

Financial frictions and wages[†]

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October 2, 2018

Very preliminary and incomplete. Please do not circulate.

Abstract

This paper analyzes the interaction between financial frictions and wages. We use a large data set for Germany for 2006 to 2014 that combines administrative data on workers and wages with detailed information on firms' balance sheets. Controlling for firm characteristics and time fixed effects, we find that higher leverage (as a measure for financial frictions) implies on average lower wages. We build a theoretical model with labor market frictions and monitoring costs in the financial market. We show that wages react differently to financial frictions depending on whether and how they affect the relative costs of wages and hiring and the surplus of the job. We further show how employment volatility depends on these different mechanisms and document how higher employment volatility can be related to less rather than more rigid wages. Our empirical results then identify these different mechanisms in the data.

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

JEL-Codes: E32, E44, J63, J64

[†] We thank Karl Walentin and participants at the DFG Macroeconomics and the Labour Market Conference and at seminars at DIW and Humboldt University for comments. We further thank Marie-Christine Laible and Heiko Stüber for valuable support and suggestions on the data.

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1 Introduction

While the macroeconomic literature has mainly focused on the effect of financial frictions on unemployment, this paper focuses on the interaction of these frictions with wages. In fact, existing contributions provide contradicting results on this interaction. On the one hand, financial frictions may affect hiring costs. Petrosky-Nadeau (2014), for example, suggests a mechanism through which higher financial frictions directly improve the relative bargaining position of workers and therefore relate to higher wages. On the other hand, financial frictions may affect working capital. Firms could therefore use wage setting as an implicit financing device when access to outside credit is restricted, Michelacci and Quadrini, 2009 provides an example in which higher financial frictions relate to lower wages. The effect of financial frictions on wages is potentially important for aggregate volatility (Boeri et al., 2015, Schoefer, 2015 or Chugh, 2013 advocate the role of rigid wages in the presence of financial frictions). Moreover, the effect of financial frictions on wages is important in itself, e.g. by affecting consumption or economic inequality.

This paper provides empirical evidence that higher financial frictions imply lower wages, in particular in ongoing job relationships. 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 complement the existing literature (Guiso et al., 2013) by considering the effect of balance-sheet measures of financial constraints rather than indirect measures of frictions (such as firm growth). Moreover, we consider wages in ongoing full-time work relationships rather than new hires and investigate a period including the financial crisis in which frictions may have applied to more firms and firms more generally than before the crisis. We find a negative and significant effect on both average firm wages and individual workers wages when financial conditions worsen in a firm.

We propose a theoretical model that is based on Petrosky-Nadeau (2014) which combines the Mortensen-Pissarides model of a frictional labor market with financial frictions as in Carlstrom and Fuerst (1997). We document that simple variations of this model can generate wages rules that positively or negatively depend on financial frictions. We argue that two different effects are responsible for these different results. First, external finance may be used for both hiring (new investments) and/or wage payments (ongoing costs, working capital). Financial frictions may therefore affect the relative cost of hiring versus wages. Since, in this case, financial frictions interact with labor market frictions, we label this the tightness effect. If frictions make hiring more expensive relative to wages, wages increase as an outcome of Nash bargaining. If frictions make wages more expensive than hiring, wages decrease. Second, external finance affects the effective bargaining power of the worker when part of wages are externally financed. This means that financial frictions may drive a wedge between wages and productivity and part of the cost of finance are shifted to the workers. This is similar to the idea Michelacci and Quadrini, 2009 have stated for new hires. The contributions by Garin (2015) and Zanetti (2017) imply this effect as well.

We use our empirical findings to test for the sign and presence of these different effects in the data. Our empirical findings clearly contradict the idea that financial frictions increase wages and induce wage rigidity through this mechanism. This suggests that the tightness effect is either negative or positive and small relative to the productivity wedge.

Our model is simple enough that we can derive analytic expressions on how financial frictions affect wage rigidity and economic volatility (amplification towards tightness) over the cycle. If the tightness effect makes vacancies relatively more expensive than wages, counter-cyclical financial frictions generate upward pressure on wages in a recession and amplify the reduction in vacancy posting. According to the surplus effect, the wedge between productivity and wages in-

creases with higher frictions and is therefore also counter-cyclical. In contrast to before, the wedge intensifies wage flexibility over the cycle. Due to higher frictions, wages fall more in recessions. As a higher wedge implies a lower job surplus, this leads to tightness amplification in analogy to the arguments of Hagedorn and Manovskii (2008). The latter mechanism amplifies, even if the financial friction itself would not respond to the cycle. Even if financial frictions do not interact with the labor market frictions, the surplus effect is important in the presence of these frictions as it breaks the link between wage rigidity and tightness amplification.

The remainder of the paper is organized as follows. Section 2 introduces the model, Section 3 presents our data and the empirical results, Section 4 discusses aggregate model implications. Section 5 concludes.

2 Wages in the presence of financial frictions

2.1 Setup

Our model is based on the model in Petrosky-Nadeau (2009) and is similar to Chugh (2013) and Garin (2015). The model represents a standard Mortensen-Pissarides labor market model with exogenous separations and financial frictions. The advantage of the model is that we can derive analytical results for the steady states which delivers a wage equation that we estimate below and that allows us to discuss the effect of financial frictions on the level of wages and unemployment as well as on amplification. The model nests the standard Mortensen-Pissarides (MP) model case without financial frictions in the limit. Firms solve the following optimization problem

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

subject to

$$N_{t+1} = (1 - \delta)N_t + p(\theta_t)V_t \quad (2)$$

$$[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)] [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V] = (1 - \lambda_w)W_t N_t + (1 - \lambda_v)\gamma V_t - A_t \quad (3)$$

Just as in the standard MP model, J_t describes the value of the job to the firm, X_t is productivity per unit of labor input N_t which we refer to as workers, W_t are the corresponding wages, γ is the cost of posting vacancies V_t and β is the time discount factor. Equation (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 $\theta_t = \frac{V_t}{U_t}$. Job separations occur exogenously at rate δ . Firms in our model need to pay for wages and vacancy costs. Generally, wage payments are included in working capital, while vacancy costs relate to recurring and new investment. Firms rely on external finance in case they need to pay for these costs before production and sales have realized. Existing models usually assume that firms use external finance for either wage payments or vacancy posting costs. Empirical evidence suggests that firms use external funds for both working capital and hiring costs. In our model, a share of $1 - \lambda_w$ of the wage bill and a share of $1 - \lambda_v$ of the vacancy posting cost need to be paid before production and therefore need to be financed externally. While wages may be paid after production, other wage-related aspects of working capital need to be paid upfront to make production possible. As workers are hired in one period, but start working in the next, search costs are paid before, while costs related to installing the worker in the workplace (training, providing facilities, etc.) may be paid after production.

The financial market setup builds on Carlstrom and Fuerst (1997). External finance is subject to financial frictions due to monitoring costs that lenders pay in case of default. To obtain external finance, firms and lenders

sign a financial contract which based on the value of the firm measured by $x_t [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t]$. Here, x_t is a shock to the firm value, e.g. to the stock price of the firm. The firm and the lender set a cutoff value \bar{x} such that if $x_t > \bar{x}$, the firm pays back $\bar{x} [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t]$ and keeps $(x_t - \bar{x}) [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t]$. If $x_t < \bar{x}$, the firm keeps nothing and the lender claims the residual. The value of x_t realizes after the financial contract is signed and needs to be monitored by the lender at a cost μ in case that $x_t < \bar{x}$ (asymmetric information with respect to x_t). x_t is *iid* across firms and time and is drawn from a distribution $H(x)$, with density $h(x)$ and positive support with $E(x) = 1$.

Firms base their decisions on expected output net of the expected loan payment before x_t is realized. Here, $\Gamma(\bar{x}_t) = \int_0^{\bar{x}_t} x dH(x) + \int_{\bar{x}_t}^{\infty} \bar{x}_t dH(x)$ denotes the expected gross share of returns going to the lender. Since $\Gamma(\bar{x}_t)$ is increasing in the threshold \bar{x}_t , firms would like to set this cutoff as low as possible, while lenders favor a high cutoff. The optimal cutoff is determined in the maximization problem where firms take into account the participation constraint of the lender given by equation (3). Here, $\mu G(\bar{x}_t) = \mu \int_0^{\bar{x}_t} x dH(x)$. Due to perfect competition in the supply side of financial market, lenders only give credit if their expected payment net of monitoring costs is at least the amount borrowed. Firms use external finance to pay for $1 - \lambda_w$ of the wage cost and $1 - \lambda_v$ of the vacancy net of assets A_t .

Solving the optimization problem delivers the following first order conditions

$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta E_t J_{N_{t+1}} \quad (4)$$

$$\phi_t = \frac{\Gamma'(\bar{x}_t)}{\Gamma'(\bar{x}_t) - \mu G'(\bar{x}_t)} \quad (5)$$

Here, $\chi_t^v = \lambda_v \Omega_t + (1 - \lambda_v) \phi_t$. ϕ_t is the Lagrange multiplier on the participation constraint and increases as the friction, and hence \bar{x}_t , increases. $\Omega(\bar{x}_t) = \frac{\partial J_t}{\partial X_t} = 1 - \Gamma(\bar{x}_t) + \phi_t (\Gamma(\bar{x}_t) - \mu G(\bar{x}_t))$ measures the marginal value of productivity per

worker. An increase in productivity increases the expected profit and also allows firms to borrow more. In the absence of financial frictions, $\lim_{\bar{x} \rightarrow 0} \phi = 1$ and $\lim_{\bar{x} \rightarrow 0} \Omega = 1$ and therefore $\lim_{\bar{x} \rightarrow 0} \chi^v = 1$. 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.

As $\Omega'(\bar{x}_t) > 0$ higher frictions increase the marginal value of productivity since the fall in expected profit is more than offset by the increase in the value of the loan. χ_t^v reflects the financial cost of posting vacancies and multiplies γ . The higher the financial friction, the higher the total cost of posting vacancies. This is driven by a direct effect through the higher financing cost on the vacancies that are externally financed, but also through the fact that internally financed vacancies reduce the value of the firm and hence the value of the loan. The larger the share of externally financed vacancies, the larger the direct effect and the larger χ_t^v and the total cost of posting vacancies.

The marginal value of a worker to the firms is

$$J'_{N_t} = \Omega_t X_t - \chi_t^w W_t + (1 - \delta)\beta E_t J'_{N_{t+1}} \quad (6)$$

with $\chi_t^w = \lambda_w \Omega_t + (1 - \lambda_w)\phi_t$ describing the financial cost of paying wages. In analogy to χ_t^v , $\lim_{\bar{x} \rightarrow 0} \chi^w = 1$ when financial frictions vanish. The higher the financial friction, the higher χ_t^w and the higher the total cost of the wage bill. Externally financed wages directly increase these costs, while internally financed wages reduce the value of the firm and hence the value of the loan. χ_t^w increases in the share of externally financed wages.

One can then write down the job creation condition

$$\frac{\chi_t^v \gamma}{p(\theta_t)} = \beta \left[\Omega_{t+1} X_{t+1} - \chi_{t+1}^w W_{t+1} + (1 - \delta) \frac{\chi_{t+1}^v \gamma}{p(\theta_{t+1})} \right] \quad (7)$$

As financial frictions vanish, the job creation condition converges to the respective condition in a model without financial frictions.

Firms pay a share $1 - \zeta$ of expected profits to shareholders and retain the rest as assets

$$E_t A_{t+1} = \zeta(1 - \Gamma(\bar{x}_t)) [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t] \quad (8)$$

Assets are not taken into account in firm optimization and merely serve as an accounting device that affects the amount of borrowing, in particular over the business cycle. Accumulation of assets ensures that the firm always relies on external finance, i.e., $A_t > (1 - \lambda_w)W_t N_t + (1 - \lambda_v)\gamma V_t$ never occurs.

Define the value of the job to the worker as

$$H_t^N = W_t + \beta E_t [(1 - \delta)H_{t+1}^N + \delta H_{t+1}^U] \quad (9)$$

and the value of unemployment as

$$H_t^U = b + \beta E_t [(1 - f(\theta_t))H_{t+1}^U + f(\theta_t)H_{t+1}^N]. \quad (10)$$

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

2.2 Wage determination

Workers and firms apply Nash bargaining to set wages

$$W_t = \arg \max_{W_t} (H_t^N - H_t^U)^\eta (J'_{N,t})^{1-\eta} \quad (11)$$

which delivers

$$(H_t^N - H_t^U) = \frac{\eta}{(1 - \eta)\chi_t^w} J'_{N,t}. \quad (12)$$

Higher financial frictions increase the surplus share of employers relative to workers. Put differently, financial frictions reduce the effective bargaining power of workers.

Iteration and a few steps of algebra deliver the following wage equation

$$W_t = \eta \left[\frac{\Omega_t}{\chi_t^w} X_t + ((1 - \delta) - (1 - \delta - f(\theta_t)) \frac{\chi_t^w}{E_t \chi_{t+1}^w}) \frac{\chi_t^v}{\chi_t^w} \frac{\gamma}{p(\theta_t)} \right] + (1 - \eta)b \quad (13)$$

Again, without financial frictions, this wage equation is equivalent to the one in the standard MP model. In the presence of financial frictions, these may affect wages in a number of ways.

The productivity wedge Equation (13) shows that the marginal effect of an increase of productivity on the wage may be affected by the financial friction, i.e. $\frac{\partial W_t}{\partial X_t} = \eta \frac{\Omega_t}{\chi_t^w}$. If wages are not 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 $\frac{\Omega_t}{\chi_t^w} < 1$. This means that as soon as part of the wages need to be paid before sales realize, financial frictions induce a wedge such that wages increase less than η when productivity increases. This wedge is independent of how vacancies are financed. Even though higher financial frictions increase the marginal value of the job to the firm as discussed above, firms share less of this increase in value with the worker, i.e. they shift the part of the financing cost to the worker which leads to a fall in wages. The higher the frictions, the higher the wedge, as $\frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{x}_t} < 0$.

Interaction with tightness Equation (13) further shows how financial frictions might interact with labor market frictions. First, assume that $\frac{\chi_t^w}{E_t \chi_{t+1}^w} = 1$. The wage equation then collapses to $W_t = \eta \left[\frac{\Omega_t}{\chi_t^w} X_t + \frac{\chi_t^v}{\chi_t^w} \gamma \theta_t \right] + (1 - \eta)b$. If the part of wages and vacancies that is financed internally is equal, i.e. $\lambda_v = \lambda_w$, then the ratio of the financial costs of paying vacancies and wages $\frac{\chi_t^v}{\chi_t^w} = 1$ and financial frictions do not interact with labor market tightness. If vacancies are

exposed to external finance to a larger degree than wages, i.e. $\lambda_v < \lambda_w$, then $\frac{\chi_t^v}{\chi_t^w} > 1$ and the ratio of financial costs is increasing in the financial friction. Hence, financial frictions make rehiring more expensive for firms and therefore improve the position of the workers already employed and increases wages. The opposite happens when vacancies are exposed to external finance less than wages, i.e. $\lambda_v > \lambda_w$.

Inspecting the mechanism To illustrate the above-mentioned effects, we consider four special cases of our model. Continue to assume that $\frac{\chi_t^w}{E_t \chi_{t+1}^w} = 1$. First, both vacancies and wages are financed internally, i.e. $\lambda_v = 1$ and $\lambda_w = 1$ (case MP). Second, only vacancy posting costs are externally financed and wages are fully financed internally, i.e. $\lambda_v = 0$ and $\lambda_w = 1$ (case V). In the opposite case, wages are financed externally and vacancy posting is financed internally, i.e. $\lambda_v = 1$ and $\lambda_w = 0$ (case W). Finally, both vacancy posting costs and the wage bill are financed externally, i.e. $\lambda_v = 0$ and $\lambda_w = 0$ (case VW). The respective wage equations for all cases are described here

$$W_t^{MP} = \eta [X_t + \gamma \theta_t] + (1 - \eta)b \quad (14)$$

$$W_t^V = \eta \left[X_t + \frac{\phi_t}{\Omega_t} \gamma \theta \right] + (1 - \eta)b \quad (15)$$

$$W_t^W = \eta \left[\frac{\Omega_t}{\phi_t} X_t + \frac{\Omega_t}{\phi_t} \gamma \theta_t \right] + (1 - \eta)b \quad (16)$$

$$W_t^{VW} = \eta \left[\frac{\Omega_t}{\phi_t} X_t + \gamma \theta_t \right] + (1 - \eta)b \quad (17)$$

From this we see that financial frictions affect wages differently depending on what external finance is used for. Case V reflects Petrosky-Nadeau (2014). When vacancies are financed externally the outside option becomes more expensive for the firm and employed workers benefit. When wages are financed externally (cases W and VW), they are subject to the productivity wedge as described above. When only wages are financed externally (case W), the increased costs makes the outside option relatively cheaper for the firm and, hence, the

marginal effect of tightness on wages falls. When both wages and vacancies are financed externally (case VW), the latter effect vanished as wage and vacancy costs are affected by the financial friction in the same way.

Role of expectations 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 frictions tomorrow equal frictions today (frictions follow a random walk). In this case, frictions have no further influence on the wage. Frictions tomorrow may differ from frictions today if changes in monitoring costs μ follow some autoregressive structure or if other terms, e.g. cyclical components affect the evolution of the frictions. In this case, it is reasonable to assume that $\frac{\chi_t^w}{E_t \chi_{t+1}^w} > 1$. One can rewrite

$$(1 - \delta) - (1 - \delta - f(\theta_t)) \frac{\chi_t^w}{E_t \chi_{t+1}^w} = (1 - \delta) \left(1 - \frac{\chi_t^w}{E_t \chi_{t+1}^w}\right) + f(\theta_t) \frac{\chi_t^w}{E_t \chi_{t+1}^w} \quad (18)$$

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. We expect the term $\frac{\chi_t^w}{E_t \chi_{t+1}^w}$ to be small quantitatively. We need verify this in a calibrated version of the model.

Measuring financial frictions Note that our empirical results establish a relationship between leverage and wages. If higher leverage represents higher financial frictions, the wage equation is supported by the empirical results. Leverage in this model can be described the value of debt (borrowing) to assets

$$\frac{\bar{x}_t X_t N_t}{A_t} \quad (19)$$

Financial frictions increase the cost of borrowing \bar{x}_t and hence leverage in this model. As a result, the model provides a rationale for our empirical results on why higher leverage decreases wages.

3 Financial strength and wages in the data

3.1 Data and measurement

We use a unique 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. The administrative data is characterized by an enormous amount of information on workers and establishments and a high degree of reliability of the earnings data. 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). The earnings information on pre-tax wages includes one time pay and bonuses. We restrict the analysis to full-time workers to deal with the issue that we do not have information on hours worked. Further, we consider only wages up to statutory insurance contributions ('Beitragsbemessungsgrenze') to avoid right-censoring. We deflate wages (and all further nominal variables) using the CPI index.

To measure financial strength, we rely on firms' balance sheet information in the ORBIS database as provided by Bureau van Dijk. 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.

The annual balance sheet data has been merged to the administrative establish-

ment data. At the establishment level, we have the administrative employment spells and earnings information for all workers.¹ Our final data set is an unbalanced panel for 2006 to 2014.² We have on average 350,000 establishment and 8 mio. worker observations per year.

Our focus is on how firms' financial strength relates to their wage setting. For financial strength, we aim at measuring how likely it is that a firm faces credit constraints. A firm is more likely to face credit constraints if it is already highly indebted. Thus, our preferred measure of credit constraints at the firm-level is leverage defined as the ratio of debt to total assets. Giroud and Mueller (2017) measure credit constraints by leverage with debt as the sum of current liabilities and long-term debt. We follow their approach in the following. In Appendix B, we provide robustness with other widely applied balance sheet measures of financial constraints (e.g., total assets, the liquidity ratio, short-term debt, collateral and interest coverage ratios). In Table 1, we summarize key characteristics on firms in our sample by leverage. In line with typical arguments in the literature on firms that face credit constraints, high leverage firms are smaller in terms of assets, employees, and sales compared to high leverage firms. They have lower liquidity (see e.g., Gilchrist et al., 2017 on how liquidity relates to financial constraints), are younger, and face a higher probability of exiting the market. The further pay more on interest relative to their earnings, i.e., they have a lower interest coverage ratio. High leverage firms further pay on average lower wages. Naturally, the correlation with wages may be driven by many different explanatory factors. In the following, we develop an empirical approach that allows to control for observed and unobserved characteristics in order to isolate the effect of credit constraints on wage setting.

¹ Note that 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).

² Due to changes in the German financial reporting system, the BvD data is the most reliable from 2006 onward.

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

Table 1: High and low leverage is defined relative to the previous year’s median across firms. Summary statistics for selected establishment characteristics, 2006-2014, mean across all establishments. Interest coverage ratio measures earnings before interest and taxes (EBIT) over interest payments.

3.2 Empirical approach and results

To investigate the effect of financial constraints on wages, our regression model relates to the wage equations derived in Section 2 (equation 13). In these equations, wages depend on financial frictions, productivity which may be influenced by aggregate or idiosyncratic shocks as well as aggregate labor market conditions (tightness) and unemployment benefits. We therefore regress log mean real wages w in June of year t in establishment i on leverage lev (in percent) end of year $t - 1$.

$$w_{it} = \beta_1 lev_{it-1} + \beta_2 x_{it} + \beta_3 x_{it-1} + \beta_4 \mathbf{z}_{it} + \alpha_i + \gamma_t + \epsilon_{it} \quad (20)$$

We include sales over employment x_{it} which is a proxy for model productivity. In the model, productivity may be influenced by both changes in supply and demand. In the data, idiosyncratic changes in supply or demand may affect both wages and leverage. Controlling for sales is therefore important in order to isolate the effect of leverage on wages we will consider in the model below. Given that we look at leverage in $t - 1$, this could potentially be affected by

	(1)	(2)
Leverage (log)	-0.0058***	-0.0046***
Sales t (log)	0.0105***	0.0174***
Sales $t - 1$ (log)	0.0017***	0.0005
Profits $t - 1$ (log)		0.0015***
Est. size dummies	yes	yes
Est. fixed effects	yes	yes
Year fixed effects	yes	yes
R^2 (within)	0.12	0.15
Observations	333,290	115,238

Table 2: Regressions on establishment level. Dependent variable is the log average real wage level at the establishment level. Only private firms. We control for time fixed effects and several establishment characteristics (age, skill, gender of workers). Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

shocks in $t - 1$ as well. For that reason, we control also for sales in period $t - 1$. For robustness, we further control for profits, i.e., sales net of costs as these may potentially affect leverage and wages jointly.³

Next to observable firm and worker characteristics \mathbf{z} and year effects γ_t , we control for establishment fixed effects α_i . This implies that we interpret within-firm changes in leverage only. Observable control variables include average workers' age, the share of high and low skilled workers and the share of females in the establishment's workforce. The year (and sector \times year) fixed effects control for aggregate changes (on the sector level). This is important given that, in the labor market model that we present in Section ??, aggregate labor market conditions affect wages next to firm-specific variables.

The results are summarized in Table 2. If leverage goes up by one percent, real wages fall by 0.006 percent. If leverage increases by one standard deviation⁴, real wages fall by 0.15 percent. Hence, higher leverage results in wage cuts. The wage cuts appear to be small, but relate in size to about one fourth of overall

³ However, we only observe profits for a subset of our firms. For that reason, we treat these results only as a robustness check.

⁴ The mean in-firm standard deviation across leverage is 25 percent

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 wage to leverage is higher in manufacturing (it doubles in some sectors), whereas it tends to be lower in service sectors.

Is it surprising that wages actually 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. 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. These cuts tend to be accepted by workers in particular in times of firm-specific crises situations. Our wages include bonus payments and, consequently, wage cuts may therefore reflect cuts in bonuses. Grund and Walter (2015) show how firms in the German chemical industry cut bonuses of managers in times of economic crisis in these firms. Our finding is 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).

Since we use annual compensation, one may wonder if our estimates reflect that firms adjust hours rather than actual wages? In the data we cannot differentiate the two, but we use full-time workers only. First, the cyclicity of hours of full-time workers in Germany tends to be rather low in general (Snell et al., 2018). Second, hours adjustments may then work through overtime. We believe this to play a small role, however, since more than 50% of employees in Germany have working time accounts (even more in large firms) which substitute for paid overtime hours to a large extent. In addition, paid overtime hours have been decreasing for years in Germany.

The effect of leverage on wages is similar if we make the regression on the worker level (instead of the establishment level). To control for unobservables, we use match specific fixed effects (See Table 3). In Appendix B, we show robustness for different measures of financial strength (next to leverage).

	(1)	(2)
Leverage (log)	-0.0046***	-0.0054***
Sales t (log)	0.0138***	0.0165***
Sales $t - 1$ (log)	0.0034***	0.0033**
Profits $t - 1$ (log)		0.0007
Est. size dummies	yes	yes
Match-fixed effects	yes	yes
Year fixed effects	yes	yes
R^2 (within)	0.10	0.14
Observations	9,888,150	6,524,586

Table 3: Regressions on the worker level. Dependent variable is the (log) real wage at the worker level (non-censored). Only private firms. We control for match and time fixed effects and several worker (age, tenure) and establishment characteristics. Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

In line with other studies (e.g., Boeri et al., 2017), higher leverage decreases employment. Higher leverage increases separations, but there is no significant effect on hiring (See Table 7 in the Appendix).

4 Aggregate implications

4.1 Steady state equilibrium

The following two equations describe the labor market equilibrium in steady state. Wages are given by

$$W = \eta \left[\frac{\Omega}{\chi_w} X + \frac{\chi_v}{\chi_w} \gamma \theta \right] + (1 - \eta)b. \quad (21)$$

and job creation is given by

$$\frac{\gamma}{p(\theta)} = \frac{\beta}{1 - \beta(1 - \delta)} \left(\frac{\Omega}{\chi_v} X - \frac{\chi_w}{\chi_v} W \right) \quad (22)$$

Equilibrium labor market tightness is then determined by (21) and (22) as

$$\frac{\Omega}{\chi_v} X - \frac{\chi_w}{\chi_v} b = \frac{\gamma}{1-\eta} \left(\frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)} + \eta\theta \right) \quad (23)$$

In this equation, the left hand side of the equation unambiguously decreases with financial frictions and relates to what Hagedorn and Manovskii (2008) refer to as the surplus of the job. Since the right-hand side of the equation increases with θ , tightness unambiguously falls with higher frictions (see proof in the Appendix) Hence, since the presence of financial frictions generates the additional cost of obtaining external finance, the surplus from the match always falls. This happens regardless of whether some of these costs are shifted to the worker (wages fall, the surplus still decreases due to the productivity wedge, but not by as much) or not (wages increase which further decreases the surplus in addition to the productivity wedge).

4.1.1 Amplification

Based on the steady state equilibrium in equation (23), one can derive amplification results for labor market tightness with respect to productivity Without financial frictions, amplification is equivalent to the one derived by Hagedorn and Manovskii (2008) for the standard MP model:

$$\epsilon_{\theta, X}^{MP} = \frac{\partial \theta}{\partial X} \frac{X}{\theta} = \frac{\eta\theta + \frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)}}{\eta\theta + \epsilon \frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)}} \left(\frac{X}{X-b} \right) \quad (24)$$

With financial frictions, this expression changes to

$$\epsilon_{\theta, X} = \left(\frac{\frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)} + \eta\theta}{\frac{\frac{1-\beta}{\beta} + \delta}{p(\theta)} \epsilon + \eta\theta} \right) \left[\frac{\frac{\Omega}{\chi_w} X}{\frac{\Omega}{\chi_w} X - b} + \frac{\frac{\partial \frac{\Omega}{\chi_v}}{\partial \bar{x}} X - \frac{\partial \frac{\chi_w}{\partial \bar{x}} b}{\partial \bar{x}}}{\frac{\Omega}{\chi_w} X - b} \frac{\partial \bar{x}}{\partial X} X \right] \quad (25)$$

From this comparison, we see that financial frictions affect the amplification of tightness through two different channels. First, amplification is higher with

compared to without financial frictions, since it induces a lower surplus from the job (as discussed above) (see Appendix for deriving that $\frac{\frac{\Omega}{\chi^w} X}{\frac{\Omega}{\chi^w} X - b} > \frac{X}{X - b}$). A lower level of the surplus induces a larger gain in the surplus when productivity increases which follows the argumentation by Hagedorn and Manovskii. Second, higher productivity implies lower financial frictions, i.e. $\frac{\partial \bar{x}}{\partial X} < 0$. Since this makes the surplus fall, amplification increases over and above the level effect. The following two equations compare the effect of the business cycle on wages. Following the literature, we address wage rigidity through the direct effect of productivity on the wage only, i.e., by setting $\frac{\partial \theta}{\partial X} = 0$. Without financial frictions

$$\frac{\partial W}{\partial X} = \eta \quad (26)$$

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

$$\frac{\partial W}{\partial X} = \eta \left(\frac{\Omega}{\chi^w} + X \frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} + \gamma \theta \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} \right) \quad (27)$$

Since it decreases wages, the presence of the productivity wedge makes wages respond to the cycle less compared to a situation without financial frictions. Since the wedge increases with frictions and frictions decrease with productivity, the disappearing wedge makes wages respond more to the cycle. If frictions interact with labor market tightness in such a way that increasing frictions decrease the wage when tightness increases (i.e. $\lambda_v > \lambda_w$ and vacancies are exposed less to external finance than wages), wages respond even more to the cycle. The response is muted in the opposite case.

As before, it is insightful to consider different special cases. With differing assumptions about whether vacancy posting costs are fully externally financed and/or wages are fully externally financed, the reactions of tightness are given

by

$$\epsilon_{\theta,X}^V = \frac{\eta\theta + \frac{1-\beta}{p(\theta)} + \delta}{\eta\theta + \epsilon \frac{1-\beta}{p(\theta)} + \delta} \left[\frac{X}{X-b} + \frac{\frac{\partial \Omega}{\partial \bar{x}} X - \frac{\partial \Omega}{\partial \bar{x}} b}{X-b} \frac{\partial \bar{x}}{\partial X} X \right] \quad (28)$$

$$\epsilon_{\theta,X}^W = \frac{\eta\theta + \frac{1-\beta}{p(\theta)} + \delta}{\eta\theta + \epsilon \frac{1-\beta}{p(\theta)} + \delta} \left[\frac{\frac{\Omega}{\phi} X}{\frac{\Omega}{\phi} X - b} + \frac{-\frac{\partial \phi}{\partial \bar{x}} b}{\frac{\Omega}{\phi} X - b} \frac{\partial \bar{x}}{\partial X} X \right] \quad (29)$$

$$\epsilon_{\theta,X}^{VW} = \frac{\eta\theta + \frac{1-\beta}{p(\theta)} + \delta}{\eta\theta + \epsilon \frac{1-\beta}{p(\theta)} + \delta} \left[\frac{\frac{\Omega}{\phi} X}{\frac{\Omega}{\phi} X - b} + \frac{\frac{\partial \Omega}{\partial \bar{x}} X}{\frac{\Omega}{\phi} X - b} \frac{\partial \bar{x}}{\partial X} X \right] \quad (30)$$

The corresponding reactions of wages are given by

$$\frac{\partial W^V}{\partial X} = \eta \left(1 + \gamma\theta \frac{\partial \phi}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} \right) \quad (31)$$

$$\frac{\partial W^W}{\partial X} = \eta \left(\frac{\Omega}{\phi} + \frac{\partial \Omega}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} (X + \gamma\theta) \right) \quad (32)$$

$$\frac{\partial W^{VW}}{\partial X} = \eta \left(\frac{\Omega}{\phi} + X \frac{\partial \Omega}{\partial \bar{x}} \frac{\partial \bar{x}}{\partial X} \right) \quad (33)$$

In case V, i.e. only vacancy posting costs are externally financed and wages are fully financed internally, wages respond positively to financial frictions. Hence, when frictions decrease with increasing aggregate productivity, wages increase less and can hence be considered to be more rigid than in the case without financial frictions. Tightness, however, reacts more to the cycle. Higher wages decrease the surplus and the surplus can increase by more if wages do not respond as much if productivity enhances.

If wages are externally financed, the productivity wedge affects the response of wages to the cycle (negatively through the level and positively through its cyclical response as discussed above). If vacancies are also externally financed (case VW), there is no interaction of financial frictions and the reaction labor market tightness and wages and tightness works through the productivity wedge only. If vacancies are not externally financed (case W), financial frictions negatively

interact with financial frictions, since the relative cost of posting vacancies decreases. This makes wages respond more than in the case VW. The elasticity of tightness, however, driven by two different mechanisms.

This establishes two main results: Depending on how much wages and vacancies are subject to external finance and also depending on how much the relative financial cost of wages and vacancy is affected by external finance, wages may increase or decrease and react more or less strongly to the cycle. The elasticity of tightness over the cycle increases irrespective of the underlying financial structure. Put differently, in the presence of financial frictions, it may be possible to observe higher economic volatility together with both lower but also higher wage rigidity. Our results supports the latter relationship in contrast to what has been argued in the literature . Different effects are responsible for the increase in tightness and the elasticity may differ in strength depending on this structure.

5 Conclusions

To be completed.

References

- Antoni, M., K. Koller, M.-C. Laible, and F. Zimmermann (2018). Orbis-adiab: From record linkage key to research dataset: Combining commercial company data with administrative employer-employee data. *FDZ Methodenreport 04/2018*.
- Benmelech, E., N. K. Bergman, and R. J. Enriquez (2012). Negotiating with labor under financial distress. *The Review of Corporate Finance Studies* 1(1), 28–67.
- Bernanke, B. S., M. Gertler, and S. Gilchrist (1996). The flight to quality and the financial accelerator. *Review of Economics and Statistics* 78(1), 1–15.
- Blanchflower, D. G., A. J. Oswald, and M. D. Garrett (1990). Insider power in wage determination. *Economica* 57(226), 143–170.
- Boeri, T., P. Garibaldi, and E. R. Moen (2015). Financial frictions, financial shocks and unemployment volatility. *CEPR Discussion Paper 10648*.
- Boeri, T., P. Garibaldi, and E. R. Moen (2017). Financial constraints in search equilibrium: Mortensen pissarides meet holmstrom and tirole. *Labour Economics*. forthcoming.
- Carlstrom, C. T. and T. S. Fuerst (1997). Agency costs, net worth, and business fluctuations: A computable general equilibrium analysis. *The American Economic Review* 87(5), 893–910.
- Chugh, S. K. (2013). Costly external finance and labor market dynamics. *Journal of Economic Dynamics and Control* 37(12), 2882–2912.
- Garin, J. (2015). Borrowing constraints, collateral fluctuations, and the labor market. *Journal of Economic Dynamics and Control* 57, 112 – 130.

- Gerlach, K., D. Levine, G. Stephan, and O. Struck (2006). The acceptability of layoffs and pay cuts: Comparing north america with germany. *IAB Discussion Paper 01/2006*.
- Gilchrist, S., R. Schoenle, J. Sim, and E. Zakrajšek (2017). Inflation dynamics during the financial crisis. *The American Economic Review* 107(3), 785–823.
- Giroud, X. and H. M. Mueller (2017). Firm leverage, consumer demand, and employment losses during the great recession. *The Quarterly Journal of Economics* 132(1), 271–316.
- Grund, C. and T. Walter (2015). Management compensation and the economic crisis: longitudinal evidence from the german chemical sector. *Review of Managerial Science* 9(4), 751–777.
- Guiso, L., L. Pistaferri, and F. Schivardi (2013). Credit within the firm. *The Review of Economic Studies* 80, 211–247.
- Hagedorn, M. and I. Manovskii (2008). The cyclical behavior of equilibrium unemployment and vacancies revisited. *American Economic Review* 98(4), 1692–1706.
- Kalemli-Ozcan, S., B. Sorensen, and S. Yesiltas (2012). Leverage across firms, banks, and countries. *Journal of International Economics* 88(2), 284–298.
- Michelacci, C. and V. Quadrini (2009). Financial markets and wages. *The Review of Economic Studies* 76(2), 795–827.
- Petrosky-Nadeau, N. (2009). Credit, vacancies and unemployment fluctuations. *Carnegie Mellon University Working Paper*.
- Petrosky-Nadeau, N. (2014). Credit, vacancies and unemployment fluctuations. *Review of Economic Dynamics* 17, 191–205.
- Schoefer, B. (2015). The financial channel of wage rigidity. Working Paper.

- Snell, A., H. Stüber, and J. P. Thomas (2018). Downward real wage rigidity and equal treatment wage contracts: Theory and evidence. *Review of Economic Dynamics* 30, 265 – 284.
- Stüber, H. (2017). The real wage cyclicalities of newly hired and incumbent workers in Germany. *The Economic Journal* 127(600), 522–546.
- Zanetti, F. (2017). Financial shocks, job destruction and labor market fluctuations. *Macroeconomic Dynamics* forthcoming.

A Data appendix

Details on Orbis-ADIAB:

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

Details on balance sheet data:

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

B Robustness for empirical results

B.1 Different measures of financial constraints

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

These measures include:

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

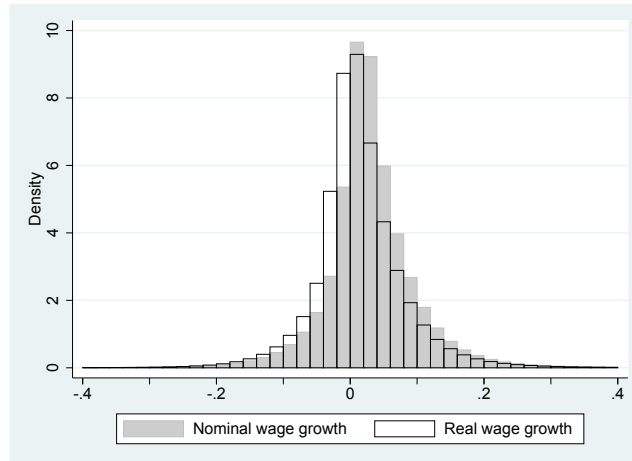


Figure 1: Wage growth distribution: 2007-2014, Germany.

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

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

	(1)	(2)	(3)	(4)	(5)
	Short-term debt (%)	Total assets (log)	Liq. ratio (log)	Collateral over debt (log)	Interest over debt (log)
Financial variable	-0.00101***	0.01157***	0.00112***	0.00122***	-0.00072***
Sales t (log)	0.01023***	0.00908***	0.00953***	0.00967***	0.01437***
Sales $t - 1$ (log)	0.00279***	0.000940 *	0.00157***	0.00182***	0.00608***
Est. size dummies	yes	yes	yes		
Est. fixed effects	yes	yes	yes		
Year \times sector	yes	yes	yes		
R^2 (within)	0.13	0.12	0.12	0.16	
Observations	252,036	333,634	333,602	331,378	91,022

Table 4: Dependent variable is the log average real wage level at the establishment level. Only private firms. We control for time fixed effects and several establishment characteristics (age, skill, gender of workers). Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

	(1)	(2)
Leverage (log)	-.0591811***	-0.0586936***
Sales t (log)	0.0823404***	0.0816869***
Sales $t - 1$ (log)	0.0275546***	0.0284709***
Est. size dummies	yes	yes
Year \times sector fixed effects		yes
R^2 (within)	0.61	0.61
Observations	220,643	220,643

Table 5: Dependent variable is the log average real wage level at the establishment level. Leverage in 2006 only. Only private firms. We control for time fixed effects and several establishment characteristics (age, skill, gender of workers, sector, state). Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

B.2 Leverage in 2006 only

B.3 By sector

[tbd]

B.4 Controlling for worker and establishment fixed effects

	(1)	(2)
Leverage (log)	-0.00557***	-0.00837***
Sales t (log)	0.01324***	0.02184***
Sales $t - 1$ (log)	0.00299***	0.00800***
Est. size dummies	yes	yes
Fixed effects	establishment	worker
Year \times sector fixed effects	yes	yes
R^2	0.98	0.98
Observations	7,614,214	9,467,475

Table 6: Dependent variable is the (log) real wage at the worker level (non-censored only). Only private firms. We control for establishment and worker and time fixed effects and several worker and establishment characteristics (the number of observations changes because we use different control variables in each setting). Standard errors are clustered at the establishment level. Sample period is 2007 to 2014.

B.5 Employment and flow rate regressions

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

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

C Calibration

The calibration follows Petrosky-Nadeau (2014) one to one.

Parameter	Value	Target
β	0.992	3.3% annual return
γ	0.14	cost of vacancies 3%
δ	0.06	
ϵ	0.72	
η	0.5	
b	0.71	
σ_x	0.015	quarterly default rate 1.5%
ζ	0.0098	proportion of externally funded vacancy costs 1/3
$s_0 = 1 - \mu$	0.9	

Table 8: Baseline calibration in line with Petrosky-Nadeau (2014).