Uncovering the mechanism(s): Financial constraints and wages†

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Very preliminary and incomplete. Please do not circulate.

Abstract

A large macroeconomic literature has documented how financial constraints increase the volatility of output and unemployment. This paper investigates how different (combinations of) existing mechanisms imply very different effects of financial constraints on wages. We explore these mechanisms based on a large data set for Germany for 2006 to 2014 that combines administrative data on workers and wages with detailed information on the balance sheets of firms. We then interpret the evidence using a theoretical model with frictions in both the financial and the labor market. We show that higher financial constraints lead to real wage cuts. We show both in the model and in the data that financial constraints affect wages through two channels: The presence of a financial labor wedge lowers wages and provides the dominant mechanism of how finance affects wages. Financial frictions interact with labor market tightness such that they increase wages which buffers part of the effect through the financial labor wedge. We show that financial constraints increase economic volatility and decrease wage rigidity over the business cycle.

Keywords: financial frictions, wages, search and matching, unemployment
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1 Introduction

The macroeconomic literature about the effect of financial frictions has widely documented how these frictions increase (the volatility of) output and (un)employment. Based on different mechanisms, various strands of the literature imply or assume very different effects of financial frictions on wages, however. This paper addresses the relationship between financial constraints and wages. We argue that wages can be used to investigate the presence, direction and strength of different mechanisms. This is important in order to understand how financial frictions affect the transmission of economic policy, but also income and consumption inequality in the economy.

We consider two particular mechanisms about how financial conditions of firms affect their labor demand. In the early contributions on financial frictions, introducing a working capital constraint into an otherwise frictionless macroeconomy generates the so-called financial labor wedge (see e.g. Jermann and Quadrini (2006) or Neumeyer and Perri (2005)). This wedge implies that wages, which are part of or complementary to working capital, increase less in response to productivity improvements when financial frictions are present. The financial labor wedge also implies that wages should fall when financial conditions are tighter. Another, smaller, part of the literature investigates the interaction between financial and labor market frictions. Here, hiring is seen as an investment activity the cost of which is related to the financial condition of firms (e.g. the cost of posting vacancies is paid with external finance as in Petrosky-Nadeau (2014) or Monacelli et al. (2011)).[1] An increase in this cost increases the bargaining position of workers already employed and therefore implies that wages should increase when financial conditions are tighter.

Apart from these two mechanisms, a number of additional studies assume that wages do not directly interact with financial constraints. Here, wages are either

[1] Midrigan et al. (2018) has a similar view, but considers the effect of household finance rather than firm finance on labor demand. We will discuss this mechanism further below.

completely rigid or partly respond to changes in financial conditions through changes in aggregate conditions only (examples include Caggese et al. (2018), Boeri et al. (2017), or Schoefer (2015)).

We investigate the presence, strength and direction of the financial labor wedge and the tightness interaction mechanism in the data. To this end, we use a large data set for Germany for the years 2006 to 2014 that combines administrative data on workers and wages with detailed information on firms' balance sheets. We measure financial constraints by past firm-level leverage and investigate how this affects individual wages. Doing so, we specifically consider how leverage interacts with productivity and tightness controlling for a large number of observed and unobserved aspects that may affect firm leverage and individual wages. Our empirical setup is similar in spirit to Giroud and Mueller (2017) who investigate the effect of financial constraints on employment. In our tightest specification, we consider how match-specific changes in productivity (measured to be reflected in a change in the complexity of the job of a particular worker in a particular firm) and tightness (measured for a particular occupation) affect individual wages, and how these changes affect wages differently depending on the level of leverage in the firm. In addition to match-specific fixed effects, we include sector-state and year fixed effects and control for profits, sales, age and size of the firm.

We find that higher financial constraints imply real wage cuts. These wage cuts are significant and relate in size to about one fourth of wage inflation in the sample period. We find that more complex jobs relate to higher wages, but these wage increases are smaller when financial conditions are tight. We also document that tighter labor markets imply higher wages, and these wage increases rise when financial conditions worsen.

We interpret our empirical results using a theoretical model that contains frictions on both the labor market (as in Mortensen and Pissarides (1994)) and on the financial market (as in Carlstrom and Fuerst (1998)). The model features both the financial labor wedge and the tightness interaction channel and nests several existing mechanisms as special cases. We document that the presence, strength and direction of the two mechanisms depends on how the firm uses external finance. Quite intuitively, the financial labor wedge is present in our model if firms use external finance to pay for wages (working capital). When labor market frictions are present, external finance then not only affects the cost of paying wages, but also the cost of paying the marginal employed worker relative to hiring a new worker. If external finance does not affect these two costs in the same way, changes in labor market tightness interact with the cost of external finance. When hiring a new worker becomes more/less expensive relative to paying the marginal employed worker, the bargaining position of the employed worker improves/worsens and her wage increases/decreases. We call this channel the tightness interaction channel of financial frictions.

Our empirical results suggest that both mechanisms are present in the data. While the financial labor wedge effect dominates the tightness interaction channel, the interaction effect buffers part of the labor wedge effect, however. From the viewpoint of our model, this means that firms use external finance to pay for both wages and hiring costs. Our results also suggest that a larger share of total hiring costs than of total wage costs is paid for with external finance. Put differently, hiring is exposed to external finance to a larger degree than wages. This is intuitive if hiring (investment) expenses need to be paid for before production, while only some of the wage (working capital) costs may incur before production.

Our model is simple enough that we can derive analytic expressions on how financial frictions affect wage rigidity and economic volatility (amplification towards tightness) over the cycle. Regardless of the underlying mechanism, higher financial constraints imply higher economic volatility, but for different reasons. The financial labor wedge lowers the match surplus which increases amplification following the argumentation by Hagedorn and Manovskii (2008).

When financial frictions decrease in a boom, the increasing surplus further boosts this effect. The tightness interaction channels affects the relative costs of hiring versus wages. When these costs decrease over the cycle, hiring increases more strongly and amplification increases. Both mechanisms have very different and opposing effects on wage rigidity, however. As the financial labor wedge dominates, wage rigidity decreases mildly when financial conditions become tighter.

Our study relates to the existing literature in different dimension. Michelacci and Quadrini, 2009 have formulated how financial frictions affect small, growing firms which offer new hires lower entry wages, but higher wage growth compared to large financially unconstrained firms. (Guiso et al., 2013) have complemented this study providing empirical evidence in favor of this mechanism. In contrast, we focus on how financial conditions affect wages in ongoing full-time employment relationships. Our effects may therefore be seen as complementary to wages of new hires and cover a much larger part of the workforce.

There exists little evidence of how financial constraints affect wages. Michelacci and Quadrini use firm growth (which we include as a control) to measure financial constraints. Guiso et al. use regional variation in financial conditions in Italy. Blanchflower et al. (1990) has used cross-sectional evidence in 1984 to document a positive relationship between financial performance (using a qualitative measure of 5 categories) and wages. Benmelech et al. (2012) investigate data for an US airline company between 2003 and 2006 and document how financial distress generated wage concessions. Apart from this paper, only Moser et al. (2018) uses a large administrative panel-data set that includes the Great Recession. While we use balance-sheet information to measure the financial conditions of firms directly and over time, Moser et al. explore the regional variation of bank relationships together with the variation in monetary policy rates to address the effect of credit supply. They focus on the effects of financial conditions on within and between firm wage inequality, while we investigate how the above-outlined mechanisms affect individual wages.

As stated above, our model nests a number of existing mechanisms in the literature. We show that our empirical results reject all of these special cases. First, if labor market frictions are absent and firms use external finance exclusively to pay for working capital, the tightness interaction channel is absent. Second, if labor market frictions are present and firms use external finance exclusively to pay for working capital (as in Garin (2015)), the tightness interaction channel implies decreasing wages over and above the financial labor wedge channel. Third, if firms use external finance exclusively to pay for all of hiring costs (as in Petrosky-Nadeau (2014)), the financial labor wedge is absent and wages would increase if financial conditions tighten. Fourth, if firms use external finance to pay for all of hiring costs and working capital (as in Chugh (2013) or Zanetti (2017)), the tightness interaction channel is absent.

The remainder of the paper is organized as follows. Section 2 presents the data and the empirical results, Section 3 shows the model, interprets the empirical results and explores aggregate implications. Section 4 discusses the calibration and simulated resulds and Section 5 concludes.

2 Financial strength and wages in the data

2.1 Empirical approach and data

Our empirical investigation aims at investigating whether the financial situation of a firm has a significant effect on wages, what is the sign and the size of this effect and, last but not least, how financial constraints affect wages through the financial labor wedge and/or the tightness interaction channel. To this end, we estimate the following equation

$$
\begin{aligned}
w_{ijt} =& \beta_1 fin_{jt} + \beta_2 x_{it} + \beta_3 \theta_{it} + \beta_4 fin_{jt} x_{it} + \beta_5 fin_{jt} \theta_{it} \\
&+ \alpha_{ij} + \gamma_t + \phi_1 \mathbf{z}_{it} + \phi_2 \mathbf{z}_{it-1} \epsilon_{it} \qquad (1)
\end{aligned}
$$

Wages w_{ijt} of worker i in firm j in year t depend on the financial strength fin_{it} of a firm j (in logs). The financial labor wedge implies that wages should decrease if financial constraints tighten. It also implies that an increase in the marginal product of labor translates into a smaller increase in wages when financial constraints are present. We therefore investigate how our measure of financial strength interacts with worker (or match) productivity x_{it}. If wage setting may take place in the presence of search frictions, the cost of hiring as well as labor market conditions (tightness) may affect the wage. The cost of hiring may further be affected by the financial strength of the firm. We therefore investigate how our measure of financial strength interacts with labor market tightness θ_{it}. In section 3 below, we show how to our regression equation relates to a wage equation in a model with financial constraints and search frictions in the labor market.

We use a unique data set for Germany for the years 2006 to 2014 that combines administrative data on establishments and employee biographies (LIAB) with information on firms' balance sheets.[2] The administrative data is characterized by detailed information on workers and establishments and a high degree of reliability of the earnings data, since social security institutions run plausibility checks and sanction misreporting. Measurement errors due to erroneous reporting should thus be much lower than in household surveys (see Stüber, 2017). Earnings are annual pre-tax payments which include the base wage plus extra pay. According to aggregate statistics for Germany, extra pay can constitute up to 25% of earnings and consists of regular and irregular extra pay, bonuses and other financial amenities.[3] We restrict the analysis to full-time workers to deal with the issue that we do not have information on hours worked. Since overtime is mostly captured in working time accounts, extra hours affect earnings very

[2] The administrative data has information on all establishments and employees covered by social security in Germany. The data set was constructed by the Research Data Center of the Institute for Employment Research (IAB) of the Federal Employment Agency Germany (see Antoni et al., 2018).

[3] See Labor Cost Statistics as provided by the Statistical Office for Germany ('Arbeitskostenerhebung')

little.[4] Due to missing hours, we consider only workers that are employed all year. This also avoids seasonal effects in earnings. Further, we consider only earnings up to statutory insurance contributions ('Beitragsbemessungsgrenze') to avoid right-censoring. We deflate wages (and all further nominal variables) using the CPI index.

We match the LIAB data to the ORBIS database as provided by Bureau van Dijk. This allows us to measure financial strength from detailed balance sheet information of firms. The data has information on corporate enterprises (mainly GmbHs, AGs) including firms that are not market-listed. One major advantage is that firm size varies between very small to large and is not restricted to very large companies. Variables include assets, debt, equity, cash flows, sales, capital, etc. and are reported at annual frequency. In our study, we focus on private, non-financial firms. See Kalemli-Ozcan et al. (2012) for a recent study based on ORBIS and detailed information about the data. Our final data set is an unbalanced panel for 2006 to 2014.[5] We have on average 350,000 establishment and 8 mio. worker observations per year.

In order to measure financial constraints, we employ firm-level leverage defined as the ratio of debt to total assets. This follows Giroud and Mueller (2017) who argue that US firms with higher leverage not only appear to be more financially constrained but also act like financially constrained firms. As in Giroud and Mueller (2017) we measure debt as the sum of current liabilities and long-term debt. In our model outlined in section 3 below, leverage is defined as debt plus interest payments relative to assets (see Equation (**??**)). We will consider this alternative leverage measure when discussing the robustness of the empirical results below. Table 1 summarizes key characteristics on firms and establishments in our sample for high and low firm leverage. Leverage can be related to alternative balance sheet measures of financial constraints.

[4] Over 50% of employees are covered by working time accounts.

[5] Due to changes in the German financial reporting system, the BvD data is most reliable from 2006 onwards.

	High leverage	Low leverage
Leverage (debt/assets)	0.94	0.30
Liquidity ratio	0.12	0.24
Interest coverage ratio	8.02	15.46
Firm exit prob. (%)	0.69	0.52
Total assets (bil. Euro)	0.21	1.45
Sales (bil. Euro)	0.17	1.03
Employees	23.03	32.42
Emp. growth	0.12	0.09
Firm age	10.75	12.10
Real wages	10.15	11.56
Wage growth (%)	1.50	1.80

Table 1: High and low leverage is defined relative to the previous year's median across firms. Summary statistics for selected firm and establishment characteristics, 2006-2014, mean across all establishments.

Highly leveraged firms have lower liquidity (see e.g., Gilchrist et al., 2017 on how liquidity relates to financial constraints) and pay more interest relative to their earnings[6], i.e., they have a lower interest coverage ratio. In line with typical arguments in the literature, highly leveraged firms are smaller in terms of assets, employees, and sales compared to firms with low leverage. Highly leveraged firms have a higher probability to exit the market. While high leverage may therefore present easy access to credit in the past, we use it as an indirect measure of current and future credit constraints of firms.

Table 1 documents that highly leveraged firms pay lower wages and exhibit lower wage growth on average. Naturally, the correlation between leverage and wages may be driven by many different explanatory factors. In the following, we develop an empirical approach to isolate the effect of credit constraints on wage setting that allows to control for observed and unobserved characteristics and that attempts to prevent reverse causality of wages on leverage in the best possible way. First, the feedback from individual wages on firm-level leverage is potentially much smaller than the average wage in a firm. Moreover, we use

[6] This relates to earnings before interest and taxes (EBIT)

firm leverage as measured at the end of year $t-1$ to avoid any remaining direct feedback effects from individual wages in t on the financial situation of the firm. Second, we control for observable factors that may affect both leverage and wages such as both aggregate and idiosyncratic changes in supply or demand. The variables $\mathbf{z}_t$ and $\mathbf{z}_{t-1}$ include current and lagged sales over employment (to capture productivity) as well as profits measured as sales net of costs. We add year fixed effects γ_t that capture time trends and other aggregate changes, e.g., the business cycle or changes in economic policy. $\mathbf{z}_t$ further includes firm and worker age, number of employees in the establishment, tenure of the worker (also squared), gender and occupation of the worker and sector as well as state dummies.

Across different specifications, firm, worker and match fixed effects, jointly denoted by α_{ij}, control for time-invariant unobserved heterogeneity. In some cases, we add a sector-state interaction at the establishment level. In line with Giroud and Mueller (2017), the state-sector interaction controls for differing demand conditions that establishments may face although they are part of the same firm. This implies that we use a different variation in leverage and wages in different specifications (within firms, for the same workers or within the same worker-firm match). In all cases, given the various observed and unobserved controls, we interpret the remaining variation in leverage as reflecting a change in the financial conditions of the firm. As spelled out by the model in section 3, this variation may stem from a change in financial conditions which differ across firms and time. This change in conditions may be due to higher financial frictions (monitoring costs) of the (pool) of lenders of the firm. This change in conditions may also be due to an unexpected change in the demand for credit that is unrelated to supply or demand factors of the firm, such as an unexpected devaluation of internal savings (asset price) of the firm.

The financial labor wedge channel implies that more productive workers should earn lower wages in firms in which financial conditions are tight. To measure productivity at the worker level, we use a categorical variable that has information on the complexity of the individual worker's job (1: simple job, 2: trained job, 3: complex job, 4: very complex job). We then interact worker productivity with firm-level leverage in our specification. The tightness interaction channel implies that workers in tight labor markets should earn higher or lower wages in firms in which financial conditions are tight. We measure tightness related to the occupation of the worker.[7]

2.2 Results

Table 2 exhibits the results of estimating equation (1) using our baseline measure of leverage and the various controls in specifications with different (combinations of) fixed effects. The first column shows the results without any fixed effects. The second column shows the results with firm fixed effects and sector-state fixed effects and is closest to the specification in Giroud and Mueller (2017). Here, we consider how changes in leverage within firm affect the wages of different workers. Since workers may switch firms, we compare this to both changes in firm leverage within worker (column 3) and, in the tightest specification, changes in firm leverage within the firm-worker match (columns 4 and 5). The different specifications imply different controls as the time-invariant controls of firms, workers and matches are dropped respectively.

The table shows the estimated coefficients of leverage (in logs), tightness (in logs) and job complexity as well as the coefficients of the interaction between leverage and complexity as well as the constant. The overall marginal effect of leverage on wages is not shown in the table. If leverage goes up by one percent, real wages fall by about 0.011 percent (in model (3)). If leverage increases by one standard deviation[8], real wages fall by 0.275 percent. Hence, wages are

[7] See Appendix A for visualization in Figure 2. The Federal Employment Agency has information on registered vacancies by occupation in 36 occupation groups according to the German system of occupation classification (KldB2010). Likewise, unemployment is classified according to the target occupation of the worker. We use these 36 occupation groups to link the tightness measures to the individual workers.

[8] The mean in-firm standard deviation across leverage is 25 percent

	LHS variable is log wage				
	(1)	(2)	(3)	(4)	(5)
Log leverage	−0.0074***	−0.0056***	−0.0097***	−0.0051***	−0.0050***
	(0.0016)	(0.00043)	(0.00036)	(0.00054)	(0.00054)
Log θ	−0.037***	−0.0038***	0.0062***	0.0018***	0.0021***
	(0.0017)	(0.00045)	(0.00040)	(0.00057)	(0.00057)
Log leverage × Log θ	0.018***	0.00017**	0.00041**	0.00041***	0.00034**
	(0.00044)	(0.00011)	(0.00009)	(0.00015)	(0.00015)
Trained × Log leverage	−0.020***	−0.0027***	−0.0010***	−0.0014***	−0.0019***
	(0.0012)	(0.00031)	(0.00029)	(0.00044)	(0.00044)
Complex × Log leverage	−0.042***	−0.0044***	−0.0014***	−0.0023***	−0.0026***
	(0.0014)	(0.00037)	(0.00035)	(0.00055)	(0.00055)
Very complex × Log leverage	−0.042***	−0.0047***	−0.0030***	−0.0045***	−0.0049***
	(0.0015)	(0.00042)	(0.00037)	(0.00061)	(0.00061)
Trained	0.15***	0.016***	−0.00031	−0.00067	0.0010
	(0.0046)	(0.0012)	(0.0011)	(0.0016)	(0.0016)
Complex	0.32***	0.030***	0.00042	0.0018	0.0032
	(0.0055)	(0.0014)	(0.0013)	(0.0020)	(0.0020)
Very complex	0.38***	0.038***	0.0082***	0.012***	0.014***
	(0.0058)	(0.0016)	(0.0014)	(0.0023)	(0.0023)
Log sales t	0.094***	0.021***	0.021***	0.020***	0.020***
	(0.00053)	(0.00024)	(0.00014)	(0.00030)	(0.00030)
Log sales $t-1$	0.0075***	0.0019***	0.0053***	−0.00059***	−0.00040**
	(0.00052)	(0.00016)	(0.00012)	(0.00016)	(0.00016)
Log profits t			0.0042***		
			(0.000049)		
Log profits $t-1$	0.025***	0.00098***	0.00019***	0.0013***	0.0013***
	(0.00018)	(0.000056)	(0.000048)	(0.000059)	(0.000059)
Constant	2.37***	2.47***	2.37***	2.50***	2.54***
	(0.0071)	(0.0056)	(0.0046)	(0.022)	(0.022)
Observations	3951531	3951531	3951531	3951531	3951531
Workers (cluster)	1555807	1555807	1555807	1555807	1555807
R^2	0.56	0.96	0.99	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match	Match
Sector state interaction	No	Yes	No	No	Yes

Table 2: Dependent variables is the log real wage at the worker level. Complexity base category: low. Here: Leverage as the measure of financial constraints. Sales and profits relative to total employment in the firm. Only private firms. Only full-time workers with yearly spells. We control for establishment and worker characteristics (if applicable firm and worker age, tenure (also squared), gender, occupation of workers, sector, state). Standard errors are clustered at the worker level. Sample period is 2007 to 2014.

adjusted downwards when the financial situation of firms worsens. These wage cuts appear to be small, but relate in size to about one fourth of overall real wage changes of 0.7 percent per year on average between 2007 and 2014. If we differentiate the results by sector, we observe that the elasticity of wages to leverage is higher in manufacturing (it doubles in some sectors), whereas it tends to be lower in service sectors.

Against the background of assuming rigid, or downward rigid wages, it may be surprising that wages fall. From the viewpoint of the model, workers may accept moderate wage cuts due to the presence of search frictions, in particular in times of low labor market tightness. Since our earnings measure includes bonus payments and other variable compensation, wage cuts may therefore likely reflect cuts in these wage components. Our finding relates to earlier studies that document wage cuts in Germany, especially in the recent decade and in firm-specific crisis situations.[9] Our finding is also in line with some previous empirical literature that finds a negative relation between financial distress and wages (see e.g., Blanchflower et al., 1990 and Benmelech et al., 2012).

The results support the presence of the financial labor wedge channel in the data. While higher job complexity is associated with higher wages, it significantly and negatively interacts with leverage. Hence, when firm leverage increases, workers with more complex jobs experience larger wage cuts. Put differently, when increasing job complexity, workers in highly leveraged firms obtain smaller pay raises than workers in lowly leveraged firms. If job complexity approximates match productivity well, the negative interaction corresponds to the financial labor wedge that drives an increasing wedge between wages and the marginal product of labor in the model (see also section 3). From our model, we know that this means that working capital (wages) are at least partly

[9] Gerlach et al. (2006) find based on survey evidence that about one fourth of employees in Germany has experienced wage cuts in the last five years. . Grund and Walter (2015) show how firms in the German chemical industry cut bonuses of managers in times of economic crisis in these firms.

externally financed.

Our results also support the presence of the tightness interaction channel in the data. The level effect of tightness on the wage is positive once we control at least for worker fixed effects.[10] The interaction of tightness and leverage is significant and positive in all specifications. This means that tighter financial constraints (higher leverage) generate upward pressure on wages and this effect is stronger the tighter the labor market. From our model, we know that tightness and financial constraints interact if hiring costs (posting vacancies) are at least partly paid for with external finance. The direction of the tightness interaction channel is ambiguous in our model and depends on how external finance affects the relative cost of wages versus vacancies. If the tightness interaction is positive, as found in the data, external finance is used for a larger share of total hiring costs than as for a share of total wage costs.[11] However, since total wage costs are much higher than hiring costs, the financial labor wedge channel dominates and explains why higher leverage results in real wage cuts. The tightness interaction channel then buffers some of these negative effects.

In Appendix B, we show robustness using different measures of financial strength such as the alternative measure of leverage, the liquidity ratio or the interest rate coverage. To rule out that our specification still leaves out omitted firm-level variables that equally affect leverage and wages and are time-varying, we estimate a specification where we measure financial constraints by leverage in the year 2006. This is the year before our regression sample starts and can thus be considered exogenous. This date also lies before the start of the Great Recession. In this setting, we can then only interpret the results with worker fixed effects, because leverage in 2006 is time constant and drops out with firm/match fixed effects.

Note that wage adjustments happens together with the adjustment of employ-

[10] Without worker or match fixed effects, we do not sufficiently control for unobserved heterogeneity at the worker level which affects the occupation-specific measure of tightness.

[11] In terms of the model, this means that $\lambda_V < \lambda_W$, see section 3 below.

ment. In line with the large literature cited above, we confirm that higher financial constraints decrease employment.

3 A model with financial and labor market frictions

In this section, we present a model that describes the relationship between wages and financial frictions in a setup with both financial market and labor market frictions. As outlined in the introduction, there exists a large variety of models that contain financial frictions and have implications for wages. Our model serves a number of purposes. First, it should allow for wages to react to financial constraints. The most prominent channel through which this happens is the financial labor wedge which is present in our model. The presence of the financial labor wedge is independent of labor market frictions. Second, the model should have a meaningful theory of wage setting. This is one reason to add labor market frictions to the model and describe wage setting through Nash bargaining between workers and firms. Third, our model should allow for an interaction between financial and labor market frictions, i.e. the tightness interaction channel. We can then use our model to interpret the results based on estimating equation (1) in section 2. Our model is presented such that we can describe the steady state equilibrium analytically. We can then compare the effect of financial frictions on economic amplification and wage rigidity to an economy without frictions in a simple analytical way. In order to do this, we use a number of simplifying assumptions as will be discussed below. In the Appendix, we discuss the robustness of the results to a more general model.

3.1 Setup

Our model incorporates financial frictions as in Carlstrom and Fuerst (1997) and (1998) into the standard Mortensen-Pissarides (MP) labor market model with exogenous separations. Our model nests several contributions to the literature as special cases (see discussion below).

Firms in our economy solve the following optimization problem

$$J_t = \max_{V_t, \bar{x}_t} \left[1 - \Gamma(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right] + \beta E_t J_{t+1}, \tag{2}$$

subject to

$$N_{t+1} = (1 - \delta) N_t + p(\theta_t) V_t \tag{3}$$

$$\left[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V\right] = (1 - \lambda_w) W_t N_t + (1 - \lambda_v) \gamma V_t - Q_t A_t \tag{4}$$

Just as in the standard MP model, J_t describes the value of the job to the firm, X_t is productivity per unit of labor input N_t which we refer to as workers, W_t are the corresponding wages, γ is the cost of posting vacancies V_t and β is the time discount factor. Equation (3) describes the law of motion for labor. The worker finding rate $p(\theta_t) = \xi \theta_t^{-\epsilon}$ depends on the underlying matching function in labor market tightness $\theta_t = \frac{V_t}{U_t}$. Here, ϵ measures the matching elasticity with respect to unemployment and ξ measures matching efficiency. Job separations occur exogenously at rate δ.

Firms in our model need to pay for wages and vacancy costs which we interpret more generally as hiring costs. In the literature, wage payments are usually included in working capital, while vacancy costs relate to recurring and new investment. Due to a cash flow mismatch, e.g. because some of the wage and hiring cost incur before production and sales have realized, firms rely on external finance to pay for a share $(1-\lambda_w)$ of the wage bill and a share of $(1-\lambda_v)$ of hiring costs. The remainder of the costs is then financed internally (out of realized profits). Note that most existing models either focus on the use of external finance for wages (working capital) or hiring costs (investment).[12] Our model is more general as it allows firms to pay for both of these costs. This replicates

[12] See for example in Petrosky-Nadeau (2014) or Garin (2015).

evidence for Germany that firms use 34% and 26% of their external finance to pay for working capital and hiring and training costs respectively.[13] The shares λ_w and λ_v are exogenously given in our model. As we will discuss further below, they determine the presence, direction and strength of the financial labor wedge and the tightness interaction channel in the model. They can also be used to describe special cases of the model some of which constitute mechanisms present in the literature.

The financial market setup builds on Carlstrom and Fuerst (1998). To obtain external finance, firms and lenders sign a financial contract which based on the revenue of the firm measured by $x_t\left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right]$. Here, x_t is a shock to the firm revenue which cannot be observed by the lender without paying a monitoring cost. x_t is *iid* across firms and time and is drawn from a distribution $H(x)$, with density $h(x)$ and positive support with $E(x) = 1$. The financial contract is signed before x_t is realized and the firm and the lender agree on a cutoff value $\bar{x}$ such that if $x_t > \bar{x}$, the firm pays back $\bar{x}\left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right]$ and keeps $\left(x_t - \bar{x}\right)\left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right]$.

Firms base their decisions on expected revenue before x_t is realized. Here, $\Gamma(\bar{x}_t) = \int_0^{\bar{x}_t} x dH(x) + \int_{\bar{x}_t}^{\infty} \bar{x}_t dH(x)$ denotes the expected gross share of revenue going to the lender. Since $\Gamma(\bar{x}_t)$ is increasing in the threshold $\bar{x}_t$, firms would like to set this cutoff as low as possible, while lenders favor a high cutoff. The optimal cutoff is determined in the maximization problem where firms take into account the participation constraint of the lender given by equation (4). Here, $\mu G(\bar{x}_t) = \mu \int_0^{\bar{x}_t} x dH(x)$. Due to perfect competition on the supply side of the financial market, lenders only give credit if their expected payment net of monitoring costs is at least the amount borrowed.

Firms have committed to pay a fixed share $1 - \zeta$ of expected profits to share-

[13] Numbers for small and medium enterprises in Germany, 2017. See Survey on the access of finance of enterprises (SAFE) conducted by the ECB.

holders. They retain the rest as assets

$$E_t A_{t+1} = \zeta(1 - \Gamma(\bar{x}_t)) \left[(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t \right] \tag{5}$$

Assets next period are valued with their respective stock price Q_t and serve as internal finance, i.e. they reduce the amount that needs to be borrowed by $Q_t A_t$. Firms do not take into account equation (5) as a constraint in the optimization in the baseline model. If the price of the loan increases, savings fall which increases the overall cost of borrowing if firms internalize this constraint. Appendix C.3 shows that this does not change our steady state results and changes the results of the dynamic model only quantitatively and very little.

If firms could partially react to changes in financial constraints by using more internal finance, this would buffer the effects described in the baseline model. In fact, if firms could freely and optimally choose their savings, they save such that any change in the price of the loan, e.g. due to an increase in financial frictions, is buffered with an increase in savings such that the cost of borrowing remains constant. Put differently, financial frictions have no effect on the labor market equilibrium and wages in this setup (see Appendix C.3). This could apply to firms that are owned and managed by their shareholders, e.g. family firms with a sufficient scope for internal finance. Hence, restrictions like equation (5) are reasonable in order to explain how external finance affects the labor market. This restriction may be reasonable for large firms operating on the stock market. The lenders participation constraint (equation (4)) allows us to define firm leverage in this model as debt (loan payments) over assets

$$\frac{\bar{x} \left[(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t \right]}{Q_t A_t}. \tag{6}$$

In the data, we interpret variation in leverage to reflect variation in the financial constraints of firms given a number of time-constant and time-varying controls. In the model, this corresponds to an increase in monitoring costs while loan demand is constant. Alternatively, this corresponds to an exogenous change in loan demand (e.g. a fall in Q_t) while monitoring costs are constant. In fact, Midrigan et al. (2018) present a mechanism through which household finance affects labor demand that, in a reduced form, generates similar effects as a change in Q_t in this model.

In both of these scenarios, the price of the loan ($\bar{x}_t$) increases and leverage increases.[14]

To close the model, we define the value of the job to the worker as

$$H_t^N = W_t + \beta E_t \left[(1-\delta) H_{t+1}^N + \delta H_{t+1}^U \right] \tag{7}$$

and the value of unemployment as

$$H_t^U = b + \beta E_t \left[(1 - f(\theta_t)) H_{t+1}^U + f(\theta_t) H_{t+1}^N \right]. \tag{8}$$

Here, b describes unemployment benefit and $f(\theta_t) = \xi \theta_t^{1-\epsilon}$ the job finding rate.

3.2 The wage equation

Solving the optimization problem delivers the following first order conditions

$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta E_t J_{N_{t+1}} \tag{9}$$

$$\phi_t = \frac{\Gamma'(\bar{x}_t)}{\Gamma'(\bar{x}_t) - \mu G'(\bar{x}_t)} \tag{10}$$

where the marginal value of a worker to the firms is

$$J_{N_t} = \Omega_t X_t - \chi_t^w W_t + (1-\delta) \beta E_t J_{N_{t+1}} \tag{11}$$

[14] Equivalently, the external finance premium increases. The external finance premium in this model can be described by expected monitoring costs relative to the amount borrowed $\frac{\mu G(\bar{x}_t)[(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t]}{(1-\lambda_w) W_t N_t + (1-\lambda_v)\gamma V_t - Q_t A_t}$.

Here, ϕ_t is the Lagrange multiplier on the participation constraint. When $\bar{x}$ increases, expected profits decrease by Γ' but firms can also borrow more $(\Gamma' - \mu G')$, hence ϕ reflects the cost of borrowing. $\chi_t^w = \lambda_w \Omega_t + (1 - \lambda_w)\phi_t$ describes the financial cost of paying wages. When financial frictions increase χ_t^w and the total cost of the wage bill increases. Externally financed wages directly increase these costs, while internally financed wages reduce the value of the firm and hence the value of the loan. χ_t^w increases in the share of externally financed wages. $\chi_t^v = \lambda_v \Omega_t + (1 - \lambda_v)\phi_t$ reflects the financial cost of posting vacancies and multiplies γ. Here, $\Omega(\bar{x}_t) = \frac{\partial J_{N_t}}{\partial X_t} = 1 - \Gamma(\bar{x}_t) + \phi_t\big(\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)\big)$ measures how an increase in productivity affects the marginal value of a worker. An increase in productivity increases the expected profit and also allows firms to borrow more. ϕ_t, Ω_t and χ_t^v increase when financial frictions increase. Hence, the higher the financial friction, the higher are the cost of borrowing and hiring and the more valuable is an increase in productivity.[15]

Without financial frictions, $\mu = 0$ and from equation (10) $\phi = 1$. This then delivers $\Omega = \chi^v = \chi^w = 1$. Equations (9) and (11) then describe the standard MP model. No frictions imply zero monitoring costs which means that lenders do not have to pay attention who is below or above the cutoff. If there are no monitoring costs, lenders do not charge a premium to finance these, hence firms keep the entire profits to themselves and get the necessary credit for posting vacancies for free.

From the first order conditions, one can then derive the job creation condition. Workers and firms apply Nash bargaining to set wages. Here, firms do not take into account the effect of wages on the price of the loan when bargaining with the worker. Iteration and a few steps of algebra then deliver the following

[15] See Appendix C.2 for detailed derivations.

wage equation[16]

$$W_t = \eta\left[\frac{\Omega_t}{\chi_t^w}X_t + \left((1-\delta) - (1-\delta-f(\theta_t))\frac{\chi_t^w}{E_t\chi_{t+1}^w}\right)\frac{\chi_t^v}{\chi_t^w}\frac{\gamma}{p(\theta_t)}\right] + (1-\eta)b \quad (12)$$

Without financial frictions, this wage equation is equivalent to the one in the standard MP model. To investigate the effect of financial frictions on wages, we start to consider the steady state version of the wage equation

$$W = \eta\left[\frac{\Omega}{\chi^w}X + \frac{\chi^v}{\chi^w}\gamma\theta\right] + (1-\eta)b \quad (13)$$

The financial labor wedge Equation (13) shows that the marginal effect of an increase of productivity on the wage may be affected by the financial friction, i.e. $\frac{\partial W_t}{\partial X_t} = \eta\frac{\Omega_t}{\chi_t^w}$. Note that this marginal effect ignores feedback effects from a change in X on the financial variables. This then nicely corresponds to the regression results documented in section 2. If not even a part of wages are externally financed, $\lambda_w = 1$ and $\Omega_t = \chi_t^w$, the wage increase in response to a productivity increase is given by η. If a part of wages is externally financed $\lambda_w < 1$ and $\frac{\Omega_t}{\chi_t^w} < 1$. We refer to this as the financial labor wedge. The higher the frictions, the higher the wedge, as $\frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{x}_t} < 0$[17]. This means that an increase in productivity leads to a smaller increase in wages when financial frictions are high. This also means that higher financial frictions lead to smaller wages ceteris paribus. Put differently, firms shift the part of the financing cost to the worker. The presence of the financial labor wedge is independent of labor market frictions and independent of how vacancies are financed.

Interaction with tightness Equation (13) further shows how the effect of an increase in labor market tightness on the wage may be affected by the financial friction, i.e. $\frac{\partial W_t}{\partial \theta_t} = \eta\frac{\chi_t^v}{\chi_t^w}\gamma$ ceteris paribus. Financial frictions interact with tightness is $\lambda_v \neq \lambda_w$, since in this case $\frac{\chi_t^v}{\chi_t^w} \neq 1$. This means that financial

[16] See Appendix C.1 for all equations and intermediate steps.
[17] See Appendix C.2

frictions only interact with tightness if they change the *relative* financial cost of wages to vacancies. Hence, if an increase in financial frictions increases the financial cost of hiring relatively more than it increases the financial cost of wages, this improves the position of the already employed workers in the wage bargain and increases wages ($\lambda_v < \lambda_w$).[18] Put differently, an increase in tightness leads to larger wage increases if financial frictions are high. If the financial cost of hiring decreases relative to the financial cost of wages ($\lambda_v > \lambda_w$), the bargaining position of workers worsens and wages fall. Hence, an increase in tightness leads to smaller wage increases if financial frictions are high in this case.

Special cases Our wage equation nests special cases that have been discussed in the literature.[19] First, all of vacancies and wages are financed internally which corresponds to the standard MP model ($\lambda_v = \lambda_w = 1$, case MP). Second, all vacancy posting costs are externally financed, while all wage costs are financed internally ($\lambda_v = 0$ and $\lambda_w = 1$, case V). This case presents the mechanism discussed in Petrosky-Nadeau (2014), i.e. it encompasses the tightness channel, but not the financial labor wedge. Wages increase if financial frictions increase. In the opposite case, all wage costs are financed externally and all vacancy posting costs are financed internally ($\lambda_v = 1$ and $\lambda_w = 0$, case W). This case encompasses both the financial labor wedge and the tightness channel and describes the mechanism contained in Garin (2015). When tightness increases, wages fall in case W. Finally, all vacancy posting costs and the entire wage bill are financed externally ($\lambda_v = 0$ and $\lambda_w = 0$, case VW). This corresponds to the mechanism contained in Chugh (2013) or Zanetti (2017) and encompasses the financial labor wedge, but no tightness interaction. All of our special cases are rejected by the empirical results described in section 2. Instead, our results suggest that $0 \leq \lambda_v < \lambda_w < 1$.

[18] See Appendix C.2 for the derivation.

[19] See Appendix C.1 for the respective wage equations of the different cases.

3.3 Steady state equilibrium and amplification

The wage equation (13) and the corresponding job creation equation (26) describe the labor market equilibrium in steady state. Equilibrium labor market tightness is then determined by

$$\frac{\Omega}{\chi^v}X - \frac{\chi^w}{\chi^v}b = \frac{\gamma}{1-\eta}\left(\frac{\frac{1-\beta}{\beta}+\delta}{p(\theta)} + \eta\theta\right) \tag{14}$$

In this equation, the left hand side of the equation unambiguously decreases with financial frictions and relates to what Hagedorn and Manovskii (2008) refer to as the surplus of the job. Since the right-hand side of the equation increases with θ, tightness unambiguously falls with higher frictions. Hence, since the presence of financial frictions generates the additional cost of obtaining external finance, the surplus from the match always falls. This happens independent of the presence and direction of the two different channels.[20] Since the job creation condition shifts down when financial frictions increase, equilibrium wages decrease in case the wage equation also shifts down (due to the financial labor wedge) or does not shift up too much (due to the tightness interaction channel).

Based on the steady state equilibrium in equation (14), one can derive amplification results for labor market tightness with respect to productivity. Without financial frictions, amplification is equivalent to the one derived by Hagedorn and Manovskii (2008) for the standard MP model:

$$\epsilon^{MP}_{\theta,X} = \frac{\partial\theta}{\partial X}\frac{X}{\theta} = \frac{\eta\theta + \frac{\frac{1-\beta}{\beta}+\delta}{p(\theta)}}{\eta\theta + \epsilon\frac{\frac{1-\beta}{\beta}+\delta}{p(\theta)}}\left(\frac{X}{X-b}\right) \tag{15}$$

[20] See Appendix C.2 for detailed derivations.

With financial frictions, this expression changes to

$$\epsilon_{\theta,X} = \left(\frac{\frac{\frac{1-\beta}{\beta}+\delta}{p(\theta)} + \eta\theta}{\frac{\frac{1-\beta}{\beta}+\delta}{p(\theta)}\epsilon + \eta\theta} \right) \left[\frac{\frac{\Omega}{\chi^w}X}{\frac{\Omega}{\chi^w}X - b} + \frac{\frac{\partial \frac{\Omega}{\chi^v}}{\partial \bar{x}}X - \frac{\partial \frac{\chi^w}{\chi^v}}{\partial \bar{x}}b}{\frac{\Omega}{\chi^w}X - b} \frac{\partial \bar{x}}{\partial X} X \right] \tag{16}$$

From this comparison, we see that financial frictions affect the amplification of tightness in two different ways. First, the presence of the financial labor wedge reduces the surplus (see also discussion above) which leads to more amplification following the argumentation by Hagedorn and Manovskii (Appendix C.2 shows that $\frac{\frac{\Omega}{\chi^v}X}{\frac{\Omega}{\chi^v}X-b} > \frac{X}{X-b}$). Second, a higher productivity level X implies lower financial frictions if $\frac{\partial \bar{x}}{\partial X} < 0$ (since $\frac{\frac{\partial \frac{\Omega}{\chi^v}}{\partial \bar{x}}X - \frac{\partial \frac{\chi^w}{\chi^v}}{\partial \bar{x}}b}{\frac{\Omega}{\chi^w}X-b} < 0$, see Appendix C.2). This effect further enhances amplification. Note that here the tightness interaction channel also enhances amplification independent of the financial labor wedge. If financial frictions decrease with higher productivity X, vacancies become cheaper which boots hiring. Hence, amplification is intensified through both mechanisms, but for different reasons.

The following two equations compare the effect of the business cycle on wages. Following the literature, we address wage rigidity through the direct effect of productivity on the wage only, i.e., by setting $\frac{\partial \theta}{\partial X} = 0$. Without financial frictions

$$\frac{\partial W}{\partial X} = \eta \tag{17}$$

the reaction of wages to changes in the cycle is given by a constant. With financial frictions, wages react to the cycle as follows

$$\frac{\partial W}{\partial X} = \eta \left(\frac{\Omega}{\chi^w} + X \frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} + \gamma\theta \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} \right) \tag{18}$$

Since it decreases wages, the financial labor wedge makes wages respond to the cycle less compared to a situation without financial frictions. Since the wedge increases with frictions and frictions decrease with productivity, the disappearing wedge makes wages respond more to the cycle. If frictions interact with labor market tightness in such a way that increasing frictions increase the wage when tightness increases (i.e. $\lambda_v < \lambda_w$), this buffers the wage response to the cycle.

The effect of financial frictions on wage rigidity is therefore ambiguous and affected by the financial labor wedge and the tightness interaction channel in a very different way. While both channels increase amplification, wage rigidity may increase or decrease. As our model shows, whether and how the two channels are in place depends on how wage and vacancies costs are exposed to internal finance. While the effect of financial frictions on wage rigidity is not unambiguous, we can consider the sign and size of the effect based on our calibration below.

4 Model simulation

How large are these effects? To address this question, we parameterize the model as follows. Parameters relating to the labor market are set to match the German situation. Unemployment benefits are 60% of wages ($b = 0.6$). The average monthly job separation rate in our sample is given by 0.785% and the unemployment rate by 8.65% (source: IAB). From this, we use the steady state relationship $u = \frac{s}{f+s}$ to compute the corresponding job finding rate. The elasticity of the matching function with respect to unemployment is set to $\varepsilon = 0.72$ which follows the literature (see e.g. Balleer et al. (2016)). Normalizing $\theta = 1$, we can then find ξ to match the job finding rate. The bargaining power of workers and firms respectively is set to $\eta = 0.5$. The vacancy posting cost is then pinned down by the job creation condition in steady state ($\gamma = 0.34$). The discount rate $\beta = 0.9977$ matches an annual interest rate of 2.75% (as an average from 2006-2014, source: OECD).

Table 3: Amplification and wage rigidity

	no frictions		frictions	
variable	mean	S.D.	mean	S.D.
X	1	0.013	1	0.013
θ	1.0075	0.0236	1	0.028
W	0.9582	0.0105	0.9568	0.0116

The saving rate $\zeta = 0.55$ reflects the average dividends paid out by German firms between 2015 and 2018. The parameters μ and the distribution of x are set to match the an annual default rate of 1.76% (2008-2015, source: Creditreform) and an external finance premium of 0.05%. This results in $\sigma_x = 0.027$ and $\mu = 0.33$. Hence, financial frictions are present, but relatively low on average in this economy. Finally, we assume that all of vacancy posting costs have to be paid before production and are fully financed externally, i.e. $\lambda_v = 0$. We then calibrate λ_w to match the estimated wage elasticity of leverage.[21] This delivers $\lambda_w = 0.72$. This means that the financial labor wedge is present, but by far not as important as in the special cases that set $\lambda_w = 0$. However, the financial labor wedge still dominates the tightness interaction channel even if only a small part of wages are financed externally.

We then simulate the full dynamic model adding a exogenous shocks to productivity X.[22] Table 3 shows the tightness amplification and wage rigidity in our model, i.e. the standard deviations of the tightness and equilibrium wage. We compare the model with financial frictions to the case without financial friction keeping all other parameters as in our baseline calibration. One can see that both tightness and wages are more volatile when financial frictions are present. Note that the dynamic and steady state wage equation differ (compare equa-

[21] Appendix C.2 derives this elasticity in our model.

[22] This replicates the dynamics of aggregate labor productivity in Germany using that $\rho_X = 0.9$ and $\sigma_X = 0.013$.

tions (12) and (13)). In particular, expectations about future financial costs of wages may also affect the role of tightness for wages. $\frac{\chi_t^w}{E_t\chi_{t+1}^w} = 1$ if expected constraints tomorrow equal constraints today (i.e., follow a random walk). In this case, financial constraints have no further influence on the wage over and above the ones discussed above. Financial constraints tomorrow may differ from constraints today, e.g. if changes in monitoring costs μ follow some autoregressive structure or if other autoregressive terms such as cyclical components affect the evolution of the constraints. In this case, it is reasonable to assume that $\frac{\chi_t^w}{E_t\chi_{t+1}^w} > 1$. One can rewrite

$$(1-\delta) - (1-\delta - f(\theta_t))\frac{\chi_t^w}{E_t\chi_{t+1}^w} = (1-\delta)(1 - \frac{\chi_t^w}{E_t\chi_{t+1}^w}) + f(\theta_t)\frac{\chi_t^w}{E_t\chi_{t+1}^w} \quad (19)$$

The first term is negative and relates to exogenously separated workers. If it is cheaper to rehire these tomorrow than today, the effect of tightness on wages will be lower. The second term is positive and relates to the job finding rate. If frictions are smaller tomorrow, workers may find jobs more easily which increases their outside option and therefore their wage. In our simulated model, we confirm that the term $\frac{\chi_t^w}{E_t\chi_{t+1}^w}$ is quantitatively small.[23]

5 Conclusions

To be completed.

[23] The standard deviation of wages is 0.0112 when we remove the expectation term in the wage equation. This is less, but very close to the volatility in the baseline calibration.

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A Data appendix

Details on Orbis-ADIAB:

- The data has been merged using record key linkage using the firm name, legal form and address by the FDZ of the IAB.
- The final data set represents 52% of the firms in Orbis and 18% of the establishments in the BHP.
- On average 1.19 establishments per firm (median is 1).
- Most German firms are one establishment organizations.
  - 88 percent of all firms in IAB establishment panel are single site companies (years 2006-2014).

Details on balance sheet data:

- Only unconsolidated accounts.
- Balance sheet information filed according to local GAAP (here HGB).
- In Orbis, a firm is assigned to year x if the account has been filed between June of year x and May of year $x+1$. 92 percent of our firms file their account in December, 2 percent in June, 1.6 percent in September, 1 percent in March.

B Robustness for empirical results

B.1 Different measures of financial constraints

We investigate the robustness of our empirical results with respect to using alternative measures of financial constraints as typically applied in the literature. These measures include:

- Leverage (debt/assets): Giroud and Mueller (2017)

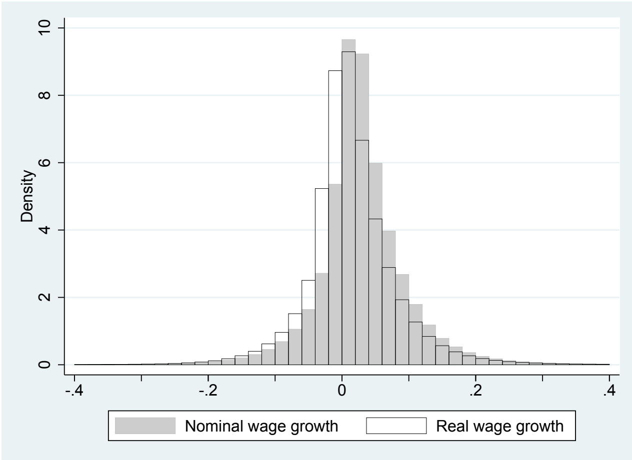

Figure 1: Wage growth distribution: 2007-2014, Germany.

- Leverage with short-term debt only
- Size of balance sheet (total assets): Bernanke et al. (1996)
  - Little information available on firms with small balance sheets (asymmetric information).
- Collateral (fixed assets/debt): Baeurle et al. (2017)
- Liquidity ratio (cash/assets): Gilchrist et al. (2017)
- Interest payments (coverage ratio or interest relative to long term debt)

All the results in Table 4 to 5 confirm the finding that financial constraints have a negative effect on wages. Note that total assets, the liquidity ratio and collateral have a positive sign because an increase in these variables implies less financial constraints (rather than more financial constraints as with leverage and interest over debt). All results in Table **??** are robust to adding profits as an additional control variable.

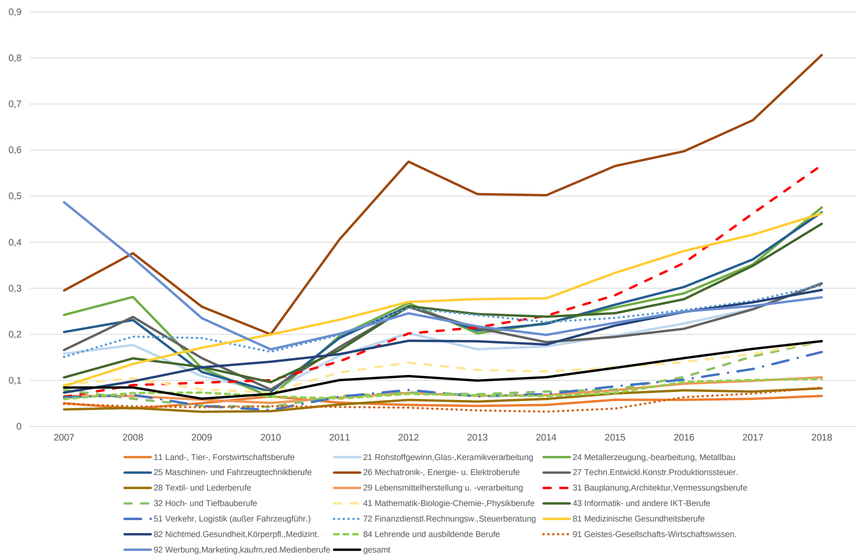

Figure 2: Aggregate tightness and tightness by occupations (selected groups). Source: Federal Employment Agency of Germany.

	LHS variable is log wage				
	(1)	(2)	(3)	(4)	(5)
Log leverage incl. int.	−0.0042***	−0.0053***	−0.0083***	−0.0059***	−0.0056***
	(0.0016)	(0.00045)	(0.00066)	(0.00057)	(0.00057)
Log θ	−0.051***	−0.0045***	0.0028***	0.0022***	0.0024***
	(0.0017)	(0.00048)	(0.00071)	(0.00061)	(0.00062)
Log leverage incl. int. × Log θ	0.021***	0.0010***	0.00030	0.00032**	0.00025
	(0.00044)	(0.00012)	(0.00019)	(0.00016)	(0.00016)
Low × Log leverage incl. int.	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained × Log leverage incl. int.	−0.019***	−0.0032***	−0.0023***	−0.0014***	−0.0018***
	(0.0012)	(0.00032)	(0.00052)	(0.00046)	(0.00046)
Complex × Log leverage incl. int.	−0.046***	−0.0047***	−0.0024***	−0.0018***	−0.0020***
	(0.0014)	(0.00039)	(0.00068)	(0.00058)	(0.00058)
Very complex × Log leverage incl. int.	−0.045***	−0.0046***	−0.0037***	−0.0032***	−0.0036***
	(0.0016)	(0.00044)	(0.00080)	(0.00066)	(0.00066)
Low	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained	0.15***	0.018***	0.0029	−0.0012	0.00032
	(0.0047)	(0.0013)	(0.0019)	(0.0017)	(0.0017)
Complex	0.33***	0.031***	0.0017	−0.00084	0.00041
	(0.0056)	(0.0015)	(0.0025)	(0.0021)	(0.0021)
Very complex	0.39***	0.038***	0.0090***	0.0067***	0.0083***
	(0.0061)	(0.0017)	(0.0030)	(0.0025)	(0.0025)
Log sales t	0.10***	0.021***	0.027***	0.020***	0.020***
	(0.00054)	(0.00025)	(0.00043)	(0.00031)	(0.00030)
Log sales $t-1$	0.012***	0.0020***	0.0031***	−0.00070***	−0.00045***
	(0.00055)	(0.00016)	(0.00028)	(0.00017)	(0.00016)
Log profits $t-1$	0.023***	0.0012***	0.0017***	0.0014***	0.0014***
	(0.00018)	(0.000058)	(0.000074)	(0.000061)	(0.000061)
Constant	2.36***	2.46***	2.29***	2.46***	2.51***
	(0.0072)	(0.0057)	(0.021)	(0.023)	(0.023)
Observations	3827693	3827693	3827693	3827693	3827693
Workers (cluster)	1521609	1521609	1521609	1521609	1521609
R^2	0.57	0.96	0.99	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match	Match
Sector state interaction	No	Yes	No	No	Yes

Table 4: Dependent variables is the log real wage at the worker level. Here: Leverage including interest as the measure of financial constraints. Sales and profits relative to total employment in the firm. Only private firms. Only full-time workers with yearly spells. We control for establishment and worker characteristics (if applicable firm and worker age, tenure (also squared), gender, occupation of workers, sector, state). Standard errors are clustered at the worker level. Sample period is 2007 to 2014.

	LHS variable is log wage				
	(1)	(2)	(3)	(4)	(5)
Log liquidity ratio	−0.0060***	0.0011***	−0.00022	0.00024**	0.00023*
	(0.00030)	(0.00010)	(0.00014)	(0.00012)	(0.00012)
Log θ	0.037***	−0.0015***	0.0027***	0.0020***	0.0019***
	(0.00053)	(0.00015)	(0.00027)	(0.00023)	(0.00023)
Log liquidity ratio × Log θ	0.0019***	−0.00019***	−0.00027***	−0.00030***	−0.00032***
	(0.000093)	(0.000031)	(0.000038)	(0.000032)	(0.000032)
Low × Log liquidity ratio	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained × Log liquidity ratio	0.0011***	−0.00039***	−0.000082	−0.00033***	−0.00035***
	(0.00024)	(0.000074)	(0.00012)	(0.00010)	(0.00010)
Complex × Log liquidity ratio	0.0029***	−0.00099***	−0.00020	−0.00024*	−0.00028**
	(0.00030)	(0.000094)	(0.00015)	(0.00013)	(0.00012)
Very complex × Log liquidity ratio	0.0068***	−0.0025***	−0.00030	−0.000069	0.0000092
	(0.00035)	(0.00012)	(0.00019)	(0.00016)	(0.00016)
Low	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained	0.083***	0.0045***	−0.0053***	−0.0072***	−0.0072***
	(0.0013)	(0.00035)	(0.00065)	(0.00059)	(0.00058)
Complex	0.18***	0.0093***	−0.0072***	−0.0076***	−0.0075***
	(0.0016)	(0.00043)	(0.00084)	(0.00073)	(0.00072)
Very complex	0.27***	0.011***	−0.0051***	−0.0047***	−0.0042***
	(0.0018)	(0.00051)	(0.0010)	(0.00086)	(0.00086)
Log sales t	0.090***	0.020***	0.026***	0.020***	0.019***
	(0.00052)	(0.00024)	(0.00042)	(0.00030)	(0.00029)
Log sales $t-1$	−0.00052	0.0015***	0.0026***	−0.00088***	−0.00067***
	(0.00052)	(0.00016)	(0.00028)	(0.00016)	(0.00016)
Log profits $t-1$	0.032***	0.0011***	0.0019***	0.0014***	0.0014***
	(0.00018)	(0.000056)	(0.000074)	(0.000059)	(0.000059)
Constant	2.32***	2.45***	2.28***	2.47***	2.53***
	(0.0041)	(0.0055)	(0.020)	(0.022)	(0.022)
Observations	3951488	3951488	3951488	3951488	3951488
Workers (cluster)	1555782	1555782	1555782	1555782	1555782
R^2	0.55	0.96	0.99	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match	Match
Sector state interaction	No	Yes	No	No	Yes

Table 5: Dependent variables is the log real wage at the worker level. Here: Liquidity ratio as the measure of financial constraints (higher liquidity ratio, lower financial constraints). Sales and profits relative to total employment in the firm. Only private firms. Only full-time workers with yearly spells. We control for establishment and worker characteristics (if applicable firm and worker age, tenure (also squared), gender, occupation of workers, sector, state). Standard errors are clustered at the worker level. Sample period is 2007 to 2014.

	LHS variable is log wage				
	(1)	(2)	(3)	(4)	(5)
Log leverage in 2006	0.0048***	0	−0.061***	0	0
	(0.0018)	(.)	(0.0051)	(.)	(.)
Log θ	0.028***	0.0018***	0.0065***	0.0064***	0.0065***
	(0.00054)	(0.00016)	(0.00029)	(0.00025)	(0.00025)
Log leverage in 2006 × Log θ	0.011***	0.0026***	0.0019***	0.0022***	0.0022***
	(0.00051)	(0.00015)	(0.00022)	(0.00018)	(0.00018)
Low × Log leverage in 2006	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained × Log leverage in 2006	−0.045***	−0.0052***	−0.00089	−0.0013**	−0.0015***
	(0.0013)	(0.00045)	(0.00057)	(0.00054)	(0.00054)
Complex × Log leverage in 2006	−0.059***	−0.010***	−0.00062	−0.0023***	−0.0025***
	(0.0016)	(0.00054)	(0.00082)	(0.00071)	(0.00071)
Very complex × Log leverage in 2006	−0.067***	−0.0088***	−0.0025**	−0.0051***	−0.0055***
	(0.0017)	(0.00060)	(0.0010)	(0.00085)	(0.00084)
Low	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)
Trained	0.033***	0.0030***	−0.0035***	−0.0047***	−0.0048***
	(0.0013)	(0.00043)	(0.00067)	(0.00063)	(0.00062)
Complex	0.10***	0.0054***	−0.0045***	−0.0064***	−0.0064***
	(0.0016)	(0.00053)	(0.00093)	(0.00082)	(0.00082)
Very complex	0.15***	0.015***	−0.0036***	−0.0065***	−0.0068***
	(0.0018)	(0.00062)	(0.0011)	(0.00096)	(0.00095)
Log sales t	0.081***	0.020***	0.024***	0.019***	0.019***
	(0.00058)	(0.00025)	(0.00041)	(0.00030)	(0.00029)
Log sales $t-1$	0.0085***	−0.00034*	0.0010***	−0.0024***	−0.0023***
	(0.00058)	(0.00018)	(0.00029)	(0.00018)	(0.00017)
Log profits $t-1$	0.027***	0.0012***	0.0018***	0.0016***	0.0016***
	(0.00020)	(0.000062)	(0.000074)	(0.000063)	(0.000063)
Constant	2.30***	2.46***	2.33***	2.52***	2.59***
	(0.0045)	(0.0056)	(0.022)	(0.023)	(0.023)
Observations	3202494	3202494	3202494	3202494	3202494
Workers (cluster)	1183917	1183917	1183917	1183917	1183917
R^2	0.57	0.96	0.99	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match	Match
Sector state interaction	No	Yes	No	No	Yes

Table 6: Dependent variables is the log real wage at the worker level. Here: Leverage in 2006 only as the measure of financial constraints. Sales and profits relative to total employment in the firm. Only private firms. Only full-time workers with yearly spells. We control for establishment and worker characteristics (if applicable firm and worker age, tenure (also squared), gender, occupation of workers, sector, state). Standard errors are clustered at the worker level. Sample period is 2007 to 2014.

B.2 Employment and flow rate regressions

	Employment (log) (1)	Hiring rate (2)	Separation rate (3)
Leverage (log)	−0.0054397**	−0.0165376	0.585064***
Log wages	−0.0633124***	−8.89364***	−1.03029***
Sales t (log)	0.0944433***	1.76289***	−0.3025702***
Sales $t-1$ (log)	0.0568602***	1.709704***	−0.4258656***
Est. fixed effects	yes	yes	yes
Year × sector fixed effects	yes	yes	yes
R^2	0.47	0.03	0.08
Observations	444,868	333,290	333,290

Table 7: Regressions on the establishment level: employment and flows. Only private firms. We control for time fixed effects and several establishment characteristics (age, skill, gender of workers). Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

C Model appendix

C.1 Additional model equations

C.1.1 Wage determination

The job creation condition is given by

$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta \left[\Omega_{t+1} X_{t+1} - \chi_{t+1}^w W_{t+1} + (1-\delta) \frac{\chi_{t+1}^v \gamma}{p(\theta_{t+1})} \right] \tag{20}$$

Workers and firms apply Nash bargaining to set wages

$$W_t = \arg\max_{W_t} \left(H_t^N - H_t^U \right)^{\eta} \left(J_{N,t} \right)^{1-\eta} \tag{21}$$

Using equation (11) this delivers

$$(1-\eta) \overbrace{\frac{\partial J_{N_t}}{\partial w_t}}^{=-\chi_{w,t}} (H_t^N - H_t^U) + \eta J_{N_t} = 0 \tag{22}$$

and hence the following sharing rule

$$\left(H_t^N - H_t^U \right) = \frac{\eta}{(1-\eta)\chi_t^w} J_{N,t} \tag{23}$$

Since financial frictions affect the cost of paying wages, higher financial frictions increase the surplus share of employers relative to workers. Put differently, financial frictions reduce the effective bargaining power of workers.
Using equations (7) and (8) gives

$$H_t^N - H_t^U = W_t - b + \beta E_t \left[(1 - \delta - f(\theta_t))(H_{t+1}^N - H_{t+1}^U) \right] \tag{24}$$

Iterating equation (23) forward and inserting into (8) yields

$$J_{N_t} = \frac{(1-\eta)\chi_{w,t}}{\eta}(W_t - b) + \beta E_t (1 - \delta - f(\theta_t)) \frac{\chi_{w,t}}{\chi_{w,t+1}} J_{N_{t+1}} \tag{25}$$

Together with (11), this then gives the wage equation (12).

C.1.2 Steady state

Steady state job creation

$$\frac{\gamma}{p(\theta)} = \frac{\beta}{1-\beta(1-\delta)}\big(\frac{\Omega}{\chi_v}X - \frac{\chi_w}{\chi_v}W\big) \tag{26}$$

Wage equations for four special cases

$$W_t^{MP} = \eta\left[X_t + \gamma\theta_t\right] + (1-\eta)b \tag{27}$$

$$W_t^{V} = \eta\left[X_t + \frac{\phi_t}{\Omega_t}\gamma\theta\right] + (1-\eta)b \tag{28}$$

$$W_t^{W} = \eta\left[\frac{\Omega_t}{\phi_t}X_t + \frac{\Omega_t}{\phi_t}\gamma\theta_t\right] + (1-\eta)b \tag{29}$$

$$W_t^{VW} = \eta\left[\frac{\Omega_t}{\phi_t}X_t + \gamma\theta_t\right] + (1-\eta)b \tag{30}$$

C.2 Derivations

C.2.1 χ^w increases in $1-\lambda_w$

First we show that $\phi > \Omega$:

$$\phi > \Omega = 1 - \Gamma + \phi(\Gamma - \mu G) \tag{31}$$

$$\Leftrightarrow \phi > \frac{\Gamma - \mu G}{(1 - \Gamma + \mu G)} \tag{32}$$

The last inequality is always true since $\phi > 1$ and the RHS is less than one. Then,

$$\frac{\partial\chi^w}{\partial\lambda_w} = \lambda_w(\overbrace{\Omega - \phi}^{<0}) < 0 \tag{33}$$

C.2.2 ϕ, Ω and χ^v increase with $\bar{x}$

Use that

$$\Gamma'(\bar{x}) = 1 - H(\bar{x}) \tag{34}$$

$$\Gamma''(\bar{x}) = -h(\bar{x}) \tag{35}$$

$$G'(\bar{x}) = \bar{x} \cdot h(\bar{x}) \tag{36}$$

$$G''(\bar{x}) = h(\bar{x}) + \bar{x} \cdot h'(\bar{x}) \tag{37}$$

Then

$$\frac{\partial \phi}{\partial \bar{x}} = \frac{\mu(G''\Gamma' - G'\Gamma'')}{(\Gamma' - \mu G')^2} \tag{38}$$

$$= \mu \cdot \frac{\big(h(\bar{x}) + \bar{x}h'(\bar{x})\big) \cdot (1 - H(\bar{x})) + \bar{x}h^2(\bar{x})}{(\Gamma' - \mu G')^2} \tag{39}$$

$\frac{\partial \phi}{\partial \bar{x}} > 0$ if $h'(\bar{x}) > -\big(\frac{h^2(\bar{x})}{1-H(\bar{x})} + \frac{h(\bar{x})}{\bar{x}}\big)$. We assume x to follow a log-normal distribution with $E(x) = 1$. If the standard deviation of this distribution is not too large, $h'(\bar{x})$ turns negative if $\bar{x}$ is larger than $E(x) = 1$. We can exclude that $\bar{x} > E(x)$ in equilibrium, since this implies negative expected profits for the firm.

We further know that $\Gamma' = \frac{\partial \Gamma}{\partial \bar{x}} > 0$ and that $G' = \frac{\partial G}{\partial \bar{x}} > 0$. Then,

$$\Omega' = \frac{\partial \Omega}{\partial \bar{x}} = -\Gamma' + \phi(\Gamma' - \mu G') + (\Gamma - \mu G)\phi' \tag{40}$$

$$= -\Gamma' + (\Gamma' - \mu G')\frac{\Gamma'}{\Gamma' - \mu G'} + (\Gamma - \mu G)\phi' \tag{41}$$

$$= (\Gamma - \mu G)\phi' > 0 \tag{42}$$

and

$$(\chi^v)' = \frac{\partial \chi^w}{\partial \bar{x}} = \lambda_v \Omega' + (1 - \lambda_v)\phi' > 0 \tag{43}$$

C.2.3 Financial labor wedge $\frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{x}_t} < 0$

First, note that

$$\phi'\Omega - \Omega'\phi = \phi'(1 - \Gamma + \phi(\Gamma - \mu G)) - (\Gamma - \mu G)\phi'\phi = \phi'(1 - \Gamma) > 0 \tag{44}$$

Then,

$$\frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{x}_t} = \frac{\overbrace{(1 - \lambda_w)}^{>0}\overbrace{(\Omega'\phi - \phi'\Omega)}^{<0}}{(\chi^w)^2} < 0 \tag{45}$$

C.2.4 Tightness interaction $\frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial \bar{x}_t} > 0$ if $\lambda_v < \lambda_w$

$$\frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial \bar{x}_t} = \frac{(\lambda_v(1 - \lambda_w) - \lambda_w(1 - \lambda_v))(\Omega'\phi - \phi'\Omega)}{(\chi^w)^2} \tag{46}$$

$$= \frac{(\lambda_v - \lambda_w)\overbrace{(\Omega'\phi - \phi'\Omega)}^{<0}}{(\chi^w)^2} \tag{47}$$

C.2.5 Labor market equilibrium

Show that the surplus $\frac{\Omega}{\chi_v}X - \frac{\chi^w}{\chi^v}b$ decreases with $\bar{x}$. First, show that $\frac{\Omega}{\chi_v} - \frac{\chi^w}{\chi^v}$ decreases with $\bar{x}$.

$$\frac{\partial \frac{\Omega}{\chi^v}}{\partial \bar{x}} - \frac{\partial \frac{\chi^w}{\chi^v}}{\partial \bar{x}} = \frac{(1 - \lambda_v)(\Omega'\phi - \phi'\Omega)}{(\chi^v)^2} - \frac{(\lambda_w - \lambda_v)(\Omega'\phi - \phi'\Omega)}{(\chi^v)^2} \tag{48}$$

$$= \frac{(1 - \lambda_w)\overbrace{(\Omega'\phi - \phi'\Omega)}^{<0}}{(\chi^v)^2} < 0 \tag{49}$$

if the financial labor wedge channel is present, i.e. $\lambda_w < 1$. This means that $\frac{\Omega}{\chi_v} < \frac{\chi^w}{\chi^v}$.

Note that $\frac{\chi^w}{\Omega} > 1$, since $\Omega < \phi$ as shown above. For the surplus to be positive,

$$\frac{\Omega}{\chi_v} X > \frac{\chi^w}{\chi^v} b \tag{50}$$

$$X > \frac{\chi^w}{\Omega} b > b \tag{51}$$

We can then show that $\frac{\Omega}{\chi_v} X - \frac{\chi^w}{\chi^v} b$ decreases with $\bar{x}$:

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \bar{x}} X < \frac{\partial \frac{\Omega}{\chi_v}}{\partial \bar{x}} b < \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \bar{x}} b \tag{52}$$

Therefore

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \bar{x}} X - \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \bar{x}} b < 0 \tag{53}$$

C.2.6 Amplification

More amplification when financial labor wedge is present, since

$$\frac{\frac{\Omega}{\chi^v} X}{\frac{\Omega}{\chi^v} X - b} > \frac{X}{X - b} \tag{54}$$

$$\frac{\Omega}{\chi^v} X^2 - \frac{\Omega}{\chi^v} X b > \frac{\Omega}{\chi^v} X^2 - X b \tag{55}$$

$$-\frac{\Omega}{\chi^v} > -1 \tag{56}$$

$$\frac{\Omega}{\chi^v} < 1 \tag{57}$$

where the last inequality is true, since $\Omega < \phi$.

Further, $\frac{\frac{\partial \frac{\Omega}{\chi^v}}{\partial \bar{x}} X - \frac{\partial \frac{\chi^w}{\chi^v}}{\partial \bar{x}} b}{\frac{\Omega}{\chi^w} X - b} < 0$, since the nominator is negative and the denominator is positive if the surplus is positive (both shown above).

C.2.7 Elasticity of wages with respect to leverage

$$\epsilon_{W,lev} = \frac{lev}{W}\frac{\partial W}{\partial lev} = \frac{lev}{W}\frac{\partial W}{\partial \bar{x}}\frac{\partial \bar{x}}{\partial lev} \tag{58}$$

$$= \frac{lev}{W}[\eta(\frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{x}}X + \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{x}}\gamma\theta)][\frac{1}{\frac{\partial lev}{\partial \bar{x}}}] \tag{59}$$

We use that

$$\frac{\partial lev}{\partial \bar{x}} \approx \frac{((X-\lambda^w W)N - \lambda^v)\gamma V)}{\alpha A} = \frac{lev}{\bar{x}} \tag{60}$$

and the expression of $\frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{x}}$ and $\frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{x}}$ derived above. This delivers

$$\epsilon_{W,lev} = -\frac{\bar{x}}{W}[\frac{\eta\phi'(1-\Gamma)}{\chi^{w2}}][(1-\lambda^w)X + (\lambda^v - \lambda^w)\gamma\theta] \tag{61}$$

C.3 Two models with saving

C.3.1 Internalizing the fixed savings rule

In this version of the model, firms have committed to a fixed dividend rule, but take into account that dividends depend on their labor market decisions and affect the amount borrowed. That is, firms optimize

$$J_t = \max_{V_t,\bar{x}_t} [1-\Gamma(\bar{x}_t)]\left[(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t\right] + \beta E_t J_{t+1}, \tag{62}$$

subject to

$$N_{t+1} = (1-\delta)N_t + p(\theta_t)V_t \tag{63}$$

$$[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)]\left[(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V\right] = (1-\lambda_w)W_t N_t + (1-\lambda_v)\gamma V_t - Q_t A_t \tag{64}$$

$$A_{t+1} = \zeta(1-\Gamma(\bar{x}_t))[(X_t - \lambda_w W_t)N_t - \lambda_v \gamma V_t] \tag{65}$$

Define ϕ^* and Δ to be the Lagrangian multipliers of the participation constraint and the savings equation respectively. The first order conditions to this problem with respect to V_t, $\bar{x}_t$ and A_{t+1} are then given by

$$\frac{\chi_t^{v*}\gamma}{p(\theta_t)} = \beta E_t J_{N_{t+1}} \tag{66}$$

$$\phi_t^* = \frac{(1+\zeta\Delta_t)\Gamma'(\bar{x}_t)}{\Gamma'(\bar{x}_t) - \mu G'(\bar{x}_t)} \tag{67}$$

$$\Delta_t = \beta Q_{t+1}\phi_{t+1}^* \tag{68}$$

It is easy to see that $\phi_t^* = (1+\zeta\Delta_t)\phi_t$, where ϕ_t is defined as in the baseline model. This means that the cost of borrowing is larger when savings are internalized. The reason is that higher $\bar{x}$ decreases savings which increases the cost of borrowing tomorrow and makes financial overall more costly to the firm. Similarly, $\chi_t^{v*} = (1+\zeta\Delta_t)\chi_t^v$ and $\Omega_t^* = (1+\zeta\Delta_t)\Omega_t$. Equation (68) states that the marginal value of one unit increase in savings is equal to the discounted marginal value of relaxing the financial constraint next period.

The wage equation can then be derived to be the following

$$W_t = \eta[\frac{\Omega_t}{\chi_t^w}X_t + \big((1-\delta) - (1-\delta-f(\theta_t))\frac{\chi_t^w}{\chi_{t+1}^w}\frac{(1+\zeta\Delta_t)}{(1+\zeta\Delta_{t+1})}\big)\frac{\chi_t^v}{\chi_t^w}\frac{\gamma}{p(\theta_t)}] + (1-\eta)b \tag{69}$$

One can see that savings add to the effect that future financial frictions affect the tightness interaction. When frictions tomorrow are lower than today, the cost of borrowing will be decrease. This reduces the future impact of the tightness interaction on the wage over and above the effects discussed in case of the baseline model. Future terms therefore matter even less.

The corresponding steady state equation is then given by

$$W = \eta[\frac{\Omega}{\chi^w}X + \frac{\chi^v}{\chi^w}\gamma\theta] + (1-\eta)b \tag{70}$$

which is identical to the baseline model.

C.3.2 Endogenous savings

In this version of the model, firms can freely decide about their savings. They optimize

$$J_t = \max_{V_t, \bar{x}_t, S_t} \left[1 - \Gamma(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right] - S_t + \beta E_t J_{t+1} \tag{71}$$

subject to

$$N_{t+1} = (1-\delta)N_t + p(\theta_t)V_t \tag{72}$$

$$\left[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V\right] = (1-\lambda_w) W_t N_t + (1-\lambda_v)\gamma V_t - Q_t A_t \tag{73}$$

$$A_{t+1} = (1+r)S_t \tag{74}$$

This delivers the following first order condition with respect to S_t:

$$E_t(\phi_{t+1}) = \frac{1}{\beta E_t (1+r) Q_{t+1}} \tag{75}$$

Note that we need $\beta(1+r)Q < 1$ to ensure that firms use external finance at all. Also note that this condition pins down ϕ. The remaining first order conditions are the same as in the baseline model:

$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta E_t J_{N_{t+1}} \tag{76}$$

$$\phi_t = \frac{\Gamma'(\bar{x}_t)}{\Gamma'(\bar{x}_t) - \mu G'(\bar{x}_t)} \tag{77}$$

Since ϕ is already given in equation (75), financial frictions (e.g. a change in $\bar{x}$) will not have an effect on ϕ, Ω, χ^v and χ^w in this model and, hence, not affect wages. The intuition is that firms react to worsening financial conditions with an increase in savings thus keeping the price of borrowing (and also their

Table 8: Calibration of parameters

Variable	Description	Value	Target
η	workers' bargaining power	0.5	
ϵ	matching function parameter	0.72	
δ	monthly separation rate	0.00785	data
ξ	efficiency of matching function	0.082	unemployment rate
b	unemployment benefit	0.5741	replacement rate
r	monthly interest rate for riskless assets	0.5	data
β	monthly discount factor	0.9977	$\beta = 1/(1+r)$
μ	monitoring cost	0.33573	monthly premium= 0.0005
σ_x	S.D. of idiosyncratic productivity	0.027011	monthly default rate = 0.0015
ζ	Firms' saving rate	0.55	data
γ	vacancy cost	0.33968	$\theta = 1$
λ^v	internally financed share of vacancy cost	0	
λ^w	externally financed share of wage cost	0.71629	elasticity of wage to leverage (=-0.011)

leverage) constant.

C.4 Model calibration