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. The presence of a financial labor wedge lowers wages when financial constraints increase. But financial frictions may also interact with labor market tightness such that they increase wages. We use a model with financial and labor market frictions to derive testable implications of these two mechanisms with respect to wages. We then test these 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 find that higher financial constraints lead to real wage cuts and that both mechanisms are present in the data, with offsetting effects on wages. The two mechanisms therefore affect the fluctuations and comovement of tightness and wages over the business cycle in very different ways.

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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. Different mechanisms will therefore affect the co-movement of wages with other labor market variables in different ways. 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 (2012) 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.

[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.

Apart from these two mechanisms, a number of additional studies assume that wages do not directly interact with financial constraints. Here, wages are either 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 relationship between financial constraints and wages in a theoretical framework 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 model is simple enough that we can derive analytic expressions on how financial frictions affect the dynamics of tightness and wages over the business 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 fluctuations, however. While wages fluctuate more when the financial labor wedge is present, they fluctuate less/more if the tightness interaction is positive/negative. Through the change in the relative dynamics of tightness and wages, financial frictions may affect the co-movement of tightness and wages, and differently depending on the presence of different mechanisms. Financial frictions may therefore have implications for the relationship of the wage Philips curve which is prominently discussed in the economic policy debate.

We then 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 firm profitability and tightness 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 as well as various worker characteristics whenever appropriate.

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. Our empirical results suggest that the financial labor wedge is present in the data and that tightness interacts positively with financial conditions in a firm. 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 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. 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, 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. We show that our empirical results reject all of these special cases.

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

2 Financial strength and wages in the theory

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 as we discuss below. 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. 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. We will discuss reasonable extensions of the model below.

2.1 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

$$J_{it} = \max_{V_{it},\bar{\omega}_{it},A_{i,t+1}} (1-\zeta)\left[1-\Gamma(\bar{\omega}_{it})\right]\left[\left(X_{it}-\lambda_w W_{it}\right)N_{it}-\lambda_v\gamma V_{it}\right]+\beta E_t J_{i,t+1}, \tag{1}$$

subject to

$$N_{i,t+1} = (1-\delta)N_{it}+p(\theta_t)V_{it} \tag{2}$$

$$\begin{aligned}\left[\Gamma(\bar{\omega}_{it})-\mu G(\bar{\omega}_{it})\right]\left[\left(X_{it}-\lambda_w W_{it}\right)N_{it}-\lambda_v\gamma V_{it}\right]&\\ = (1-\lambda_w)W_{it}N_{it}+(1-\lambda_v)\gamma V_{it}-A_{it}&\end{aligned} \tag{3}$$

$$A_{i,t+1} = (1+r)\zeta(1-\Gamma(\bar{\omega}_{it}))[(X_{it}-\lambda_w W_{it})N_{it}-\lambda_v\gamma V_{it}] \tag{4}$$

Just as in the standard MP model, J_{it} describes the value of the job to the firm i.

Firms have many employees N_{it} and all workers work at the same productivity determined at the firm level X_{it}. Firm productivity is exogenous and given by the sum of a common component and an idiosyncratic component: $X_{it} = X_t + x_{it}$. W_{it} are the corresponding wages, γ is the cost of posting vacancies V_{it} and β is the time discount factor. Equation (2) 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. Firms do not take into account the effect of opening vacancies on labor market tightness. One may assume that there is a measure one of firms in the economy. Aggregate labor input is then given by $N_t = \int_0^1 N_{it}di$ and aggregate vacancies by $V_t = \int_0^1 V_{it}di$. 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, firms rely on external finance to pay for the wage bill and hiring costs. The remainder of the costs is then financed internally (out of savings, see below). Note that most existing models focus on the use of external finance either for wages (working capital) or for hiring costs (investment) only.[2] Our model allows firms to pay for both of these costs.[3] This replicates evidence for Germany that firms use 34% and 26% of their external finance to pay for working capital and hiring and training costs respectively.[4] Our model is more general in a different dimension as only a part $(1 - \lambda_w)$ of wage and a part $(1 - \lambda_v)$ of hiring costs may have to be paid before production and sales have realized. The wage bill and hiring costs may therefore be exposed to external finance to a different degree. The shares λ_w

[2] See for example the discussion in Carlstrom and Fuerst (1998) or Quadrini (2011).

[3] As also in Chugh (2013) or Garin (2015).

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

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 $\omega_{it}\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right]$. Here, ω_{it} is a shock to the firm revenue which cannot be observed by the lender without paying a monitoring cost. ω_{it} is *iid* across firms and time and is drawn from a distribution $H(\omega)$, with density $h(\omega)$ and positive support with $E(\omega) = 1$. The financial contract is signed before ω_{it} is realized and the firm and the lender agree on a cutoff value $\bar{\omega}_{it}$ such that if $\omega_{it} > \bar{\omega}_{it}$, the firm pays back $\bar{\omega}_{it}\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right]$ and keeps $(\omega_{it} - \bar{\omega}_{it})\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right]$. If $\omega_{it} < \bar{\omega}_{it}$, the firm defaults and all revenue is claimed by the lender. The firm keeps assets and workers, however, and can continue to produce in the next period.

Firms base their decisions on expected revenue before ω_{it} is realized. Here, $\Gamma(\bar{\omega}_{it}) = \int_0^{\bar{\omega}_{it}} \omega dH(\omega) + \int_{\bar{\omega}_{it}}^{\infty} \bar{\omega}_t dH(\omega)$ denotes the expected gross share of revenue going to the lender. Since $\Gamma(\bar{\omega_{it}})$ is increasing in the threshold $\bar{\omega}_{it}$, 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 (3). Here, $\mu G(\bar{\omega}_{it}) = \mu \int_0^{\bar{\omega}_{it}} \omega dH(\omega)$. 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 shareholders and retain the rest as assets for which they receive interest r (see equation (4). Assets next period serve as internal finance, i.e. they reduce the amount that needs to be borrowed. If the price of the loan increases, savings fall which increases the overall cost of borrowing. 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 A.4.3). 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 (4) 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.

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

$$H_{it}^N = W_{it} + \beta E_t \left[(1-\delta) H_{i,t+1}^N + \delta H_{t+1}^U \right] \tag{5}$$

and the value of unemployment as

$$H_t^U = b + \beta E_t \left[(1 - f(\theta_t)) H_{t+1}^U + f(\theta_t) H_{i,t+1}^N \right]. \tag{6}$$

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

2.2 The wage equation

Solving the optimization problem delivers the following first order conditions

$$\frac{\chi_{it}^v \gamma}{p(\theta_t)} = \beta E_t J_{N_{i,t+1}} \tag{7}$$

$$\phi_{it} = \frac{(1 - \zeta + (1+r)\zeta \Delta_{it}) \Gamma'(\bar{\omega}_{it})}{\Gamma'(\bar{\omega}_{it}) - \mu G'(\bar{\omega}_{it})} \tag{8}$$

$$\Delta_{it} = \beta \phi_{i,t+1} \tag{9}$$

Here, the marginal value of a worker to the firms is

$$J_{N_{it}} = \Omega_{it} X_{it} - \chi_{it}^{w} W_{it} + (1-\delta)\beta E_t J_{N_{i,t+1}} \tag{10}$$

Here, ϕ_{it} the Lagrange multiplier on the participation constraint and Δ_{it} the Lagrange multiplier on the savings constraint. Further,

$$\Omega_{it} = (1 - \zeta + (1+r)\zeta\Delta_{it})\left[1 - \Gamma(\bar{\omega}_{it})\right] + \phi_{it}\left[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})\right] \tag{11}$$

$$\chi_{it}^{w} = \lambda_w \Omega_{it} + (1-\lambda_w)\phi_{it} \tag{12}$$

$$\chi_{it}^{v} = \lambda_v \Omega_{it} + (1-\lambda_v)\phi_{it} \tag{13}$$

When $\bar{\omega}$ increases, expected profits decrease by Γ' but firms can also borrow more $(\Gamma' - \mu G')$, hence ϕ_{it} reflects the cost of borrowing. The marginal value of a one unit increase in savings Δ_{it} is then equal to the discounted marginal value of relaxing the financial constraint. Equation (12) describes the financial cost of paying wages. When financial frictions increase χ_{it}^{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_{it}^{w} increases in the share of externally financed wages (see A.2.2 in the Appendix). Equation (13) reflects the financial cost of posting vacancies and multiplies γ. $\Omega(\bar{\omega}_{it}) = \frac{\partial J_{N_{it}}}{\partial X_t}$ measures how an increase in productivity affects the marginal value of a worker.

Without financial frictions, $\mu = 0$ and also $\phi = 1$ (see A.2.3 in the Appendix). This then delivers $\Omega = \chi^{v} = \chi^{w} = 1$. Equations (7) and (10) 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, we follow the literature in assuming that firms do not take into account the mutual effect of wages on the price of the loan and vice versa when bargaining with the worker or when determining the financial contract[5]. Appendix A.1 shows the details of how we arrive at the following wage equation:

$$W_{it} = \eta \left[\frac{\Omega_{it}}{\chi_{it}^w} X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t)) \frac{\chi_{it}^w}{E_t \chi_{i,t+1}^w} \big) \frac{\chi_{it}^v}{\chi_{it}^w} \frac{\gamma}{p(\theta_t)} \right] + (1-\eta) b \tag{14}$$

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

$$W_i = \eta \left[\Phi_i^w X_i + \Phi_i^v \gamma \theta \right] + (1-\eta) b \tag{15}$$

The financial labor wedge $\Phi_i^w = \frac{\Omega_i}{\chi_i^w}$ Equation (15) shows that the marginal effect of an increase of productivity on the wage may be affected by the financial friction, i.e. $\frac{\partial W}{\partial X} = \eta \Phi_i$. 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 (see A.2.4 in the Appendix). 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 lower wages ceteris paribus. Put differently, firms shift 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.

[5] See Petrosky-Nadeau (2014) or Chugh (2013)

Interaction with tightness $\Phi_i^v = \frac{\chi_i^v}{\chi_i^w}$ Equation (15) further shows how the effect of an increase in labor market tightness on the wage may be affected by the financial friction, i.e. $\frac{\partial W}{\partial \theta} = \eta\gamma\Phi^v$ ceteris paribus. Financial frictions interact with tightness if $\lambda_v \neq \lambda_w$, since in this case $\frac{\chi_t^v}{\chi_t^w} \neq 1$. Financial frictions therefore only interact with tightness if they change the financial cost of paying a marginal employed worker *relative* to the financial cost of hiring a new worker. This means that wage costs and hiring costs are exposed to external financing needs to a different degree. 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 ($\lambda_v < \lambda_w \rightarrow \Phi^v > 1$).[6] Put differently, an increase in tightness leads to larger wage increases if financial frictions are high. Note that tightness interaction is present if hiring costs are not externally financed at all. If the financial cost of hiring decreases relative to the financial cost of wages ($\lambda_v > \lambda_w \rightarrow \Phi^v < 1$), 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. First, all of vacancies and wages are financed internally which corresponds to the standard MP model ($\lambda_v = \lambda_w = 1$). Second, all vacancy posting costs are externally financed, while all wage costs are financed internally ($\lambda_v = 0$ and $\lambda_w = 1$). This case presents the mechanism discussed in Petrosky-Nadeau (2014), i.e. it encompasses the tightness channel, but not the financial labor wedge. In this case, 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 $\lambda_w = 0$). This case encompasses both the financial labor wedge and the tightness channel. When tightness increases,

[6] See Appendix A.2.4 for the derivation.

wages fall in this case. Finally, all vacancy posting costs and the entire wage bill are financed externally ($\lambda_v = 0$ and $\lambda_w = 0$). This corresponds to the mechanism contained in Chugh (2013) or Zanetti (2017) and encompasses the financial labor wedge, but no tightness interaction. We discuss below that these special cases are rejected by the empirical results described in section 3. Instead, our results suggest that $0 \leq \lambda_v < \lambda_w < 1$.

Our wage equation nests the case of financial, but no labor market frictions. In this case, only the financial labor wedge is present and $\eta = 1$. See Appendix A.4.1 for details. Also this case is rejected by the results in 3. Appendix A.4.2 documents that our results do not rely on financial frictions to be formulated as costly state-verification. In fact, when using a collateral constraint similar to Jermann and Quadrini (2012) and Garin (2015), the wage equation is very similar to equation (14).

2.3 The two mechanisms in steady state equilibrium

Equilibrium The wage equation (15) and the corresponding job creation equation (80) describe the labor market equilibrium in steady state. Equilibrium labor market tightness is then determined by

$$\frac{\Phi^w}{\Phi^v} X - \frac{1}{\Phi^v} b = \frac{\gamma}{1-\eta} \left(\frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)} + \eta\theta \right) \tag{16}$$

The left-hand side of this equation is affected by the presence of financial frictions and drives what is usually referred to as the surplus of the job (compare Hagedorn and Manovskii (2008)). The additional cost of finance induces the surplus to fall, but only if the financial labor wedge is present (see A.3.2 in the Appendix). In this case, both the job creation condition and the wage equation shifts down when financial frictions increase.

Tightness amplification Based on the steady state equilibrium in equation (16), one can derive amplification results for labor market tightness with respect to the aggregate part of productivity X_t. Without financial frictions, amplification is equivalent to the one derived by Hagedorn and Manovskii (2008) for the standard MP model:

$$\epsilon_{\theta,X}^{MP} = \left(\frac{\partial\theta}{\partial X}\frac{X}{\theta}\right)^{MP} = \frac{\frac{r+\delta}{p(\theta)} + \eta\theta}{\frac{r+\delta}{p(\theta)}\epsilon + \eta\theta}\left(\frac{X}{X-b}\right) \tag{17}$$

With financial frictions, this expression changes to

$$\epsilon_{\theta,X} = \frac{\partial\theta}{\partial X}\frac{X}{\theta} = \frac{\frac{r+\delta}{p(\theta)} + \eta\theta}{\frac{r+\delta}{p(\theta)}\epsilon + \eta\theta}\left[\frac{\frac{\Phi^w}{\Phi^v}X}{\frac{\Phi^w}{\Phi^v}X - \frac{1}{\Phi^v}b} + \frac{\frac{\partial\frac{\Phi^w}{\Phi^v}}{\partial\frac{\phi}{\Omega}}X - \frac{\partial\frac{1}{\Phi^v}}{\partial\frac{\phi}{\Omega}}b}{\frac{\Phi^w}{\Phi^v}X - \frac{1}{\Phi^v}b}\frac{\partial\frac{\phi}{\Omega}}{\partial X}X\right] \tag{18}$$

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 A.3.3 shows that $\frac{\frac{\Phi^w}{\Phi^v}X}{\frac{\Phi^w}{\Phi^v}X-\frac{1}{\Phi^v}b} > \frac{X}{X-b}$). Second, financial conditions loosen as the cycle improves, i.e. $\frac{\partial\frac{\phi}{\Omega}}{\partial X} > 0$, which is suggested by Carlstrom and Fuerst (1997) and by our simulations in section 4. Since, $\frac{\partial\frac{\Phi^w}{\Phi^v}}{\partial\frac{\phi}{\Omega}}X - \frac{\partial\frac{1}{\Phi^v}}{\partial\frac{\phi}{\Omega}}b < 0$ (see Appendix) A.3.2), financial frictions further enhance amplification, also through the tightness interaction channel. The intuition is that a decrease in financial conditions further boosts the surplus and decreases the financial cost of hiring.

Wage rigidity The following two equations compare the effect of the business cycle on wages. Without financial frictions

$$\epsilon_{W,X}^{MP} = \left(\frac{\partial W}{\partial X}\frac{X}{W}\right)^{MP} = \eta\frac{X}{W}\left(1 + \gamma\frac{\partial\theta}{\partial X}\right) \tag{19}$$

With financial frictions, wages react to the cycle as follows

$$\epsilon_{W,X} = \frac{\partial W}{\partial X}\frac{X}{W} = \eta\frac{X}{W}\left(\Phi^w + X\frac{\partial\Phi^w}{\partial\frac{\phi}{\Omega}}\frac{\partial\frac{\phi}{\Omega}}{\partial X} + \gamma\theta\frac{\partial\Phi^v}{\partial\frac{\phi}{\Omega}}\frac{\partial\frac{\phi}{\Omega}}{\partial X} + \gamma\Phi^v\frac{\partial\theta}{\partial X}\right) \tag{20}$$

The different mechanisms have opposing effects on wage rigidity. First, the presence of the financial labor wedge makes wages respond to the cycle less compared to a situation without financial frictions. Since the wedge increases when financial conditions tighten and financial conditions loosen when productivity increases, the disappearing wedge makes wages respond more to the cycle. If the tightness interaction is such that $\Phi^v > 1$, decreasing frictional constraints over the cycle buffer the wage response. Since the wage response depends on the amplification of tightness, this intensifies wage response to productivity. The opposite is the case when $\Phi^v < 1$. We will consider the sign and size of the effect based in our model simulation in section 4.

The correlation of wages and labor market tightness One can also derive the elasticity of wages with respect to labor market tightness

$$\epsilon_{W,\theta} \equiv \frac{\partial W}{\partial \theta}\frac{\theta}{W} = \frac{\theta}{W}\eta\gamma\Phi^v \approx \rho_{W,\theta}\frac{\sigma_\theta}{\sigma_W}, \tag{21}$$

where the first equation is derived from equation (15) and the second equation follows the definition of the slope coefficient in a linear equation using that $\rho_{W,\theta}$ is the correlation coefficient and σ_θ and σ_W are the standard deviations of wages and tightness respectively. This elasticity is smaller or larger than in the model without financial frictions if the tightness interaction is at work. This elasticity is independent of the presence of the financial labor wedge.

If one approximates $\epsilon_{\theta,X} \approx \frac{\sigma_\theta}{\sigma_X}$ and $\epsilon_{W,X} \approx \frac{\sigma_W}{\sigma_X}$, one can write

$$\rho_{W,\theta} \approx \epsilon_{W,\theta}\frac{W}{\theta}\frac{\epsilon_{\theta,X}}{\epsilon_{W,X}}. \tag{22}$$

This equation shows us how to relate the results on amplification of tightness and wages as well as the two mechanisms to the correlation between wages and labor market tightness. This correlation closely relates to the wage Phillips curve which is prominently referred to in the policy debate. Financial frictions change this correlation. If the financial labor wedge is absent, the correlation between wages and tightness increases if $\Phi^v > 1$, since $\epsilon_{W,\theta}$ and $\epsilon_{\theta,X}$ increase and $\epsilon_{W,X}$ most likely falls. The opposite can happen when $\Phi^v < 1$ or if only the financial labor wedge is present. This depends, however, on the relative change in the amplification of tightness and wages.

3 Financial strength and wages in the data

3.1 Deriving the regression equation

The wage equation (15) is a function of firm productivity X_{it}, labor market tightness θ_t and the two financial variables Φ^w_{it} and Φ^v_{it}. As described in section 2, our two financial mechanisms affect wages ceteris paribus, i.e. not taking into account feedback effects of productivity on the financial variables or tightness or the financial variables on tightness. This corresponds to the effects that we will estimate in the data.

The two financial variables cannot be directly measured in the data, but both are functions of the price of the loan $\bar{\omega}$ which in turn in closely linked to the following way to describe firm leverage in the model

$$\frac{\bar{\omega}\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right]}{A_{it}}. \tag{23}$$

Leverage is hence given by debt (loan payments) over assets. For a given productivity, wage and firm size, a change in leverage can then reflect either a change in μ which for a given participation constraint will result in an increase in $\bar{\omega}$ and an increase in leverage or an exogenous change in loan demand, e.g. through a devaluation or destruction of assets (a negative shock to A_{it}), which for a given μ and a given participation constraint will increase in $\bar{\omega}$ and leverage. Given a number of time-constant and time-varying controls in the estimation, we therefore interpret variation in leverage to reflect variation in financial constraints of the firm.[7]

We therefore rewrite the equation (14) as

$$W_{it} = \eta \left[\Phi^w(\bar{\omega}_{it}) X_{it} + \Phi^v(\bar{\omega}_{it})\gamma\theta_t\right] + (1-\eta)b \tag{24}$$

assuming that $\frac{X^w_{it}}{E_t X^w_{i,t+1}} = 1$ (see section 4 for a discussion of this assumption). We then derive the second-order multivariate Taylor approximation of this equation around the steady state which, written in log-deviations is given by

$$\begin{aligned}
\frac{W_{it}-W}{W} \approx{} & \eta\Phi^w(\bar{\omega})\frac{X}{W}\frac{X_{it}-X}{X} + \eta\Phi^v(\bar{\omega})\gamma\frac{\theta}{W}\frac{\theta_t-\theta}{\theta} \\
& + \frac{\eta\bar{\omega}}{W}\left[X\frac{\partial\Phi^w}{\partial\bar{\omega}}(\bar{\omega}) + \gamma\theta\frac{\partial\Phi^v}{\partial\bar{\omega}}(\bar{\omega})\right]\frac{\bar{\omega}_{it}-\bar{\omega}}{\bar{\omega}} \\
& + \frac{1}{2}\frac{\eta\bar{\omega}^2}{W}\left[X\frac{\partial^2\Phi^w}{\partial\bar{\omega}\partial\bar{\omega}}(\bar{\omega}) + \theta\frac{\partial^2\Phi^v}{\partial\bar{\omega}\partial\bar{\omega}}(\bar{\omega})\right](\frac{\bar{\omega}_{it}-\bar{\omega}}{\bar{\omega}})^2 \\
& + \eta\bar{\omega}\frac{X}{W}\frac{\partial\Phi^w}{\partial\bar{\omega}}(\bar{\omega})\frac{X_{it}-X}{X}\frac{\bar{\omega}_{it}-\bar{\omega}}{\bar{\omega}} + \eta\bar{\omega}\gamma\frac{\theta}{W}\frac{\partial\Phi^v}{\partial\bar{\omega}}(\bar{\omega})\frac{\theta_t-\theta}{\theta}\frac{\bar{\omega}_{it}-\bar{\omega}}{\bar{\omega}}
\end{aligned} \tag{25}$$

In the model, all workers are the same. In the data, we observe different workers j with different wages W_{ijt} in a firm i in time t. Wages may be different because of observed and unobserved heterogeneity which we need to control for in the specification. When workers are different, job matches can differ from one another with respect to their outside option, especially if they relate to different occupations and/or regions. Hence, tightness refers specifically to a worker θ_{jt}. We therefore reach the following estimation equation

$$\begin{aligned}
\ln(W_{ijt}) ={} & \beta_0 + \beta_1\ln(X_{it}) + \beta_2\ln(\theta_{jt}) + \beta_3\ln(X_{it})\ln(\bar{\omega}_{it}) + \beta_4\ln(\bar{\omega}_{it})\ln(\theta_{jt}) \\
& + \beta_5\ln(\bar{\omega}_{it}) + \beta_6\ln(\bar{\omega}_{it})^2 + \alpha_{ij} + \gamma_t + \phi_1\mathbf{z}_{ijt} + \phi_2\mathbf{z}_{ijt-1}\epsilon_{ijt},
\end{aligned} \tag{26}$$

where α_{ij} refer to firm, worker and match fixed effects which we will include

[7] In these scenarios, the external finance premium also increases. The external finance premium in this model can be described by expected monitoring costs relative to the amount borrowed $\frac{\mu G(\bar{\omega}_{it})[(X_{it}-\lambda_w W_{it})N_{it}-\lambda_v\gamma V_{it}]}{(1-\lambda_w)W_{it}N_{it}+(1-\lambda_v)\gamma V_{it}-A_{it}}$.

across different specifications to control for various types of time-invariant unobserved heterogeneity. In some cases, we also add a sector-state interaction to take into account regional differences. The variables $\mathbf{z}_{ijt}$ and $\mathbf{z}_{ijt-1}$ include current and lagged controls on the firm and worker level. 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.

In line with the discussion of the different channels in section 2, our model has predictions about the parameters of equation (26). First, the interaction coefficient between X and $\bar{\omega}$ tells about the presence of the financial labor wedge. In this case $\frac{\partial \Phi^w}{\partial \bar{\omega}}(\bar{\omega}) < 0$ and hence $\beta_3 = \eta \bar{x} \frac{X}{W} \frac{\partial \Phi^w}{\partial \bar{\omega}}(\bar{\omega}) < 0$. Second, the interaction coefficient between θ and $\bar{\omega}$ tells us about the presence and direction of the tightness interaction. If $\frac{\partial \Phi^v}{\partial \bar{\omega}}(\bar{\omega}) \lesseqgtr 0$, then $\beta_4 = \eta \bar{\omega} \gamma \frac{\theta}{W} \frac{\partial \Phi^v}{\partial \bar{\omega}}(\bar{\omega}) \lesseqgtr 0$. See A.2.5 in the Appendix for details on these claims. If search frictions do not affect wages altogether, both β_2 and β_4 should be zero (see also A.4.1 in the Appendix). We cannot say anything specific about the sign of β_5 and β_6.

3.2 Data

We use the ORBIS-ADIAB dataset, 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 from ORBIS.[8] 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 to persons covered by social security which include the base wage plus extra pay. According to aggregate statistics for Germany, extra pay can constitute up

[8] 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).

to 25% of earnings and consists of regular and irregular extra pay, bonuses and other financial amenities.[9] 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 little.[10] 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 compute hourly wages from these annual earnings and deflate wages (and all further nominal variables) using the CPI index.

The LIAB data is matched 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.[11] We have on average 350,000 establishment and 8 mio. worker observations per year.

As argued above, we employ firm-level leverage in order to measure financial constraints of firms. Leverage is 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. Equation (23) measures

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

[10] Over 50% of employees are covered by working time accounts, see Balleer et al. (2017) for details.

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

Table 1: Descriptive statistics

	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

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.

leverage is defined as debt plus interest payments relative to assets. 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. 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[12], 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 also documents that highly leveraged firms pay lower wages and exhibit lower wage growth on average.

One might be concerned that wages and leverage may affect each other in

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

equation (26). First, the feedback from individual wages on firm-level leverage is potentially much smaller than the average wage in a firm. Second, we use 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 and to capture the forward-looking aspect of leverage as a constraint as described above. In a robustness check, we use leverage measured before the GFC in 2006. Third, over and above measuring X we control for observable factors that may affect both leverage and wages such as both aggregate and idiosyncratic changes in supply or demand. Our firm control variables include current and lagged sales over employment (to capture productivity), profits measured as sales net of costs, the export exposure of firms, firm and worker age, number of employees in the establishment, tenure of the worker (also squared), gender and occupation of the worker. Sector-state dummies capture regional differences (similar to Giroud and Mueller (2017)) and time fixed effects reflect changes in aggregate demand.

In our baseline regressions, we measure firm-level productivity X by firm profitability (profits over employment). We measure labor market tightness θ relevant for worker j based on the occupation of the worker. See Appendix B for visualization in Figure 3. 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. In the model, X may vary because productivity or supply may change, but also because demand for the firms product may change. We capture this notion in a robustness check measuring changes in demand on the county level. Changes in demand are captured by changes in exports which was the pre-dominant driver of demand changes in the Great Recession in Germany and may be considered as exogenous to the firm (in the short- to medium run). In order to do this, we aggregate the firm-level export shares measured as export revenue over total revenue to the county level. Doing this, export variations may also affect non-exporting firms in a county with large exposure to exports. We then multiply the county level export-exposure with the aggregate export variation in Germany measured as export share in GDP.

An additional robustness check employs yet another measure of X. Here, we acknowledge that productivity in a job match may not only vary with firm, but also with worker productivity. 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).

3.3 Results

Table 2 exhibits the results of estimating equation (26) 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. 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). We therefore use a different variation in leverage and wages in different specifications. 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 profitability (profit over employment, in logs, denoted as profits) as well as the coefficients of the interaction between leverage and profitability as well as leverage and tightness. The overall marginal effect of leverage on wages is shown at the bottom of the table. If leverage goes up by one percent,

Table 2: Baseline results

	LHS variable is log wage			
	(1)	(2)	(3)	(4)
Log leverage	0.11***	0.0016**	0.0086***	0.0066***
	(0.0013)	(0.00079)	(0.00060)	(0.00055)
Log profits t	−0.013***	0.0072***	0.0064***	0.0060***
	(0.00052)	(0.00030)	(0.00022)	(0.00020)
Log profits t × Log leverage	0.0095***	−0.00090***	−0.00059***	−0.00059***
	(0.00013)	(0.000079)	(0.000058)	(0.000053)
Log θ	−0.013***	−0.0030***	0.0021***	0.0021***
	(0.00093)	(0.00032)	(0.00036)	(0.00032)
Log leverage × Log leverage	−0.017***	−0.0023***	−0.0035***	−0.0028***
	(0.00018)	(0.00011)	(0.000083)	(0.000076)
Log leverage × Log θ	0.016***	0.00087***	0.00027***	0.00011
	(0.00025)	(0.000087)	(0.000094)	(0.000085)
Log profits $t-1$	0.013***	−0.00036***	0.000075	−0.000097**
	(0.00016)	(0.000067)	(0.000048)	(0.000044)
Log sales t	0.075***	0.017***	0.021***	0.014***
	(0.00040)	(0.00019)	(0.00014)	(0.00013)
Log sales $t-1$	0.018***	0.0035***	0.0055***	0.0018***
	(0.00039)	(0.00016)	(0.00012)	(0.00011)
Constant	2.32***	2.47***	2.33***	2.50***
	(0.0040)	(0.0023)	(0.0041)	(0.0050)
Observations	3563136	3563136	3563136	3563136
R^2	0.55	0.96	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match
Sector state interaction	No	Yes	Yes	Yes
ME Financial	−0.091	−0.013	−0.015	−0.011
ME Tightness	0.044	0.00018	0.0031	0.0025
ME Productivity	0.023	0.0038	0.0042	0.0038

Notes: Dependent variables is the log real wage at the worker level. Here: Leverage (using debt) as the measure of financial constraints. Sample period is 2007 to 2014.

real wages fall by about 0.011 percent (in model (4)). If leverage increases by one standard deviation[13], real wages fall by 0.275 percent. Hence, wages are 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.

Note that real wage adjustments correspond to nominal wage adjustments in this case due to the presence of year fixed effects in the estimation. 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.[14] 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 profitability is associated with higher wages, it significantly and negatively interacts with leverage. Hence, when firm leverage increases, workers in firms with higher profitability experience larger wage cuts. Put differently, when firm profitability increases, workers in highly leveraged firms obtain smaller pay raises than workers in lowly leveraged firms. If profitability

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

[14] 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.

approximates firm 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. From our model in section 2, we know that this means that working capital (wages) are at least partly externally financed ($\lambda_w < 1$).

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.[15] The interaction of tightness and leverage is significant in most 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. In terms of the model, this means that $\lambda_V < \lambda_W$. 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.2, 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

[15] 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.

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.

Appendix **??** also contains robustness on the productivity measure. First, we replicate the original setup by Giroud and Mueller (2017) replacing employment growth with wage growth and the housing demand shock with the export shock described in the previous section. This this setup uses cross-sectional data, we can employ firm, but not individual worker fixed effects. Similar to our baseline results, tightness has a negative effect on wages, which reflects compositional changes in a firm. In spite of the different setup, the interaction effects exhibit the same sign and significance as in our baseline estimation. Second, we replace firm profitability by job complexity. The effects are robust to this variation as well.

4 Model simulation

The purpose of this section is to quantify the effects discussed in section 2 and verify these in the full dynamic setup (not just the deterministic steady state). Moreover, we can investigate the importance of the different mechanisms for the overall dynamics.

Calibration We parameterize the model as follows and as is summarized in table 3. Parameters relating to the labor market are set to match the German situation. Unemployment benefits are 60% of wages. 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

Table 3: Calibration

Variable	Description	Value	Target
η	workers' bargaining power	0.5	literature
ϵ	matching function parameter	0.72	literature
δ	monthly separation rate	0.00785	data
ξ	efficiency of matching function	0.082	unemployment rate 8.65%
b	unemployment benefit	0.5741	replacement rate 60%
γ	vacancy cost	0.33968	$\theta = 1$
β	monthly discount factor	0.9977	$\beta = 1/(1+r)$
r	riskfree interest rate	0.0023	data
ζ	Firms' saving rate	0.55	data
μ	monitoring cost	0.33573	finance premium 0.05%
σ_ω	S.D. of idiosyncratic revenue	0.027011	default rate 0.15%
λ^v	internally financed share of vacancy cost	0	
λ^w	internally financed share of wage cost	0.71629	elasticity of wage to leverage (-0.011%)

respectively is set to $\eta = 0.5$. The vacancy posting cost is then pinned down by the job creation condition in steady state.

The discount rate β matches an annual interest rate of 2.75% (as an average from 2006-2014, source: OECD). The saving rate $\zeta = 0.55$ reflects the average dividends paid out by German firms between 2015 and 2018. The cutoff parameter ω follows a log-normal distribution. The parameters μ and σ_ω are then chosen to match the an annual default rate of 1.76% (2008-2015, source: Creditreform) and an external finance premium of 0.05%. . Hence, financial frictions are present, but on average relatively small 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. This delivers $\lambda_w = 0.72$.

Dynamic wage equation Note that the dynamic and steady state wage equation differ (compare equations (14) and (15)). 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

$$(1-\delta) - (1-\delta - f(\theta_t))\frac{\chi_t^w}{E_t\chi_{t+1}^w} = (1-\delta)(1 - \frac{\chi_t^w}{E_t\chi_{t+1}^w}) + f(\theta_t)\frac{\chi_t^w}{E_t\chi_{t+1}^w} \quad (27)$$

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.[16]

Simulation results We then simulate the full dynamic model adding a exogenous shocks to productivity X.[17] Table 4 exhibits simulated moments, figures 1 and 2 in the Appendix show the impulse-response functions to shocks in productivity and shocks to the financial friction μ, respectively. When financial frictions change, we can allow $1-\mu_t = s_0(\exp{(X_t - 1)}s_1)$ which therefore varies with the cycle. We can then simulate normal recessions (financial constraints change, but frictions μ remain constant) and recessions in which μ changes

[16] In the tables and figures, taking out the expectation term in the dynamic model is denoted with W^* or WW.

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

with X. In this case, we parameterize s_0 and s_1 such that the monitoring cost doubles when productivity drops by 1%.

Even though our model generates small volatility of tightness relative to productivity (as widely discussed starting with Shimer (2005)), table 4 documents that financial recessions amplify tightness relative to output substantially. Also, wages are more volatile when financial frictions are present. Since wages are reset immediately when tightness changes, these two variables are perfectly correlated in the model without financial frictions. If financial frictions are present and change with the business cycle, this correlation is dampened to a small degree.

Table 5 in the Appendix considers second moments when different mechanisms are present in the data. Based on the current calibration in which both the financial labor wedge and the tightness interaction (positive) are present, we consider a case in which we increase $\lambda_v = 1$ which turns around the tightness interaction (negative), a case in which we increase $\lambda_w = 1$ such that we eliminate the financial labor wedge channel and a case in which we set $\lambda_v = \lambda_w = 0.71$ such that we eliminate the tightness interaction channel. In line with our discussion in section 2, one can see that the two channels are partly offsetting their mutual effects. Eliminating the tightness interaction boosts volatility of tightness and further reduces wage rigidity when financial frictions are present. This then also reduces the correlation between tightness and wages. Eliminating the financial labor wedge reduces the volatility of tightness and wage rigidity compared to the baseline calibration. Changing the sign of the tightness interaction increases the volatility of tightness and wage rigidity. This case also reduces the correlation of tightness and wages.

5 Conclusions

To be completed.

Table 4: Simulated moments

	No frictions $\mu = 0$	Frictions $\mu = 0.335$	Frictions varying μ
		Standard deviations	
X	0.0171	0.0171	0.0171
XN	0.0157	0.0157	0.0158
θ	0.0379	0.0399	0.0596
W	0.015	0.0154	0.0211
W^*	0.015	0.0153	0.0189
		Correlations	
θ, W	1	0.9999	0.9921

Notes: W^* refers to the simplified wage equation.
For time varying μ, we use $s_0 = 0.665$ and $s_1 = 160.58$.

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A Model appendix

A.1 Wage determination

Iterate (10) forward and insert (7) to get the job creation condition

$$\frac{\chi^v_{it}\gamma}{p(\theta_t)} = \beta\left[\Omega_{i,t+1}X_{i,t+1} - \chi^w_{i,t+1}W_{i,t+1} + (1-\delta)\frac{\chi^v_{i,t+1}\gamma}{p(\theta_{t+1})}\right] \tag{28}$$

Workers and firms apply Nash bargaining to set wages

$$W_{it} = \arg\max_{W_{it}} \left(H^N_{it} - H^U_{jt}\right)^\eta \left(J_{N_{it}}\right)^{1-\eta} \tag{29}$$

Using equation (10) this delivers

$$(1-\eta)\overbrace{\frac{\partial J_{N_{it}}}{\partial W_{it}}}^{=-\chi^w_{it}}(H^N_{it} - H^U_t) + \eta J_{N_{it}} = 0 \tag{30}$$

and hence the following sharing rule

$$\left(H^N_{it} - H^U_t\right) = \frac{\eta}{(1-\eta)\chi^w_{it}} J_{N_{it}} \tag{31}$$

Using equations (5) and (6) gives

$$H^N_{it} - H^U_t = W_{it} - b + \beta E_t\left[(1-\delta-f(\theta_t))(H^N_{i,t+1} - H^U_{t+1})\right] \tag{32}$$

Iterating equation (31) forward and inserting into (32) yields

$$J_{N_{it}} = \frac{(1-\eta)\chi^w_{it}}{\eta}(W_{it} - b) + \beta E_t(1-\delta-f(\theta_t))\frac{\chi^w_{it}}{\chi^w_{i,t+1}} J_{N_{i,t+1}} \tag{33}$$

Together with (10), this then gives the wage equation:

$$W_{it} = \eta \left[\frac{\Omega_{it}}{\chi^w_{it}} X_{it} + \big((1-\delta) - (1-\delta - f(\theta_t)) \frac{\chi^w_{it}}{E_t \chi^w_{i,t+1}} \big) \frac{\chi^v_{it}}{\chi^w_{it}} \frac{\gamma}{p(\theta_t)} \right] + (1-\eta) b \tag{34}$$

A.2 Effect of financial frictions on wages

A.2.1 $\phi > \Omega$

$$\phi > \Omega \tag{35}$$

$$\phi > (1-\zeta + (1+r)\zeta\Delta)(1-\Gamma) + \phi(\Gamma - \mu G) \tag{36}$$

$$\phi > \frac{(1-\zeta + (1+r)\zeta\Delta)(1-\Gamma)}{(1-\Gamma+\mu G)} \tag{37}$$

$$\frac{(1-\zeta+(1+r)\zeta\Delta)\Gamma'}{\Gamma' - \mu G'} > \frac{(1-\zeta + (1+r)\zeta\Delta)(1-\Gamma)}{(1-\Gamma+\mu G)} \tag{38}$$

$$\frac{\Gamma'}{\Gamma' - \mu G'} > 1 > \frac{(1-\Gamma)}{(1-\Gamma+\mu G)} \tag{39}$$

A.2.2 χ^w increases in $1 - \lambda_w$

Using A.2.2

$$\frac{\partial \chi^w}{\partial \lambda_w} = \lambda_w (\overbrace{\Omega - \phi}^{<0}) < 0 \tag{40}$$

A.2.3 No frictions

From equation (8) and (9),

$$\phi_{it} = (1-\zeta + (1+r)\zeta\Delta_{it}) = (1-\zeta+(1+r)\zeta\beta\phi_{i,t+1}) \tag{41}$$

which is independent of the financial market variables and all other choice variables. Hence, $\phi_{it} = \phi_{i,t+1} = \phi_i$. Further, it is reasonable to assume that $\beta(1+r) = 1$ which would come out of a usual steady state Euler relationship and may be described as an intertemporal no-arbitrage condition. Then

$$\phi_i = \frac{1-\zeta}{1-(1+r)\zeta\beta} = 1 \tag{42}$$

From equation (11),

$$\begin{aligned}
\Omega_{it} &= (1-\zeta+(1+r)\zeta\Delta_{it})\left[1-\Gamma(\bar{\omega}_{it})\right] + \phi_{it}\left[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})\right] && (43)\\
&= (1-\zeta+(1+r)\zeta\beta)\left[1-\Gamma(\bar{\omega}_{it})\right] + \left[\Gamma(\bar{\omega}_{it})\right] && (44)\\
&= 1-\Gamma(\bar{\omega}_{it}) + \Gamma(\bar{\omega}_{it}) = 1 && (45)
\end{aligned}$$

It then follows that $\chi_i^w = \chi_i^v = 1$ and therefore also $\Phi_i^v = \Phi_i^w = 1$.

A.2.4 Changing μ

First, we show that

$$\frac{\partial \Phi^w}{\partial \mu} = \frac{\partial \Phi^w}{\partial \frac{\phi}{\Omega}} \frac{\partial \frac{\phi}{\Omega}}{\partial \mu} < 0 \tag{46}$$

if $\lambda^w < 1$.

Rewrite

$$\Phi^w = \frac{\Omega}{\chi^w} = \frac{1}{\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}} \tag{47}$$

Then,

$$\frac{\partial \Phi^w}{\partial \frac{\phi}{\Omega}} = -\frac{1-\lambda_w}{(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega})^2} < 0 \tag{48}$$

unless $\lambda_w = 1$.

Next, show that $\frac{\partial \frac{\phi}{\Omega}}{\partial \mu} > 0$

$$\frac{\partial(\frac{\phi}{\Omega})}{\partial \mu} = \frac{\frac{\partial \phi}{\partial \mu}\Omega - \frac{\partial \Omega}{\partial \mu}\phi}{\Omega^2} \tag{49}$$

$$= \frac{\frac{\partial \phi}{\partial \mu}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right] + \phi\left[\Gamma(\bar{\omega}) - \mu G(\bar{\omega})\right]\big)}{\Omega^2}$$

$$- \frac{\phi\big((\Gamma(\bar{\omega}) - \mu G(\bar{\omega}))\frac{\partial \phi}{\partial \mu} - \phi G(\bar{\omega})\big)}{\Omega^2} \tag{50}$$

$$= \frac{\frac{\partial \phi}{\partial \mu}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big) + \phi^2 G(\bar{\omega})}{\Omega^2} \tag{51}$$

From this, $\frac{\partial \frac{\phi}{\Omega}}{\partial \mu} > 0$ if $\frac{\partial \phi}{\partial \mu} > 0$. Looking at equation (8), ϕ unambiguously increases in μ when all other things remain constant. In equilibrium, an increase in μ will also change $\bar{\omega}$. If $\bar{\omega}$ increases, this intensifies the effect, since ϕ increases in $\bar{\omega}$ (proof below). $\bar{\omega}$ may decrease in equilibrium, since higher monitoring costs decrease the demand for credit which decreases its price. As the simulations show, ϕ still increases in this case.

Second, we show that

$$\frac{\partial \Phi^v}{\partial \mu} = \frac{\partial \Phi^v}{\partial \frac{\phi}{\Omega}} \frac{\partial \frac{\phi}{\Omega}}{\partial \mu} > 0 \tag{52}$$

if $\lambda_w > \lambda_v$.

Similar to before, rewrite

$$\Phi^v = \frac{\chi^v}{\chi^w} = \frac{\lambda_v + (1-\lambda_v)\frac{\phi}{\Omega}}{\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}} \tag{53}$$

Then,

$$\frac{\partial \Phi^v}{\partial \frac{\phi}{\Omega}} = \frac{(1-\lambda_v)(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}) - (1-\lambda_w)(\lambda_v + (1-\lambda_v)\frac{\phi}{\Omega})}{(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega})^2} > 0 \tag{54}$$

if

$$(1-\lambda_v)(\lambda_w+(1-\lambda_w)\frac{\phi}{\Omega})-(1-\lambda_w)(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})>0 \tag{55}$$

$$(1-\lambda_v)\lambda_w-(1-\lambda_w)\lambda_v>0 \tag{56}$$

$$\lambda_w-\lambda_v>0 \tag{57}$$

A.2.5 Interaction coefficients

Financial labor wedge:

$$\begin{aligned}\frac{\partial\Phi^w}{\partial\bar{\omega}}&=\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}}=\frac{\frac{\partial\Omega}{\partial\bar{\omega}}\chi^w-\frac{\partial\chi^w}{\partial\bar{\omega}}\Omega}{(\chi^w)^2}\\&=\frac{\frac{\partial\Omega}{\partial\bar{\omega}}(\lambda_w\Omega+(1-\lambda_w)\phi)-(\lambda_w\frac{\partial\Omega}{\partial\bar{\omega}}+(1-\lambda_w)\frac{\partial\phi}{\partial\bar{\omega}})\Omega}{(\chi^w)^2}\\&=\frac{(1-\lambda_w)\left[\frac{\partial\Omega}{\partial\bar{\omega}}\phi-\frac{\partial\phi}{\partial\bar{\omega}}\Omega\right]}{(\chi^w)^2}\end{aligned} \tag{58}$$

The financial labor wedge is zero if $\lambda_w=1$. If $\lambda_w<1$, the financial labor wedge falls with increasing $\bar{\omega}$ if $\frac{\partial\Omega}{\partial\bar{\omega}}\phi-\frac{\partial\phi}{\partial\bar{\omega}}\Omega<0$ which we show next.

$$\begin{aligned}\frac{\partial\Omega}{\partial\bar{\omega}}\phi-\frac{\partial\phi}{\partial\bar{\omega}}\Omega&=\big(-(1-\zeta+(1+r)\zeta\Delta)\Gamma'(\bar{\omega})+\phi\left[\Gamma'(\bar{\omega})-\mu G'(\bar{\omega})\right]+\frac{\partial\phi}{\partial\bar{\omega}}\left[\Gamma(\bar{\omega})-\mu G(\bar{\omega})\right]\big)\phi\\&\quad-\frac{\partial\phi}{\partial\bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]+\phi\left[\Gamma(\bar{\omega})-\mu G(\bar{\omega})\right]\big) &&(59)\\&=\big(-(1-\zeta+(1+r)\zeta\Delta)\Gamma'(\bar{\omega})+\phi\left[\Gamma'(\bar{\omega})-\mu G'(\bar{\omega})\right]\\&\quad-\frac{\partial\phi}{\partial\bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big) &&(60)\\&=-\frac{\partial\phi}{\partial\bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big) &&(61)\end{aligned}$$

where the last step uses the definition of ϕ in (8). $\frac{\partial\Omega}{\partial\bar{\omega}}\phi-\frac{\partial\phi}{\partial\bar{\omega}}\Omega<0$ if $\frac{\partial\phi}{\partial\bar{\omega}}>0$.
Show that $\frac{\partial\phi}{\partial\bar{\omega}}>0$:

First note that we evaluate this expression at steady state, hence we use

$$\phi_i = \frac{(1 - \zeta + (1+r)\zeta\Delta_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)} \tag{62}$$

$$\phi_i = \frac{(1 - \zeta + (1+r)\zeta\beta\phi_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)} \tag{63}$$

$$\phi_i = \frac{(1 - \zeta + \zeta\phi_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)} \tag{64}$$

$$\phi_i = \frac{(1 - \zeta)\Gamma'(\bar{\omega}_i)}{(1-\zeta)\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)} \tag{65}$$

Use that

$$\Gamma'(\bar{\omega}) = 1 - H(\bar{\omega}) \tag{66}$$

$$\Gamma''(\bar{\omega}) = -h(\bar{\omega}) \tag{67}$$

$$G'(\bar{\omega}) = \bar{\omega} \cdot h(\bar{\omega}) \tag{68}$$

$$G''(\bar{\omega}) = h(\bar{\omega}) + \bar{\omega} \cdot h'(\bar{\omega}) \tag{69}$$

Then

$$\frac{\partial \phi}{\partial \bar{\omega}} = \frac{\mu(1-\zeta)(G''\Gamma' - G'\Gamma'')}{((1-\zeta)\Gamma' - \mu G')^2} \tag{70}$$

$$= \mu(1-\zeta) \cdot \frac{\big(h(\bar{\omega}) + \bar{\omega}h'(\bar{\omega})\big) \cdot (1 - H(\bar{\omega})) + \bar{\omega}h^2(\bar{\omega})}{((1-\zeta)\Gamma' - \mu G')^2} \tag{71}$$

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

Tightness interaction channel

$$\frac{\partial \Phi^v}{\partial \bar{\omega}} = \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}} = \frac{\frac{\partial \chi^v}{\partial \bar{\omega}} \chi^w - \frac{\partial \chi^w}{\partial \bar{\omega}} \chi^v}{(\chi^w)^2}$$

$$= \frac{\left(\lambda_v \frac{\partial \Omega}{\partial \bar{\omega}} + (1-\lambda_v) \frac{\partial \phi}{\partial \omega}\right)(\lambda_w \Omega + (1-\lambda_w)\phi)}{(\chi^w)^2}$$

$$- \frac{\left(\lambda_w \frac{\partial \Omega}{\partial \bar{\omega}} + (1-\lambda_w) \frac{\partial \phi}{\partial \omega}\right)(\lambda_v \Omega + (1-\lambda_v)\phi)}{(\chi^w)^2} \tag{72}$$

$$= \frac{(\lambda_v - \lambda_w)\left[\frac{\partial \Omega}{\partial \bar{\omega}} \phi - \frac{\partial \phi}{\partial \bar{\omega}} \Omega\right]}{(\chi^w)^2} \tag{73}$$

Using that $\frac{\partial \Omega}{\partial \bar{\omega}} \phi - \frac{\partial \phi}{\partial \bar{\omega}} \Omega < 0$, this expression is positive if $\lambda_v < \lambda_w$ and negative if $\lambda_v > \lambda_w$.

A.3 Steady state results

A.3.1 Steady state equations

$$\phi_i = \frac{(1-\zeta+(1+r)\zeta\Delta_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i)-\mu G'(\bar{\omega}_i)} \tag{74}$$

$$\Omega_i = (1-\zeta+(1+r)\zeta\Delta_i)\left[1-\Gamma(\bar{\omega}_i)\right]+\phi_i\left[\Gamma(\bar{\omega}_i)-\mu G(\bar{\omega}_i)\right] \tag{75}$$

$$\chi_i^w = \lambda_w\Omega_i+(1-\lambda_w)\phi_i \tag{76}$$

$$\chi_i^v = \lambda_v\Omega_i+(1-\lambda_v)\phi_i \tag{77}$$

$$\Delta_i = \beta\phi_i \tag{78}$$

$$\begin{aligned}&\left[\Gamma(\bar{\omega}_i)-\mu G(\bar{\omega}_i)\right]\left[\left(X_i-\lambda_w W_i\right)N_i-\lambda_v\gamma V_i\right]\\ &\qquad =(1-\lambda_w)W_iN_i+(1-\lambda_v)\gamma V_i-A_i\end{aligned} \tag{79}$$

$$\frac{\gamma}{p(\theta)} = \frac{\beta}{1-\beta(1-\delta)}\left[\frac{\Omega_i}{\chi_i^v}X_i-\frac{{\chi_i}^w}{\chi_i^v}W_i\right] \tag{80}$$

$$W_i = \eta\left[\frac{\Omega_i}{\chi_i^w}X_i+\frac{\chi_i^v}{\chi_i^w}\gamma\theta\right]+(1-\eta)b \tag{81}$$

$$A_i = (1+r)\zeta(1-\Gamma(\bar{\omega}_i))[(X_i-\lambda_wW_i)N_i-\lambda_v\gamma V_i] \tag{82}$$

$$\delta N_i = p(\theta)V_i \tag{83}$$

$$\theta = \frac{V_i}{1-N_i} \tag{84}$$

A.3.2 The surplus decreases with the financial friction

Following the argumentation in proof A.2.4, it suffices to show that $\frac{\Phi^w}{\Phi^v}X - \frac{1}{\Phi^v}b = \frac{\Omega}{\chi_v}X-\frac{\chi^w}{\chi^v}b$ decreases with $\frac{\phi}{\Omega}$. First, show that $\frac{\Phi^w}{\Phi^v}-\frac{1}{\Phi^v}$ decreases with $\frac{\phi}{\Omega}$ (the derivations here build largely on proof A.2.4).

$$\frac{\partial\frac{\Omega}{\chi^v}}{\partial\frac{\phi}{\Omega}}-\frac{\partial\frac{\chi^w}{\chi^v}}{\partial\frac{\phi}{\Omega}} = -\frac{1-\lambda_v}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2}-\frac{\lambda_v-\lambda_w}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2} \tag{85}$$

$$= \frac{\lambda_w-1}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2}<0 \tag{86}$$

if the financial labor wedge channel is present, i.e. $\lambda_w<1$.

Note that $\frac{\chi^w}{\Omega} > 1$, since $\Omega < \phi$ as shown in proof A.2.1. For the surplus to be positive,

$$\frac{\Omega}{\chi_v} X > \frac{\chi^w}{\chi^v} b \tag{87}$$

$$X > \frac{\chi^w}{\Omega} b > b \tag{88}$$

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

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} X < \frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} b < \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \frac{\phi}{\Omega}} b \tag{89}$$

Therefore

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} X - \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \frac{\phi}{\Omega}} b < 0 \tag{90}$$

A.3.3 Amplification

$$\frac{\frac{\Omega}{\chi^v} X}{\frac{\Omega}{\chi^v} X - \frac{\chi^w}{\chi^v} b} > \frac{X}{X - b} \tag{91}$$

$$\frac{\Omega}{\chi^v} X^2 - \frac{\Omega}{\chi^v} X b > \frac{\Omega}{\chi^v} X^2 - X b \tag{92}$$

$$-\frac{\Omega}{\chi^v} > -1 \tag{93}$$

$$\frac{\Omega}{\chi^v} < 1 \tag{94}$$

where the last inequality uses proof A.2.1.

A.4 Model variations

A.4.1 Model without search frictions

Firm problem:

$$\max_{N_{it}, \bar{\omega}_{it}, A_{i,t+1}} (1 - \zeta) \left[1 - \Gamma(\bar{\omega}_{it})\right] \left[(X_{it} - \lambda_w W_{it}) N_{it}\right] \tag{95}$$

subject to

$$\begin{aligned}
&[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})] \left(X_{it} - \lambda_w W_{it}\right) N_{it} \\
&\qquad = (1-\lambda_w) W_{it} N_{it} - A_{it} \qquad (96)
\end{aligned}$$

$$A_{i,t+1} = (1+r)\zeta(1-\Gamma(\bar{\omega}_{it}))(X_{it} - \lambda_w W_{it}) N_{it} \qquad (97)$$

which delivers the following first order condition with respect to N_{it}

$$0 = \Omega_{it} X_{it} - \Omega_{it}\lambda_w W_{it} - \phi_{it}(1-\lambda_w) W_{it} \qquad (98)$$

$$W_{it} = \frac{\Omega_{it} X_{it}}{\Omega_{it}\lambda_w + \phi_{it}(1-\lambda_w)} = \Phi^w_{it} X_{it} \qquad (99)$$

with $\Omega_{it} = (1-\zeta+(1+r)\zeta\Delta_{it})\left[1-\Gamma(\bar{\omega}_{it})\right] + \phi_{it}\left[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})\right]$ defined as before. The remaining first order conditions are equivalent to equations (8) and (9).

Taking equation (99) to the data delivers the following second-order Taylor approximation

$$\begin{aligned}
W_{it} \approx\ & W + \Phi^w(\bar{\omega})(X_{it} - X) + X\frac{\partial \Phi^w}{\partial \bar{\omega}}(\bar{\omega})(\bar{\omega}_{it} - \bar{\omega}) \\
& + 0 + \frac{1}{2} X \frac{\partial^2 \Phi^w}{\partial \bar{\omega}\partial \bar{\omega}}(\bar{\omega})(\bar{\omega}_{it} - \bar{\omega})^2 \\
& + \frac{\partial \Phi^w}{\partial \bar{\omega}}(\bar{\omega})(X_{it} - X)(\bar{\omega}_{it} - \bar{\omega}) \qquad (100)
\end{aligned}$$

A.4.2 Model with collateral constraint

Firm problem:

$$J_{it} = \max_{V_{it}, A_{i,t+1}} (1-\zeta)\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right] + \beta E_t J_{i,t+1}, \qquad (101)$$

subject to

$$N_{i,t+1} = (1-\delta)N_{it} + p(\theta_t)V_{it} \tag{102}$$

$$Q_{it} = (1-\lambda_w)W_{it}N_{it} + (1-\lambda_v)\gamma V_{it} - A_{it} \tag{103}$$

$$A_{i,t+1} = (1+r)\zeta[(X_{it} - \lambda_w W_{it})N_{it} - \lambda_v \gamma V_{it}] \tag{104}$$

Here, equation (103) describes the collateral constraint and Q_{it} is the (value of the) collateral. Here, this value is exogenous. In Jermann and Quadrini (2012) or Garin (2015) this value also depends on capital. Define $\tilde{\phi}$ to be the Lagrange multiplier of the collateral constraint and measures tightness on the financial market.

Marginal value of the worker

$$\begin{aligned} J_{N_i t} &= (1-\zeta)\left[X_{it} - \lambda_w W_{it}\right] - \tilde{\phi}_{it}(1-\lambda_w)W_{it} \\ &\quad + \Delta_{it}(1+r)\zeta(X_{it} - \lambda_w W_{it}) + \beta E_t J_{N_{i,t+1}} && (105) \\ &= \tilde{\Omega}_{it}\left[X_{it} - \lambda_w W_{it}\right] - \tilde{\phi}_{it}(1-\lambda_w)W_{it} + \beta E_t J_{N_{i,t+1}} && (106) \\ &= \tilde{\Omega}_{it} X_{it} - \widetilde{\chi^w}_{it} W_{it} + \beta E_t J_{N_{i,t+1}} && (107) \end{aligned}$$

which looks very similar to the baseline model, except that

$$\tilde{\Omega}_{it} = 1 - \zeta + \Delta_{it}(1+r)\zeta \tag{108}$$

$$\widetilde{\chi^w}_{it} = \tilde{\Omega}_{it}\lambda_w + \tilde{\phi}_{it}(1-\lambda_w) \tag{109}$$

The first order conditions are then

$$\frac{\widetilde{\chi^v}_{it}\gamma}{p(\theta_t)} = \beta E_t J_{N_{i,t+1}} \tag{110}$$

$$\Delta_{it} = \beta \phi_{i,t+1} \tag{111}$$

with

$$\widetilde{\chi^v}_{it} = \tilde{\Omega}_{it}\lambda_v + \tilde{\phi}_{it}(1-\lambda_v) \tag{112}$$

Using the derivations from the baseline model, the wage equation is then

$$W_{it} = \eta \left[\frac{\tilde{\Omega}_{it}}{\widetilde{\chi}^w_{it}} X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t))\frac{\widetilde{\chi}^w_{it}}{E_t\widetilde{\chi}^w_{i,t+1}}\big)\frac{\widetilde{\chi}^v_{it}}{\widetilde{\chi}^w_{it}}\frac{\gamma}{p(\theta_t)} \right] + (1-\eta)b \tag{113}$$

The difference to our model is that this wage equation is no longer directly linked to the price of the loan and the Lagrange multiplier $\tilde{\phi}$. Instead, $\tilde{\phi}$ measures the tightness of the collateral constraint.

A.4.3 Endogenous savings

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

$$J_t = \max_{V_t, \bar{x}_t, S_t} \left[1 - \Gamma(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V_t\right] - S_t + \beta E_t J_{t+1} \tag{114}$$

subject to

$$N_{t+1} = (1-\delta)N_t + p(\theta_t)V_t \tag{115}$$

$$\left[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)\right] \left[\left(X_t - \lambda_w W_t\right) N_t - \lambda_v \gamma V\right] = (1-\lambda_w)W_t N_t + (1-\lambda_v)\gamma V_t - Q_t A_t \tag{116}$$

$$A_{t+1} = (1+r)S_t \tag{117}$$

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

$$E_t(\phi_{t+1}) = \frac{1}{\beta E_t(1+r)Q_{t+1}} \tag{118}$$

Table 5: Model simulation - different mechanisms

	$\lambda^v = 0$ $\lambda^w = 0.71$	$\lambda^v = 1$ $\lambda^w = 0.71$	$\lambda^v = 0$ $\lambda^w = 1$	$\lambda^v = 0.71$ $\lambda^w = 0.71$
	Standard deviations			
X	0.0171	0.0171	0.0171	0.0171
XN	0.0157	0.0158	0.0157	0.0158
θ	0409	0.0501	0.0379	0.0527
W	0.0158	0.0208	0.015	0.0212
W^*	0.0155	0.0182	0.0150	0.0184
	Correlations			
θ, W	1	0.9949	1	0.9941

Notes: W^* refers to the simplified wage equation.

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:

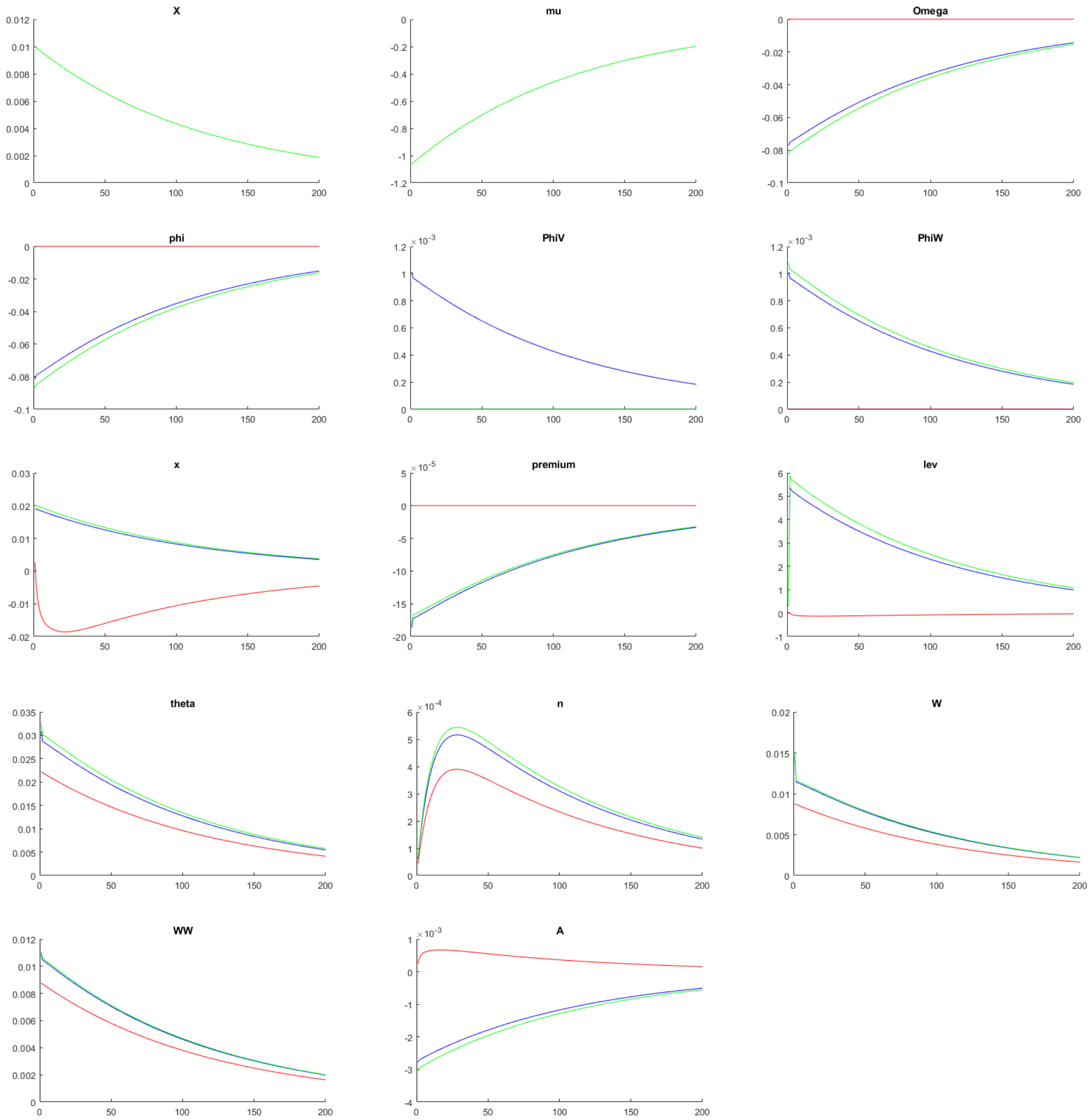
$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta E_t J_{N_{t+1}} \tag{119}$$

$$\phi_t = \frac{\Gamma'(\bar{x}_t)}{\Gamma'(\bar{x}_t) - \mu G'(\bar{x}_t)} \tag{120}$$

Since ϕ is already given in equation (118), 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 leverage) constant.

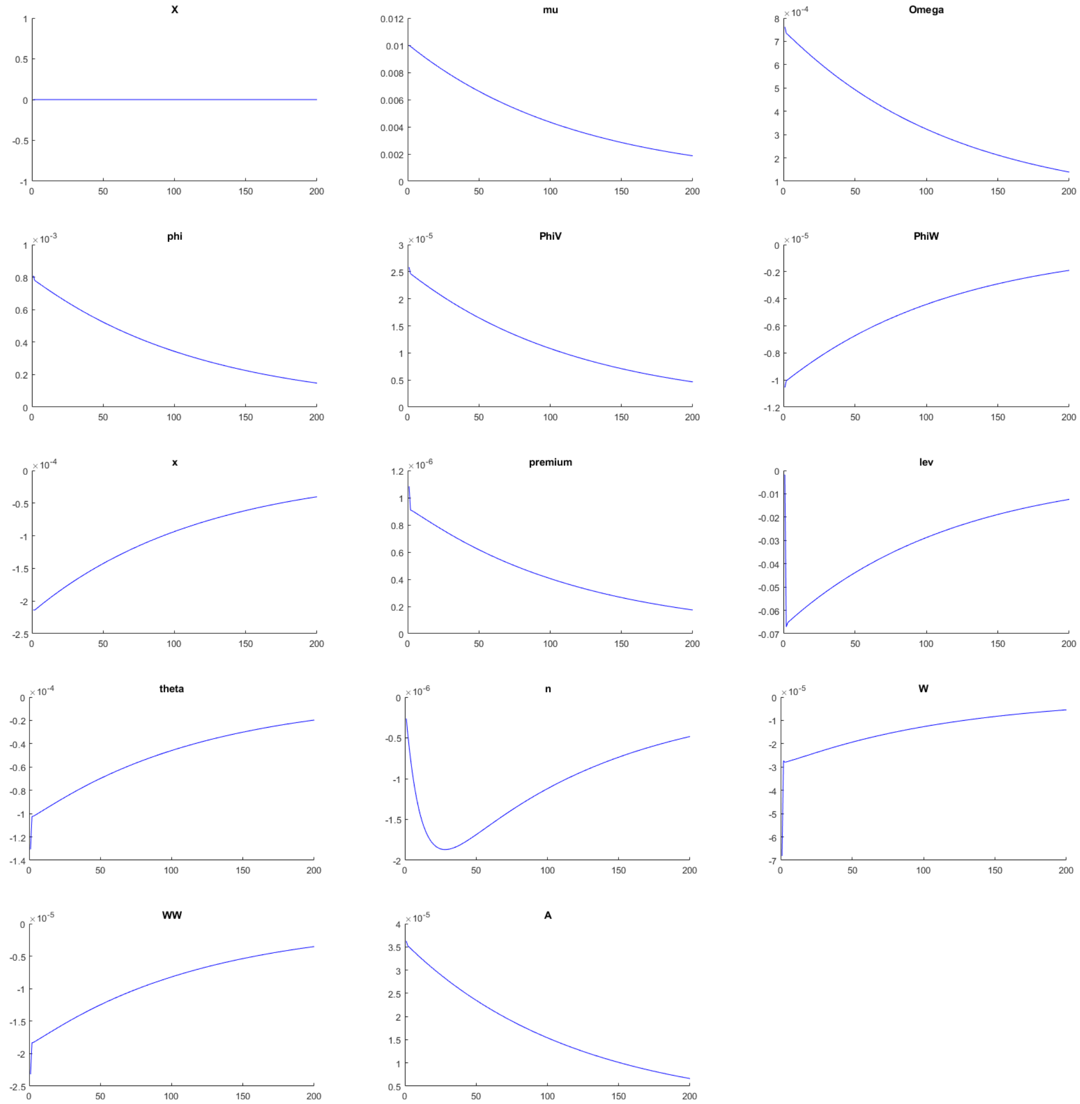
A.5 Simulation results

Figure 1: Impulse-responses to productivity shock



Notes: $\lambda^v = 1$ and $\lambda^w = 0.71$ (Blue); $\lambda^v = 0$ and $\lambda^w = 1$ (Red) ; $\lambda^v = 0.71$ and $\lambda^w = 0.71$ (Green). WW is the simplified wage equation.

Figure 2: Impulse-responses to a shock in μ



Notes: WW is the simplified wage equation.

B Data appendix

B.1 Details on the data

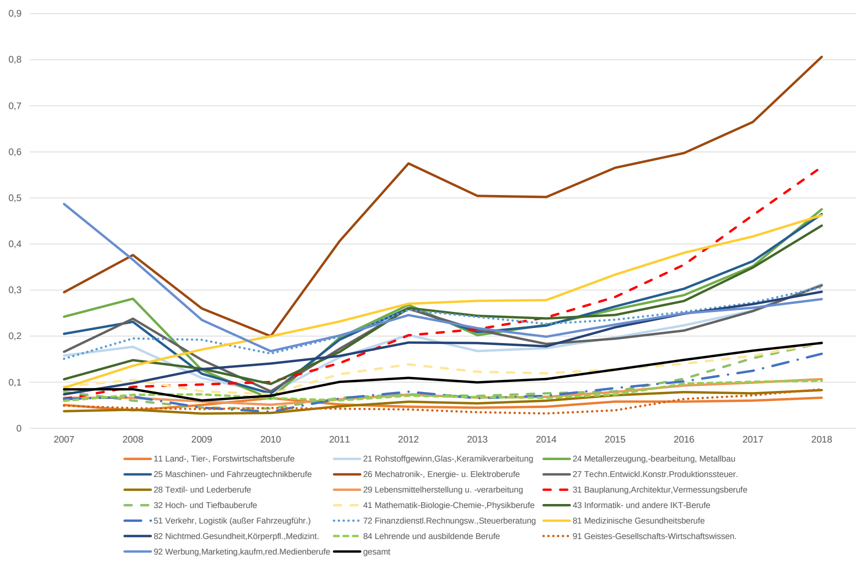
Details on Orbis-ADIAB:

- 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.

Figure 3: Aggregate tightness and tightness by occupations



Source: Federal Employment Agency of Germany.

B.2 Robustness for empirical results

B.2.1 Different measures of financial constraints

Table 6: Using leverage = debt + interest payments over assets

	LHS variable is log wage			
	(1)	(2)	(3)	(4)
Log leverage incl. int.	0.14***	−0.0014	0.0034***	0.00078
	(0.0014)	(0.00084)	(0.00064)	(0.00059)
Log profits t	−0.031***	0.011***	0.0097***	0.0094***
	(0.00056)	(0.00031)	(0.00023)	(0.00021)
Log profits t × Log leverage incl. int.	0.014***	−0.0019***	−0.0014***	−0.0015***
	(0.00014)	(0.000080)	(0.000059)	(0.000054)
Log θ	−0.021***	−0.0041***	0.0021***	0.0023***
	(0.00099)	(0.00035)	(0.00038)	(0.00035)
Log leverage incl. int. × Log leverage incl. int.	−0.017***	−0.0023***	−0.0032***	−0.0024***
	(0.00019)	(0.00012)	(0.000087)	(0.000080)
Log leverage incl. int. × Log θ	0.017***	0.0011***	0.00027***	0.000063
	(0.00026)	(0.000093)	(0.000100)	(0.000091)
Log profits $t-1$	0.012***	−0.00033***	0.000038	−0.00012***
	(0.00017)	(0.000069)	(0.000049)	(0.000045)
Log sales t	0.088***	0.016***	0.021***	0.014***
	(0.00040)	(0.00019)	(0.00014)	(0.00013)
Log sales $t-1$	0.020***	0.0036***	0.0057***	0.0019***
	(0.00039)	(0.00016)	(0.00012)	(0.00011)
Constant	2.23***	2.47***	2.31***	2.47***
	(0.0042)	(0.0024)	(0.0043)	(0.0053)
Observations	3450282	3450282	3450282	3450282
Workers (cluster)				
R^2	0.56	0.96	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match
Sector state interaction	No	Yes	Yes	Yes
ME Financial	−0.093	−0.012	−0.014	−0.011
ME Tightness	0.041	0.00017	0.0031	0.0026
ME Productivity	0.021	0.0039	0.0043	0.0039

Notes: Dependent variables is the log real wage at the worker level. Sample period is 2007 to 2014.

Table 7: Using liquidity ratio

	LHS variable is log wage			
	(1)	(2)	(3)	(4)
Log liquidity ratio	0.023***	0.0016***	0.00077***	0.0011***
	(0.00029)	(0.00014)	(0.00011)	(0.000096)
Log profits t	0.032***	0.0055***	0.0056***	0.0050***
	(0.00022)	(0.00010)	(0.000074)	(0.000068)
Log profits t $\times$ Log liquidity ratio	0.0016***	0.00041***	0.00031***	0.00028***
	(0.000033)	(0.000017)	(0.000013)	(0.000011)
Log θ	0.059***	−0.0013***	0.0017***	0.0011***
	(0.00034)	(0.00012)	(0.00014)	(0.00013)
Log liquidity ratio $\times$ Log liquidity ratio	0.0016***	−0.000048***	−0.000023***	−0.000011**
	(0.000015)	(0.0000078)	(0.0000057)	(0.0000052)
Log liquidity ratio $\times$ Log θ	0.0032***	−0.00033***	−0.00031***	−0.00033***
	(0.000065)	(0.000022)	(0.000022)	(0.000020)
Log profits $t-1$	0.018***	−0.00013**	0.00041***	0.00010**
	(0.00017)	(0.000067)	(0.000049)	(0.000044)
Log sales t	0.070***	0.016***	0.020***	0.013***
	(0.00040)	(0.00019)	(0.00014)	(0.00013)
Log sales $t-1$	0.011***	0.0029***	0.0048***	0.0012***
	(0.00039)	(0.00016)	(0.00012)	(0.00011)
Constant	2.56***	2.44***	2.30***	2.48***
	(0.0027)	(0.0015)	(0.0039)	(0.0048)
Observations	3564706	3564706	3564706	3564706
Workers (cluster)				
R^2	0.53	0.96	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match
Sector state interaction	No	Yes	Yes	Yes
ME Financial	−0.0046	0.00088	0.00022	0.00063
ME Tightness	0.046	0.00011	0.0030	0.0025
ME Productivity	0.025	0.0038	0.0043	0.0038

Notes: Dependent variables is the log real wage at the worker level. Sample period is 2007 to 2014.

Table 8: Using interest payments

	LHS variable is log wage			
	(1)	(2)	(3)	(4)
Log interest rate	0.042***	−0.00019	−0.0012***	−0.0015***
	(0.00040)	(0.00017)	(0.00013)	(0.00012)
Log profits t	0.027***	0.0038***	0.0038***	0.0035***
	(0.00026)	(0.00011)	(0.000078)	(0.000071)
Log profits t × Log interest rate	0.0011***	−0.000015	−0.00010***	−0.000084***
	(0.000047)	(0.000020)	(0.000015)	(0.000013)
Log θ	0.018***	0.00044***	0.0026***	0.0021***
	(0.00046)	(0.00016)	(0.00017)	(0.00015)
Log interest rate × Log interest rate	0.0040***	−0.000017*	0.000027***	−0.0000049
	(0.000021)	(0.0000092)	(0.0000067)	(0.0000061)
Log interest rate × Log θ	−0.0063***	0.000067*	−0.00010***	−0.000076**
	(0.000099)	(0.000035)	(0.000033)	(0.000030)
Log profits $t-1$	0.019***	−0.00014**	0.00041***	0.00014***
	(0.00017)	(0.000068)	(0.000049)	(0.000045)
Log sales t	0.084***	0.016***	0.020***	0.013***
	(0.00040)	(0.00019)	(0.00014)	(0.00013)
Log sales $t-1$	0.016***	0.0029***	0.0049***	0.0012***
	(0.00040)	(0.00016)	(0.00012)	(0.00011)
Constant	2.58***	2.43***	2.28***	2.44***
	(0.0029)	(0.0016)	(0.0041)	(0.0051)
Observations	3453981	3453981	3453981	3453981
Workers (cluster)				
R^2	0.55	0.96	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match
Sector state interaction	No	Yes	Yes	Yes
ME Financial	0.018	−0.00014	−0.00071	−0.00086
ME Tightness	0.043	0.00016	0.0030	0.0025
ME Productivity	0.022	0.0039	0.0043	0.0039

Notes: Dependent variables is the log real wage at the worker level. Sample period is 2007 to 2014.

Table 9: Using leverage in 2006 only

	LHS variable is log wage			
	(1)	(2)	(3)	(4)
Log leverage in 2006	−0.094***	0	−0.13***	0
	(0.00100)	(.)	(0.0016)	(.)
Log profits t	0.026***	0.0028***	0.0024***	0.0023***
	(0.00022)	(0.00012)	(0.000083)	(0.000077)
Log profits t × Log leverage in 2006	0.0038***	−0.0014***	−0.0019***	−0.0017***
	(0.00014)	(0.00010)	(0.000071)	(0.000067)
Log θ	0.041***	0.0023***	0.0059***	0.0056***
	(0.00033)	(0.00012)	(0.00015)	(0.00014)
Log leverage in 2006 × Log leverage in 2006	−0.025***	0	−0.024***	0
	(0.00018)	(.)	(0.00054)	(.)
Log leverage in 2006 × Log θ	0.012***	0.0023***	0.0021***	0.0021***
	(0.00027)	(0.00010)	(0.00011)	(0.00011)
Log profits $t-1$	0.013***	−0.0000040	0.00037***	0.00028***
	(0.00018)	(0.000074)	(0.000051)	(0.000047)
Log sales t	0.061***	0.013***	0.017***	0.012***
	(0.00045)	(0.00021)	(0.00014)	(0.00014)
Log sales $t-1$	0.020***	0.0014***	0.0038***	0.00010
	(0.00044)	(0.00019)	(0.00013)	(0.00012)
Constant	2.38***	2.47***	2.31***	2.53***
	(0.0028)	(0.0017)	(0.0044)	(0.0051)
Observations	2898987	2898987	2898987	2898987
Workers (cluster)				
R^2	0.56	0.96	0.99	0.99
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match
Sector state interaction	No	Yes	Yes	Yes
ME Financial	−0.093	0.0011	−0.087	0.0029
ME Tightness	0.031	0.00024	0.0040	0.0038
ME Productivity	0.022	0.0040	0.0040	0.0038

Notes: Dependent variables is the log real wage at the worker level. Sample period is 2007 to 2014.

B.2.2 Different measures of firm and match productivity

Table 10: Using the export exposure and Giroud and Mueller setup

	LHS variable is Delta log wage 07-09			
	(1)	(4)	(5)	(7)
Log leverage in 2006	0.0049***			
	(0.00030)			
Delta tightness 07-09	0.016***	−0.00016	−0.000064	0.000022
	(0.00033)	(0.00014)	(0.00013)	(0.00012)
Exposure export shock 08/09	0.0032***	0.0041***		
	(0.00016)	(0.00015)		
Exposure export shock 08/09 × Log leverage in 2006	0.0019***	−0.0030***	−0.00041***	−0.00055***
	(0.00015)	(0.00014)	(0.00015)	(0.00016)
Log leverage in 2006 × Delta tightness 07-09	−0.0042***	0.00011	0.00028**	0.00054***
	(0.00031)	(0.00013)	(0.00013)	(0.00011)
Observations	1958249	1919375	1919375	1919375
R^2	0.0054	0.90	0.91	0.93
Industry fixed effects	No	Yes	Yes	-
Firm fixed effects	No	Yes	Yes	Yes
County fixed effects	No	No	Yes	-
Industry-county interaction	No	No	No	Yes
ME Financial	0.0024	−0.00025	−0.00030	−0.00043
ME Tightness	0.020	0.0066	0.00035	0.00046
ME Exports	0.0017	0.0055	0.00070	0.00088

Notes: Dependent variables is the log real wage growth in between 2007 and 2009 at the worker level.

Table 11: Using job complexity to measure match productivity

	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

Notes: 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.