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## Firm financing and the relative demand for labor and capital

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# 1908

## Discussion Papers

Deutsches Institut für Wirtschaftsforschung

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# Firm Financing and the Relative Demand for Labor and Capital

Khalid ElFayoumi

Opinions expressed in this paper are those of the author(s) and do not necessarily reflect views of the institute.

#### IMPRESSUM

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# Firm Financing and the Relative Demand for Labor and Capital

Khalid ElFayoumi\*

October 23, 2020

## Abstract

During both the 2008 and the COVID crises, aggregate employment in Europe and the US fell despite continuing growth in the aggregate capital stock. Using more than one million firm-year observations of small and medium European firms between 2003 and 2018, this paper introduces new stylized facts on how firms' relative demand for labor and capital evolved as their capital structure adjusted to the events of the 2008 crisis. It also provides the first micro-level evidence that firms substitute capital for labor when financing costs rise. The empirical evidence lends support to the hypothesis that substitution is driven by an incentive to raise holdings of collateralizable capital. The analysis uses the heterogeneous effects of ECB monetary policy surprises across the firm distribution to identify exogenous firm-level external financing shocks. The results suggest that maintaining a well functioning credit market supports a higher labor share of economic growth.

**JEL Classification:** E3, E5, G3, J2, J3.

**Keywords:** labor demand; financial frictions; jobless growth; labor share.

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# 1 Introduction

In 2008, aggregate employment stock in Europe and the US fell despite continuing, yet weaker, growth in the aggregate capital stock. The decline was then followed by a disproportional pace of recovery between employment and output. These two observations suggest that the 2008 events triggered a substitution pattern from labor toward capital, which amplified the effects of the 2008 crisis on the labor market and led to a pattern of jobless recovery in the subsequent years. As figure 1 highlights, a similar pattern reemerges as a result of the COVID crisis in the first half of 2020. One popular hypothesis, put forward by Calvo, Coricelli, and Ottonello (2012) and Jermann and Quadrini (2012), suggests that the observed decline in the aggregate labor share around the 2008 crisis time could be explained by the increasing need for collateralizable assets as aggregate financing conditions tightened, leading firms to rely more on fixed capital in production at the expense of labor.

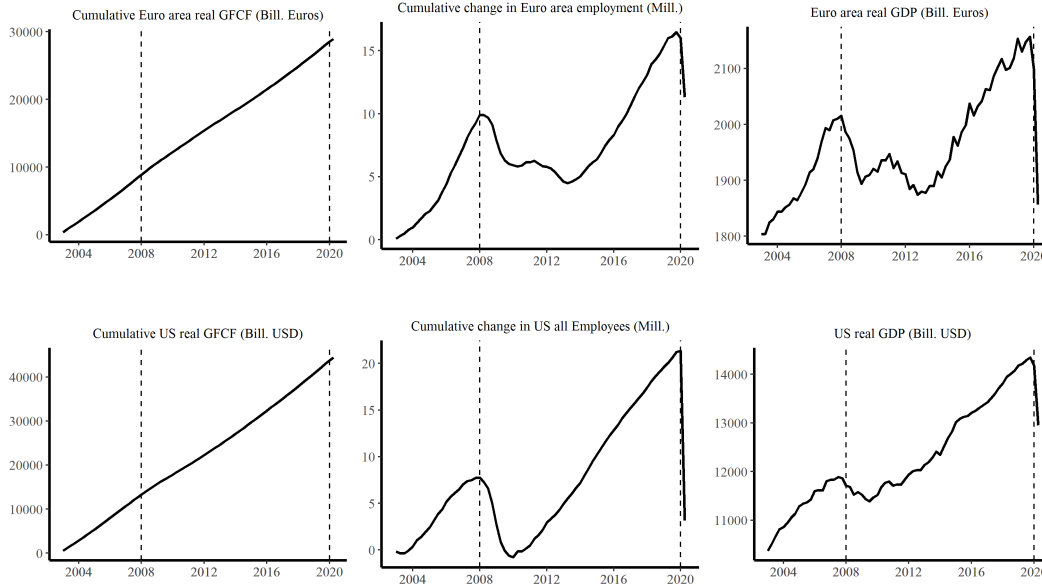
This paper explores the extent to which firm-level evidence supports this hypothesis, therefore posing the question: Do firms substitute capital for labor when their cost of financing rises? Put differently, the paper examines whether variations in financial stress across and within firms can explain why some firms may choose to bias their input factor composition toward labor or capital. Using a large European firm-level panel, this paper makes two main contributions: first, it introduces new stylized facts on how firms' input factors composition of labor and capital evolved as their capital structure adjusted to the events of the 2008 crisis;<sup>1</sup> second, it provides the first firm-level evidence on the effects of changes in external financing costs on firms' relative demand for labor and capital. The key element that distinguishes this analysis from the existing crisis literature is its focus on the *relative* changes between labor and capital stocks, not the level effects of each.

The analysis builds on a rich firm-level panel, from Orbis, that includes more than one million firm-year observation of balance sheet, financial statement, and wage bill data for firms in France, Germany, Italy, and Spain across

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<sup>1</sup>firm-level data is not yet available to study the events of 2020.

Figure 1: Real output, gross fixed capital formation and changes in employment for the Euro Area and United States.



*Note:* The figure plots cumulative quarterly deflated levels of gross fixed capital formation as well as the cumulative quarterly change in number of employees for both the Euro Area and the United States. With labor and capital stocks being the key input factors of production in the aggregate production function, the figures suggest that the crises triggered an aggregate substitution effect between capital and labor, as capital stock accumulation continued, while the labor stock shrank.

765 different industries over the 2003-2018 period. This expansive dataset allows us to explore and control for different dimensions of heterogeneity across sizes, industries, countries, and time regimes. Importantly, the median firm in the data is small-sized, allowing the analysis to focus on the dynamics of small and medium enterprises (SMEs), which are typically the main employer and main driver of growth in Europe.

I use a dynamic IV-local projection approach (Jordà 2005; Ramey and Zubairy 2017) to estimate the causal effects of external financing costs on the relative demand of firms for labor and capital. The analysis uses a novel identification approach that relies on the heterogeneous effects of ECB monetary policy surprises on financing costs (credit channel) across the firm distribu-

tion. Less credit worthy firms experience a larger unexpected change in their borrowing and equity issuance costs in reaction to ECB surprises, generating exogenous variations in financing costs within firms that are independent of unobserved firm fundamentals. For the ECB policy surprises, I use the dataset of Altavilla et al. (2019) that measures changes in European interest rates and asset prices around a narrow window of ECB policy announcements. The firm-level instrument for exogenous external financing shocks is constructed by interacting the aggregate policy surprise with a firm-level measure of financing cost, conditional on a rich specification of firm-level characteristics and fixed effects.

The data reveals a set of novel patterns with respect to firm's balance sheet adjustments. First, I find that the median firm in our panel lowered its wage bill to fixed assets (labor to capital ratio) in 2008 by 13% and that this decline was, to a large extent, triggered by an increase in the ratio of fixed assets to total assets that a firm owned. This observation ties the decline observed in the aggregate labor share around the crisis year with within-firm changes. Second, I show that, instead of slashing off debt, firms continued to borrow, relying upon raising private capital in order to improve their financial positions: between the pre- and post-crisis sub-samples, firm leverage and shareholders fund ratios rose by 9.32%, and 13.8%, respectively.

Third, in addition to improving its equity capital position, the median firm extended the maturity structure of its debt liabilities, resulting in a decline in the ratio of short-term debt to total debt by 9.14%. The final strategy that firms followed has been to change their fixed-current assets composition. Around 2008, the ratio of fixed assets to total assets increased by 24.58%, while current assets ratio fell by 9.69%. This shift toward fixed assets at the expense of liquid assets is in part motivated by the dry up in sources of firm liquidity including its revenues as well as the returns it receives on its holdings of short-term financial assets. Remarkably, this continuing growth in leverage contrasts with what standard corporate and macro-finance models predict (Bernanke, Gertler, and Gilchrist (1999), Hennessy and Whited (2005)).

In the second part of the paper, the econometric analysis indicates an

economically and statistically significant causal effect of financing costs on the difference between firm hiring and investment rates, whereby tighter external financing conditions induce firms to hire less relative to their capital investment to cope with the shock. The effect persists over time and is common to the different size quantiles. Italian and Spanish firms appear to have a higher exposure to this link between financing costs and the relative demand for labor and capital. Similarly, manufacturing firms see the strongest impact compared to other sectors.

In examining why firms substitute between capital and labor in reaction to capital market shocks, the data appears to support a significant role for the collateral channel (i.e. working capital channel) of Calvo, Coricelli, and Ottonello (2012); external financing shocks have a lesser influence on firms whose capital has a lower liquidation value. To identify the collateral channel, I use the firm depreciation rate as a measure of asset collateralizability; since the liquidation value of firms that experience higher average depreciation rate is expected to be lower, we would expect a weaker relationship between financing costs and labor to capital ratio.

This paper delivers a granular empirical backing to a growing literature on the relation between credit and labor markets (Michelacci and Quadrini 2005; Quadrini 2011; Petrosky-Nadeau 2014; Quadrini and Sun 2015; Michaels, Page, and Whited 2018). It is important to note that, despite the extensive literature on the causal effects of financing constraints and credit supply interruptions on firm decisions, labor and capital demand decisions are typically treated separately (Becker and Ivashina 2014; Chodorow-Reich 2014). Hence, it remains undocumented within a generic empirical setup whether there is a substitution effect between capital and labor at the firm level in response to changes in firm financing costs and aggregate credit supply.

The main policy message this paper delivers is that a well functioning credit market is key for an economy where labor could enjoy larger and balanced share of economic growth. The analysis also points at important limitations in the way we understand firm adjustments in response to financial shocks. The paper proceeds as follows: The second section discusses the data and documents



firm balance sheet and real adjustment around the year 2008. The third section lays down a theoretical motivation and introduces the identification and econometric frameworks. Section four discusses the results and the relevant channels. Section five concludes.

## 2 Labor, capital and balance sheet adjustment in 2008

### 2.1 Data

I use Orbis database, which includes European firms, as part of its global coverage.<sup>2</sup> A key feature of the data is its wider coverage of private micro, small, and medium firms in comparison to public and relatively large corporations.<sup>3</sup> The full available panel of firms that have at least two consecutive observations— necessary for a dynamic econometric specification— includes unbalanced 938,617 firm-year observations covering 4 European countries (France, Germany, Italy, Spain) and 765 different industries, between 2003 and 2018.

The initial sample includes a few millions firm-year observations, which I filter over a few dimensions: I drop micro firms (<10 employees) to ensure a degree of homogeneity across firms in the way they make decisions with regards to labor and capital inputs as well as capital structure. In addition, I restrict the sample to four countries: France, Germany, Italy, and Spain, which are the countries sufficiently covered before and after 2008—to avoid potential composition effects.<sup>4</sup>

I also remove potential outliers by excluding firms that fall outside the left and right quantile thresholds of 0.01 and 0.99, with respect to the variables

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<sup>2</sup>Harmonized globally, ORBIS is collected from official business registers, annual reports, news wires, and web pages.

<sup>3</sup>According to the European Commission definition, a firm is considered micro sized if it employs fewer than 10 employees, small if less than 50, medium if less than 250, and large otherwise.

<sup>4</sup>By composition effects, I refer to average effects that are driven by changes in the distribution of firms included in the sample, not changes in individual firm decisions.

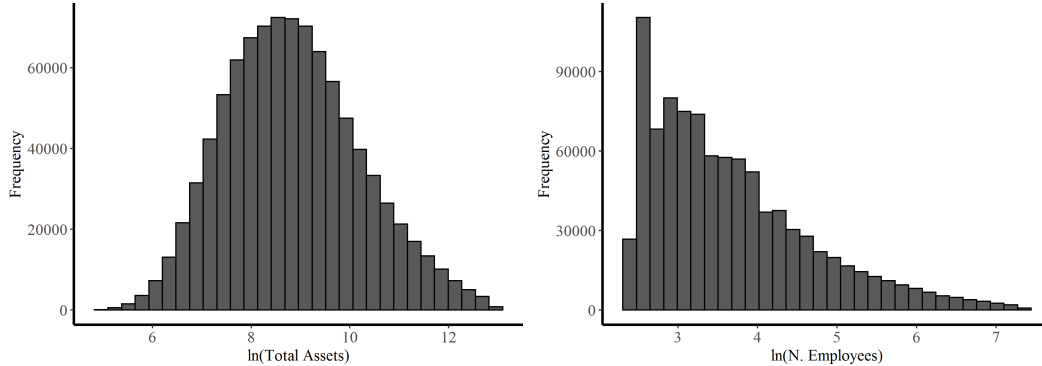
in the main econometric specification below. These variables include: 1) size variables: total assets, number of employees, wage bill, and sales to asset ratio since mega and very small firms are less likely to be homogeneous with the majority of firms in the way they make investment and hiring decisions or react to aggregate shocks; 2) debt, debt service, and current liabilities to asset ratios in order to remove firms that have peculiar financial positions; 3) fixed assets to total assets, wage bill to fixed assets, and wage bill to sales to make sure that output of all remaining firms require a mix of both labor and capital; finally, 4) profit to total assets and the average wage to remove extraordinarily hyper productive and profitable firms; and 5) growth rates of wage bill and fixed assets, the difference between the two, as well as growth in total debt, revenues and profits. This last criterion is meant to remove observations where there is potential for reporting errors that would show up as unrealistic jumps in reported numbers. Finally, I exclude firms with ambiguous legal corporation form, which are not reported as either private or public.

Figure 2 plots the distribution of firm sizes with regards to their assets and number of employees. The distribution of firm size is skewed toward the left and the median firm in our panel is a *small* private firm, based on the value of median total assets and median number of employees. However, the sample still spans the full size spectrum of small, medium, and large European firms according to the EU Commission definition of SMEs.

## 2.2 Firm adjustment in 2008

The main goal of the paper is to empirically study the joint decisions of firms with regards to their labor and capital stocks, and how these relate to the state of their balance sheet. Of particular interest in this regard is how labor to capital ratios at the firm level reacted to the global financial meltdown of 2008. The key element that distinguishes this analysis from existing crisis literature is its focus on the *relative* changes between labor and capital stocks, not the level effects of each. Table 1 reports the main statistical moments for the distribution of firm real and balance sheet variables over the full sample

Figure 2: Size distribution w.r.t. total assets (thous. Euro) and number of employees



and the two sub-samples corresponding to pre-2008 and post-2008 regimes.<sup>5</sup> Tables 2 and 3 repeat the same exercise across countries and sectors.

The first remark I make is that while firms shrank in size—with respect to real assets and number of employees, instead of slashing off debt, firms continued to borrow and relied on raising private equity capital in order to improve their financial positions; between the pre- and post-2008 sub-samples, the median firm leverage did not change, while shareholders fund ratios grew by 16.85%. In addition to improving its equity capital position, the median firm in the sample extended the maturity structure of its debt liabilities, resulting in a decline in the ratio of short-term debt to total debt by 2.13%.

The other strategy firms followed was to change their fixed-current assets composition. Around 2008, the ratio of fixed assets to total assets increased by 14.48%, while the current assets ratio fell by 6.68%. This shift toward fixed

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<sup>5</sup>For the full sample, the financial position of the median firm is consistent with the median firm typically studied in the literature using other data sources (e.g. Hennessy and Whited (2005), Covas and Den Haan (2012)). However, it is important to also bear in mind that the majority of our firms are private and small, having no access to equity markets in the typical sense. I also construct the variable 'debt service' as the ratio of interest expenses to total debt, which I use as a close proxy to borrowing costs. Although this measure ignores the maturity structure of firm debt, the median debt service I compute is well within the documented values for the interest rates of high yield borrowers, who share many characteristics with the firms in our sample.

assets at the expense of liquid assets could, in part, be motivated by the dry up in sources of firm liquidity including its revenues as well as the returns it received on its holdings of short-term financial assets. However, the marginal decline in total assets implies a smaller role for this latter channel.

What is of more importance to our analysis is the change in the composition of firm input factors (fixed capital and labor). Table 1 reports a decline of 10.53% in the median labor to capital ratio. This observation is quite significant as it shows that the observed aggregate decline in the labor share triggered by the 2008 crisis has been a firm-level reaction as much as it was an aggregate phenomenon. Hence, it casts doubt on the relevance of composition changes in explaining the aggregate pattern. What the figures also tell us is that this decline in the median firm labor to capital ratio was primarily motivated by the rise in the magnitude of the fixed capital firms own and not by a decline in the wage bill of the firm.

Table 2 and 3 indicate that the decline in the relative demand for labor was felt by all the countries and sectors in the sample, yet at different degrees, especially across countries. Relative demand for labor by firms in France and Germany was more resilient to the 2008 events in comparison to the Spanish and Italian firms. In Italy, the wage bill to fixed assets ratio declined by a -23.33% compared to only -0.58% drop in France. Across sectors, differences were not as large, with the strongest impact being in the manufacturing sector.

Table 1: Main labor, capital and balance sheet distribution moments for the full sample and pre- and post-2008.

	Aggregate		Pre-2008		Post-2008		%Δ
	Median	Std.	Median	Std.	Median	Std.	
Total assets (mill.)	6.77	3228.83	13.92	4603.24	13.81	4543.65	-0.79
Revenues	123.06	104.82	132.64	99.74	115.82	102.71	-12.68
Profits	7.74	9.33	9.5	8.52	7.07	9.26	-25.58
Fixed assets	34.74	24.17	31.55	22.64	36.12	23.16	14.48
Current assets	65.26	24.17	68.45	22.64	63.88	23.16	-6.68
Cash	3.82	11.08	3.89	10.72	3.25	10.88	-16.45
N. Employees	32	5692.74	49	7726.64	48	7634.65	-2.04
Wage bill	25.08	38.16	21.91	31.44	22	32.5	0.41
Avg. wage (thous.)	45.25	22.55	52.72	21.48	53.45	21.77	1.38
Labor to capital ratio	0.81	103	0.76	3.66	0.68	3.66	-10.53
Shareholder funds	30.81	20.39	27.96	18.33	32.67	19.37	16.85
Leverage	0.25	0.2	0.26	0.19	0.26	0.19	0
Short-term debt ratio	43.95	28.31	47.86	27.6	46.84	27.57	-2.13
Debt service	4.88	509.77	6.57	390.18	4.46	113.87	-32.12
Capital growth rate	-0.8	30.02	13.87	32.78	0.76	24.28	-94.52
Labor growth rate	1.75	15.85	18.15	13.34	1.19	12.88	-93.44
Number of observations	1,039,691		31,357		31,357		

*Note:* Except for total assets and the average wage, other nominal variables are presented as ratios to firm total assets. Average real wage is the ratio of wage bill to number of employees. Labor to capital ratio is the ratio of the wage bill to fixed assets. Leverage is the ratio of total debt to total assets. Short-term debt is the ratio of short-term debt to total debt. Debt service is the ratio of interest expenses to total debt. The last column is the growth rate of the median values reported between 2009 and 2007. The moments reported in Pre-2008 and Post-2008 columns correspond to 2007 and 2009 moments only for firms that reported at least the three years 2007 to 2009 to exclude composition effects.

Table 2: Main labor, capital and balance sheet distribution moments by country for pre- and post-2008 regimes.

Moments	France		Germany		Italy		Spain	
	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008
Total assets (mill)	4.5	4.46	63.98	64.38	16.06	16.81	15.06	14.17
Revenues	179.28	176.18	135.86	123.85	111.61	91.49	127.39	107.83
Profits	11.86	9.34	11.33	9.28	8.33	5.99	9	6.46
Fixed assets	25.99	27.48	51.11	53.2	28.42	35.35	34.66	39.04
Current assets	74	72.52	48.89	46.8	71.58	64.65	65.34	60.96
Cash	9.05	9.15	4.13	4.75	1.87	1.55	4.21	2.68
Number of employees	33	33	236	240	43	44	60	55
Wage bill	41.84	43.93	28.89	29.51	15.75	14.9	17.82	18.74
Average wage (thous.)	52.67	54.68	65.36	64.91	54.31	53.62	46.33	48.2
Labor to capital ratio	1.72	1.71	0.67	0.65	0.6	0.46	0.55	0.52
Shareholder funds ratio	33.96	37.53	34.28	36.14	18.22	24.32	32.95	37.96
Leverage	0.13	0.13	0.29	0.29	0.34	0.33	0.3	0.29
Short-term debt ratio	39.99	42.5	20.28	18.2	60	59.19	52.32	46.55
Debt service	6.93	5.15	6.37	5.86	6.59	3.75	6.42	4.1
Capital growth rate	12.4	-2.04	13.17	2.22	14.05	1.49	15.35	0.63
Labor growth rate	17.03	1.28	15.24	4.36	18.62	1.87	20.45	-1.18
N. Obs.	8269	8269	3692	3692	10808	10808	8588	8588
%Δ Labor to capital ratio	-0.58		-2.99		-23.33		-5.45	

*Note:* Except for total assets and the average wage, other nominal variables are presented as ratios to firm total assets. Average real wage is the ratio of wage bill to number of employees. Labor to capital ratio is the ratio of the wage bill to fixed assets. Leverage is the ratio of total debt to total assets. Short-term debt is the ratio of short-term debt to total debt. Debt service is the ratio of interest expenses to total debt. The last column is the growth rate of the median values reported between 2009 and 2007. The moments reported in Pre-2008 and Post-2008 columns correspond to 2007 and 2009 moments only for firms that reported at least the three years 2007 to 2009 to exclude composition effects.

Table 3: Main labor, capital and balance sheet distribution moments by sector for pre- and post-2008 regimes.

Moments	Manufacturing		Construction		Trade		Financial		Services & others	
	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008
Total assets (mill)	16.1	15.91	7.52	7.33	11.16	10.7	62.95	68.43	16.69	17.64
Revenues	121.95	102.07	143.65	130.91	189.74	172.32	107.61	98.81	108.53	100.03
Profits	9.91	6.95	9.48	7.45	8.01	5.99	10.71	7.66	10.58	8.41
Fixed assets	30.57	36.13	17.2	19.62	24.56	28.48	43.64	48.19	50.64	53.37
Current assets	69.43	63.87	82.8	80.38	75.44	71.52	56.36	51.81	49.36	46.63
Cash	2.88	2.44	6.6	5.87	3.94	3.19	5.92	5.58	5	4.16
Number of employees	56	54	38	38	37	36	202	201	65	66
Wage bill	20.22	19.84	34.13	35.36	18.16	19.13	21.71	22.06	29.45	29.88
Average wage (thous.)	53.57	53.5	54.09	55.82	48.48	49.67	60.42	59.41	54.97	55.98
Labor to capital ratio	0.69	0.58	2.01	1.89	0.78	0.74	0.56	0.51	0.67	0.63
Shareholder funds ratio	28.2	33.95	23.84	27.9	25.77	30.25	32.13	36.27	31.24	34.37
Leverage	0.28	0.28	0.17	0.17	0.25	0.25	0.25	0.25	0.26	0.25
Short-term debt ratio	53.62	50.29	49.87	50.63	57.02	55.55	35.68	37.95	32.86	34.14
Debt service	6.68	4.16	6.74	5.11	7.08	4.56	6.54	4.89	5.99	4.55
Capital growth rate	13.86	0.5	16.73	0.73	13.61	0.06	13.72	1.6	13.5	1.72
Labor growth rate	17.94	-0.96	19.96	1.81	18.68	1.08	19.24	2.52	17.67	3.84
Number of observations	12093	12093	2857	2857	7361	7361	299	299	8409	8409
% $\Delta$ Labor / capital ratio	-15.95		-5.97		-5.13		-8.93		-5.97	

*Note:* Except for total assets and the average wage, other nominal variables are presented as ratios to firm total assets. Average real wage is the ratio of wage bill to number of employees. Labor to capital ratio is the ratio of the wage bill to fixed assets. Leverage is the ratio of total debt to total assets. Short-term debt is the ratio of short-term debt to total debt. Debt service is the ratio of interest expenses to total debt. The last column is the growth rate of the median values reported between 2009 and 2007. The moments reported in Pre-2008 and Post-2008 columns correspond to 2007 and 2009 moments only for firms that reported at least the three years 2007 to 2009 to exclude composition effects. 'Others' include firms in a set of services and utilities industries: Electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities; transportation and storage; accommodation and food service activities; real estate activities.

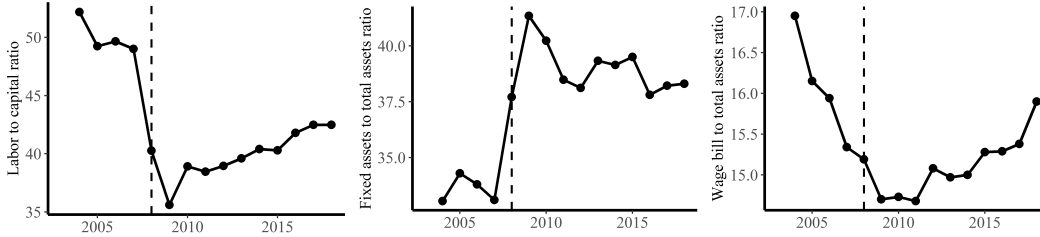
Furthermore, figure 3 shows that the decline in labor intensity was not gradual; it reached its lowest point in 2009 and was driven by a large increase in firms' use of fixed assets and a drop in the wage bill. Figure 4 takes a closer look, examining the extent to which the decline in the median value of labor to capital ratio in the full sample was a general characteristic across the distribution of firms. Using only firms whose observations are available for the entire sample period (2004 to 2018), the data shows that the decline took place for most firms despite their differing levels of profitability, size, and financial position. To compliment these figures, Table 4 reports the *conditional* relevance of this group of firm characteristics through an interaction term with a year dummy for 2008. The interacting variables are normalized by their standard deviation; that is, the interaction term coefficient corresponds to the effects of one standard deviation change in the variable of interest (e.g. total assets).

Estimates indicate that firms with larger total assets tend to have, on average, a higher hiring rate relative to their investment rates in comparison to smaller firms; however, asset size does not appear to have been a significant factor in explaining the decline in the use of labor in 2008, conditioning on the number of employees. The picture is different when looking at firm size in terms of its number of employees. On average, firms with a larger number of employees hire less relative to their investment rate. However, in 2008, these firms had a lower decline in their labor to capital ratio, conditioning on the total assets size. Similarly, I find that more profitable firms were less likely to lower their hiring rate relative to investment.

On the other hand, more leveraged firms hire, on average, less relative to their investment level in comparison to less leveraged firms. They also experienced a larger decline in 2008, suggesting that firms' financial position played a significant role in their optimal choice of labor to capital ratio. Compared to leverage, working capital (a proxy for liquidity) appears to have played a lesser role in this respect during the events of 2008. Finally, I find that firms in industries that are characterized by higher wage rigidity (lower wage volatility) reduced their hiring relative to investment rate by a larger degree compared



Figure 3: Median firm-level wage bill and fixed assets ratios by year.



to more flexible industries.

### 3 Do firms substitute capital for labor when financing costs rise?

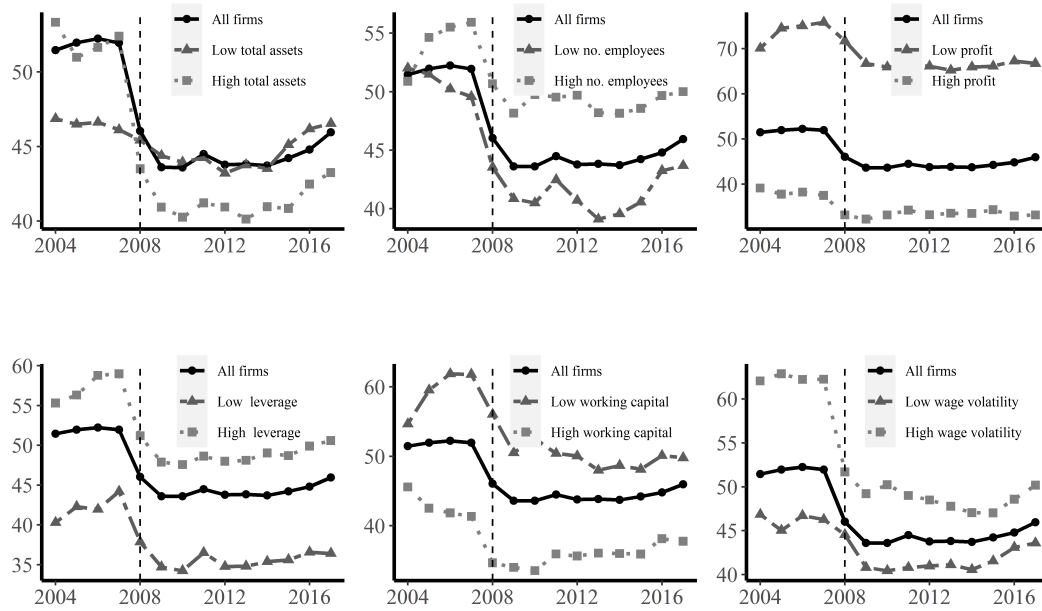
Having documented the firm-level change in labor-capital composition in 2008, I examine whether the change in aggregate financing conditions that was associated with the events of 2008 could provide a plausible explanation for this pattern. To answer this question, I abstract from the 2008 episode and discuss the more general question: what is the effect of external financing costs on the firm optimal labor to capital ratio (i.e. labor intensity) decision? In other words, do firms substitute capital for labor as their financing conditions deteriorate?

More formally, I am interested in estimating the following elasticity of the relative effect of firm financing costs on hiring and investment,

$$\eta_{l/k,r} \equiv \frac{\partial g^{l-k}}{\partial r} \quad (1)$$

where  $g^{l-k} \equiv \% \Delta l - \% \Delta k$  is the difference between hiring (wage bill growth) and investment rates (fixed capital growth).  $r$  is the cost of debt financing. It is paid on firm debt as a sum of the risk free interest rate (i.e. opportunity

Figure 4: The development in firm-level wage bill to fixed assets ratio by group in 2008



*Note:* The figures plot the median wage bill to fixed assets ratio. For each of the six plots, the sample is divided to high and low sub-samples with respect to the respective conditioning variable. High corresponds to the highest quartile, while low is the lowest quartile.

Table 4: The role of conditional firm characteristics in the decline of hiring rate relative to capital investment in 2008. LHS:  $g^{l-k} \equiv \% \Delta \text{wage bill} - \% \Delta \text{fixed assets}$ .

	(1)	(2)	(3)	(4)	(5)	(6)
$\log(\text{Total Assets})_{i,j,k,t-1}$	29.179*** (1.772)	29.398*** (1.768)	29.277*** (1.771)	29.259*** (1.767)	29.206*** (1.773)	29.262*** (1.771)
$\% \Delta \text{ Wage Bill}_{i,j,k,t-1}$	0.037** (0.018)	0.036** (0.018)	0.037** (0.018)	0.038** (0.018)	0.037** (0.018)	0.036** (0.018)
$\% \Delta \text{ Fixed Assets}_{i,j,k,t-1}$	-0.033*** (0.007)	-0.033*** (0.007)	-0.033*** (0.007)	-0.032*** (0.007)	-0.033*** (0.007)	-0.033*** (0.007)
Avg. $\text{Wage}_{i,j,k,t-1}$	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
$\text{Profit}_{i,j,k,t-1}$	2.236*** (0.445)	2.210*** (0.445)	2.066*** (0.453)	2.186*** (0.445)	2.258*** (0.446)	2.263*** (0.445)
$\ln(\text{Revenue})_{i,j,k,t-1}$	-13.569*** (1.274)	-13.336*** (1.271)	-13.555*** (1.273)	-13.586*** (1.269)	-13.569*** (1.274)	-13.430*** (1.270)
$\% \Delta \text{ Revenue}_{i,j,k,t-1}$	0.003 (0.012)	0.002 (0.012)	0.002 (0.012)	0.003 (0.012)	0.003 (0.012)	0.003 (0.012)
$\text{Leverage}_{i,j,k,t-1}$	-0.900** (0.452)	-0.876* (0.450)	-0.913** (0.452)	-0.630 (0.443)	-0.892** (0.452)	-0.840* (0.451)
$\text{Working capital}_{i,j,k,t-1}$	-11.460*** (0.496)	-11.491*** (0.496)	-11.424*** (0.495)	-11.356*** (0.495)	-11.391*** (0.495)	-11.423*** (0.496)
$\text{N. Employees}_{i,j,k,t-1}$	-17.077*** (1.312)	-17.336*** (1.308)	-17.030*** (1.311)	-17.093*** (1.309)	-17.085*** (1.312)	-17.089*** (1.311)
$\log(\text{Total Assets})_{i,j,k,t-1} \times D_t^{\text{Crisis}}$	0.786 (1.090)					
$\log(\text{N. Employees})_{i,j,k,t-1} \times D_t^{\text{Crisis}}$		3.081*** (0.801)				
$\text{Profits}_{i,j,k,t-1} \times D_t^{\text{Crisis}}$			2.105* (1.178)			
$\text{Leverage}_{i,j,k,t-1} \times D_t^{\text{Crisis}}$				-3.167*** (0.912)		
$\text{Working capital}_{i,j,k,t-1} \times D_t^{\text{Crisis}}$					-1.154 (1.184)	
$\text{Wage volatility}_{j,k,t-1} \times D_t^{\text{Crisis}}$						4.247*** (0.859)
Num. obs.	34496	34496	34496	34496	34496	34496
R <sup>2</sup> (full Column)	0.169	0.170	0.169	0.170	0.169	0.171
Adj. R <sup>2</sup> (full Column)	0.100	0.101	0.100	0.101	0.100	0.101
Firm and Year fixed effects	yes	yes	yes	yes	yes	yes
Country $\times$ year fixed effects	yes	yes	yes	yes	yes	yes
Industry $\times$ year fixed effects	yes	yes	yes	yes	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

*Note:* Interacting variables are normalized such that the interaction term coefficient corresponds to the effects of one standard deviation change. Sample is confined to firms whose observations are available for the entire length of the sample period (2004-2018).

cost of capital) and additional risk premiums,  $\delta$ , that compensate lenders for market (i.e. country and industry) and firm-specific risks.

The present endogeneity between firm labor intensity and its financing costs poses a challenge to the empirical estimation of the elasticity of labor intensity to external financing premium,  $\eta_{l/k,r}$ ; that is, a simple OLS regression of the form  $g_{i,j,t}^{l-k} = \beta \log(r)_{i,j,t} + u_{i,j,t}$  would yield a biased estimate of the causal effect of changes in  $r$  on  $L/K$ . To analyze these endogeneity concerns and understand how the two variables are simultaneously determined to a large degree, I explore the determinants of both variables in the following section, where I show how financing costs could factor into firm labor share decisions. Afterwards, I propose an empirical approach that circumvents these endogeneity concerns and identifies *exogenous* variations in firm financing costs and their causal effects on firm labor to capital ratio.

### **3.1 Theory of the determinants of firm financing costs and labor to capital ratio**

Standard assumptions of neo-classical theory of firm behavior predict that firms optimize their levels of labor and capital stocks such that the marginal return to labor and capital are equal to their marginal costs, respectively; that is, the relative factor-specific productivities and relative factor prices are the main determinants of firm choice of its hiring to investment rates and labor to capital composition. In addition, real frictions, like capital and labor adjustment costs, introduce an important role for firm size—with respect to its number of employees and physical assets.

Importantly, when firms need to borrow or raise equity to finance their investment and hiring decisions, the presence of financial frictions and external financing costs add to the marginal cost of additional units of labor and capital. However, since physical capital can be collateralized such that it lowers the adverse selection against firms in loan contracts and equity markets, the marginal financing cost of capital investment is effectively cheaper than the marginal financing cost of hiring (Calvo, Coricelli, and Ottonello (2012), Petrosky-Nadeau (2014)). In such an environment, the financial position of

the firm becomes another determinant of its optimal labor to capital ratio in production.

To formally see this and provide an analytical structural framework that can guide our econometric specification, I present a stylized structural model of firm dynamic hiring and investment decisions under financial constraints. While the model provides suggestions of the determinants of firm financing costs and labor to capital ratio in the cross section of firm distribution and over time, the empirical approach that follows remains agnostic and is not tied to the specific parametric and timing assumptions of the analytical model.

Consider the following standard *CES* specifications of a firm production function  $F(k, l)$ ,

$$Y' \equiv F(k, l) = A' \left( \gamma (a^k k)^{\frac{\sigma-1}{\sigma}} + (1 - \gamma) (a^l l)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad (2)$$

$Y$  is firm production.  $A'$  is next period's firm productivity process, which captures firm-specific as well as aggregate factors, like changes in the demand environment of the firm.  $a^k$  and  $a^l$  are firm-specific capital- and labor-augmenting technologies, respectively.  $\gamma$  is the share of capital in the production process and  $\sigma$  determines the degree of substitutability between the input factors. For any variable  $X$ , I use  $X'$  to imply its next period value at  $t + 1$ .

This *CES* specification with *lagged* capital and labor stocks embeds the assumption that firms need to build both their capital and labor stocks at time  $t$  prior to the realization of their production at time  $t + 1$ . Introducing this lag in input factor accumulation makes the specification more realistic as it captures the *time-to-build* characteristic of firm production, and allows for a non-trivial role for firm liquidity and external borrowing cost (Jermann and Quadrini (2012)).

In addition, firms are subject to a budget constraint, where future dividends, debt service, capital investment, hiring costs, and adjustment costs are typically financed via future cash flow, cash holdings, and new borrowing,

$$Div + rb + Q^k \Delta k' + W \Delta l' = PY + cash + \Delta b' - C'^{\Delta} \quad (3)$$

where  $rb$  is debt service payments.  $Q^k$  is the cost of capital, which depends on asset prices.  $W$  is the labor wage, and  $P$  is the price of firm output goods.  $C^\Delta$  includes all adjustment costs linked to factors of production.

Financing costs include both debt service and equity issuance costs, with both functions of firm default risk. Within our stylized analytical framework, individual firm default risk is determined by the probability distribution of future returns, net worth, and liquidation value. These factors are represented by the state of firm cash flow and productivity processes  $A, a^l, a^k$ , and its expected net worth in case of default.

Lending suffers asymmetric information frictions and, therefore, the loan contract is subject to an incentive compatibility constraint. Assume the more popular costly state verification (CSV) formulation of Townsend (1979)<sup>6</sup>,

$$(1 + r^b)b' = E \{P\{Success\}(1 + r)b' + (1 - \mu)Q'^K \int_0^{\bar{A}} \{P'Y' + (1 - \delta)k'\} Q(A, dA')\} \quad (4)$$

where  $r^b \geq r$  is the minimum rate a bank charges on a risk-less loan. This rate can be higher than the risk free rate if the aggregate banking system faces costs in raising enough funds to meet lending needs.  $\mu$  summarizes the losses in firm value, which creditors incur in case of liquidation.<sup>7</sup> Hence, a firm that maximizes its lifelong dividends to its shareholders faces the following first order conditions with respect to its optimal choices of capital and labor stocks,

$$Q^k = \frac{1}{1 + r^f} E \left\{ \frac{\partial NetWorth'}{\partial k'} - \frac{\partial C'^\Delta}{\partial k'} \right\} - \frac{\partial C^\Delta}{\partial k'} \quad (5)$$

$$W = \frac{1}{1 + r^f} E \left\{ \frac{\partial NetWorth'}{\partial l'} - \frac{\partial C'^\Delta}{\partial l'} \right\} - \frac{\partial C^\Delta}{\partial l'} \quad (6)$$

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<sup>6</sup>Lian and Ma (2018) demonstrate that earning based lending play a significant role for large US firms, which may limit the exposure of the labor share to the collateral channel we discuss in this paper. The significance of this channel remains undocumented for European firms, where more traditional lending and banking patterns are likely to remain prevalent.

<sup>7</sup>Similarly, equity is subject to issuance costs that depend on potential shareholders' incentives to buy stakes in the firm capital.

Both first order conditions imply that firms would optimize their capital and labor stocks such that the marginal cost of an additional unit of capital or labor would equal their marginal return; the latter consists of the expected marginal increase in firm net worth, net of adjustment costs,

$$\frac{\partial NetWorth'}{\partial k'} = P' \frac{\partial Y'}{\partial k'} + Q'^k (1 - \delta) + \frac{\partial \Delta E q'}{\partial k'} - b' \frac{\partial r'}{\partial k'} \quad (7)$$

$$\frac{\partial NetWorth'}{\partial l'} = P' \frac{\partial Y'}{\partial l'} + \frac{\partial \Delta E q'}{\partial l'} - b' \frac{\partial r'}{\partial l'} \quad (8)$$

$$\frac{\partial Y'}{\partial k'} = \gamma a_k^{\frac{\sigma-1}{\sigma}} \left( \frac{Y'}{k'} \right)^{\frac{1}{\sigma}} \quad (9)$$

$$\frac{\partial Y'}{\partial l'} = (1 - \gamma) a_l^{\frac{\sigma-1}{\sigma}} \left( \frac{Y'}{l'} \right)^{\frac{1}{\sigma}} \quad (10)$$

To get the optimal labor to capital ratio in firm production, I take the ratio of the two first order conditions. Under the assumptions of no financing costs (i.e.  $\tilde{r} = r^f$  and  $\frac{\partial r}{\partial k'} = \frac{\partial r}{\partial l'} = 0$ ), no adjustment costs (i.e.  $C^\Delta = 0$  and full capital depreciation (i.e.  $\delta = 1$ ), this ratio takes the simpler form,

$$\frac{l'}{k'} \equiv \frac{W l'}{Q^k k'} = E \left\{ \left( \frac{1 - \gamma}{\gamma} \right)^\sigma \left( \frac{a_l}{a_k} \right)^{\sigma-1} \left( \frac{Q^k}{W} \right)^{\sigma+1} \right\} \quad (11)$$

equation (11) implies that within the simplest classical setting, the firm labor to capital ratio depends on the *relative* prices of both factors of production as well as the corresponding factor-specific technologies. When labor and capital markets are fairly competitive, relative factor prices are less likely to vary across firms within the same sector. Hence, under both standard neo-classical assumptions and the aforementioned simplifying assumptions with regards to financing and adjustment costs, variations in labor to capital ratios across firms within the same sector, country and year group can be explained by differences across firms in the ratios of factor-specific productivity,  $\frac{a_l}{a_k}$ , and other technological parameters,  $\gamma$ , which could be firm specific.

Relaxing the simplifying assumptions introduces a role for external financ-

ing costs as well as firm capital and labor stock size in explaining observed variations in labor to capital ratios across firms and over time. These roles come at the expense of a closed form expression of the optimal labor to capital ratio,

$$\frac{l'}{k'} = E \left\{ \frac{\int_{l'} \left\{ (1 - \gamma) a_l^{\frac{\sigma-1}{\sigma}} \left( P' \frac{Y'}{l'} \right)^{\frac{1}{\sigma}} - b' \frac{\partial r'}{\partial l'} \right\} dl'}{\int_{k'} \left\{ \gamma a_k^{\frac{\sigma-1}{\sigma}} \left( P' \frac{Y'}{k'} \right)^{\frac{1}{\sigma}} + Q'^k (1 - \delta) - b' \frac{\partial r'_i}{\partial k'} \right\} dk'} \right\} \quad (12)$$

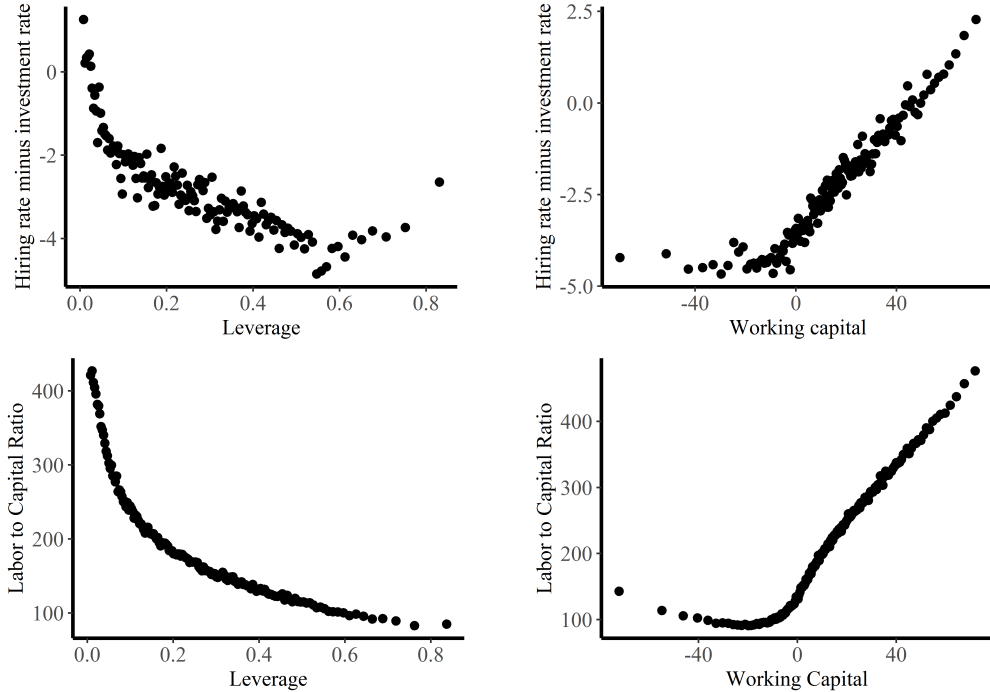
ElFayoumi (2019) presents a numerical solution of a closely similar model that shows how the firm optimal labor to capital ratio varies as a function of firm credit worthiness (i.e. net worth and productivity). The solution predicts that when firms face higher borrowing costs  $r_i$ , they assign a higher value to physical capital thanks to its collateral value in comparison to labor, which can not be collateralized in a loan contract; that is,  $\frac{\partial r'}{\partial k'} < \frac{\partial r'}{\partial l'}$  due to the  $(1 - \delta)k'$  term in the loan contract, equation (4); as a result, equations (7) and (8) indicate a more positive marginal effect on tomorrow's net worth from capital compared to labor. Similarly, firms that suffer more from information asymmetry concerns and face greater difficulty in raising private equity are more likely to increase their capital share of production to attract risk averse investors.

Turning to the data, the correlation patterns in figure 5 suggest a potential role for the financial position of the firm in its labor to capital ratio decisions in line with our theoretical exposition: firms with lower leverage and larger working capital (or current ratio) use more labor in production. The correlation is present with respect to the labor to capital ratio (as stock variables) and the relative hiring to investment rates (as flow variables).

Testing the role of external financing costs in driving variations in the firm-level labor to capital ratio empirically amounts to estimating the causal effects of the  $b'r'$  term in equation (12). However, equation (4) predicts  $r'$  to be also dependent on the same fundamentals that determine  $\frac{l'}{k'}$  in equation (12), which implies that the firm choice of labor to capital ratio and the level



Figure 5: Bin-Scatter plots of labor to capital ratio and endogenous measures of credit risk.



*Note:* The figure uses a bin scatter plot to summarize the relationship between firm-level wage bill to fixed assets and leverage ( $\equiv$  total debt to total assets) as well as working capital ( $\equiv$  current assets - current liabilities).

of financing costs it faces in the market are simultaneously determined and, therefore, endogenous. A plausible identification of the roles of  $b'r'$  needs to isolate exogenous variations in  $r'$ , which are independent of firm characteristics that are simultaneous determinants of  $l'/k'$ . In the following section, I discuss the identification strategy, which I use to explore this correlation and estimate the causal link between financing costs and firm optimal choice of relative hiring and investment rates.

### 3.2 Identifying the effects of exogenous variations in external financing costs

Equations (4) and (12) show that firm fundamentals that determine its access to credit market and cost of financing (i.e. technology, total and factor-

augmenting productivities, expected cash flow, size of physical assets) simultaneously determine its labor to capital ratio in production. Therefore, determining the causal effects of financial stress on the firms' decision to substitute between capital and labor requires isolating exogenous variations in financing conditions, e.g.  $r_{i,t}$ , that are independent of variations in fundamentals.<sup>8</sup>

This paper introduces a novel identification strategy to identify exogenous variations in firm financing costs. I rely on the within-firm variations in the pass-through of aggregate monetary policy surprises to the financing costs of firms (the credit channel), as a function of their liquidity and solvency positions; changes in the aggregate monetary conditions have a disproportionately larger impact on the external financing costs of less liquid and solvent firms.

To be more specific, monetary policy actions affect firms through three main channels: demand, investment, and credit.<sup>9</sup> The demand channel refers to the reaction of current and expected demand of firm products to changes in aggregate consumption, investment, and household spending. On the other hand, the investment channel works through changes in the base interest rate, which affects the hurdle rates set by firms and their shareholders with regards to investment decisions. Finally, monetary policy actions are also transmitted through their effect on the firm financial position and credit supply. This third channel, commonly labeled as the credit channel (Bernanke and Gertler (1995)), refers to the effect of monetary changes on firm net worth and asset prices (i.e. credit worthiness), the price of risk and risk appetite in loan contracts as well as the supply of credit and liquidity in lending and interbank markets.

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<sup>8</sup>Using a measure of net worth or liquidity, such as leverage or current ratio, as proxies for financing costs is not appropriate; such indicators are endogenously determined based on firm fundamentals, including the forward-looking outlook of the firm (i.e. expected growth), which is typically unobservable and difficult to control for. Hence, higher leverage could be a sign of stronger profitability and investment opportunities (i.e. risk bearing capacity), and not necessarily higher financial stress.

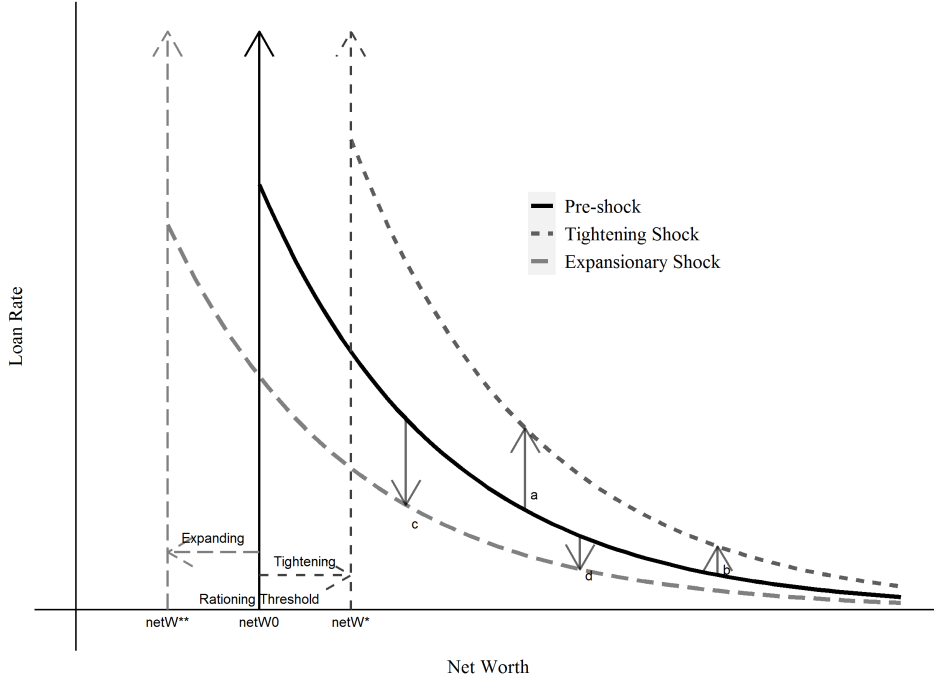
<sup>9</sup>The information channel is another important factor in explaining the impact of central bank actions on the economy (Nakamura and Steinsson 2018; Jarociński and Karadi 2020). However, its mechanism still relies on the three classical channels: demand, investment and credit. By introducing information on present and expected aggregate macroeconomic environment, central bank actions alter consumption, investment and lending behaviour.

Using the lens of the stylized model presented above, the demand channel of monetary policy works through the effect of the policy actions on current and future prices of firm output goods  $P$  and its expected cash flow  $A'$ , net of its effect on current and future wages  $W$ . On the other hand, the investment channel enters the firm problem through the hurdle rate  $r$ . More relevant for the credit channel is the effect of the shock on the price of firm assets  $Q$  and its cash flow. Fluctuations in asset prices (hence, collateral value) and expected returns, in turn, drive the probability of firm default and its credit worthiness, which eventually affect the borrowing rate  $r_i$  the firm faces in the loan market. In addition, apart from its direct effect on firm credit worthiness,  $r_i$  is influenced by the effect of monetary policy actions on the aggregate lending environment, which is reflected by  $r^b$  and  $\mu$  in the simple model described above.

Identification relies on the non-linearity of the credit channel of monetary policy transmission. By non-linearity, I refer to the heterogeneity in the size of the effects of the policy surprise, propagated through the credit channel, which are amplified at higher levels of default risk; that is, for any two identical firms (or for any two time instances within the same firm) that differ only with respect to their default risk, due to differences in liquidity or net worth (i.e. leverage), the effect of monetary policy tightening or expansion on external financing costs is stronger for the riskier firm-year. Figure (6) plots the relation between borrowing costs and firm net worth as well as the effects of monetary tightening and expansion, qualitatively as predicted by a standard Neo-Keynesian model with financial frictions (Christiano, Motto, and Rostagno (2014)); net worth is the main factor determining default risk in the standard financial accelerator model (Bernanke, Gertler, and Gilchrist (1999)).

This prediction that monetary policy exerts heterogeneous effects across firms according to the magnitude of their risk is motivated by the works of the financial accelerator. The accelerator points at the role played by fluctuations in external financing costs following changes to asset prices and firm cash flow in amplifying the effect of aggregate shocks (e.g. monetary policy surprises);

Figure 6: The non-linear effects of monetary policy for different levels of default risks.



*Note:* The figure plots the borrowing costs firms pay on their debt as a function of net worth (the main determinant of default risk), as argued in the text and predicted by standard NK models with financial frictions (Bernanke, Gertler, and Gilchrist (1999)). A tightening monetary policy shock pushes the curve upward while an expansionary policy pushes it downward. In addition, the slope of the curve as a function of net worth also changes. Hence, a firm with a net worth value at  $x^a$  experiences a larger increase in borrowing cost in reaction to a tightening shock in comparison to a firm whose net worth is  $x^b$ ; that is,  $a > b$ . The effect is also amplified in reaction to an expansionary shock;  $c > d$ .

an increase in the volume of firm operating profits, for example, commands a multiplier above one with regards to overall firm profitability and investment since it has the added advantage of lowering firm borrowing costs. Key to my identification is the diminishing rate at which financing costs decline as credit worthiness increases in response to monetary expansion. This convexity, which motivates the empirical identification strategy, is driven by three main factors:

First, when credit could be rationed such that some credit-worthy firms have access to credit and some are locked out, a rise in asset prices and expected cash flow streams would only have a marginal effect on the financing costs of

wealthier firms. In contrast, the credit-rationed firms would experience a jump (i.e. kink or step) effect as they gain access to credit. Figure (6) compares the effects of monetary expansion on two firms  $i$  and  $j$  with  $netW_i > netW_0$  and  $netW_j < netW_0$ ; prior to the policy shock, the former faces a loan rate of finite value, while firm  $j$  is rationed (i.e. effectively facing infinite financing costs). When monetary policy expands, the cost of financing for firm  $i$  declines by a marginal value, unlike firm  $j$ , which experiences a fall in financing costs from infinity to its new finite magnitude.<sup>10</sup>

Second, among firms that already have access to credit, the marginal increase in expected growth in cash flow (i.e. output) diminishes with size (i.e. scale); that is, relative to their size, the marginal growth in expected output (i.e. sales) by smaller firms is larger than the marginal expected growth rate of the revenues of larger (therefore, credit-worthier) firms. Since expected cash flow plays an important role in determining default risk, the decline in financing costs for smaller firms occurs at a higher rate compared to larger firms.<sup>11</sup>

The third factor behind the convexity in the relation between firm default risk and financing costs, and consequently the heterogeneity in monetary policy effects across the firm net worth distribution, relates to the concavity of the probability distributions that describes the uncertainty surrounding firms' future. Borrowers with higher default risk require a more favorable, but less probable, future scenario in order to maintain their debt sustainability and investors' confidence. However, realistic probability density functions that can describe the distribution of potential future outcomes are not linear; that is, the decline in the likelihood of an event as we move toward the tails of the distribution occurs at an increasing pace. For example, consider two firms: a less risky firm, which needs to only achieve a 10% increase in its future cash flow to meet creditors demands, and a riskier firm, which needs to achieve a

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<sup>10</sup>Similar intuition follows in situations of *partial* credit rationing, where credit allocation to firms may be capped depending on their risk brackets.

<sup>11</sup>That said, the econometric specification in the empirical analysis below controls for the size of firm assets, workforce and revenues, which limits the role of this channel in explaining the cross-firm variations produced by the aggregate policy shock.

20% increase; the probability of this 20% rise can be much less than half the probability of 10%. This probability element, in addition to the diminishing returns to scale, explains why the curves in figure (6) are convex and why the effect of a policy tightening or expansion is amplified at firms with higher risk (i.e. lower net worth).

Hence, weighing aggregate monetary policy shocks with a firm-level proxy of its credit worthiness provides a measure of exogenous variations in external financing costs at the firm level (i.e. idiosyncratic shocks). A key maintained assumption in this empirical design is that idiosyncratic shocks to firm demand environments and hurdle rates do not impact its input factors composition (i.e. relative marginal utility and cost of capital and labor).<sup>12</sup> The assumption is supported by the theoretical framework presented above and is essential for the exclusion restriction needed to implement an IV design that uses the identified shock as an instrument to estimate the impact of debt service costs on the firm labor to capital ratio.<sup>13</sup>

### **Constructing aggregate shocks**

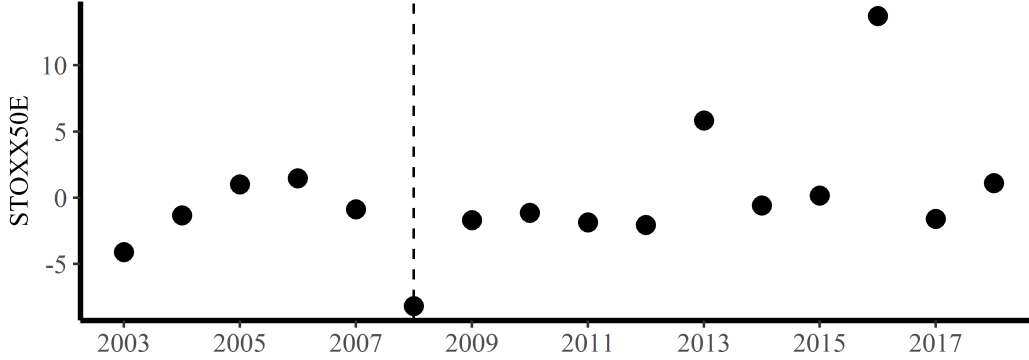
For a measure of aggregate unexpected ECB monetary policy actions, I use the monthly time series provided by Altavilla et al. (2019). This series of shocks is identified using high frequency identification, which relies on the intra-day movements in prices within a tight window around monetary policy announcements (Nakamura and Steinsson (2018), Miranda-Agrippino and Ricco (2018), Swanson (2017)). As a benchmark specification, I use the first principle component of the high frequency changes in two main European stock indices (STOXX50E and SX7E), normalized by the changes in STOXX50E; that is, one unit change in the extracted factor implies one unit change in in

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<sup>12</sup>Ottonello and Winberry (2020) argue that firms facing lower financing costs are more ready to use the new opportunities created by a monetary expansion and, therefore, they are likely to invest and grow at a higher rate; that is, in addition to providing a distribution of exogenous firm-level financing shocks, an interaction of monetary policy shocks with firm financial positions yields a distribution of exogenous firm-level hurdle rate shocks as well.

<sup>13</sup>The analysis focuses on the impact of external financing shocks on the labor demand relative to capital, where the credit channel of monetary policy actions is only an instrument. On the other hand, a growing literature studies the interaction between monetary policy and labor market dynamics in the presence of financial frictions (among others, König 2020).

Figure 7: Time series of the constructed aggregate monetary policy shock.



STOX50. Figure 7 plots the aggregate shock series.

An important feature of this high frequency identification approach is that the constructed shocks are exogenous to other fundamental macroeconomic shocks, including demand or supply shocks. In addition, the series includes both conventional and unconventional policy actions, which allows us to capture the credit channel of monetary policy despite the zero lower bound. Finally, I aggregate the shock series by summing over the monthly shocks for every 12 months period (Kilian (2009), Ottonello and Winberry (2020)) to match the annual frequency of the firm-level panel.

### Constructing firm-level shocks

For each firm, I multiply the annualized aggregate shock by a *lagged* proxy of each firm’s credit worthiness, i.e. its exposure to the effects of the credit channel of monetary policy, to construct a firm-level shock  $\xi_{i,j,k,t}$ : in the main body of the analysis I interact firm leverage with the monetary policy instrument. This measure of firm net worth is one of the main factors behind its dependency on short term interest rates and monetary policy decisions, since it captures the size of the firm financing gap as well as its default risk.<sup>14</sup>

It is worth noting here that the constructed firm-level instrument  $x_{i,j,k,t-1} \times$

<sup>14</sup>In the appendix, I repeat the analysis using other measures: e.g. firm liquidity, the ratio of its short-term to total liabilities.

$\epsilon_{k,t}^{ECB}$  is created by projecting an endogenous firm-level variable on an aggregate exogenous instrument, i.e. the policy shocks. Therefore, exogeneity of the identified shock holds over the within and cross-section variations because  $x_{i,j,k,t-1}$  is *lagged*, removing the potential for *reverse-causality*, and  $x_{i,j,k,t-1}$  is also included among the regressors to address the omitted variable concern and ensure that the common trend assumption holds.

To sum up, the identification strategy considers a thought experiment of a single firm over two points in time, belonging to the same country and industry and share similar levels of size, productivity and growth prospects, but is different in terms of its default risk over the two points in time as a result of having different net worth positions. When faced by exogenous aggregate monetary policy tightening, its financing costs would rise disproportionately at the two periods of time, providing exogenous within-firm variations in its financing costs.

### Baseline estimation

Having constructed an instrument for exogenous variations in firm financing costs, I estimate the following regressions to identify the causal effects of firm financing on its labor to capital ratio,

$$y_{i,j,k,t} = \beta_1 y_{i,j,k,t-1} + \beta_2 \overbrace{\{x_{i,j,k,t-1} \times \epsilon_{k,t}^{ECB}\}}^{\text{Firm-level Shock } \xi_{i,j,k,t}} + \beta_3 x_{i,j,k,t-1} + \beta_4 \epsilon_{k,t}^{ECB} + \beta_5 Z_{i,j,k,t-1} + \eta_i + \eta_t + \{\eta_j \times \eta_k \times \eta_t\} + u_{i,j,k,t} \quad (13)$$

where  $y$  is the dependent variable of interest and  $x_{i,j,k,t}$  corresponds to leverage in the main analysis.  $Z_{i,j,k,t}$  is a vector of control variables: current assets to total assets ratio; total debt to total assets ratio; growth rates of wage bill and fixed assets; wage bill to fixed assets ratio; logged average wage; levels and growth rates of profits and revenues (as a ratio to total assets); logged number of employees; and logged total assets. I also include firm,  $\eta_i$ , and time,  $\eta_t$ , fixed effects as well as industry  $\times$  country  $\times$  year fixed effects,  $\{\eta_j \times \eta_k \times \eta_t\}$ .

Hence, for any two firms sharing similar levels of productivity, cash flow



and profitability (measured by the average wage and profit and revenues to total assets ratios), growth momentum (measured by growth rates in revenues, profits and labor and capital stocks), and size (measured by number of employees and value of total assets),  $\beta_2$  measures the effect of external financing costs on their optimal decisions.

Alternatively, I also embed  $\xi_{i,j,k,t}$  in an IV specification to estimate the effect of exogenous changes in the cost of borrowing on firm decisions. I rely on the ratio of interest expenses (i.e. debt service payments) to total assets as a measure of the cost of borrowing, conditional on the magnitude of total debt to total assets. Projecting interest expenses on  $\xi_{i,j,k,t}$  in the first stage of an IV estimation enables us to circumvent the endogeneity inherent in this measure and study its causal effect on firm decisions. For the main variable of interest, i.e. wage bill to fixed assets ratio, this specification largely aligns with equation (12).  $\xi_{i,j,k,t}$  satisfies the two conditions required for a valid IV instrument: First, as has been argued earlier, it is exogenous to firm decisions. Second, its main effect takes place through its impact on the price schedule the firm faces in credit markets, which is proxied by interest expenses, conditional on total leverage.

$$y_{i,j,k,t} = \beta_1 y_{i,j,k,t-1} + \beta_2 \overbrace{\{\text{Interest Expense}_{i,j,k,t}\}}^{\text{IV}(\xi_{i,j,k,t})} + \beta_3 x_{i,j,k,t-1} + \beta_4 \epsilon_{k,t}^{ECB} + \beta_5 Z_{i,j,k,t-1} + \eta_i + \eta_t + \{\eta_j \times \eta_k \times \eta_t\} + u_{i,j,k,t} \quad (14)$$

## 4 Findings

### Instrument relevance

I start by examining the *relevance* criterion of the constructed instrument with respect to firm financing costs. The findings in Table 5 indicate that the constructed shock has a significant effect on borrowing costs, where column (3) represents the first stage regression in the IV estimation for the latter regressions. The results suggest that between two firms that differ in leverage by one standard deviation, an accommodating monetary policy shock that

raises the *Stoxx50* index by one lowers debt service payments significantly by an additional 0.01% of total assets at the more leveraged firm.<sup>15</sup> Lending further support to the identified instrument, the results in Table 6 show a negative impact from an increase in financing costs on firm total debt; an exogenous one percent increase in debt service to total asset ratio leads to a decline in firm total debt by 21.4\$ (Column 4).

### **The impact on the relative demand for labor and capital**

The findings in Table 7 support the hypothesis of a causal relationship between financing costs and firm decision with regards to its labor-capital composition, implying that European firms substitute capital for labor when financing conditions tighten and vice versa. Following the IV specification in column 4, one percent increase in the debt service payments to total assets facing the average firm leads to a decline in hiring rate relative to capital investment by 5.75%. Alternatively, using the diff-in-diff results from column 3, for two firms that differ by one standard deviation (17.1%) with respect to their leverage ratios, an expansionary monetary policy shock that raises the *Stoxx50* index by one is associated with a 0.05% higher hiring rate relative to capital investment rate at the more leveraged firm.

Table 8 reports the results over multiple horizons following the dynamic IV-local projection approach (Jordà (2005), Ramey and Zubairy (2017)). Estimated coefficients show that the decline in hiring rate relative to investment is strongest on impact, with a cumulative negative effect over the five years horizon as firms reach a new equilibrium ratio between labor and capital stocks.

Table 9 uses the IV specification to translate what the previous estimates mean in terms of the labor share of value added (proxied by profits) and the size of the wage bill in terms of total assets. The results indicate that the decline in hiring relative to investment as a result of a 1% exogenous increase financing costs is associated with a decline of the labor share in profit by 20% of the latter. A similar effect goes for the wage bill to total assets ratio, which

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<sup>15</sup>Standard deviation of debt service payment to total assets is 1.25%, with a median of 1.15%.

Table 5: The effect of financing costs shock on debt service payments

	(1)	(2)	(3)
Leverage $_{i,j,k,t-1}$	0.499*** (0.003)	0.446*** (0.003)	0.443*** (0.003)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	0.002*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
$\ln(\text{Avg. wage})_{i,j,k,t-1}$	-0.065*** (0.009)	0.013 (0.010)	-0.020** (0.009)
Profit $_{i,j,k,t-1}$	-0.006*** (0.000)	-0.008*** (0.000)	-0.007*** (0.000)
$\ln(\text{Revenue})_{i,j,k,t-1}$	0.137*** (0.007)	-0.053*** (0.007)	-0.047*** (0.007)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	-0.191*** (0.009)	-0.007 (0.008)	-0.011 (0.008)
$\ln(\text{Total assets})_{i,j,k,t-1}$	0.143*** (0.008)	0.119*** (0.008)	0.134*** (0.008)
$\epsilon_t^{\text{Stock prices}}$	-0.005*** (0.000)		
Leverage $_{i,j,k,t-1} \times \epsilon_t^{\text{Stock prices}}$	-0.009*** (0.000)	-0.009*** (0.000)	-0.009*** (0.000)
Num. obs.	1030427	1030427	1030427
R <sup>2</sup> (full Column)	0.783	0.807	0.814
Adj. R <sup>2</sup> (full Column)	0.733	0.763	0.771
Firm fixed effects	yes	yes	yes
Year fixed effects	No	yes	yes
Industry $\times$ year fixed effects	No	No	yes
Country $\times$ year fixed effects	No	No	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Table 6: The effect of financing costs on total debt growth

	(1)	(2)	(3)	(4) IV
Leverage $_{i,j,k,t-1}$	-72.489*** (0.959)	-74.006*** (0.973)	-74.381*** (0.982)	-65.178*** (3.369)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	0.154*** (0.016)	0.051*** (0.016)	0.031* (0.016)	0.020 (0.017)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.103*** (0.007)	0.080*** (0.007)	0.081*** (0.007)	0.079*** (0.007)
$\ln(\text{Avg. wage})_{i,j,k,t-1}$	-15.855*** (1.982)	0.391 (2.044)	3.566* (2.089)	3.306 (2.104)
Profit $_{i,j,k,t-1}$	-0.011 (0.060)	-0.116* (0.061)	-0.126** (0.063)	-0.267*** (0.083)
$\ln(\text{Revenue})_{i,j,k,t-1}$	17.142*** (1.911)	12.291*** (2.046)	10.311*** (2.143)	9.342*** (2.168)
% $\Delta$ Revenue $_{i,j,k,t-1}$	-0.055*** (0.014)	-0.036** (0.014)	-0.028* (0.015)	-0.013 (0.016)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	7.029*** (2.021)	11.535*** (2.051)	12.748*** (2.070)	12.394*** (2.088)
$\ln(\text{Total assets})_{i,j,k,t-1}$	-54.678*** (2.361)	-53.103*** (2.425)	-55.723*** (2.463)	-52.968*** (2.486)
$\epsilon_t^{\text{Stock prices}}$	-0.957*** (0.111)			
Leverage $_{i,j,k,t-1} \times \epsilon_t^{\text{Stock prices}}$	0.113** (0.052)	0.119** (0.052)	0.184*** (0.065)	
Interest service $_{i,j,k,t}$				-21.431*** (7.787)
Num. obs.	945905	945905	945905	940267
R <sup>2</sup> (full Column)	0.263	0.265	0.267	0.260
Adj. R <sup>2</sup> (full Column)	0.075	0.077	0.079	0.068
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	No	yes	yes	yes
Industry $\times$ year fixed effects	No	No	yes	yes
Country $\times$ year fixed effects	No	No	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Table 7: The effect of financing costs on the difference between hiring and investment rates. LHS:  $g^{l-k} \equiv \% \Delta \text{wage bill} - \% \Delta \text{fixed assets}$ .

	(1)	(2)	(3)	(4) IV
Leverage $_{i,j,k,t-1}$	2.269*** (0.083)	2.538*** (0.084)	2.641*** (0.084)	5.199*** (0.357)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	-0.032*** (0.003)	-0.001 (0.003)	-0.002 (0.003)	-0.005 (0.003)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.038*** (0.001)	0.043*** (0.001)	0.044*** (0.001)	0.044*** (0.001)
$\ln(\text{Avg. wage})_{i,j,k,t-1}$	-35.978*** (0.344)	-40.898*** (0.386)	-40.695*** (0.390)	-40.812*** (0.398)
Profit $_{i,j,k,t-1}$	0.019*** (0.007)	0.051*** (0.007)	0.046*** (0.007)	0.008 (0.009)
$\ln(\text{Revenue})_{i,j,k,t-1}$	-5.015*** (0.260)	-3.497*** (0.264)	-3.333*** (0.272)	-3.629*** (0.282)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.007*** (0.002)	0.011*** (0.002)	0.008*** (0.002)	0.012*** (0.002)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	-22.721*** (0.314)	-23.919*** (0.318)	-24.486*** (0.321)	-24.553*** (0.328)
$\ln(\text{Total assets})_{i,j,k,t-1}$	20.874*** (0.286)	20.881*** (0.291)	20.844*** (0.297)	21.602*** (0.321)
Stock prices $\epsilon_t$	-0.057*** (0.012)			
Leverage $_{i,j,k,t-1} \times \epsilon_t^{\text{Stock prices}}$	0.098*** (0.006)	0.097*** (0.006)	0.048*** (0.007)	
Interest service $_{i,j,k,t}$				-5.752*** (0.787)
Num. obs.	1024692	1024692	1024692	1017709
R <sup>2</sup> (full Column)	0.250	0.254	0.262	0.245
Adj. R <sup>2</sup> (full Column)	0.076	0.082	0.090	0.068
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	No	yes	yes	yes
Industry $\times$ year fixed effects	No	No	yes	yes
Country $\times$ year fixed effects	No	No	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Table 8: The dynamic effects of borrowing costs on the growth rate of firm labor to capital ratio

	h = 0	h = 1	h = 2	h = 3	h = 4
Interest service $_{i,j,k,t}$	-5.752*** (0.787)	-5.034*** (0.666)	-1.482 (0.951)	-0.036 (1.130)	-5.509*** (1.214)
Num. obs.	1017709	883179	765556	657043	555265
R <sup>2</sup> (full model)	0.245	0.267	0.286	0.304	0.314
Adj. R <sup>2</sup> (full model)	0.068	0.075	0.080	0.081	0.066
Firm fixed effects	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes
Industry $\times$ year fixed effects	yes	yes	yes	yes	yes
Country $\times$ year fixed effects	yes	yes	yes	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

shows a decline of 0.87% for every 1% exogenous increase in financing costs.

### Heterogeneity across countries, sectors and size quantiles

Interestingly, the strength of this mechanism differs considerably across countries, as shown in Table 10. Although France, Italy, and Spain show a negative effect of tighter financing on hiring relative to investment, the coefficients are only statistically significant for Spain and Italy at -6.9% and -5.77%, respectively. Similarly, there is a pronounced heterogeneity across industries, where the average result appears to be largely driven by manufacturing and trade sectors.

Table 9: The effect of financing costs on the labor share of profit and total assets

	Wage bill to profit (IV)	Wage bill to total assets (IV)
Leverage $_{i,j,k,t-1}$	-8.515 (7.240)	-0.053 (0.101)
% $\Delta$ wage bill $_{i,j,k,t-1}$	0.097 (0.060)	0.019*** (0.001)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	-0.001 (0.025)	-0.006*** (0.000)
$\ln(\text{Average wage})_{i,j,k,t-1}$	131.205*** (7.272)	12.306*** (0.132)
Profit $_{i,j,k,t-1}$	-2.234*** (0.230)	-0.055*** (0.004)
$\ln(\text{Revenue})_{i,j,k,t-1}$	-17.552*** (5.336)	1.389*** (0.087)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.128*** (0.047)	0.013*** (0.001)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	171.476*** (5.677)	16.308*** (0.119)
$\ln(\text{Total assets})_{i,j,k,t-1}$	-126.448*** (5.892)	-15.898*** (0.116)
Interest service $_{i,j,k,t}$	-19.329 (16.019)	-0.872*** (0.219)
Num. obs.	1000848	1027789
R <sup>2</sup> (full model)	0.394	0.944
Adj. R <sup>2</sup> (full model)	0.249	0.931

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Table 10: The effect of borrowing costs on the difference between hiring and investment rates by country (IV specification)

	DE	ES	FR	IT
Leverage $_{i,j,k,t-1}$	-0.645 (1.549)	3.761*** (0.722)	1.940* (0.990)	3.597** (1.429)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	0.014 (0.017)	0.001 (0.007)	-0.004 (0.010)	-0.015** (0.007)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.027*** (0.008)	0.016*** (0.003)	0.029*** (0.003)	0.022*** (0.003)
$\ln$ (Avg. wage) $_{i,j,k,t-1}$	-3.409 (2.532)	-3.429*** (0.892)	-2.723** (1.306)	-2.838*** (0.859)
Profit $_{i,j,k,t-1}$	0.037 (0.055)	-0.073*** (0.021)	-0.020 (0.031)	-0.032 (0.029)
$\ln$ (Revenue) $_{i,j,k,t-1}$	-2.522 (1.638)	-4.440*** (0.604)	0.733 (1.151)	-1.224** (0.619)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.006 (0.013)	0.002 (0.005)	-0.019** (0.009)	-0.004 (0.005)
$\ln$ (N. Employees) $_{i,j,k,t-1}$	-1.283 (2.210)	-3.969*** (0.747)	-5.912*** (1.162)	-4.607*** (0.703)
$\ln$ (Total assets) $_{i,j,k,t-1}$	3.789* (2.273)	2.514*** (0.816)	8.692*** (1.357)	5.123*** (0.874)
Interest service $_{i,j,k,t}$	0.893 (3.588)	-6.914*** (1.686)	-4.230 (2.597)	-5.768** (2.826)
Num. obs.	31426	185472	136256	202111
R <sup>2</sup> (full model)	0.389	0.314	0.310	0.319
Adj. R <sup>2</sup> (full model)	0.151	0.067	0.026	0.083
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
Industry $\times$ year fixed effects	yes	yes	yes	yes
Country $\times$ year fixed effects	yes	yes	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$



Table 11: The effect of borrowing costs on the difference between hiring and investment rates by sector (IV specification)

	Manufactuirng	Construction	Trade	Service and Others	Agriculture	Financial
Leverage $_{i,j,k,t-1}$	4.156*** (0.960)	0.310 (2.127)	2.707*** (0.892)	2.442** (1.090)	6.527 (4.375)	-2.023 (9.269)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	-0.016** (0.007)	0.001 (0.014)	-0.002 (0.009)	-0.005 (0.008)	-0.014 (0.030)	0.043 (0.062)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.024*** (0.003)	0.026*** (0.005)	0.023*** (0.003)	0.016*** (0.003)	0.033** (0.015)	0.021 (0.021)
$\ln(\text{Avg. wage})_{i,j,k,t-1}$	-2.835*** (0.880)	-1.950 (1.848)	-3.687*** (1.098)	-2.063** (1.046)	1.113 (3.992)	-3.841 (8.023)
Profit $_{i,j,k,t-1}$	-0.036 (0.023)	0.012 (0.050)	-0.109*** (0.031)	-0.019 (0.026)	0.031 (0.140)	-0.247 (0.168)
$\ln(\text{Revenue})_{i,j,k,t-1}$	-3.174*** (0.631)	-0.255 (1.134)	-2.701*** (0.810)	-3.101*** (0.801)	-12.227*** (3.825)	2.047 (6.233)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.002 (0.005)	-0.013 (0.008)	-0.008 (0.008)	0.001 (0.007)	0.038 (0.025)	0.016 (0.044)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	-5.438*** (0.738)	-4.915*** (1.486)	-4.865*** (0.931)	-2.554*** (0.885)	1.336 (3.985)	-1.086 (5.884)
$\ln(\text{Total assets})_{i,j,k,t-1}$	5.875*** (0.788)	3.608** (1.839)	3.561*** (1.107)	3.627*** (1.087)	1.542 (3.679)	4.972 (7.161)
Interest service $_{i,j,k,t}$	-7.628*** (2.034)	0.165 (4.789)	-5.743*** (2.199)	-3.395 (2.368)	-16.891 (10.726)	5.049 (21.264)
Num. obs.	207298	55846	129305	150217	8747	3666
R <sup>2</sup> (full model)	0.283	0.342	0.304	0.348	0.256	0.371
Adj. R <sup>2</sup> (full model)	0.049	0.064	0.059	0.089	-0.024	0.065
Firm fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Industry $\times$ year fixed effects	yes	yes	yes	yes	yes	yes
Country $\times$ year fixed effects	yes	yes	yes	yes	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

*Note:* 'Others' include firms in a set of services and utilities industries: Electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities; transportation and storage; accommodation and food service activities; real estate activities.

Finally, Table 12 compares the effect across distribution quantiles with respect to firm size. The estimated quantile regressions for firm size imply that firms with a larger number of employees are more likely to bias their input factor composition toward capital in response to an exogenous increase in their financing costs. This result is consistent with the mechanism of the model presented above, where the size of a firm staff increases its dependency on working capital, making it more vulnerable to liquidity and financing shocks. Moreover, a larger number of employees does not necessarily help attract other sources of financing when credit markets tighten in the same fashion physical assets could.

In contrast, I find that larger firms with respect to asset size are more conservative in their labor to capital ratio adjustment. This latter observation is consistent with the greater flexibility that larger firms (by asset size) enjoy with regards to their ability to smooth capital market shocks by issuing bonds and equity or raising private funds. This flexibility comes on top of their lower exposure to a binding financial shock due to the higher collateral value of their assets.

### **The role of the collateral channel**

The theory proposed by Calvo, Coricelli, and Ottonello (2012) and Jermann and Quadrini (2012) to explain the differential effects of the great recession on capital stock and employment suggests that this substitution effect is motivated by the *collateral* value of capital, which becomes increasingly important as financing conditions tighten. To test the role of this collateral channel, I examine the extent to which this substitution response differs for firms whose physical assets carry a higher degree of collateralizability. One potential measure of this collateral value of physical assets is its depreciation rate; as equation (4) suggests, a higher depreciation rate implies less liquidation value of physical assets, hence, lower collateral value. Alternatively, equation (7) also shows that as depreciation rises, the added contribution, in comparison to labor, of capital to firm tomorrow's net worth declines.

The results in Table 13 support the collateral channel hypothesis;<sup>16</sup> based

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<sup>16</sup>To avoid short term fluctuations in the depreciation rate, I use the average of the

Table 12: The effect of borrowing costs on the difference between hiring and investment rates by size quantiles

	{Total Assets, N. Employees} Quantiles			
	(1 <sup>st</sup> , 1 <sup>st</sup> )	(1 <sup>st</sup> , 2 <sup>nd</sup> )	(2 <sup>nd</sup> , 1 <sup>st</sup> )	(2 <sup>nd</sup> , 2 <sup>nd</sup> )
Leverage <sub><i>i,j,k,t-1</i></sub>	4.404** (1.897)	8.614*** (1.853)	19.585 (24.635)	2.418*** (0.638)
%Δ Wage bill <sub><i>i,j,k,t-1</i></sub>	-0.006 (0.010)	0.004 (0.012)	-0.052 (0.076)	-0.015** (0.007)
%Δ Fixed assets <sub><i>i,j,k,t-1</i></sub>	0.017*** (0.004)	0.024*** (0.005)	0.011 (0.016)	0.022*** (0.002)
ln(Avg. wage) <sub><i>i,j,k,t-1</i></sub>	0.459 (1.432)	-2.436 (1.657)	-9.131 (9.108)	-3.841*** (0.849)
Profit <sub><i>i,j,k,t-1</i></sub>	-0.043 (0.039)	-0.092* (0.049)	-0.302 (0.447)	-0.038* (0.021)
ln(Revenue) <sub><i>i,j,k,t-1</i></sub>	-3.928*** (1.160)	-2.738*** (1.030)	-3.068 (9.875)	-3.815*** (0.586)
%Δ Revenue <sub><i>i,j,k,t-1</i></sub>	-0.001 (0.009)	0.005 (0.008)	0.126 (0.101)	-0.004 (0.005)
ln(N. Employees) <sub><i>i,j,k,t-1</i></sub>	-0.343 (1.443)	-3.787** (1.556)	-6.833 (8.186)	-5.202*** (0.691)
ln(Total assets) <sub><i>i,j,k,t-1</i></sub>	4.722** (1.905)	7.250*** (2.044)	17.834 (20.784)	4.910*** (0.716)
Interest service <sub><i>i,j,k,t</i></sub>	-8.646** (4.402)	-17.012*** (4.251)	-45.568 (57.493)	-4.102*** (1.373)
Num. obs.	136104	63559	14405	200320
R <sup>2</sup> (full model)	0.394	0.351	0.212	0.305
Adj. R <sup>2</sup> (full model)	0.036	0.004	-0.586	0.071
Firm fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
Industry × year fixed effects	yes	yes	yes	yes
Country × year fixed effects	yes	yes	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

on the IV specification in column 2, the estimated coefficient for the interaction term indicates that the effect of financing costs on the firm's choice of labor to capital ratio is weaker for firms with a higher depreciation rate of capital. A one standard deviation higher depreciation rate is associated with almost half the average effect: for the average firm, an exogenous 1% rise in interest service payments lowers hiring rate by 10.65% relative to investment; the decline is only 5.13% for firms whose depreciation rate is one standard deviation above average.

## 5 Conclusion

Understanding why the response of labor and capital to recessions differs is key to the design of recovery policies. This labor angle is particularly important in times when an economic crisis poses a challenge to domestic demand upon which a sustainable recovery needs to be based. The paper provides a granular empirical evidence that external financing conditions are a significant factor in firm choice of input factors (labor and capital) composition, which, in turn, determines the share of labor in the aggregate production function. This causal evidence remained mostly lacking in a growing theoretical literature that studies the labor and financial markets linkages. Overall, the analysis promotes the message that a well functioning credit market is key for an economy where labor could enjoy a larger and more balanced share of economic growth.

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depreciation rate values for each firm over the time period of the sample.

Table 13: The role of depreciation rate in the effect of borrowing costs on the difference between hiring and investment rates

	(1)	(2) IV
Leverage $_{i,j,k,t-1}$	-0.422*** (0.151)	4.834*** (0.663)
% $\Delta$ Wage bill $_{i,j,k,t-1}$	-0.003 (0.003)	-0.005 (0.003)
% $\Delta$ Fixed assets $_{i,j,k,t-1}$	0.044*** (0.001)	0.045*** (0.001)
$\ln(\text{Avg. wage})_{i,j,k,t-1}$	-40.611*** (0.389)	-40.675*** (0.396)
Profit $_{i,j,k,t-1}$	0.052*** (0.007)	0.038*** (0.010)
$\ln(\text{Revenue})_{i,j,k,t-1}$	-3.311*** (0.272)	-3.256*** (0.285)
% $\Delta$ Revenue $_{i,j,k,t-1}$	0.008*** (0.002)	0.009*** (0.002)
$\ln(\text{N. Employees})_{i,j,k,t-1}$	-24.416*** (0.320)	-24.342*** (0.327)
$\ln(\text{Total assets})_{i,j,k,t-1}$	20.848*** (0.297)	21.380*** (0.318)
Leverage $_{i,j,k,t-1} \times \epsilon_t^{\text{Stock Prices}}$	0.097*** (0.011)	
Depreciation rate $_{i,j,k,t-1} \times \epsilon_t^{\text{Stock Prices}}$	-0.079*** (0.014)	-0.045** (0.019)
Leverage $_{i,j,k,t-1} \times \text{Depreciation Rate}_{i,j,k,t-1}$	2.190*** (0.100)	-0.423 (0.469)
Leverage $_{i,j,k,t-1} \times \text{Depreciation rate}_{i,j,k,t-1} \times \epsilon_t^{\text{Stock Prices}}$	-0.048*** (0.008)	
Interest service $_{i,j,k,t}$		-10.652*** (1.294)
Depreciation rate $_{i,j,k,t-1} \times \text{Interest service}_{i,j,k,t}$		5.130*** (0.892)
Num. obs.	1023961	1016989
R <sup>2</sup> (full Column)	0.263	0.251
Adj. R <sup>2</sup> (full Column)	0.091	0.075
Firm fixed effects	yes	yes
Year fixed effects	yes	yes
Industry $\times$ country $\times$ year fixed effects	yes	yes

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

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