile-bins of respective groups are depicted from left to right in a descending order. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

A.5 Responses of Labor Share Components - Within Variation

Figure 14: Value Added & Payroll Response to Monetary Tightening - Sample Splits & Within Variation



Notes: Figure shows the firm-level response of value added (upper panel) and costs of employees (lower panel) to a one standard deviation monetary tightening shock. The exposure measure is the within variation of leverage. The sample is split into six quantile-bins for the leverage ratio and the labor share. A firm is put into a bin based on its sample mean. Quantile-bins of respective groups are depicted from left to right in a descending order. We plot 95 (68) percent (dark) blue confidence bands calculated from standard errors clustered at the industry and firm level.

References

Ackerberg, D. A., Caves, K., & Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, 83(6), 2411–2451.

Auclert, A. (2019). Monetary policy and the redistribution channel. *American Economic Review*, 109(6), 2333–2367.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., & Van Reenen, J. (2020). The fall of the labor share and the rise of superstar firms. *The Quarterly Journal of Economics*, 135(2), 645–709.

Belenzon, S., Chatterji, A., & Daley, B. (2017). Eponymous entrepreneurs. *American Economic Review*, 107(6), 1638–55.

Cantore, C., Ferroni, F., & León-Ledesma, M. (2020). The missing link: monetary policy and the labor share. *Journal of the European Economic Association*.

Carlstrom, C. & Fuerst, T. (1995). Why isn't investment more sensitive to interest rates: Evidence from surveys. *Journal of Monetary Economics*, 36(2), 247–267.

Christiano, L. J., Eichenbaum, M. S., & Trabandt, M. (2016). Unemployment and business cycles. *Econometrica*, 84(4), 1523–1569.

Cloyne, J., Ferreira, C., Froemel, M., & Surico, P. (2018). Monetary policy, corporate finance and investment. *NBER Working Paper*, w25366.

Galí, J. (2011). The return of the wage phillips curve. *Journal of the European Economic Association*, 9(3), 436–461.

Galí, J. (2015). *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*. Princeton University Press.

Galí, J., Smets, F., & Wouters, R. (2012). Unemployment in an estimated new keynesian model. *NBER macroeconomics annual*, 26(1), 329–360.

Gertler, M. & Gilchrist, S. (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics*, 109(2), 309–340.

Gopinath, G., Kalemli-Özcan, S., Karabarbounis, L., & Villegas-Sanchez, C. (2017). Capital allocation and productivity in south europe. *The Quarterly Journal of Economics*, 132(4), 1915–1967.

Gorodnichenko, Y. & Weber, M. (2016). Are sticky prices costly? evidence from the stock market. *American Economic Review*, 106(1), 165–99.

Gutierrez, G. & Piton, S. (2020). Revisiting the global decline of the (non-housing) labor share. *American Economic Review: Insights*, 2(3), 321–38.

Holm, M., Paul, P., & Tischbirek, A. (2021). The transmission of monetary policy under the microscope. *Journal of Political Economy (forthcoming)*.

Jarociński, M. & Karadi, P. (2020). Deconstructing monetary policy surprises — the role of information shocks. *American Economic Journal: Macroeconomics*, 12(2), 1–43.

Jeenas, P. (2019). Firm balance sheet liquidity, monetary policy shocks, and investment dynamics. *Work in progress*.

Jordà, O. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1), 161–182.

Kalemli-Özcan, c., Sørensen, B., Villegas-Sanchez, C., Volosovych, V., & Yeşiltaş, S. (2019). How to construct nationally representative firm leveldata from the orbis global database:new facts and aggregate implications. *Tinbergen Institute Discussion Paper*, TI 2015-110/IV.

Kehrig, M. & Vincent, N. (2021). The micro-level anatomy of the labor share decline. *The Quarterly Journal of Economics*, 136(2), 1031–1087.

Kiyotaki, N. & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, 105(2), 211–248.

Lanteri, A. (2018). The market for used capital: Endogenous irreversibility and reallocation over the business cycle. *American Economic Review*, 108(9), 2383–2419.

Lucas, R. & Stokey, N. (1985). *Money and interest in a cash-in-advance economy*. Technical report, NBER Working Paper.

Nakamura, E. & Steinsson, J. (2018). High-frequency identification of monetary non-neutrality: the information effect. *The Quarterly Journal of Economics*, 133(3), 1283–1330.

Nekarda, C. J. & Ramey, V. A. (2020). The cyclical behavior of the price-cost markup. *Journal of Money, Credit and Banking*, 52(S2), 319–353.

Ottonello, P. & Winberry, T. (2020). Financial heterogeneity and the investment channel of monetary policy. *Econometrica*, 88(6), 2473–2502.

Piketty, T. (2015). Putting distribution back at the center of economics: Reflections on capital in the twenty-first century. *Journal of Economic Perspectives*, 29(1), 67–88.

Plagborg-Møller, M. & Wolf, C. (2021). Local projections and vars estimate the same impulse responses. *Econometrica*, 89(2), 955–980.

Rajan, R. & Zingales, L. (1998). Financial dependence and growth. *American Economic Review*, 88(3), 559–586.

Ramey, V. A. & Shapiro, M. D. (2001). Displaced capital: A study of aerospace plant closings. *Journal of political Economy*, 109(5), 958–992.

Sharpe, S. A. & Suarez, G. (2015). Interest rate rules vs. money growth rules a welfare comparison in a cash-in-advance economy. *Management Science*, 67(2), 720–741.

Swanson, E. (2020). Implications of labor market frictions for risk aversion and risk premia. *American Economic Journal: Macroeconomics*, 12(2), 194–240.