Financial constraints, wages, and macroeconomic implications†

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November 2, 2023

Abstract

How do individual wages adjust to changes in financial constraints at the firm level and what does this imply about aggregate wage dynamics in recessions with tight financial constraints? We derive testable implications for different theoretical mechanisms and estimate these based on German administrative data on workers linked to detailed information on the balance sheets of firms. Larger financial constraints induce lower wages overall. Using a model with labor market and financial frictions, we link our micro-estimates to the aggregate volatility of wages and unemployment. Tighter financial conditions make both wages and unemployment more volatile in financial recessions. Financial constraints render hiring subsidies in financial recessions less effective.

Keywords: financial frictions, wages, search and matching, unemployment, business cycles
JEL-Codes: E32, E44, J63, J64

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† We thank various participants at the EM^{3}C 2018, the DFG Macroeconomics and the Labor Market Conference in Mannheim, the EES Workshop in Vienna, the Vienna Macro Workshop 2018, the ifo Conference on Macroeconomics and Survey Data 2018, ESSIM 2019, the IZA Workshop: Heterogeneity and the Labor Market and at various seminar presentations for useful comments. We further thank Martin Scheffel, Dmitriy Sergeyev, Ludo Visschers and Karl Walentin for helpful discussions of earlier versions of the paper and Marie-Christine Laible and Heiko Stüber for valuable support with the data. We acknowledge financial support from the German Research Foundation (DFG, GE 3542/2-1).

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1 Introduction

It is well documented in the macroeconomic literature how the presence of financial frictions increases the volatility of output and unemployment.[1] This paper focuses on two related questions that have received much less attention so far: How do individual wages adjust to changes in financial constraints at the firm level and what does this imply about aggregate wage dynamics in recessions with tight financial constraints?

In this paper, we use a model with financial and labor market frictions that unifies different theoretical mechanisms of how wages respond to firms' financial constraints. Based on linked employer-employee data, we then test the presence, direction and relative strength of the different theoretical mechanisms empirically and find that firms with tighter financial constraints pay lower wages on average. We link our micro-level estimates to our model and document how small estimated ceteris paribus effects can be in line with substantial aggregate volatility. Financial constraints weaken the link between wage rigidity and unemployment volatility in financial compared to normal recessions. As a consequence, both aggregate wages and unemployment become more volatile. We further show how a subsidy to hiring may be less effective in financial recessions and may generate additional downward pressure on wages. As wages largely determine household income, financial constraints turn out to be crucial to evaluate the cost of business cycles not only through their effect on unemployment, but also through their effect on wages.

We present 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). We consider three mechanisms of how the financial conditions of firms affect their labor demand and wages. First, firms use external finance to pay for wages (or more generally working capital if wages are part of or complementary to working capital). This creates a financial labor wedge (see e.g., Jermann and Quadrini, 2012 or Neumeyer and Perri, 2005) which implies that wages fall when financial conditions are tighter. Second, if labor market frictions are present, hiring can be seen as an investment activity that is determined by labor market conditions (tightness) as well as by the cost of paying the marginally employed worker relative to searching for and hiring a new worker. The cost of hiring affects the bargaining position of workers already employed and, hence, wages. Financial conditions affect this relative cost either directly when the cost of posting vacancies is paid for with external finance (compare Petrosky-Nadeau, 2014, Wasmer and Weil, 2004 or Monacelli et al., 2023) or indirectly when hiring today implies the use of external finance to pay for wages in the future. If the direct financial cost of hiring is large, wages are higher when financial conditions are tighter. Wages are lower if the indirect financial cost of hiring is large. Third, the financial costs change over time. If firms expect the indirect cost of hiring to increase, e.g., when moving towards a financial recession, wages fall.

We derive empirically testable implications based on the theoretical wage equation which we estimate using a large data set for Germany for the years 2006 to 2014. Our data combines administrative data on workers and firms with detailed information on firms' balance sheets. Motivated by the model, we measure financial constraints using the interest burden, i.e., interest payments relative to long-term debt. We control for a large number of observed and unobserved aspects that may affect the financial conditions of firms as well as wages. In our tightest specification,

[1] See e.g., Wasmer and Weil (2004).

we consider how changes in firm output and labor market tightness affect individual wages in ongoing worker-firm matches, and how these changes interact with the financial conditions of the firm. This allows us to rule out composition effects on the firm and worker levels.

Our empirical results suggest that the financial labor wedge is present in the data. We also document a significant and positive effect of financial hiring costs on wages. From the viewpoint of our model, this means that firms use external finance to pay for both wages and hiring costs and that hiring costs are exposed to external finance to a larger degree compared to wages. This is intuitive if hiring (investment) expenses need to be paid before production, while only some of the wage (working capital) costs may be incurred before production. Our results therefore reject existing special cases in the literature that exclusively rely on the use of external finance for either the full wage costs or the full vacancy costs (Chugh, 2013, Petrosky-Nadeau, 2014, Garin, 2015, Zanetti, 2019). Our results reject that wages are completely rigid or respond to changes in financial conditions through changes in aggregate conditions only (as in Caggese et al., 2019, Boeri et al., 2018, or Schoefer, 2021).

Our estimation provides ceteris paribus effects of productivity, tightness and financial conditions on wages. We then link the estimated coefficients to parameters in our model. In particular, we use the implied shares of external finance in wage and vacancy posting cost as a portable statistic to inform the aggregate dynamics (see Nakamura and Steinsson, 2018). The aggregate model dynamics contain a level effect of the business cycle, feedback from the labor market equilibrium and feedback from financial conditions that change over the cycle. Our estimated effect of productivity refers to the level effect of the business cycle under the assumption that match-level wages react to idiosyncratic and aggregate changes in productivity in the same way which is a conventional assumption in the search-and-matching literature.[2] Our calibrated model is able to match the estimated level effects which are small on average.

Financial constraints endogenously loosen in a boom and tighten in a recession. These feedback effects are not reflected in the estimation, but can be addressed by the model. Our model shows that a counter-cyclical financial labor wedge amplifies the wage response over the cycle. In contrast, a counter-cyclical financial cost of hiring relative to paying wages today buffers the wage response. In a boom, firms further expect financial constraints to increase in the future when the boom ends. Consequently, the expected financial cost of paying wages tomorrow compared to today increases. This raises the indirect financial cost of investing in hiring and future employment and makes current employees more valuable such that firms are willing to pay higher wages in the current boom. This last effect turns out to be quantitatively large (ten times larger than the estimated level effect). As a result, on net, wages become more pro-cyclical.

All financial channels amplify tightness and unemployment volatility. Generally, a larger volatility in wages leads to less volatility in tightness as higher wages depress the surplus. However, we find that wages are not the main driver of unemployment amplification when financial constraints are present. Instead, firms' expectations about future financial constraints are crucial. While financial constraints are low in a boom, firms expect them to increase again in the future rendering future hires more expensive. This makes current workers more valuable and hence, increases hiring today. As a result, financial constraints de-couple the direct link between wage rigidity and tightness volatility that has been discussed in the literature (e.g., Hall, 2005 or Shimer, 2005).

[2] To back this empirically, we confirm our baseline estimates exploring county-level variation in export exposure. Export exposure reflects changes in aggregate demand in the spirit of Giroud and Mueller (2017).

We show that the different financial mechanisms play a crucial role when investigating countercyclical labor market policy. In a normal recession, a subsidy to hiring decreases unemployment and increases wages together with labor market tightness. In a financial recession, the subsidy makes unemployment fall less as financial constraints increase with more hiring both directly and indirectly through financing wages. A subsidy to hiring may even decrease wages if the dynamic effect is strong and hiring tightens financial constraints more today than tomorrow.

This study abstracts from additional channels through which firm finance and wages may interact. One aspect is the financing of additional labor costs due to training or on-the-job bargaining. Two more aspects are widely discussed in the empirical finance literature (see e.g., Matsa, 2018). On the one hand, financial distress in a firm increases unemployment risk for which the worker seeks to be compensated for in terms of higher wages. On the other hand, the capital structure in a firm may strategically be used to affect wages (see e.g., Monacelli et al., 2023) or firms may adjust their capital-labor structure in response to financial constraints (Laeven et al., 2023).

Our study relates to the empirical literature on the relationship between financial conditions in a firm and wages.[3] Michelacci and Quadrini (2009) use firm growth to measure financial constraints and find that small, growing firms offer lower entry wages. This finding is confirmed by Guiso et al. (2013). Blanchflower et al. (1990) have used cross-sectional evidence to document a positive relationship between financial performance and wages. Benmelech et al. (2012) find that financial distress generated wage concessions in a US airline company between 2003 and 2006. Popov and Rocholl (2018) use regional variation in shocks to German savings banks during the financial crisis to show that average firm-level wages in Germany were reduced in response to negative credit shocks. Apart from our paper, only Moser et al. (2020) apply a large administrative employer-employee panel data. While we use balance-sheet information to measure the financial conditions of firms directly and over time, Moser et al. (2020) explore credit supply through exposure to negative monetary policy rates in an event study for the year 2014. They focus on the effects of credit supply on within and between firm wage inequality without taking into account specific financial channels or general equilibrium effects. Our study further relates to DSGE models with labor and financial frictions such as Mumtaz and Zanetti (2016) and speaks to the literature that shows that labor market variables become more volatile during recessions (Ferraro, 2018, Pizzinelli et al., 2020, Petrosky-Nadeau and Zhang, 2021). Our results suggest an important role of financial factors for this state dependence.

The remainder of the paper is organized as follows. Section 2 develops the model and derives the theoretical mechanisms how financial constraints affect wages. Section 3 presents the data and the empirical results on the estimation of the wage equation. Section 4 discusses the calibration of the quantitative model, the simulation and the policy experiment. Section 5 concludes.

2 Financial strength and wages: Theory

In this section, we present a theoretical model that describes the relationship between wages and financial frictions of firms in a setup with 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

[3] The literature on firms' financial conditions and employment since the Great Recession is much larger and includes, e.g., Chodorow-Reich (2013) and Giroud and Mueller (2017).

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. 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 analytic way. We will discuss 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. This means that we abstract from a consumption-savings choice and capital. Our model nests several existing contributions to the literature as special cases (see discussion below).
Firms in our economy solve the following optimization problem

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

subject to

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

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

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

J_{it} describes discounted profits of the shareholders of the firm i in period t. Firms have many employees N_{it} who all 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: $X_{it} = X_t + x_{it}$, where $E(x_{it}) = 0$. 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 $U_t = 1 - N_t$ and ξ measures matching efficiency. Firms do not take into account that opening vacancies has an effect on labor market tightness. There is a measure one of firms in the economy. Aggregate labor input is then given by $N_t = \int_0^1 N_{it}di$, aggregate vacancies are described by $V_t = \int_0^1 V_{it}di$, and aggregate output is defined as $Y_t = X_t N_t$.[4] Job separations occur exogenously at rate δ.
Firms in our model need to pay for wages and vacancy posting costs which we interpret more generally as also including costs for personnel, for search and interviewing. In the literature, wage payments are usually included in working capital, while vacancy costs relate to recurring

[4] For aggregate output, we use that $E(x_{it}) = 0$.

and new investment. Due to a cash flow mismatch, firms may rely on external finance to pay for the wage bill and vacancy costs. The remainder of the costs is then financed internally (out of savings, defined below). Note that most existing models focus on the use of external finance either for wages (working capital) or for vacancy posting costs (investment) only.[5] Our model allows firms to use external finance for both of these costs.[6] This replicates evidence for Germany that firms use 34% and 26% of their external finance to pay for working capital and for hiring and training costs respectively.[7] Our model is generalized compared to existing studies in a different dimension: Only a part $(1-\lambda_w)$ of wages and a part $(1-\lambda_v)$ of vacancy posting costs have to be paid before production and sales have been realized. The wage bill and vacancy posting costs may therefore be exposed to external finance to different degrees. The shares λ_w and λ_v are exogenously given in our model. As we will discuss further below, they determine the presence, direction and strength of the financial channels in the model. We will use empirical evidence to pin down the relevance of these shares. 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).[8] To obtain external finance, firms and lenders sign a financial contract which is 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 μ. 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 $\left(\omega_{it}-\bar{\omega}_{it}\right)\left[\left(X_{it}-\lambda_w W_{it}\right)N_{it}-\lambda_v\gamma V_{it}\right]$. If $\omega_{it}<\bar{\omega}_{it}$, the firm defaults and all revenue is claimed by the lender. The firm keeps its 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, $\mu G(\bar{\omega}_{it})=\mu\int_0^{\bar{\omega}_{it}}\omega dH(\omega)$ describes the expected monitoring cost. Due to perfect competition on the supply side of the financial market, lenders only give credit if their expected payment net of monitoring costs equals the amount borrowed.

The external finance premium in our model can be described by expected monitoring costs relative to the amount borrowed

$$\frac{\mu G(\bar{\omega}_{it})\left[\left(X_{it}-\lambda_w W_{it}\right)N_{it}-\lambda_v\gamma V_{it}\right]}{(1-\lambda_w)W_{it}N_{it}+(1-\lambda_v)\gamma V_{it}-A_{it}}. \tag{5}$$

Firms have committed to pay a fixed share $1-\zeta$ of expected profits to shareholders and retain the rest as assets A_{it} 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. This ensures that, in

5 See for example the discussion in Carlstrom and Fuerst (1998) or Quadrini (2011).
6 As also in Chugh (2013) or Garin (2015).
7 Numbers for small and medium enterprises in Germany, 2017. See Survey on the access of finance of enterprises (SAFE) conducted by the ECB.
8 As discussed in more detail later, our results do not depend on this assumption. A setting with collateral constraints as in Jermann and Quadrini (2012) generates similar results. See also Appendix A.4.2.

line with the data, firms use a mixture of internal and external finance and follows much of the literature (see e.g. Chugh, 2013). If the price of the loan increases, savings fall which increases the overall cost of borrowing in the next period. In Appendix A.4.3 we relax this constraint and allow firms to react to changes in financial constraints by using more internal savings. In this case. they could in principle outsave the financial constraints. This would buffer the effects described in the baseline model. However, given that costs are typically high relative to profits, internal savings cannot fully replace external finance.

The timing of events in each period is as follows: Productivity X_{it} is realized, and given employment and savings from the last period, firms decide about posting vacancies. Firms borrow from financial markets to pay the wage and vacancy costs that are due before production ($(1-\lambda^v)\gamma V$ and $(1-\lambda^w)WN$). Then, firms produce and pay the outstanding wage and vacancy posting costs ($\lambda^v\gamma V$ and $\lambda^w WN$). Then, the idiosyncratic revenue shocks ω_{it} are realized. Firms repay their debt or default on the loan. New matches are made at the end of the period and turn productive in the next period.

Solving the optimization problem delivers the following first-order conditions

$$\phi_{it} = \frac{(1-\zeta+(1+r)\zeta\Delta_{it})\Gamma'(\bar{\omega}_{it})}{\Gamma'(\bar{\omega}_{it})-\mu G'(\bar{\omega}_{it})} \tag{6}$$

$$\Delta_{it} = \beta\phi_{i,t+1} \tag{7}$$

$$\frac{\chi^v_{it}\gamma}{p(\theta_t)} = \beta E_t J_{N_{i,t+1}} \tag{8}$$

Here, ϕ_{it} describes the Lagrange multiplier on the participation constraint and Δ_{it} the Lagrange multiplier on the savings constraint. Equation (6) indicates that when the threshold $\bar{\omega}$ increases, expected dividends to shareholders decrease (numerator) but firms can also borrow more (denominator). Hence, ϕ_{it} reflects the cost of borrowing. Equation (7) implies that the marginal value of a one unit increase in savings Δ_{it} is equal to the discounted marginal value of relaxing the financial constraint in the next period. In Equation (8), $E_t J_{N_{i,t+1}}$ is the expected marginal value of a representative worker to firm i at $t+1$. The current marginal value is given by

$$J_{N_{it}} = \frac{\partial J_{i,t}}{\partial N_t} = \Omega_{it}X_{it} - \chi^w_{it}W_{it} + (1-\delta)\beta E_t J_{N_{i,t+1}}. \tag{9}$$

Further,

$$\Omega_{it} = (1-\zeta)\left[1-\Gamma(\bar{\omega}_{it})\right] + (1+r)\zeta\Delta_{it}\left[1-\Gamma(\bar{\omega}_{it})\right] + \phi_{it}\left[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})\right] \tag{10}$$

$$\chi^w_{it} = \lambda_w\Omega_{it} + (1-\lambda_w)\phi_{it} \tag{11}$$

$$\chi^v_{it} = \lambda_v\Omega_{it} + (1-\lambda_v)\phi_{it} \tag{12}$$

Equation (10) measures how an increase in productivity net of internally financed wage and vacancy costs affects the value of a firm $\Omega(\bar{\omega}_{it}) = \frac{\partial J_{it}}{\partial(X_{it}-\lambda_w W_{it})N_{it}-\lambda_v\gamma V_{it}}$. An increase in productivity net of internally financed wage and vacancy costs relaxes the participation constraint of the financial contract directly (third term) and indirectly through more savings (second term) and generates higher dividends to shareholders (first term). Equations (11) and (12) describe the financial cost of paying wages, χ^w, and vacancies, χ^v, respectively. An increase in financial frictions raises these costs. This happens directly via ϕ, since the amount borrowed tightens the participation

constraint of the lender. There is also an indirect financial cost, since internally financed wages or vacancies reduce revenues. The indirect cost hence increases in the financial benefit of revenues described by Ω_{it}.[9]
From the first-order conditions, one can then derive the job creation condition

$$\frac{\chi_{it}^{v}\gamma}{p(\theta_t)} = \beta\left[E_t\Omega_{i,t+1}X_{i,t+1} - E_t\chi_{i,t+1}^{w}W_{i,t+1} + (1-\delta)E_t\frac{\chi_{i,t+1}^{v}\gamma}{p(\theta_{t+1})}\right]. \tag{13}$$

Firms post vacancies until the expected cost of posting a vacancy including the cost of external finance, χ^v, and weighted by the probability to fill the vacancy $p(\theta_t)$ equals the expected profit. The expected profit is affected by the conditions of external finance and depends on the opportunity cost of not having to search once the vacancy is filled.
The present value of the job to the worker in firm i depends on the current wage plus the discounted expected future values weighted with the separation risk

$$H_{it}^{N} = W_{it} + \beta E_t\left[(1-\delta)H_{i,t+1}^{N} + \delta H_{t+1}^{U}\right] \tag{14}$$

and the value of unemployment

$$H_{t}^{U} = b + \beta E_t\left[(1-f(\theta_t))H_{t+1}^{U} + f(\theta_t)H_{i,t+1}^{N}\right] \tag{15}$$

depends on the unemployment benefit b and the discounted expected future values weighted with the job finding rate $f(\theta_t) = \xi\theta_t^{1-\epsilon}$.
Workers and firms apply Nash bargaining to set wages. Workers and firms take the financial variables as given when bargaining as firms and lenders take wage and hiring costs as given when signing financial contracts. We follow Petrosky-Nadeau (2014) and Chugh (2013) in assuming that the wage contract does not internalize the effect of wages on the financial constraint (price of the loan) itself as the financial contract does not internalize the effect of the price of the loan on the wage. This can be justified by a timing assumption or one may argue that bargaining happens at the individual level and firms do not take into account how individual wages affect firm-level financial conditions.
Based on this, we obtain the following wage equation (see Appendix A.1 for the derivation):

$$W_{it} = \eta\left[\frac{\Omega_{it}}{\chi_{it}^{w}}X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t))\frac{\chi_{it}^{w}}{E_t\chi_{i,t+1}^{w}}\big)\frac{\chi_{it}^{v}}{\chi_{it}^{w}}\frac{\gamma}{p(\theta_t)}\right] + (1-\eta)b \tag{16}$$

Wages are set as a weighted average (weighted with the bargaining power of workers) of the outside option of workers, unemployment benefit b, and the profits of firms. Wages depend on the terms of external finance. Without financial frictions, $\mu = 0$ and also $\phi = 1$ (see A.2.3 in the Appendix). This then delivers $\Omega = \chi^v = \chi^w = 1$ and equations (13) and (16) describe the labor market equilibrium in the standard MP model. No financial frictions imply zero monitoring costs which means that lenders do not have to pay attention to who is below or above the cutoff. If there are no monitoring costs, lenders do not charge a premium. When financial frictions are present, these affect wages through different channels which we will discuss in detail in the next section.

[9] Note that $\phi > \Omega$ and that the financial cost of wages (or vacancies) increases in $1-\lambda^w$ (or $1-\lambda^v$), see Appendix A.2.1 and A.2.2.

2.2 How finance affects wages

Financial frictions affect wages through the financial benefit of revenues Ω_{it}, the financial cost of paying wages today χ^w_{it}, expectations about this financial cost tomorrow $\chi^w_{i,t+1}$, and the financial cost of paying vacancies χ^v_{it}. These financial variables are endogenous and move for example with firm productivity X_{it}. Whether and how they affect wages depends, however, on how external finance is used in the firm, i.e., on λ_w and λ_v.

2.2.1 The financial labor wedge

The first summand in equation (16) shows that there exists a labor wedge between firm productivity and the wage which depends on the wage bargaining parameter η and the term $\frac{\Omega_{it}}{\chi^w_{it}}$ which is the ratio of the financial value of productivity to the financial cost of paying wages. If wages are not externally financed, $\lambda_w = 1$ and $\chi^w_{it} = \Omega_{it}$. If a part of wages is externally financed $\lambda_w < 1$ and $\frac{\Omega_{it}}{\chi^w_{it}} < 1$. We refer to this as the financial labor wedge channel. The higher the financial friction μ, the larger the wedge for a given X_{it} (i.e., the smaller $\frac{\Omega_{it}}{\chi^w_{it}}$, see A.2.4 in the Appendix for the derivation). An improvement in X_{it} reduces financial constraints and therefore reduces the financial labor wedge. Note that the financial labor wedge is present even if vacancies are not financed externally ($\lambda_v = 1$) and even if there are no labor market frictions in the economy.

2.2.2 The financial cost of hiring

If $\frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}} = 1$, the second summand in equation (16) collapses to $\eta\frac{\chi^v_{it}}{\chi^w_{it}}\gamma\theta_t$. This happens in steady state and whenever the financial cost of paying wages is not expected to change. Financial frictions therefore interact with tightness if $\lambda_v \neq \lambda_w$, since in this case $\frac{\chi^v_{it}}{\chi^w_{it}} \neq 1$, i.e., the financial cost of paying vacancies differs from the financial cost of paying wages. 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 vacancy posting costs are exposed to external financing needs to different degrees. If $\lambda_v < \lambda_w$, the financial cost of hiring is larger than the financial cost of wages ($\frac{\chi^v_{it}}{\chi^w_{it}} > 1$) which improves the bargaining position of the already employed workers. If $\lambda_v > \lambda_w$, the financial cost of hiring is smaller than the financial cost of wages and the bargaining position of workers worsens ($\frac{\chi^v_{it}}{\chi^w_{it}} < 1$). For a given X_{it} and θ_t, a higher financial friction μ intensifies/weakens this effect on the overall hiring cost, respectively.[10] An improvement in X_{it} reduces financial constraints and therefore weakens/intensifies the effect of the financial cost of hiring, respectively.

2.2.3 The forward-looking hiring cost

In the model, it generally holds that $\frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}} \neq 1$. Then, the expected financial cost of paying wages tomorrow is different from today. In this case, finance interacts with labor market tightness even if $\lambda^v = \lambda^w$ and if $\lambda^v \neq \lambda^w$ even if hiring is not financed externally at all ($\lambda^v = 1$). This is the case since new hires today will be paid wages tomorrow which constitutes an indirect financial cost of hiring. If the financial cost of paying wages is expected to increase in the future compared to today ($\frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}} < 1$), the overall hiring cost is larger and the bargaining position of the already employed workers improves. If the financial cost of paying wages is expected to decrease in the

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

future compared to today, $\frac{\chi_{it}^{w}}{E_t\chi_{i,t+1}^{w}} > 1$, which weakens the position of the already employed. The forward-looking hiring cost therefore intensifies or offsets some of the direct effects discussed above. It holds that $\frac{\chi_{it}^{w}}{E_t\chi_{i,t+1}^{w}} \neq 1$ if X_{it} is expected to change over time, e.g. over the business cycle or if μ exogenously changes over time for a given X_{it}.

2.2.4 Feedback from job creation

Financial frictions and financial constraints affect job creation and, hence, labor market tightness as described by Equation (13). Financial frictions therefore also affect wages through their effect on θ_t. This will be particularly important over the business cycle, since financial constraints intensify tightness volatility as discussed in the literature (see introduction) and as we will document below in Section 4.

2.2.5 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 ($\lambda_v = \lambda_w = 1$, case 0). Second, all vacancy posting costs are externally financed, while all wage costs are financed internally ($\lambda_v = 0$ and $\lambda_w = 1$, case I). Case I encompasses the financial cost of hiring, but not the financial labor wedge. Under the assumption that $\frac{\chi_{it}^{w}}{E_t\chi_{i,t+1}^{w}} = 1$, this case presents the mechanism discussed by Petrosky-Nadeau (2014). Alternatively, all vacancy posting costs and the entire wage bill may be financed externally ($\lambda_v = 0$ and $\lambda_w = 0$, case II). This corresponds to the mechanism contained in Chugh (2013) and Zanetti (2019). Case II encompasses the financial labor wedge. It contains the forward-looking hiring cost only if $\frac{\chi_{it}^{w}}{E_t\chi_{i,t+1}^{w}} \neq 1$. Note that the existing studies do not explicitly distinguish between these mechanisms. Last, opposite to case I, all wage costs are financed externally and all vacancy posting costs are financed internally ($\lambda_v = 1$ and $\lambda_w = 0$, case III). This case encompasses both the financial labor wedge and the financial cost of hiring.

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 (16). Our wage equation nests the case of financial, but no labor market frictions ($\gamma = 0$ and $\eta = 1$). In this case, wages are equal to the marginal product of labor, only the financial labor wedge is present and the financial cost of hiring does not interact with labor market tightness. See Appendix A.4.1 for details.

There exist a number of wage-setting mechanisms alternative to Nash bargaining which are not nested as special cases in our model. These address different aspects such as strategic wage bargaining as in Hall and Milgrom (2008), endogenous mechanisms that decrease the responsiveness of wages to firm outcomes (such as Den Haan and Kaltenbrunner, 2009 or Guiso et al., 2005) or bargaining in multi-worker firms as in Stole and Zwiebel (1996). Common to these very different mechanisms is no or a substantially smaller role of labor market tightness for the wage, since the outside option of the wage bargain is not the breakup of the match or search. Consequently, the financial cost of hiring, both current and forward-looking, would be absent or quantitatively less important under these wage-setting mechanisms. All three mechanisms will possibly affect the financial labor wedge. If wages are smaller on average as a result of multi-worker bargaining or respond less to firm outcomes, here X, the financial labor wedge will be smaller and vary less over the cycle. Also, if the wages of new hires need to be externally financed, the bargaining power of existing workers falls less and wages may be larger in a multi-worker setup with compared to without financial frictions.

Alternative wage settings may formulate additional aspects of how financial constraints affect wages. First, additional costs must be financed externally, e.g., during wage negotiations in which workers remain employed, but no production occurs (Hall and Milgrom, 2008). Second, external finance as such or the structure of debt, in particular, may influence wage setting directly (Monacelli et al., 2023 or Matsa, 2018). These additional aspects are not modeled here.

3 Financial strength and wages: Data

3.1 From theory to data

We will now investigate the presence and direction of how different financial channels affect wages in the data. We proceed as follows. We derive a regression equation based on the wage equation (16). This regression equation describes the ceteris paribus effects of productivity and labor market tightness as well as financial variables on wages. By construction, this cannot capture the full effect of either productivity nor financial constraints on wages as productivity and financial constraints affect each other and the financial variables in our model equilibrium. But if financial constraints matter as described in our model, they should interact with productivity and labor market tightness in a particular way reflected in the regression equation as we document below. We use the significance and direction of these interactions to investigate whether the financial channels outlined above play a role in the data. The estimated effects inform us about the relative size of λ_w and λ_v.

Based on the estimated effects, we will then calibrate and simulate the model to investigate how financial constraints affect the labor market equilibrium and, in particular, labor market dynamics over the business cycle in section 4. We will then also be able to compare the estimated direct pass-through of productivity to wages to the corresponding direct channel driving aggregate wage dynamics in our calibrated model. Considering match-level variation in wages allows us to address composition effects and unobserved heterogeneity in the data and takes out a common, but not the firm-, worker- or match-specific aggregate component of the joint variation with productivity, financial variables and tightness. This means that we follow the general intuition of Mortensen and Pissarides (1994) that average match-specific variation is indicative of aggregate variation. This may not hold quantitatively if wages react less to idiosyncratic than to aggregate shocks. For example, this is the case if firms can insure their workers against idiosyncratic, but not aggregate shocks (see Balke and Lamadon (2020)).

In the wage equation (16), the financial variables Ω_{it}, ϕ_{it}, χ^w_{it} and χ^v_{it} cannot directly be measured in the data, but are all functions of the current price of the loan $\bar{\omega}_t$. We hence describe the wage as $W(X_t, \theta_t, \bar{\omega}_t, \bar{\omega}_{t+1})$ and derive the second-order multivariate Taylor approximation of the wage equation around the steady state in order to fully account for the non-linearity between productivity, tightness and the price of the loan (see Appendix A.5 and Equation (A.74) for the derivation and the complete expression). The corresponding regression equation adding control variables and an error term is given by

$$\begin{aligned}\ln(W_{ijt}) = &\beta_0 + \beta_1 \ln(X_{it}) + \beta_2 \ln(\theta_{jt}) + \beta_3 \ln(\bar{\omega}_{it}) + \beta_4 \left(\ln(E_t \omega_{it+1}) - \ln(\omega_{it})\right) \\ &+ \beta_5 \ln(X_{it}) \ln(\bar{\omega}_{it}) + \beta_6 \ln(\theta_{jt}) \ln(\bar{\omega}_{it}) + \beta_7 \ln(\theta_{jt}) \left(\ln(E_t \omega_{it+1}) - \ln(\bar{\omega}_{it})\right) \\ &+ \beta_8 \ln(\bar{\omega}_{it})^2 + \beta_9 \left(\ln(E_t \bar{\omega}_{it+1}) - \ln(\bar{\omega}_{it})\right)^2 + \beta_{10} \ln(\bar{\omega}_{it}) \left(\ln(E_t \bar{\omega}_{it+1}) - \ln(\bar{\omega}_{it})\right) \\ &+ \alpha_{ij} + \gamma_t + \phi_1 \mathbf{z}_{ijt} + \phi_2 \mathbf{z}_{ijt-1} + \phi_3 \Delta \mathbf{z}_{ijt} + \epsilon_{ijt}, \end{aligned} \tag{17}$$

In the model, all workers are the same. In the data, we observe different workers j with different wages W_{ijt} in different firms i at time t. Wages may be different because of observed and unobserved heterogeneity at the worker and firm level which we need to control for in the specification. Wages for different job matches may differ due to variation in match productivity X_{it}. Wages for different job matches may differ due to different outside options. Labor market tightness θ_{jt} considered here refers to characteristics at the worker level, in particular different occupations and/or regions. Further, α_{ij} refers to firm, worker and match fixed effects which we will include across different specifications to control for various types of time-invariant unobserved heterogeneity. The variables $\mathbf{z}_{ijt}$, $\mathbf{z}_{ijt-1}$ and $\Delta\mathbf{z}_{ijt}$ 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. This takes out the effect of the aggregate common component X_t of firm productivity X_{it} on wages. But this keeps the effect of aggregate X_t that is differential to each firm, worker or match, depending on the specification.

We can relate some of the estimated coefficients of Equation (17) to the model predictions. First, our model predicts that wages increase with productivity and tightness, i.e., $\beta_1 > 0$ and $\beta_2 > 0$, in line with the wage dynamics in a search and matching setup. $\beta_1 = \frac{X}{W}\eta\frac{\Omega}{\chi^w}$ measures the direct effect of productivity on wages when labor market tightness and financial constraints are kept constant. Both ceteris paribus effects are components of the overall wage elasticity to changes in productivity as outlined in detail in section 4.2.3.

Second, we interpret the variation in the cost of the loan $\bar{\omega}_{it}$ as reflecting variations in the financial constraints of a firm. In addition to firm productivity, we therefore need to control for aspects that affect loan demand this and next period, such as firm size and firm growth. According to our participation constraint (3), remaining changes in $\bar{\omega}$ then reflect either a change in the financial friction μ or an exogenous change in loan demand, e.g. through a devaluation or destruction of assets (a negative shock to A_{it}).[11] The coefficient $\beta_3 = \frac{\bar{\omega}}{W}\eta\left[X\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}} + \gamma\theta\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}\right]$ then measures the effect of financial constraints on wages when productivity and labor market tightness are constant. This direct effect of financial constraints is another component of the overall wage elasticity. We will use direct measures of the cost of the loan as well as other balance sheet information to capture variations in $\bar{\omega}$ in the data (see Section 3.2).

Third, our particular focus lies on the significance and the sign of the interaction coefficients of the cost of the loan with productivity (β_5) and tightness (β_6). The coefficient $\beta_5 = \frac{X\bar{\omega}}{W}\eta\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}}$ refers to the financial labor wedge and depends on how the ratio of the financial value of productivity to the financial cost of paying wages changes with the financial constraint. As discussed above, β_5 should be significant and negative if the financial labor wedge is present. In this case, an

[11] Under these conditions, our model implies that the external finance premium increases in $\bar{\omega}$. See Equation (5).

increase in productivity leads to a smaller increase in wages when financial frictions are high. Put differently, firms shift part of the financing cost to the worker.

The coefficient $\beta_6 = \frac{\theta\bar{\omega}}{W}\eta\gamma\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}$ refers to the financial cost of hiring and depends on how the financial cost of paying a marginal employed worker relative to the financial cost of hiring a new worker changes with the financial constraint. As discussed above and derived in detail in Appendix A.2.5, our model does not deliver unambiguous predictions about the sign of β_6. β_6 should be negative if the share of internal finance of vacancy cost is larger than for wages ($\lambda^v > \lambda^w$) and positive if $\lambda^v < \lambda^w$. Hence, financial constraints induce wages to increase more when tightness rises in the first case and to increase less when tightness increases in the second case. Note that

$$\frac{\beta_5}{\beta_6} = \frac{X(1-\lambda^w)}{\gamma\theta(\lambda^v - \lambda^w)} \tag{18}$$

which we will use as a central calibration condition in our simulation in Section 4.[12]

If search frictions do not affect wages altogether, both β_2 and β_6 should be zero (see also Appendix A.4.1). Our model does not deliver unambiguous predictions about the sign of the other coefficients. The level coefficient on financial constraints, β_3, is negative if $\lambda^v > \lambda^w$ and ambiguous if $\lambda^v < \lambda^w$. The sign of the coefficients on the expected change in constraints β_4 and β_7 depend on the steady-state values of the model. For a reasonable range of values, these coefficients should both be positive. This is intuitive since the wage negatively depends on the development of the financial cost of paying wages. When higher financial constraints increase the cost of paying future wages relative to today, this makes hiring today more costly and, hence, increases bargaining power of workers and, hence, wages.

3.2 Data

We use the ORBIS-ADIAB dataset, a unique data set for Germany for the years 2006 to 2014 that links administrative data on establishments and employee biographies with information on firms' balance sheets from ORBIS as provided by Bureau van Dijk.[13] 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 (Stüber, 2017). Earnings are annual pre-tax payments to persons covered by social security which include the base wage plus extra pay. We look at daily wages that are defined as total wage payments divided by the number of calendar days. While a large part of the base wage is the result of union bargaining which mostly takes place at the industry level and at fixed points in time, a smaller part of the base wage as well as extra pay are bargained individually or at the firm level (via the works council). It is this latter part of wages that can respond flexibly to firm-level developments. According to aggregate statistics for Germany, extra

[12] See Appendix A.6.3 for the derivation.

[13] 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 (Antoni et al., 2018) and has also been used in the recent study of Jäger et al. (2020). The data has been merged using record key linkage using the firm name, legal form and address by the FDZ of the IAB. Balance sheet information filed according to local GAAP (HGB). Unconsolidated accounts only. In Orbis, a firm is assigned to year t if the account has been filed between June in t and May in $t+1$. 92% of firms file their account in December, 2% in June, 1.6% in September, 1% in March in t.

pay can constitute up to 25% of earnings and consists of regular and irregular extra pay, bonuses and other financial amenities.[14]

The annual balance sheet information allows us to measure financial strength of firms.[15] In our study, we focus on private, non-financial firms. The data include a variety of legal types, most firms are limited liability companies ('GmbH'). Due to changes in the German financial reporting system, the BvD data is most reliable from 2006 onward. Financial variables are available in ORBIS-ADIAB until 2014. We restrict the analysis to full-time workers to deal with the issue that we do not have information on exact hours worked. However, it is reasonable to assume that extra hours affect earnings very little, since overtime in Germany is mostly captured in working time accounts.[16] Reported earnings in our data are not affected by short-time work schemes, i.e., we do not capture any adjustment in response to financial constraints that happens through short-time work. We consider only workers that are employed all year. This avoids seasonal effects in earnings due to seasonal bonuses. Because the earnings data are right-censored at the contribution assessment ceiling, we consider only employees with wages up to this limit.

Our final sample is an unbalanced annual panel for 2006 to 2014 with on average 250,000 firms, 290,000 establishments and 4,4 million worker observations per year. Table 1 exhibits medians as well as 1- and 99-percentiles of key variables in our sample. We report daily wages for which annual pre-tax earnings are divided by the reported number of working days in the employment spell. Nominal wages (and all further nominal variables) are deflated using the CPI index. The median employee earns about 80 Euros daily on average in the sample. Our sample includes a broad range of firms including many small firms (below 5 employees) and few very large firms (of up to 60,000 employees). In the median firm, 11 persons are employed per establishment. Establishments in our data are young and old. Our data covers all large sectors of the economy. We exclude the public sector, temporary agency work, agriculture and mining. and includes both firms that have very little and firms that have very high capital intensity.

In our baseline, we follow the argument in Section 3.1 that conditional on the controls the price of the loan reflects the financial constraints of the firm. We use total interest payments relative to the size of long-term debt to measure the average price of credit in a firm. We use interest over total debt in a robustness check. The median firm in our sample pays interest of about 7.4% of long-term debt. As discussed above, the price of the loan is an indicator of both current and future financial constraints of firms. We use the interest burden at the end of year $t-1$ in our analysis.[17] One might be concerned that the wage bill of the firm affects current credit and credit costs. The timing assumption alleviates this concern. Moreover, since wage dynamics are measured at the match and not the firm level, the feedback from individual wages on firm-level financial conditions is, if at all, much smaller than in case of the firm-level wage bill or average wages.

Interest payments can be related to other measures of financial constraints at the firm level. Prominent in the literature is the use of leverage. In line with our model, we define leverage as the ratio of debt plus interest payments to total assets.[18] Giroud and Mueller (2017) argue

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

[15] See Kalemli-Ozcan et al. (2012) for a study based on ORBIS and detailed information about the data.

[16] With a working time account, hours can be flexibly adjusted in a given time frame without adjusting wage payments. Over 50% of German employees are covered by working time accounts, see Balleer et al. (2017) for details.

[17] We show below that results are robust to including interest burden at the end of year t instead.

[18] Leverage is given by $\frac{\bar{\omega}[(X_{it}-\lambda_w W_{it})N_{it}-\lambda_v \gamma V_{it}]}{A_{it}}$ in our model.

Variable	Median	1%	99%
Mean daily wage	80.55	24.09	152.48
Mean real daily wage	80.30	24.18	150.77
Interest over long-term debt	0.074	0.0002	24.25
Leverage	60.32	2.78	328.55
Capital-to-labor ratio	7023.5	0.1	1,681,659
Total assets	622,323	23,265	95.1 mio
Sales	1.5 mio	100,000	197 mio
Mean employees in establishment	11	1	297
Mean establishment age	11	1	34

Table 1: Descriptive statistics. Summary statistics at the firm level, 2006-2014. Number of employees and establishment age show the median across firms for averages across the establishments. Wage, assets and sales are denoted in Euro.

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. It is a valid concern that high leverage reflects easy access to credit and, hence, a low level of financial constraints in the past. High leverage affects, however, the future access to credit in terms of price and volume. We therefore use leverage in $t-1$ in our analysis.[19]

We do not have information about expected financial costs or expected changes in financial costs in our data. We can therefore not estimate the coefficients β_4, β_7, β_9 or β_{10} well. We will use current growth rates of financial cost measures to approximate future developments, but will not further interpret the associated coefficients. In the robustness checks, we confirm that our results on the other coefficients do not depend on whether we include these terms.

In our baseline regressions, we measure firm-level output X by sales per employee. Output X may vary not only because of productivity or supply in the model, but also because demand for the firms' product may change. We capture this notion in a robustness check measuring changes in demand at the county level. The county-level variation further has the advantage of being closer to measuring aggregate rather than firm-specific shocks. Changes in demand are captured by changes in export demand 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). To this end, we use data on the average export shares of total revenue at the county level for the years 2010-2015 to measure the exposure of counties to export demand shocks.[20] We then use the variation in the aggregate export share of GDP over time weighted by the county-level export exposure as a measure of X in our regressions. Doing this, export variations may also affect non-exporting firms in a county with an otherwise large exposure to exports e.g., via supply chains.

We add information about registered vacancies and unemployment from the Federal Employment Agency to our data to measure labor market tightness θ relevant for firm i and worker j at time t. Our baseline specification includes tightness for worker j matched according to the

[19] Gilchrist et al. (2017) employ a related measure and show that its effect on prices is similar to using the liquidity ratio and interest coverage ratio as alternative measures of financial constraints.

[20] Source: INKAR, Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR), Bonn `https://www.inkar.de/` and German national accounts.

target occupation of the unemployed. Here, tightness is computed for 36 occupation groups according to the German system of occupation classification (KldB2010). An alternative measures tightness for the local labor market, i.e., the county where the establishment is located.
The balance sheet data also has information about the capital stock in a firm in a given year. In the balance sheets, this position represents financial assets. We use this information to measure firm-level capital-labor intensity in our empirical analysis.

3.3 Baseline results

Table 2 exhibits the results of estimating Equation (17). Here, we employ interest payments relative to long-term debt as our measure of financial constraints, sales over employment as our measure of productivity X and occupation-specific tightness to measure θ. We further control for future growth in interest payments as well as for observable idiosyncratic and aggregate factors that may affect both firm credit and wages. This encompasses productivity X as well as lagged sales over employment, firm size in terms of number of employees and lagged number of employees to control for firm growth. Depending on the cross-sectional fixed effects, this includes the establishment age, worker age and age squared, tenure and tenure squared of the worker, and gender of the worker. Time-fixed effects reflect aggregate changes in supply and demand.
We document different (combinations of) cross-sectional fixed effects. The first column shows the results without any fixed effects. The second column shows the results with firm-fixed effects. Here, we consider how changes in financial conditions within a firm affect wages. Since workers may switch firms, we compare this to both changes in firm finance within worker (column 3) and, in the tightest specification, within firm-worker match (column 4). We therefore use a different identifying variation in financial conditions and wages across the different specifications and different controls as the time-invariant controls of firms, workers and matches are dropped respectively.
Table 2 shows the estimated coefficients of Equation (17) omitting the coefficients of the control variables that are only included in some of the specifications. We focus on the tightest specification with the match-specific effects in column 4 (the alternative specifications yield comparable results). First, our estimation confirms the model prediction on the elasticity of wages to sales (β_1 in Equation (17)). Our estimated average marginal effect is 0.02. This number is within the range but at the lower bound of estimates documented in the literature (see e.g., Card et al., 2018, Table 1, group 3). One reason is that productivity affects wages not only directly, but through financial constraints, as our model argues. Financial constraints decrease when productivity increases which positively affects wages. Omitting financial constraints in the regressions therefore increases the coefficient on the direct productivity effect. We also confirm the sign of the level effect of tightness (β_2).
Second, the results support the presence of the financial labor wedge channel in the data. While higher sales are associated with higher wages, sales per employee significantly and negatively interact with interest payments relative to long-term debt ($\beta_5 < 0$ in Equation (17)). Hence, when the interest burden increases, workers in firms with higher sales experience larger wage cuts. Put differently, when sales per employee increase in a firm, workers in firms with a high-interest burden obtain smaller pay raises than workers in firms with a low-interest burden. The negative interaction corresponds to the notion that external finance drives an increasing wedge

	(1)	(2)	(3)	(4)
β_1: Log sales $_t$	0.061***	0.013***	0.017***	0.017***
	(0.00043)	(0.00055)	(0.00017)	(0.00018)
β_2: Log θ^{occ}	0.051***	0.019***	0.0084***	0.0082***
	(0.00034)	(0.00030)	(0.00018)	(0.00018)
β_3: Log ILTD $_{t-1}$	0.017***	0.00086***	0.0011***	0.00087***
	(0.00029)	(0.00029)	(0.00012)	(0.00012)
β_4: Δ log ILTD $_{t,t-1}$	0.0072***	0.0020***	0.0011***	0.0010***
	(0.00034)	(0.00030)	(0.00011)	(0.00011)
β_5: Log sales $_t$ $\times$ Log ILTD $_{t-1}$	−0.00097***	−0.00043***	−0.00041***	−0.00038***
	(0.000063)	(0.000065)	(0.000022)	(0.000022)
β_6: Log ILTD $_{t-1}$ $\times$ Log θ^{occ}	0.0039***	0.0012***	0.00057***	0.00053***
	(0.00012)	(0.00011)	(0.000051)	(0.000050)
β_7: Δ ILTD $_{t/t-1}$ $\times$ Log θ^{occ}	0.00086***	0.0010***	0.00026***	0.00027***
	(0.00014)	(0.00012)	(0.000048)	(0.000047)
β_8: Log ILTD $_{t-1}$ $\times$ Log ILTD $_{t-1}$	0.0023***	0.000032	0.00011***	0.000084***
	(0.000022)	(0.000031)	(0.000010)	(0.000010)
β_9: Δ ILTD $_{t/t-1}$ $\times$ Δ ILTD $_{t/t-1}$	0.00057***	0.000056**	0.000078***	0.000082***
	(0.000025)	(0.000027)	(0.0000086)	(0.0000085)
β_{10}: Δ ILTD $_{t/t-1}$ $\times$ Log ILTD $_{t-1}$	0.0013***	0.000059	0.00023***	0.00022***
	(0.000041)	(0.000045)	(0.000015)	(0.000015)
Log sales $_{t-1}$	0.030***	0.0022***	0.0048***	0.0043***
	(0.00041)	(0.00050)	(0.00016)	(0.00016)
Log employment	0.030***	0.012***	0.026***	0.027***
	(0.00070)	(0.00066)	(0.00030)	(0.00032)
Log employment $_{t-1}$	0.0061***	−0.013***	−0.010***	−0.010***
	(0.00069)	(0.00063)	(0.00023)	(0.00023)
β_0: Constant	3.91***	3.97***	3.14***	3.18***
	(0.0031)	(0.0045)	(0.0062)	(0.0074)
Observations	3,170,722	3,170,722	3,170,722	3,170,722
R^2	0.40	0.63	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 2: Baseline results. Dependent variable is the log real wage at the worker level. ILTD refers to total interest payments relative to long-term debt. θ^{occ} refers to labor market tightness measured at the occupational level. The sample period is 2007 to 2014. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

between wages and the marginal product of labor. From our model in Section 2, we know that this means that working capital (the wage bill) is at least partly externally financed ($\lambda_w < 1$).
Third, our results support the presence of the financial cost of hiring in the data. The interaction of tightness and interest is significant and positive in all specifications ($\beta_6 > 0$ in Equation (17)). In the model, the sign of this interaction is ambiguous. The positive sign means that tighter financial constraints generate upward pressure on wages and this effect is stronger the tighter the labor market. The financial cost of hiring therefore buffers the negative effect from the labor wedge channel. In terms of the model, this means that external finance is used for a larger share of vacancy costs compared to wage costs ($\lambda_V < \lambda_W$).
Based on the average marginal effect, we find that if the interest burden increases by one percent, real wages fall by 0.000061 percent. Hence, wages are adjusted downwards when the financial situation of firms worsens, but by very little. The marginal effect of increasing interest burden on wages strongly increases from the mean to up to a fall in wages of about 0.0011 percent at the 99-th percentile of the interest burden. Also here, our estimated effect measures the effect

of the interest burden on wages ceteris paribus, i.e., for a given level of productivity. Hence, the substantial joint variation between productivity and financial variables that is explored in the aggregate simulation is taken out in this estimation.

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. As discussed above, it is most likely that wage cuts reflect adjustments in bonus payments and other variable compensation. Our finding relates to earlier studies that document wage cuts in Germany, especially in the recent decade and in firm-specific crises.[21]

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). Popov and Rocholl (2018) find that German firms reduced average wages in response to negative credit shocks in the Great Recession. Franklin et al. (2020) make a similar observation for the UK. Complementary evidence to ours is provided by Moser et al. (2020) who show that reduced credit supply leads to lower wage inequality as wages of previously higher-paying firms and workers fall relatively more. They find that a one standard deviation increase in exposure to a negative credit supply shock is associated with a significant reduction in mean wages of up to 1.3 percent. However, these effects do not take into account the different theoretical mechanisms and interactions that we discuss above.

3.4 Robustness and sub-sample results

3.4.1 Different specifications

We document robustness of our baseline results along several dimensions. The results are shown in Appendix B.1. First, we use variation in export exposure at the county level together with firm-fixed effects. This setup is similar in spirit to Giroud and Mueller (2017) who regress changes in firm employment on changes in housing demand at the county level in the Great Recession. Doing so, we use variation in X that is exogenous to the firm and we use variation of X at a more aggregate level (see also Section 3.2). The size of the direct effect of productivity on wages, β_1, is about the same size with and twice the size without firm-fixed effects compared to our baseline estimation. We also confirm the significance and sign of the labor wedge and the financial cost of hiring when measuring X using export exposure (Table 9).

Second, we explore robustness in our baseline specification. We drop the change in the interest burden from the regression because it might be an imperfect measure of the expected change in financial constraints. In other words, we estimate Equation (17) in steady state, i.e., $\beta_4 = \beta_7 = \beta_9 = \beta_{10} = 0$. The results confirm the sign and size of our baseline (Table 10). We further employ different measures of financial constraints. We use a different timing for interest payments relative to long-term debt and look at period t rather than in $t-1$ (Table 11). We also consider interest payments relative to total debt as well as leverage in $t-1$ (Tables 12 and 13). The results are very similar to our baseline model in particular the interactions have the same sign and significance as before.

Third, we exchange occupational labor market tightness with the corresponding regional measure at the county level (Table 14). The results are very similar. Fourth, we add firm-year fixed effects

[21] 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 prior to being interviewed. Grund and Walter (2015) show how firms in the German chemical industry cut bonuses of managers in times of economic crisis in these firms.

to the baseline regression. Firm-year fixed effects control for anything that is time-varying at the firm level, including the variation in financial constraints. In this setup, the identification comes directly from employees within a firm that face different labor market tightness. Then, firm-level variables such as productivity drop out of the regression and we cannot interpret the labor wedge any longer. However, given that tightness is measured at the worker-occupation level, we still obtain effects for tightness. As summarized in Table 15, tightness continues to have positive effect on wages and the interaction remains significant and positive.

3.4.2 Subsamples

To explore our baseline results further, we estimate Equation (17) for various sub-samples of our data. We distinguish cases for which the estimation results generally confirm our model mechanism (negative or insignificant labor wedge) and cases in which the financial cost of hiring changes sign. The first dimension to split our sample are worker characteristics. A key characteristic is job complexity. In our data, this is measured by a categorical variable that has information on the complexity of the individual worker's job and distinguishes simple jobs, trained jobs, complex jobs and very complex jobs. Our model is supported in jobs with relatively high complexity (in particular for trained jobs) and, hence, wages (Table 16). Individual wage bargaining is more likely at this level. Higher wages encompass a larger part of wage payments over and above the union-wide (and hence sector-wide) base wage and are usually the result of a bargain between management and works council within a firm. With increasing skill, the positive effect of the financial cost of hiring vanishes. Through the lens of our model, this would be the case, if wages are financed externally to a larger degree which may be likely for skilled jobs that pay higher wages. Overall, our baseline results are best reflected in the trained job category. The model mechanism is also confirmed for jobs with a low level of complexity when regional tightness is used in the specification (Table 17). As low-complexity jobs are less tightly linked to specific occupations, regional tightness constitutes the more relevant measure for these types of jobs.

The second dimension to split our sample is firm characteristics starting with establishment size (Table 18). Our model mechanism is not supported for small, especially very small establishments with up to 50 employees. Obtaining external finance works differently for small and especially young firms which may rely on venture capital or public subsidies. Young and small firms may also not have established a long-term relationship with a particular bank. Moreover, small firms do not have an established routine of wage negotiations and, usually, no works council either. Hence, wage setting may work very differently from the mechanism in the model. According to Michelacci and Quadrini (2005), small and growing firms may pay lower wages today with a promise of higher wages in the future. Since we control for employment dynamics in our specification, we do not capture this mechanism here. Our model mechanism is supported in large firms, especially those with more than 200 employees. One may think that large firms have easier access to external finance and may therefore circumvent changes in financial frictions through issuing equity. Generally, bank loans are the predominant source of external finance even for very large firms.[22]

Last, we divide our sample into percentiles of capital-labor intensity at the firm level. Our baseline results are confirmed in firms with capital-labor intensities above the median (Table 19).

[22] Compare, e.g., Financial accounts for Germany 2017 to 2012, Special Statistical Publication of Deutsche Bundesbank.

Variable	Manufacturing	Construction	Trans./comm./elect./gas/water	Wholesale/retail	Other services
Real daily wage	102.43	85.93	106.25	87.31	91.62
Job complexity (scale 1-4)	2.14	2.06	2.48	2.14	2.49
Interest over long-term debt	0.084	0.071	0.062	0.080	0.053
Capital-labor ratio	10,770.88	5,365.3	5,640	7,909.8	4,982.6

Table 3: Descriptives across sectors. Wages and job complexity are averages across workers; interest and capital intensity are medians across firms.

Unless capital and labor are perfect substitutes, financing investment and working capital involves vacancy costs as well as wage payments and, hence, these costs are subject to external finance to a larger degree when the capital-labor ratio is high. In this case, the marginal product of labor and, hence, wages are higher in firms with a high capital-labor ratio which we confirm in our data. As argued above, a higher wage bill is more likely to be financed externally to some degree. Since labor is valuable in capital-intensive firms, an increase in labor market tightness is then more likely to increase the bargaining power of workers and, hence, wages in the presence of financial constraints.
Looking across sectors (Table 20), our main results are driven by the dynamics in manufacturing which is the largest sector in terms of employment in our sample (and in Germany). Manufacturing is characterized by relatively high-interest payments and a high capital intensity (see Table 3 below). Manufacturing employs a high share of trained workers who earn comparably high wages. In addition, wages in manufacturing are characterized by a substantial share of bonus payments down to the trained worker level.[23] Our main results hold in the construction sector even though the coefficient on the financial cost of hiring is insignificant. The results also hold in the sector that comprises transport, communication and energy providers when tightness is measured at the regional level (Table 21). Our model mechanism and baseline results are not supported in retail and service industries.

4 Decomposing business cycle fluctuations in wages and tightness

We calibrate and simulate the full dynamic model from Section 2 to quantify the effects of financial constraints on wages and labor market tightness. In particular, this takes into account the expectations about the evolution of aggregate productivity and financial constraints. We consider wage and tightness dynamics in isolation and in equilibrium, i.e., when wage dynamics affect tightness dynamics and vice versa.

4.1 Calibration

Table 4 reports the parameterization of our model and the corresponding targets.[24] The model is at a monthly frequency and targets business cycle fluctuations of wages and labor market tightness. The business cycle in our model is driven by the following autoregressive process of aggregate productivity

$$\ln(X_t) = \rho_x \ln(X_{t-1}) + \varepsilon_{x,t}. \tag{19}$$

[23] See Labor Cost Statistics as provided by the Statistical Office for Germany ('Arbeitskostenerhebung').
[24] See Appendix A.3.1 for the steady state equations and Appendix A.6.1 for the resulting steady state values.

Variable	Description	Value	Target
ρ_x	autocorrelation agg. productivity	0.9	Destatis, own estimates
η	workers' bargaining power	0.029	$\epsilon_{W,X} = 0.3$, Destatis, own estimates
b	unemployment benefit	0.873	$\epsilon_{\theta,X} = 7.1$, Destatis, own estimates
ϵ	matching function exponent	0.72	literature
ξ	efficiency of matching function	0.0829	unemployment rate 8.65%, ORBIS-ADIAB
δ	monthly separation rate	0.00785	ORBIS-ADIAB
γ	vacancy cost	0.79893	$\theta = 1$
r	real interest rate	0.0023	OECD
β	monthly discount factor	0.9977	$\beta = 1/(1+r)$
ζ	Firms' saving rate	0.55	literature
μ	monitoring cost	0.543	finance premium 0.08%
σ_ω	S.D. of revenue shock	0.068	default rate 0.15%, Creditreform
λ^v	internally financed share of vacancy posting cost	0.33	estimated ratio of $\beta_{X,\bar{\omega}}$ to $\beta_{\theta,\bar{\omega}}$
λ^w	internally financed share of wages	0.756	median debt to sales 0.27, ORBIS-ADIAB

Table 4: Calibration.

Our simulation abstracts from additional idiosyncratic variation in productivity. It is important that our model replicates the dynamics in aggregate German data for our sample used for the empirical evidence in Section 3. We use detrended data on labor productivity, wages and labor market tightness for the years 2006-2016 as measures of the cyclical components.[25] For labor productivity, we obtain a monthly autocorrelation of $\rho_x = 0.9$.
We estimate aggregate elasticities of wages and labor market tightness to business cycle fluctuations by regressing these variables on lagged productivity. We obtain $\epsilon_{W,X} = 0.3$ and $\epsilon_{\theta,X} = 7.1$ and use these as central targets in our calibration. Our simulation exercise therefore does not explain the volatility itself, but rather addresses the decomposition of this volatility. We show below that the aggregate elasticity of wages and tightness can be decomposed into a level effect of the business cycle, feedback effects through the labor market and feedback effects through the financial market. Our estimate of β_1 in Section 3 reflects the level effect only and is hence smaller than the overall aggregate wage elasticity to productivity. Since we do not target β_1 in our calibration, we can then compare the size of the estimate to our calibration outcome. We follow Hagedorn and Manovskii (2008) and, first, determine the workers bargaining power η to match the overall wage elasticity $\epsilon_{W,X}$. Second, we set the unemployment benefit b to match the tightness elasticity $\epsilon_{\theta,X}$. Our model hence generates realistic magnitudes of amplification. As in Hagedorn and Manovskii (2008), this results in a relatively low value of the bargaining power of workers ($\eta = 0.029$) and a relatively high value of the unemployment benefit (0.873). A volatile surplus generates volatile financial constraints which amplifies labor market tightness even further.[26] In a robustness check, we evaluate the sensitivity of our results to this choice (Section 4.2.4).

[25] Labor productivity is measured as real GDP per employee and wages are real earnings per employee. Both series are from the German national accounts provided by the Federal Statistical Office (Destatis: https://www-genesis.destatis.de/genesis/online). To construct aggregate labor market tightness, we use time series on vacancies and unemployment from the statistics of the German Federal Employment Agency. These series are at quarterly frequency, seasonally adjusted and HP filtered with $\lambda = 1,600$.

[26] Schoefer (2021) proposes rigidity of incumbent workers' wages in a model with financial constraints as an alternative way to generate sufficient volatility in the surplus.

The elasticity of the matching function with respect to unemployment is set to $\epsilon = 0.72$ which follows the literature (e.g., Balleer et al., 2016). Normalizing $\theta = 1$, we can then use the matching efficiency ξ to match an average monthly unemployment rate of 8.65% in our sample and δ to pin down the corresponding separation rate of 0.785%. The vacancy posting cost γ then follows from the job creation condition in steady state.

We set r to match an average annual interest rate of 2.75% in 2006-2014 (source: OECD) which then gives $\beta = 0.9977$. While some German firms are obliged to pay out 50% of their earnings as dividends, average payout is lower in practice and varies greatly whether measured based on cash flow or published earnings (see Andres et al., 2009). We choose to target a mid-point of several estimates at $\zeta = 0.55$. Since the operating profits of firms are small due to our calibration of b, the results are not very sensitive to the choice of ζ. The distribution of the shock to firm revenue $H(\omega)$ is log-normal with $E(\omega) = 1$ and standard deviation σ_ω. The parameters μ and σ_ω are chosen to match an external finance premium of 0.08% (Dötz, 2014) and an annual default rate of 1.76% (source: Creditreform). Hence, financial frictions are present, but are on average relatively small in this economy.

Finally, we use Equation (18) together with

$$\frac{(1-\lambda^w)WN + (1-\lambda^v)\gamma V}{XN}, \tag{20}$$

which describes the median ratio of short-term bank credits of non-financial private firms to their total production. In our data, this ratio is equal to 27%. This pins down $\lambda^v = 0.33$ and $\lambda^w = 0.756$. Our results state that about 25% of wages are financed externally. Hence, the financial labor wedge channel is at work in our economy. Moreover, 67% of vacancy posting costs are financed externally. Since this share is larger than the one of wage payments, the tightness interaction channel is present and induces upward pressure on wages under financial frictions.

Below, we will show that our calibration implies values for the coefficients β_1, β_2 and β_3 that we can compare to our empirical estimates. Although these direct effects have not been targeted in our calibration, their values lie within a reasonable range compared to their empirical counterparts.

4.2 Simulation

In the following, we compare a model without financial frictions to our baseline model with financial constraints. To do so, we remove financial constraints by setting $\mu = 0$, but keep all other parameters identical to the baseline calibration.[27] We investigate different combinations of λ^v and λ^w that nest our special cases I to III as introduced in Section 2. We keep the parameters b and η from the baseline and recalibrate according to the strategy outlined above. To keep the finance premium and the default rate constant across the different models, we adjust the risk of firm revenue, σ_ω, since the amount borrowed differs across the different cases.

Table 5 documents business cycle statistics based on our simulated model (Appendix A.6.2 shows the corresponding impulse responses). The table shows average elasticities over the business cycle with respect to aggregate productivity, in particular for wages and tightness.[28] The first

[27] Table 6 in Appendix A.6 documents the steady state across all model variations.

[28] The elasticities are computed as $\epsilon_{Y,X} = \rho(Y,X)\frac{\sigma_Y}{\sigma_X}$, where σ_X and σ_Y denote the standard deviation and $\rho(Y,X)$ the correlation of the two variables X and Y. The series are simulated for 60,000 periods and filtered with an HP

striking observation from Table 5 is that removing financial frictions from the model largely decreases the amplification of productivity shocks to wages and tightness (row 12 and 21, compare no financial frictions and baseline). Hence, financial constraints amplify wage and tightness fluctuations substantially. This implies that both the wage bargaining weight η and unemployment benefits b would be larger if we re-calibrated the frictionless model to our targets.[29]

4.2.1 Fluctuations in financial constraints

Financial constraints in our model manifest themselves in the cost of borrowing ϕ, the marginal effect of productivity (net of internally financed wage cost) on the value of a worker Ω and the financial cost of paying wages χ^w and vacancies χ^v (see Equations (6) and (10) to (12)). Since the financial contract depends on revenues, the cost of borrowing decreases when productivity and, hence, revenues increase in a boom (see Carlstrom and Fuerst, 1997). This can be seen in rows 1-3 in Table 5 that show the elasticities of these variables with respect to productivity. As can be seen from comparing columns, financial constraints decrease more with productivity when wages are externally financed (baseline, case II and III). Since wage payments exceed vacancy costs, the amount borrowed is larger and, hence, the constraint is tighter in this case (for a given default rate, ϕ and Ω are larger in cases II and III compared to case I). Productivity improvements in a boom therefore relax the constraint more and financial constraints fluctuate more.

4.2.2 Fluctuations in the wage

Differentiating the wage Equation (16) with respect to X_t and evaluating at the steady state yields[30]

$$\begin{aligned}\epsilon_{W_t,X_t} \quad = \quad & \overbrace{\eta\frac{X}{W}}^{W_0}\Big[\overbrace{\frac{\Omega}{\chi^w}}^{W_{level}} + \overbrace{X\frac{\partial\frac{\Omega_t}{\chi^w_t}}{\partial(\frac{\phi_t}{\Omega_t})}\frac{\partial(\frac{\phi_t}{\Omega_t})}{\partial X_t}}^{W_{FLW}} + \overbrace{\gamma\theta\frac{\partial\frac{\chi^v_t}{\chi^w_t}}{\partial(\frac{\phi_t}{\Omega_t})}\frac{\partial(\frac{\phi_t}{\Omega_t})}{\partial X_t}}^{W_{hiring}} + \overbrace{\gamma\frac{\chi^v}{\chi^w}\frac{\partial\theta_t}{\partial X_t}}^{W_\theta} \\ & - \overbrace{(1-\delta-f(\theta))\frac{\gamma}{p(\theta)}\frac{\frac{\chi^v}{\chi^w}}{\chi^w}(1-\rho_x)\left(\lambda^w\frac{\partial\Omega_t}{\partial X_t}+(1-\lambda^w)\frac{\partial\phi_t}{\partial X_t}\right)}^{W_{forward}}\Big]. \end{aligned} \tag{21}$$

Equation (21) shows that the elasticity of the wage with respect to aggregate productivity X can be decomposed into different terms. Table 5 documents this decomposition in quantitative terms. When no financial frictions are present, $\frac{\Omega}{\chi^w} = \frac{\chi^v}{\chi^w} = 1$ and the elasticity is determined by wage per productivity unit ($W_{level} = 1$) as well as by the degree of which labor market tightness θ changes over the business cycle (W_θ). According to Table 5, the direct effect of productivity on wages $W_0 * W_{level} = 0.03$ is small with and without financial frictions (row 4 and 5). This can directly be compared to our estimate of $\beta_1 = \eta\frac{X}{W}\frac{\Omega}{\chi^w}$ which amounts to 0.06 without any fixed effects and to 0.02 in our baseline specification with match-specific fixed effects (see Table 2). Equation (21) highlights that the estimated ceteris paribus effect of productivity is just one component of the overall volatility of wages. Small ceteris paribus effects therefore do not contradict

filter with $\lambda = 14,400$.

[29] Without financial constraints and the same calibration targets, we obtain $b = 0.965$ and $\eta = 0.178$ which is fairly similar to the parameters set by Hagedorn and Manovskii (2008).

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

		No financial frictions	Baseline $\lambda^w = 0.756$ $\lambda^v = 0.33$	Case I $\lambda^w = 1$ $\lambda^v = 0$	Case II $\lambda^w = 0$ $\lambda^v = 0$	Case III $\lambda^w = 0$ $\lambda^v = 1$
	Elasticities of financial terms					
1.	$\epsilon_{\phi,X}$	0	-5.024	-3.154	-5.975	-6.137
2.	$\epsilon_{\Omega,X}$	0	-4.617	-2.454	-5.832	-5.979
3.	$\epsilon_{\frac{\phi}{\Omega},X}$	0	-0.408	-0.701	-0.143	-0.158
	Wage elasticity $\epsilon_{W,X}$					
4.	W_0	0.0322	0.0322	0.0322	0.0323	0.0323
5.	W_{level}	1	0.9981	1	0.9917	0.9917
6.	W_{FLW}	0	0.0998	0	0.1413	0.1570
7.	W_{hiring}	0	-0.1392	-0.5702	0	0.1202
8.	W_θ	0.9021	5.6235	3.9902	6.3704	6.3718
9.	$W_{forward}$	0	2.8392	1.1296	3.7737	3.9438
10.	$4(5+6+7)$	0.0322	0.0309	0.0138	0.0366	0.0409
11.	$4(5+6+7+8)$	0.0613	0.2121	0.1424	0.2422	0.2466
12.	$4(5+6+7+8+9) = \epsilon_{W,X}$	0.0613	0.3036	0.1788	0.3640	0.3739
	Tightness elasticity $\epsilon_{\theta,X}$					
13.	Θ_0	1.2982	1.3208	1.3048	1.3870	1.3754
14.	Θ_{level}	0.8979	0.8932	0.8921	0.8905	0.8979
15.	Θ_{FLW}	0	0.0893	0	0.1269	0.1419
16.	Θ_{hiring}	0	0.0153	0.0623	0	-0.0133
17.	Θ_W	-0.0495	-0.2270	-0.1197	-0.2843	-0.2957
18.	$\Theta_{forward}$	0	4.7131	3.0769	5.4830	5.5328
19.	$13(14+15+16)$	1.1657	1.3179	1.2453	1.4110	1.4117
20.	$13(14+15+16+17)$	1.1014	1.0180	1.0892	1.0168	1.0051
21.	$13(14+15+16+17+18) = \epsilon_{\theta,X}$	1.1014	7.2430	5.1039	8.6218	8.6147

Table 5: Simulation results. The table shows financial elasticities and wage, $\epsilon_{W,X}$, and tightness elasticities, $\epsilon_{\theta,X}$, over the business cycle and their decomposition. Columns show simulations across different model specifications. Without financial constraints, we set $\mu = 0$ and keep all parameters from the baseline. The cases I-III keep the parameters b and η and are otherwise re-calibrated to keep the default rate the same as in the baseline economy. The rows decompose the elasticities according to the decomposition in Equation (21) and Equation (22).

large overall volatility.

Since financial constraints decrease when the business cycle improves, financial mechanisms affect wage dynamics through feedback effects of financial conditions. First, the financial labor wedge channel W_{FLW} (row 6) is present as soon as wages are financed externally ($\lambda^w < 1$, see baseline and cases II and III). When the business cycle improves, financial constraints decrease which reduces the financial labor wedge and, hence, increases wages. Note that the estimated coefficient β_5 is only part of the effect W_{FLW} and ignores the change in financial constraints when X changes. Hence, while the financial labor wedge itself is negative ($\beta_5 < 0$), the effect of W_{FLW} on volatility is positive. Second, financial hiring costs W_{hiring} (row 7) matter when different proportions of vacancies and wages are financed externally ($\lambda^w \neq \lambda^v$). If $\lambda^w \geq \lambda^v$ (see baseline and case I) financial constraints affect wages positively as they improve the effective bargaining position of workers. Hence, decreasing financial frictions in a boom buffer the procyclicality of the wage. The opposite is the case if $\lambda^w \leq \lambda^v$ (see case III).

These first three channels are summarized in row 10. They reflect the elasticity of the wage to the business cycle in steady state when the equilibrium effect on labor market tightness is not taken into account. One can see that compared to the case without financial constraints, the presence of financial frictions decreases the volatility of wages over the business cycle in our baseline case. Wages would only become more responsive in special cases II and III that are not supported by our empirical results. The reason is that financial hiring costs offset the labor wedge channel. The change in the business cycle volatility of wages is small when considering the first three channels only.

Financial frictions affect the overall volatility also through the labor market. Our simulation implies a coefficient on labor market tightness $\beta_2 = 0.026$ which relates to our estimated values between 0.0082 and 0.051 ceteris paribus. Our simulation further implies $\beta_3 = 0.001$ which relates to estimated values between 0.00086 and 0.017 (see Table 2). Both coefficients do not encompass the feedback from financial constraints to labor market tightness and vice versa, however. As financial frictions increase the volatility of labor market tightness over the business cycle (a discussion follows below in Section 4.2.3), this increases the business cycle volatility of equilibrium wages in the economy (W_θ). Row 8 and 11 in Table 5 show that this effect is the largest driver of the overall wage volatility and increases its size compared to the first three drivers by about a factor of ten.

A changing business cycle affects the financial cost of paying wages today and tomorrow and, hence, the indirect financial cost of hiring (compare Section 2). As the increase in productivity is only temporary and dies out over time, the financial cost of paying wages decreases more today than tomorrow. Hence, the indirect (forward-looking) financial cost of hiring goes up, puts upward pressure on wages and makes wages respond more to the business cycle (see $W_{forward}$ in row 9 in Table 5). The forward-looking financial cost is quantitatively more important compared to the first three channels. The reason is that financial constraints affect the labor wedge and the current financial hiring cost through the relative change of the cost of borrowing (ϕ) to the marginal effect of productivity on the value of a worker (Ω) (see Equation 21). Changes in these two terms partly offset each other. The forward-looking term only depends on the (direct or indirect) financial cost of paying wages and, hence, reacts much more to changes in financial constraints (compare rows 1-3). In other words, firms anticipate that hiring in a boom implies a financial burden in the future when productivity is low again.

Adding up all drivers of the volatility of wages, financial constraints substantially increase their volatility (volatility with all feedback effects is about ten times higher than the level effect). The overall effect is substantially smaller in special case I (only vacancy cost financing). This is due to the negative effect of W_{hiring}, but also because financial constraints fluctuate much less when only vacancy costs are externally financed which leads to a smaller increase in tightness W_θ and a smaller change in the forward-looking financial cost $W_{forward}$.

4.2.3 Fluctuations in labor market tightness

In analogy to fluctuations in the wage, we differentiate the job creation Equation (13) with respect to productivity X_t and evaluate it at steady state. This delivers a decomposition of the elasticity of labor market tightness with respect to the business cycle:[31]

$$\begin{aligned}\epsilon_{\theta_t,X_t} \quad = \quad & \overbrace{\frac{X}{(1-(1-\delta)\rho_x\beta)\frac{\gamma\epsilon}{p(\theta)}}}^{\Theta_0}[\overbrace{\beta\frac{\frac{\Omega}{\chi^w}}{\frac{\chi^v}{\chi^w}}\rho_x}^{\Theta_{level}} - \overbrace{(1-\rho)\frac{\gamma}{p(\theta)}\frac{1}{\chi^v}\left(\lambda^v\frac{\partial\Omega_t}{\partial X_t}+(1-\lambda^v)\frac{\partial\phi_t}{\partial X_t}\right)}^{\Theta_{forward}} \\ + \quad & \overbrace{\beta\frac{X}{\frac{\chi^v}{\chi^w}}\rho_x\frac{\partial\frac{\Omega_t}{\chi^w_t}}{\partial(\frac{\phi_t}{\Omega_t})}\frac{\partial(\frac{\phi_t}{\Omega_t})}{\partial X_t}}^{\Theta_{FLW}} - \overbrace{\beta(\frac{\frac{\Omega}{\chi^w}X}{(\frac{\chi^v}{\chi^w})^2} - \frac{W}{(\frac{\chi^v}{\chi^w})^2})\rho_x\frac{\partial\frac{\chi^v_t}{\chi^w_t}}{\partial(\frac{\phi_t}{\Omega_t})}\frac{\partial(\frac{\phi_t}{\Omega_t})}{\partial X_t}}^{\Theta_{hiring}} - \overbrace{\beta\frac{1}{\frac{\chi^v}{\chi^w}}\rho_x\frac{W}{X}\epsilon_{W_t,X_t}}^{\Theta_W}]\end{aligned} \quad (22)$$

Table 5 shows the quantitative result of this decomposition. Without financial constraints ($\frac{\Omega}{\chi^w} = \frac{\chi^v}{\chi^w} = 1$), tightness volatility is determined by steady-state values and parameters (Θ_{level}) as well as by the cyclical dynamics of the wage (Θ_W). More flexible wages reduce tightness volatility as is discussed in the existing literature (see e.g., (Shimer, 2005) or (Hall, 2005)). In contrast, tightness volatility increases substantially when financial constraints are present. This is apparent in Table 5 when comparing the overall effect in row 21 across columns.

Considering the various financial channels separately, we see that when financial constraints fall in a boom, the decreasing financial labor wedge increases the surplus from the match and pushes vacancy creation up (see Θ_{FLW} in row 15). In addition, if the relative financial cost of posting vacancies decreases in a boom, this further intensifies tightness volatility (see baseline and case I, Θ_{hiring} in row 16) and vice versa (see case III).

Since wages are more flexible when financial constraints are present, the surplus from the match decreases in a boom which reduces the volatility of tightness (Θ_W, row 17). When only the financial hiring costs matter (case I), wages are less flexible, and the effect is distinctly smaller. This direct link between wage flexibility and low tightness elasticity has received much attention in the debate about the so-called Shimer (2005) puzzle. The presence of financial frictions, however, de-couples this link. In our baseline model, a high wage elasticity and a high tightness elasticity go hand-in-hand. One reason is that the financial channel that dampens wage fluctuations (W_θ) works through financing vacancy posting costs rather than wages. It turns out that this channel (Θ_{hiring}) matters quantitatively much less for the tightness elasticity compared to alternative channels that jointly increase the wage and tightness elasticity.

The forward-looking financial costs are the most important term for the tightness volatility. These capture the financial cost of posting vacancies today and tomorrow ($\Theta_{forward}$, see row 18 in

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

Table 5). As financial constraints decrease in a boom, while only temporarily, the financial cost of posting vacancies decreases more today than tomorrow. This increases the immediate job creation of firms and hence tightness volatility today. Interestingly, amplification from this term is larger when wages are externally financed (the financial labor wedge is present). On the one hand, this stems from the fact that the financial costs of vacancies (χ^v) are present when wages (and no vacancies) are externally financed (see discussion in Section 2). On the other hand, using external finance for wages acts as a more powerful amplifier of financial constraints as discussed above and visible in rows 1-2 of Table 5. Intuitively, what matters for firms' job creation is the current and expected financial cost of hiring and paying wages, not only the wage paid out to workers.

4.2.4 Robustness

Our results highlight the importance of equilibrium effects for both wage flexibility and tightness elasticity. Note that the value of the wage bargaining weight η increases the level of wage flexibility and, hence, its importance for tightness amplification. In an alternative calibration, we therefore increase this value to $\eta = 0.4$ as a robustness check.[32] In addition, a high value of unemployment benefits increases tightness amplification as discussed by Hagedorn and Manovskii (2008). In our alternative calibration, we therefore set $b = 0.6$ which corresponds to the replacement ratio in Germany in our period. Table 7 in Appendix A.6.5 documents the results. Not surprisingly, overall dynamics in tightness are much lower, and dynamics in wages are higher. But importantly, the overall patterns and relative quantitative effects of the various channels remain as discussed in the baseline calibration, i.e., these are independent of our calibration strategy to obtain sufficient amplification.

Further, our results highlight the importance of the forward-looking channel. This channel is only in place if financial constraints change over time, e.g., over the business cycle. Also visible in Equations (21) and (22), the forward-looking channel therefore depends on the autocorrelation of aggregate productivity ρ_x. Table 8 in Appendix A.6.5 shows the results of the simulation when we make the shock very persistent ($\rho_x = 0.99$). In this case, the forward-looking channel plays only a small role in accounting for wage and tightness dynamics. Wages are less flexible than in the baseline calibration, but wages are still more flexible than without financial constraints overall and across special cases. This is due to the fact that now tightness volatility is larger which, in turn, makes wages more flexible. Hence, wage flexibility and tightness elasticity are more directly related when the forward-looking channel is weak.

4.3 Policy implications

Do our results matter for labor market policy? As an illustrative example, we investigate a subsidy to vacancy posting that aims at reducing unemployment in recessions.[33] Equations (A.82) and (A.83) in Appendix A.6.6 describe the job creation and the wage equation in a model with the subsidy T_t. Figure 1 shows the impulse responses to a shock in T_t that triggers a one standard

[32] A large number of studies sets $\eta = 0.5$, not on empirical grounds but to match the Hosios condition. Values below 0.5 may, however, be more realistic also when comparing the Nash bargaining to other wage setting mechanisms (see Gottfries, 2020).

[33] Cahuc et al. (2019) show empirically that a hiring credit can be a very effective policy to stabilize employment in a recession. Interestingly, they find no stabilizing effect on wages.

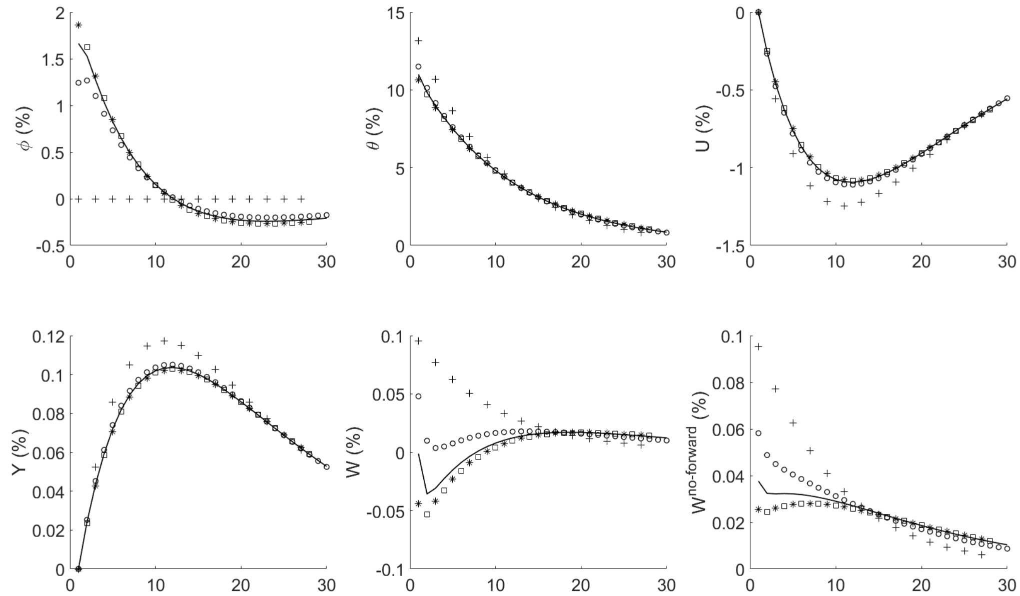

Figure 1: Impulse responses to an increase in the vacancy posting subsidy (T) that generates a one-standard-deviation increase in θ in the baseline model, all in percent deviations from steady state. Solid line: baseline, $\circ$: special case I, $\square$: special case II, $*$: special case III, $+$: no financial frictions.

deviation increase in tightness in our baseline model. Let us first consider an economy without financial frictions. While reducing the cost of posting vacancies, the policy increases the incentives to create jobs. This increases labor market tightness and reduces unemployment. The direct effect of the subsidy on the wage is negative as the policy improves the outside option of firms in the wage bargaining, but equilibrium wages increase due to the rise in labor market tightness. Hence, a subsidy to vacancy posting costs buffers both wage and unemployment dynamics in a recession.

Now consider an economy with financial frictions. While the subsidy decreases the cost of posting vacancies, the additional job creation increases the demand for external finance both through paying the financial cost of hiring and wages. Firms therefore become more financially constrained (ϕ). As a result, unemployment falls, but less in the presence of financial frictions compared to the model without financial frictions. Conditional on the sign of the financial hiring cost and the role of the forward-looking financial cost as well as the labor wedge, wages may respond differently. In particular, in cases II and III when wages are externally financed wages fall rather than rise due to the subsidy. This is the case because firms anticipate that financial constraints will be lower again in the future. In contrast, if we switch off the forward-looking term ($W^{no-forward}$), wages rise as in the model without financial constraints. In sum, a subsidy to vacancy posting buffers rising unemployment by less in financial recessions compared to normal recessions and may even lead to additional downward pressure on wages. Hiring subsidies are therefore a less effective stabilizer in recessions in which financial constraints play an important role.

5 Conclusions

We have explored the relationship between financial constraints at the firm level and individual wages. Three mechanisms play a role in this relationship. First, the labor wedge determines which part of the external financing cost of paying wages is burdened by the worker and induces wages to fall when financial constraints increase. Second, the financial hiring cost interacts with labor market tightness, since the financial cost of paying for vacancies and/or wages affects the bargaining position of the worker. If vacancy posting costs are exposed to external finance to a larger degree than wages, wages increase with financial constraints. Third, financial costs are forward-looking. If the financial cost of paying workers increases over time, this increases the indirect financial cost of hiring and puts immediate upward pressure on wages.

Central to our analysis is a dynamic macroeconomic model which includes both financial and labor market frictions. We explore the model properties that the financial mechanisms induce both through individual effects as well as aggregate effects. We estimate the presence, strength and direction of the financial channels at the micro-level focusing on match-specific ceteris paribus effects which allow us to tackle observed and unobserved confounding factors in several ways. Overall, our estimates show that wages are lower when financial conditions are more constrained in the firm.

We then use these results for calibrating the full model and to assess business cycle dynamics in equilibrium. Labor market equilibrium effects determine how labor market tightness and, hence, unemployment change over the business cycle. When wages fluctuate less, tightness fluctuates more. When financial frictions are present in the economy, financial constraints decrease in a boom and increase in a recession. All financial mechanisms increase the fluctuations of labor market tightness, unemployment and wages over the business cycle. The exception are financial hiring cost which decrease the flexibility of wages over the business cycle, but this mechanism turns out to be quantitatively small compared to the other financial mechanisms. The forward-looking financial cost is quantitatively particularly important. Financial mechanisms hence induce a co-movement between wages and tightness that counteracts the otherwise strong link between low wage flexibility and high labor market tightness amplification through the equilibrium effects.

Our financial mechanisms interact with labor market policy. In one example, we show that the forward-looking financial cost of hiring affects labor market policies that subsidize hiring. While without financial frictions, hiring subsidies stabilize unemployment and wages in recessions, unemployment stabilization may come at the cost of an even larger drop in wages if financial frictions and forward-looking financial costs are important. Our mechanisms potentially interact with further labor market policies and institutions, and may hence work differently across countries. We will explore this avenue in future research.

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A Model appendix

A.1 Wage determination

Workers and firms apply Nash bargaining to set wages

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

Using equation (9) this delivers

$$(1-\eta)\overbrace{\frac{\partial J_{N_{it}}}{\partial W_{it}}}^{=-\chi^w_{it}}(H^N_{it} - H^U_t) + \eta J_{N_{it}} = 0 \tag{A.2}$$

and hence the following sharing rule

$$\left(H^N_{it} - H^U_t\right) = \frac{\eta}{(1-\eta)\chi^w_{it}} J_{N_{it}} \tag{A.3}$$

Using equations (14) and (15) gives

$$H^N_{it} - H^U_t = W_{it} - b + \beta E_t\left[(1-\delta-f(\theta_t))(H^N_{i,t+1} - H^U_{t+1})\right] \tag{A.4}$$

Iterating equation (A.3) forward and inserting into (A.4) yields

$$J_{N_{it}} = \frac{(1-\eta)\chi^w_{it}}{\eta}(W_{it} - b) + \beta E_t(1-\delta-f(\theta_t))\frac{\chi^w_{it}}{\chi^w_{i,t+1}} J_{N_{i,t+1}} \tag{A.5}$$

Together with (9), this then gives the wage equation:

$$W_{it} = \eta\left[\frac{\Omega_{it}}{\chi^w_{it}} X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t))\frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}\big)\frac{\chi^v_{it}}{\chi^w_{it}}\frac{\gamma}{p(\theta_t)}\right] + (1-\eta)b \tag{A.6}$$

A.2 The effect of financial frictions on wages

A.2.1 $\phi > \Omega$

$$\begin{aligned}
\phi &> \Omega \\
\phi &> (1-\zeta+(1+r)\zeta\Delta)(1-\Gamma) + \phi(\Gamma - \mu G) \\
\phi &> \frac{(1-\zeta+(1+r)\zeta\Delta)(1-\Gamma)}{(1-\Gamma+\mu G)} \\
\frac{(1-\zeta+(1+r)\zeta\Delta)\Gamma'}{\Gamma' - \mu G'} &> \frac{(1-\zeta+(1+r)\zeta\Delta)(1-\Gamma)}{(1-\Gamma+\mu G)} \\
\frac{\Gamma'}{\Gamma'-\mu G'} > 1 &> \frac{(1-\Gamma)}{(1-\Gamma+\mu G)}
\end{aligned} \tag{A.7}$$

A.2.2 χ^w increases in $1-\lambda_w$

Using A.2.2

$$\frac{\partial \chi^w}{\partial \lambda_w} = \lambda_w(\overbrace{\Omega - \phi}^{<0}) < 0 \tag{A.8}$$

A.2.3 No frictions

From equation (6) and (7),

$$\phi_{it} = (1 - \zeta + (1+r)\zeta\Delta_{it}) = (1 - \zeta + (1+r)\zeta\beta\phi_{i,t+1}) \tag{A.9}$$

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

$$\phi_i = \frac{1-\zeta}{1-(1+r)\zeta\beta} = 1 \tag{A.10}$$

From equation (10),

$$\begin{aligned}\Omega_{it} &= (1 - \zeta + (1+r)\zeta\Delta_{it})\,[1 - \Gamma(\bar{\omega}_{it})] + \phi_{it}\,[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})] \\ &= (1 - \zeta + (1+r)\zeta\beta)\,[1 - \Gamma(\bar{\omega}_{it})] + [\Gamma(\bar{\omega}_{it})] \\ &= 1 - \Gamma(\bar{\omega}_{it}) + \Gamma(\bar{\omega}_{it}) = 1\end{aligned} \tag{A.11}$$

It then follows that $\chi_i^w = \chi_i^v = 1$.

A.2.4 Changing μ

First, we show that

$$\frac{\partial \frac{\Omega}{\chi^w}}{\partial \mu} = \frac{\frac{\Omega}{\chi^w}\Phi^w}{\partial \frac{\phi}{\Omega}} \frac{\partial \frac{\phi}{\Omega}}{\partial \mu} < 0 \tag{A.12}$$

if $\lambda^w < 1$.
Rewrite

$$\frac{\Omega}{\chi^w} = \frac{1}{\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}} \tag{A.13}$$

Then,

$$\frac{\partial \frac{\Omega}{\chi^w}}{\partial \frac{\phi}{\Omega}} = -\frac{1-\lambda_w}{(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega})^2} < 0 \tag{A.14}$$

unless $\lambda_w = 1$.

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

$$\begin{aligned}
\frac{\partial(\frac{\phi}{\Omega})}{\partial \mu} =& \frac{\frac{\partial \phi}{\partial \mu}\Omega - \frac{\partial \Omega}{\partial \mu}\phi}{\Omega^2} \\
=& \frac{\frac{\partial \phi}{\partial \mu}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]+\phi\left[\Gamma(\bar{\omega})-\mu G(\bar{\omega})\right]\big)}{\Omega^2} \\
-& \frac{\phi\big((\Gamma(\bar{\omega})-\mu G(\bar{\omega}))\frac{\partial \phi}{\partial \mu}-\phi G(\bar{\omega})\big)}{\Omega^2} \\
=& \frac{\frac{\partial \phi}{\partial \mu}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big)+\phi^2 G(\bar{\omega})}{\Omega^2}
\end{aligned} \tag{A.15}$$

From this, $\frac{\partial \frac{\phi}{\Omega}}{\partial \mu} > 0$ if $\frac{\partial \phi}{\partial \mu} > 0$. Looking at equation (6), 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

$$\frac{\partial \frac{\chi^v}{\chi^w}}{\partial \mu} = \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \frac{\phi}{\Omega}} \frac{\partial \frac{\phi}{\Omega}}{\partial \mu} > 0 \tag{A.16}$$

if $\lambda_w > \lambda_v$.
Similar to before, rewrite

$$\frac{\chi^v}{\chi^w} = \frac{\lambda_v + (1-\lambda_v)\frac{\phi}{\Omega}}{\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}} \tag{A.17}$$

Then,

$$\frac{\partial \frac{\chi^v}{\chi^w}}{\partial \frac{\phi}{\Omega}} = \frac{(1-\lambda_v)(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}) - (1-\lambda_w)(\lambda_v + (1-\lambda_v)\frac{\phi}{\Omega})}{(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega})^2} > 0 \tag{A.18}$$

if

$$\begin{aligned}
(1-\lambda_v)(\lambda_w + (1-\lambda_w)\frac{\phi}{\Omega}) - (1-\lambda_w)(\lambda_v + (1-\lambda_v)\frac{\phi}{\Omega}) > 0 \\
(1-\lambda_v)\lambda_w - (1-\lambda_w)\lambda_v > 0 \\
\lambda_w - \lambda_v > 0
\end{aligned} \tag{A.19}$$

A.2.5 Interaction coefficients

Financial labor wedge

$$\frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{\omega}} = \frac{\frac{\partial \Omega}{\partial \bar{\omega}} \chi^w - \frac{\partial \chi^w}{\partial \bar{\omega}} \Omega}{(\chi^w)^2}$$
$$= \frac{\frac{\partial \Omega}{\partial \bar{\omega}}(\lambda_w \Omega + (1-\lambda_w)\phi) - (\lambda_w \frac{\partial \Omega}{\partial \bar{\omega}} + (1-\lambda_w)\frac{\partial \phi}{\partial \bar{\omega}})\Omega}{(\chi^w)^2}$$
$$= \frac{(1-\lambda_w)\left[\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega\right]}{(\chi^w)^2} \tag{A.20}$$

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

$$\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega = \big(-(1-\zeta+(1+r)\zeta\Delta)\Gamma'(\bar{\omega}) + \phi\left[\Gamma'(\bar{\omega}) - \mu G'(\bar{\omega})\right] + \frac{\partial \phi}{\partial \bar{\omega}}\left[\Gamma(\bar{\omega}) - \mu G(\bar{\omega})\right]\big)\phi$$
$$- \frac{\partial \phi}{\partial \bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right] + \phi\left[\Gamma(\bar{\omega}) - \mu G(\bar{\omega})\right]\big)$$
$$= \big(-(1-\zeta+(1+r)\zeta\Delta)\Gamma'(\bar{\omega}) + \phi\left[\Gamma'(\bar{\omega}) - \mu G'(\bar{\omega})\right]$$
$$- \frac{\partial \phi}{\partial \bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big)$$
$$= -\frac{\partial \phi}{\partial \bar{\omega}}\big((1-\zeta+(1+r)\zeta\Delta)\left[1-\Gamma(\bar{\omega})\right]\big) \tag{A.21}$$

where the last step uses the definition of ϕ in (6). $\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega < 0$ if $\frac{\partial \phi}{\partial \bar{\omega}} > 0$.
Show that $\frac{\partial \phi}{\partial \bar{\omega}} > 0$:
First, we evaluate this expression at steady state, hence we use

$$\phi_i = \frac{(1-\zeta+(1+r)\zeta\Delta_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)}$$
$$\phi_i = \frac{(1-\zeta+(1+r)\zeta\beta\phi_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)}$$
$$\phi_i = \frac{(1-\zeta+\zeta\phi_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)}$$
$$\phi_i = \frac{(1-\zeta)\Gamma'(\bar{\omega}_i)}{(1-\zeta)\Gamma'(\bar{\omega}_i) - \mu G'(\bar{\omega}_i)} \tag{A.22}$$

Use that

$$\Gamma'(\bar{\omega}) = 1 - H(\bar{\omega}) \tag{A.23}$$
$$\Gamma''(\bar{\omega}) = -h(\bar{\omega}) \tag{A.24}$$
$$G'(\bar{\omega}) = \bar{\omega} \cdot h(\bar{\omega}) \tag{A.25}$$
$$G''(\bar{\omega}) = h(\bar{\omega}) + \bar{\omega} \cdot h'(\bar{\omega}) \tag{A.26}$$

Then

$$\frac{\partial \phi}{\partial \bar{\omega}} = \frac{\mu(1-\zeta)(G''\Gamma' - G'\Gamma'')}{((1-\zeta)\Gamma' - \mu G')^2} \\ = \mu(1-\zeta) \cdot \frac{\left(h(\bar{\omega}) + \bar{\omega}h'(\bar{\omega})\right) \cdot (1 - H(\bar{\omega})) + \bar{\omega}h^2(\bar{\omega})}{((1-\zeta)\Gamma' - \mu G')^2} \tag{A.27}$$

$\frac{\partial \phi}{\partial \bar{\omega}} > 0$ if $h'(\bar{\omega}) > -\left(\frac{h^2(\bar{\omega})}{1-H(\bar{\omega})} + \frac{h(\bar{\omega})}{\bar{\omega}}\right)$. 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.

Financial hiring costs The sign of the interaction coefficient depends on

$$(1-\delta)\frac{\partial \left(1 - \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}\right)\frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}} \frac{\partial \frac{1}{p(\theta_t)}}{\partial \theta_t} + \frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}\frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}}$$

$$(1-\delta)\left(\left(1 - \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}\right)\frac{\partial \frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}} - \frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial \bar{\omega}_{it}}\frac{\chi^v_{it}}{\chi^w_{it}}\right)\frac{\partial \frac{1}{p(\theta_t)}}{\partial \theta_t} + \frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial \bar{\omega}_{it}}\frac{\chi^v_{it}}{\chi^w_{it}} + \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}\frac{\partial \frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}}$$

Evaluated at steady state, this yields

$$(1-\delta)\left(-\frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial \bar{\omega}_{it}}(\bar{\omega})\frac{\chi^v}{\chi^w}\right)\frac{\partial \frac{1}{p(\theta_t)}}{\partial \theta_t}(\theta) + \frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial \bar{\omega}_{it}}(\bar{\omega})\frac{\chi^v}{\chi^w} + \frac{\partial \frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}}(\bar{\omega})$$

$$\frac{\chi^v}{\chi^w}\frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial \bar{\omega}_{it}}(\bar{\omega})\left(-(1-\delta)\frac{\partial \frac{1}{p(\theta_t)}}{\partial \theta_t}(\theta) + 1\right) + \frac{\partial \frac{\chi^v_{it}}{\chi^w_{it}}}{\partial \bar{\omega}_{it}}(\bar{\omega})$$

Regarding the last term

$$\frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}} = \frac{\frac{\partial \chi^v}{\partial \bar{\omega}}\chi^w - \frac{\partial \chi^w}{\partial \bar{\omega}}\chi^v}{(\chi^w)^2} \\ = \frac{\left(\lambda_v \frac{\partial \Omega}{\partial \bar{\omega}} + (1-\lambda_v)\frac{\partial \phi}{\partial \omega}\right)(\lambda_w \Omega + (1-\lambda_w)\phi)}{(\chi^w)^2} \\ - \frac{\left(\lambda_w \frac{\partial \Omega}{\partial \bar{\omega}} + (1-\lambda_w)\frac{\partial \phi}{\partial \omega}\right)(\lambda_v \Omega + (1-\lambda_v)\phi)}{(\chi^w)^2} \\ = \frac{(\lambda_v - \lambda_w)\left[\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega\right]}{(\chi^w)^2} \tag{A.28}$$

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 $\lambda_v > \lambda_w$.
Then, the sign of $\left(-(1-\delta)\frac{\partial \frac{1}{p(\theta_t)}}{\partial \theta_t}(\theta) + 1\right)$ is not unambiguous, but negative for typical parameter values, also in our calibration.

Last

$$\frac{\partial \frac{\chi^w_{it}}{E_t\chi^w_{i,t+1}}}{\partial\bar{\omega}_{it}}(\bar{\omega}) = \frac{\frac{\partial\chi^w_{it}}{\partial\bar{\omega}_{it}}E_t\chi^w_{i,t+1} - \frac{\partial E_t\chi^w_{i,t+1}}{\partial\bar{\omega}_{it}}\chi^w_{i,t}}{(E_t\chi^w_{i,t+1})^2}(\bar{\omega})$$

$$= \frac{\frac{\partial\chi^w_{it}}{\partial\bar{\omega}_{it}} - \frac{\partial E_t\chi^w_{i,t+1}}{\partial\bar{\omega}_{it}}}{\chi^w}(\bar{\omega})$$

This term is zero if financial constraints today affect the financial cost of paying wages today and tomorrow in the same way. If financial constraints today affect tomorrow's costs more than today, this term is negative and vice versa. The overall sign of the interaction term then depends on the combination of the use of external finance λ^w versus λ^v as well as on the sign of this last term.

A.3 Steady state results

A.3.1 Steady state equations

$$\phi_i = \frac{(1-\zeta+(1+r)\zeta\Delta_i)\Gamma'(\bar{\omega}_i)}{\Gamma'(\bar{\omega}_i)-\mu G'(\bar{\omega}_i)} \tag{A.29}$$

$$\Omega_i = (1-\zeta+(1+r)\zeta\Delta_i)\left[1-\Gamma(\bar{\omega}_i)\right] + \phi_i\left[\Gamma(\bar{\omega}_i)-\mu G(\bar{\omega}_i)\right] \tag{A.30}$$

$$\chi^w_i = \lambda_w\Omega_i + (1-\lambda_w)\phi_i \tag{A.31}$$

$$\chi^v_i = \lambda_v\Omega_i + (1-\lambda_v)\phi_i \tag{A.32}$$

$$\Delta_i = \beta\phi_i \tag{A.33}$$

$$\begin{aligned}[\Gamma(\bar{\omega}_i)-\mu G(\bar{\omega}_i)]\left[(X_i-\lambda_w W_i)N_i - \lambda_v\gamma V_i\right] \\ = (1-\lambda_w)W_iN_i + (1-\lambda_v)\gamma V_i - A_i\end{aligned} \tag{A.34}$$

$$\frac{\gamma}{p(\theta)} = \frac{\beta}{1-\beta(1-\delta)}\left[\frac{\Omega_i}{\chi^v_i}X_i - \frac{\chi_i{}^w}{\chi^v_i}W_i\right] \tag{A.35}$$

$$W_i = \eta\left[\frac{\Omega_i}{\chi^w_i}X_i + \frac{\chi^v_i}{\chi^w_i}\gamma\theta\right] + (1-\eta)b \tag{A.36}$$

$$A_i = (1+r)\zeta(1-\Gamma(\bar{\omega}_i))[(X_i-\lambda_wW_i)N_i - \lambda_v\gamma V_i] \tag{A.37}$$

$$\delta N_i = p(\theta)V_i \tag{A.38}$$

$$\theta = \frac{V_i}{1-N_i} \tag{A.39}$$

A.3.2 The surplus decreases with the financial friction

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

$$\frac{\partial\frac{\Omega}{\chi^v}}{\partial\frac{\phi}{\Omega}} - \frac{\partial\frac{\chi^w}{\chi^v}}{\partial\frac{\phi}{\Omega}} = -\frac{1-\lambda_v}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2} - \frac{\lambda_v-\lambda_w}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2} \tag{A.40}$$

$$= \frac{\lambda_w-1}{(\lambda_v+(1-\lambda_v)\frac{\phi}{\Omega})^2} < 0 \tag{A.41}$$

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,

$$\frac{\Omega}{\chi_v} X > \frac{\chi^w}{\chi^v} b \tag{A.42}$$

$$X > \frac{\chi^w}{\Omega} b > b \tag{A.43}$$

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

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} X < \frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} b < \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \frac{\phi}{\Omega}} b \tag{A.44}$$

Therefore

$$\frac{\partial \frac{\Omega}{\chi_v}}{\partial \frac{\phi}{\Omega}} X - \frac{\partial \frac{\chi_w}{\chi_v}}{\partial \frac{\phi}{\Omega}} b < 0 \tag{A.45}$$

A.4 Model variations

A.4.1 Model without search frictions

Firm problem:

$$\max_{N_{it}, \bar{\omega}_{it}, A_{i,t+1}} (1-\zeta)\left[1-\Gamma(\bar{\omega}_{it})\right]\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it}\right] \tag{A.46}$$

subject to

$$\left[\Gamma(\bar{\omega}_{it}) - \mu G(\bar{\omega}_{it})\right]\left(X_{it} - \lambda_w W_{it}\right) N_{it} = (1-\lambda_w) W_{it} N_{it} - A_{it} \tag{A.47}$$

$$A_{i,t+1} = (1+r)\zeta(1-\Gamma(\bar{\omega}_{it}))(X_{it} - \lambda_w W_{it}) N_{it} \tag{A.48}$$

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

$$0 = \Omega_{it} X_{it} - \Omega_{it}\lambda_w W_{it} - \phi_{it}(1-\lambda_w) W_{it} \tag{A.49}$$

$$W_{it} = \frac{\Omega_{it} X_{it}}{\Omega_{it}\lambda_w + \phi_{it}(1-\lambda_w)} = \frac{\Omega_{it}}{\chi^w_{it}} X_{it} \tag{A.50}$$

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 (6) and (7).
The wage equation is identical to the first part of equation (16) when $\eta = 1$. Hence, it exhibits the labor wedge, but not the financial hiring cost channel of finance.

A.4.2 Model with collateral constraint

Firm problem:

$$J_{it} = \max_{V_{it}, A_{i,t+1}} (1-\zeta)\left[\left(X_{it} - \lambda_w W_{it}\right) N_{it} - \lambda_v \gamma V_{it}\right] + \beta E_t J_{i,t+1}, \tag{A.51}$$

subject to

$$N_{i,t+1} = (1-\delta)N_{it} + p(\theta_t)V_{it} \tag{A.52}$$
$$Q_{it} = (1-\lambda_w)W_{it}N_{it} + (1-\lambda_v)\gamma V_{it} - A_{it} \tag{A.53}$$
$$A_{i,t+1} = (1+r)\zeta[(X_{it} - \lambda_w W_{it})N_{it} - \lambda_v \gamma V_{it}] \tag{A.54}$$

Here, equation (A.53) 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

$$\begin{aligned} J_{N_it} &= (1-\zeta)\left[X_{it} - \lambda_w W_{it}\right] - \tilde{\phi}_{it}(1-\lambda_w)W_{it} \\ &\quad + \Delta_{it}(1+r)\zeta(X_{it} - \lambda_w W_{it}) + \beta E_t J_{N_{i,t+1}} && \text{(A.55)} \\ &= \tilde{\Omega}_{it}\left[X_{it} - \lambda_w W_{it}\right] - \tilde{\phi}_{it}(1-\lambda_w)W_{it} + \beta E_t J_{N_{i,t+1}} && \text{(A.56)} \\ &= \tilde{\Omega}_{it}X_{it} - \widetilde{\chi^w}_{it}W_{it} + \beta E_t J_{N_{i,t+1}} && \text{(A.57)} \end{aligned}$$

which looks very similar to the baseline model, except that

$$\tilde{\Omega}_{it} = 1 - \zeta + \Delta_{it}(1+r)\zeta \tag{A.58}$$
$$\widetilde{\chi^w}_{it} = \tilde{\Omega}_{it}\lambda_w + \tilde{\phi}_{it}(1-\lambda_w) \tag{A.59}$$

The first order conditions are then

$$\frac{\widetilde{\chi^v}_{it}\gamma}{p(\theta_t)} = \beta E_t J_{N_{i,t+1}} \tag{A.60}$$
$$\Delta_{it} = \beta\phi_{i,t+1} \tag{A.61}$$

with

$$\widetilde{\chi^v}_{it} = \tilde{\Omega}_{it}\lambda_v + \tilde{\phi}_{it}(1-\lambda_v) \tag{A.62}$$

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

$$W_{it} = \eta\left[\frac{\tilde{\Omega}_{it}}{\widetilde{\chi}^w_{it}}X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t))\frac{\widetilde{\chi}^w_{it}}{E_t\widetilde{\chi}^w_{i,t+1}}\big)\frac{\widetilde{\chi}^v_{it}}{\widetilde{\chi}^w_{it}}\frac{\gamma}{p(\theta_t)}\right] + (1-\eta)b \tag{A.63}$$

This wage equation is similar in spirit to equation (16). $\tilde{\phi}$ now measures the tightness of the collateral constraint.

A.4.3 Model with endogenous savings

In this version of the model, firms can freely and optimally decide about their savings $\frac{A_{t+1}}{1+r}$, with the constraint that their per period saving cannot be larger than their profits (i.e. firms cannot borrow from shareholders): $\frac{A_{t+1}}{1+r} \leq [1-\Gamma(\bar{x}_t)]\left[(X_t - \lambda_w W_t)N_t - \lambda_v\gamma V_t\right]$
In this setup, the firms maximization problem is:

$$J_t = \max_{V_t, \bar{x}_t, A_{t+1}} [1 - \Gamma(\bar{x}_t)] [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t] - \frac{A_{t+1}}{1+r} + \beta E_t J_{t+1} \tag{A.64}$$

subject to

$$N_{t+1} = (1-\delta) N_t + p(\theta_t) V_t \quad , \tag{A.65}$$

$$[\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)] [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V] = (1-\lambda_w) W_t N_t + (1-\lambda_v)\gamma V_t - Q_t A_t \quad , \tag{A.66}$$

$$\frac{A_{t+1}}{1+r} \leq [1 - \Gamma(\bar{x}_t)] [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t] \quad , \tag{A.67}$$

where, Δ_t is now the Lagrangian multiplier of the Equation (A.67) and measures the marginal value of savings. Similarly to our baseline model, the derivative of J_t w.r.t. $\bar{\omega}$ determines the marginal cost of borrowing:

$$\phi_t = \frac{\Gamma'(\bar{x}_t)(1+\Delta_t)}{\Gamma'(\bar{x}_t - \mu G'(\bar{x}_t))} \tag{A.68}$$

Ω_t comes from the derivative of J_t w.r.t. $(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V$, which reads:

$$\Omega_t = [1 - \Gamma(\bar{x}_t)] + \Delta_t [1 - \Gamma(\bar{x}_t)] + \phi [\Gamma(\bar{x}_t) - \mu G(\bar{x}_t)] \tag{A.69}$$

Finally, the derivative of J_t w.r.t. A_{t+1} gives:

$$\Delta_t = (1+r)\beta E_t \phi_{t+1} - 1 \tag{A.70}$$

The rest of our baseline model equations remain unchanged in this model variation. According to Equation (A.70), assuming no time arbitrage ($(1+r)\beta = 1$), the risk neutrality of shareholders implies that shareholders are indifferent between dividends and savings as long as they expect no future financial constraints (i.e. $E_t \phi_{t+1} = 1$). In this case, the marginal value of saving is zero ($\Delta_t = 0$). However, if they expect that in the next period the firm faces financial constraints ($E_t \phi_{t+1} > 1$), then they would strictly prefer savings to dividends. Consequently, as long as profits are not large enough to completely relax future financial constraints, $\Delta_t > 0$ and no dividend would be distributed to shareholders (this is evident from the complementary slackness condition).[34]

The model with savings decisions corresponds to a special case of our baseline model in which $\zeta = 1$. In this case, firms would therefore save more than in our baseline model and financial constraints would be lower. The mechanism of how financial constraints affect the labor market is identical, however. $\zeta < 1$ reflects the notion that dividend payments usually exist even if firms are expected to face financial constraints. This is because of the fact that in reality shareholders are not risk neutral and, also, because some firms might have legal obligations to pay a part of their profits as dividend to shareholders.

[34] The corresponding complementary slackness condition is $\Delta_t \left[(1 - \Gamma(\bar{x}_t)) [(X_t - \lambda_w W_t) N_t - \lambda_v \gamma V_t] - \frac{A_{t+1}}{1+r} \right] = 0$.

A.5 Taylor approximation of the wage equation

We write the wage equation (16) as

$$\begin{aligned} W_{it} &= W(X_{it}, \theta_t, \bar{\omega}_{it}, \bar{\omega}_{i,t+1}) \\ &= \eta \left[\frac{\Omega(\bar{\omega}_{it})}{\chi^w(\bar{\omega}_{it})} X_{it} + \big((1-\delta) - (1-\delta-f(\theta_t)) \frac{\chi^w(\bar{\omega}_{it})}{E_t \chi^w(\bar{\omega}_{it+1})}\big) \frac{\chi^v(\bar{\omega}_{it})}{\chi^w(\bar{\omega}_{it})} \frac{\gamma}{p(\theta_t)} \right] + (1-\eta) b \end{aligned} \tag{A.71}$$

We then apply the following general formula for a second order multivariate Taylor expansion of a function $f(x, y, z)$ around the point $\bar{x}, \bar{y}, \bar{z}$

$$\begin{aligned} f(x,y,z) \approx\ & f(\bar{x},\bar{y},\bar{z}) + f_x(\bar{x},\bar{y},\bar{z})(x-\bar{x}) + f_y(\bar{x},\bar{y},\bar{z})(y-\bar{y}) + f_z(\bar{x},\bar{y},\bar{z})(z-\bar{z}) \\ & + \frac{1}{2} f_{xx}(\bar{x},\bar{y},\bar{z})(x-\bar{x})^2 + \frac{1}{2} f_{yy}(\bar{x},\bar{y},\bar{z})(y-\bar{y})^2 + \frac{1}{2} f_{zz}(\bar{x},\bar{y},\bar{z})(z-\bar{z})^2 \\ & + f_{xy}(\bar{x},\bar{y},\bar{z})(x-\bar{x})(y-\bar{y}) + f_{xz}(\bar{x},\bar{y},\bar{z})(x-\bar{x})(z-\bar{z}) + f_{zy}(\bar{x},\bar{y},\bar{z})(z-\bar{z})(y-\bar{y}) \end{aligned} \tag{A.72}$$

We will omit index i in the following for ease of notation. Applying the Taylor formulas to the wage equation delivers

$$\begin{aligned} W_t \approx\ & W + \eta \frac{\Omega}{\chi^w}(\bar{\omega})(X_t - X) + \eta X \frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{\omega}_t}(\bar{\omega})(\bar{\omega}_t - \bar{\omega}) \\ & + 0 + \frac{1}{2} \eta X \frac{\partial^2 \frac{\Omega_t}{\chi_t^w}}{\partial \bar{\omega}_t \partial \bar{\omega}_t}(\bar{\omega})(\bar{\omega}_t - \bar{\omega})^2 + \eta \frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial \bar{\omega}_t}(\bar{\omega})(X_t - X)(\bar{\omega}_t - \bar{\omega}) \\ & + \eta \frac{\chi^v}{\chi^w}(\bar{\omega}) \gamma (\theta_t - \theta) + \eta \gamma \theta \frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial \bar{\omega}_t}(\bar{\omega})(\bar{\omega}_t - \bar{\omega}) - \eta (1-\delta-f(\theta)) \frac{\chi^v}{\chi^w} \frac{1}{\chi^w}(\bar{\omega}) \frac{\gamma}{p(\theta)} \frac{\partial \chi_t^w}{\partial \bar{\omega}_t}(\bar{\omega}_t - \bar{\omega}) \\ & + 0 + \frac{1}{2} \eta \theta \gamma \frac{\partial^2 \frac{\chi_t^v}{\chi_t^w}}{\partial \bar{\omega}_t \partial \bar{\omega}_t}(\bar{\omega})(\bar{\omega}_t - \bar{\omega})^2 - \frac{1}{2} \eta (1-\delta-f(\theta)) \frac{\gamma}{p(\theta)} \left(2 \frac{1}{\chi^w} \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}_t} \frac{\partial \chi^w}{\bar{\omega}} + \frac{\chi^v}{(\chi^w)^2} \frac{\partial^2 \chi_t^w}{\partial \bar{\omega}_t \bar{\omega}_t} \right) (\bar{\omega}_t - \bar{\omega})^2 \\ & + \eta \gamma \frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial \bar{\omega}_t}(\bar{\omega})(\theta_t - \theta)(\bar{\omega}_t - \bar{\omega}) + \eta \frac{\chi^v}{(\chi^w)^2} \frac{\partial \chi_t^w}{\partial \bar{\omega}_t} \gamma \left(1 + (1-\delta) \frac{1}{(p(\theta))^2} \frac{\partial p(\theta)}{\partial \theta} \right) (\theta_t - \theta)(\bar{\omega}_t - \bar{\omega}) \\ & + \eta (1-\delta-f(\theta)) \frac{\chi^v}{\chi^w} \frac{1}{\chi^w} \frac{\gamma}{p(\theta)} \frac{\partial \chi_{t+1}^w}{\partial \bar{\omega}_{t+1}}(\bar{\omega})(\bar{\omega}_{t+1} - \bar{\omega}) \\ & - \eta (1-\delta-f(\theta)) \frac{\chi^v}{\chi^w} \frac{1}{(\chi^w)^2} \frac{\gamma}{p(\theta)} \frac{\partial^2 \chi_{t+1}^w}{\partial (\bar{\omega}_{t+1})^2}(\bar{\omega}_{t+1} - \bar{\omega})^2 \\ & - \eta \frac{\chi^v}{(\chi^w)^2} \frac{\partial \chi_{t+1}^w}{\partial \bar{\omega}_{t+1}} \gamma \left(1 + (1-\delta) \frac{1}{(p(\theta))^2} \frac{\partial p(\theta)}{\partial \theta} \right) (\theta_t - \theta)(\bar{\omega}_{t+1} - \bar{\omega}) \\ & + \eta (1-\delta-f(\theta)) \frac{\gamma}{p(\theta)} \frac{\partial \chi_{t+1}^w}{\partial \omega_{t+1}} \left(\frac{1}{(\chi^w)^2} \frac{\chi^v}{\chi^w} \frac{\partial \chi_t^w}{\partial \bar{\omega}_t} + \frac{1}{\chi^w} \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}_t} \right) (\bar{\omega}_t - \bar{\omega})(\bar{\omega}_{t+1} - \bar{\omega}) \end{aligned} \tag{A.73}$$

We use that $\frac{\partial \chi_{t+1}^w}{\partial \bar{\omega}_{t+1}} = \frac{\partial \chi_t^w}{\partial \bar{\omega}_t}$ and hence the same in steady state. We express the equation in percentage deviations from steady, re-arrange, simplify and combine terms to get the follwing

$$
\begin{aligned}
\frac{W_t - W}{W} \approx & \underbrace{\frac{X}{W}\eta\frac{\Omega}{\chi^w}}_{\beta_1}\frac{X_t - X}{X} \\
& + \underbrace{\frac{\theta}{W}\eta\frac{\chi^v}{\chi^w}\gamma}_{\beta_2}\frac{\theta_t - \theta}{\theta} \\
& + \underbrace{\frac{\bar{\omega}}{W}\eta\left[X\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}} + \gamma\theta\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}\right]}_{\beta_3}\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}} \\
& + \underbrace{\frac{\bar{\omega}}{W}\eta(1-\delta-f(\theta))\frac{\chi^v}{\chi^w}\frac{1}{\chi^w}\frac{\gamma}{p(\theta)}\frac{\partial\chi^w}{\partial\bar{\omega}}}_{\beta_4}\left(\frac{\bar{\omega}_{t+1} - \bar{\omega}}{\bar{\omega}} - \frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right) \\
& + \underbrace{\frac{X\bar{\omega}}{W}\eta\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}}}_{\beta_5}\frac{X_t - X}{X}\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}} \\
& + \underbrace{\frac{\theta\bar{\omega}}{W}\eta\gamma\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}}_{\beta_6}\frac{\theta_t - \theta}{\theta}\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}} \\
& - \underbrace{\frac{\theta\bar{\omega}}{W}\eta\frac{\chi^v}{(\chi^w)^2}\frac{\partial\chi^w}{\partial\bar{\omega}}\gamma\left(1 + (1-\delta)\frac{1}{(p(\theta))^2}\frac{\partial p(\theta)}{\partial\theta}\right)}_{\beta_7}\frac{\theta_t - \theta}{\theta}\left(\frac{\bar{\omega}_{t+1} - \bar{\omega}}{\bar{\omega}} - \frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right) \\
& + \underbrace{\frac{\bar{\omega}^2}{W}\frac{1}{2}\eta\left[X\frac{\partial^2\frac{\Omega}{\chi^w}}{\partial\bar{\omega}\partial\bar{\omega}} + \theta\gamma\frac{\partial^2\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}\partial\bar{\omega}}\right]}_{\beta_8}\left(\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right)^2 \\
& + \underbrace{\frac{\bar{\omega}^2}{W}\eta(1-\delta-f(\theta))\frac{\gamma}{p(\theta)}\frac{1}{\chi^w}\left[\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}\left(\frac{\partial\chi^v}{\partial\bar{\omega}} - \frac{\partial\chi^w}{\partial\bar{\omega}}\right) + \frac{\chi^v}{(\chi^w)^2}\left(\left(\frac{\partial\chi^w}{\partial\bar{\omega}}\right)^2 - \frac{1}{2}\frac{\partial^2\chi^w}{\partial(\bar{\omega})^2}\right)\right]}_{\beta_8}\left(\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right)^2 \\
& - \underbrace{\frac{\bar{\omega}^2}{W}\eta(1-\delta-f(\theta))\frac{\gamma}{p(\theta)}\frac{\chi^v}{\chi^w}\frac{1}{(\chi^w)^2}\frac{\partial^2\chi^w}{\partial(\bar{\omega})^2}}_{\beta_9}\left(\frac{\bar{\omega}_{t+1} - \bar{\omega}}{\bar{\omega}} - \frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right)^2 \\
& + \underbrace{\frac{\bar{\omega}^2}{W}\eta(1-\delta-f(\theta))\frac{\gamma}{p(\theta)}[\frac{1}{(\chi^w)^2}\frac{\chi^v}{\chi^w}\left(\frac{\partial\chi^w}{\partial\bar{\omega}}\right)^2 + \frac{1}{\chi^w}\frac{\partial\chi^w}{\partial\omega}\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}}_{\beta_{10}} \\
& + \underbrace{\frac{\chi^v}{\chi^w}\frac{2}{(\chi^w)^2}\frac{\partial^2\chi^w}{\partial(\bar{\omega})^2}]}_{\beta_{10}}\frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\left(\frac{\bar{\omega}_{t+1} - \bar{\omega}}{\bar{\omega}} - \frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}\right)
\end{aligned} \tag{A.74}
$$

Here, β_1 to β_{10} denote the coefficients that correspond to equation (17). Our model predicts the signs of the coefficients as follows:

- $\beta_1 > 0$ and $\beta_2 > 0$
- $\beta_3 = \frac{\bar{\omega}}{W}\eta\left[X\frac{\partial\frac{\Omega}{\chi^w}}{\partial\bar{\omega}} + \gamma\theta\frac{\partial\frac{\chi^v}{\chi^w}}{\partial\bar{\omega}}\right]$. This coefficient is negative if $\lambda^v > \lambda^w$ and ambiguous if $\lambda^v < \lambda^w$.

- $\beta_4 > 0$ as long as $1 - \delta - f(\theta) > 0$.
- $\beta_5 < 0$, compare derivation for the financial labor wedge
- $\beta_6 < 0$ if $\lambda^v > \lambda^w$. $\beta_6 > 0$ if $\lambda^v < \lambda^w$, compare derivation for the financial hiring cost
- β_7 depends on

$$
\begin{aligned}
1 + (1-\delta)\frac{1}{(p(\theta))^2}\frac{\partial p(\theta)}{\partial \theta} &= 1 - (1-\delta)\frac{1}{(\xi\theta^{-\epsilon})^2}\epsilon\xi\theta^{-\epsilon-1} \\
&= 1 - (1-\delta)\frac{1}{(\xi)^2}\epsilon\xi = 1 - (1-\delta)\frac{\epsilon}{\xi}
\end{aligned}
$$

  which for our calibration is negative. If this is the case, $\beta_7 > 0$.

- The signs of the remaining coefficients are theoretically ambiguous.

A.6 Simulation results

A.6.1 Steady state values

	no financial frictions	baseline $\lambda^w = 0.756$ $\lambda^v = 0.33$	case I $\lambda^w = 1$ $\lambda^v = 0$	case II $\lambda^w = 0$ $\lambda^v = 0$	case III $\lambda^w = 0$ $\lambda^v = 1$
		Steady state of variables			
Ω	1	1.08711	1.02027	1.3445	1.31843
ϕ	1	1.09574	1.02693	1.35576	1.32945
Φ	1	1.00794	1.00652	1.00837	1.00836
χ^v	1	1.09289	1.02693	1.35576	1.31843
χ^w	1	1.08922	1.02027	1.35576	1.32945
$\frac{\Omega}{\chi^w}$	1	0.998067	1	0.991697	0.99171
$\frac{\chi^v}{\chi^w}$	1	1.00337	1.00652	1	0.99171
$\frac{\Omega}{\chi^v}$	1	0.9947	0.9935	0.991697	1
$\bar{\omega}$	0.828631	0.816395	0.48387	0.936028	0.932353
Premium	1	1.0008	1.0008	1.0008	1.0008
n	0.914031	0.913497	0.913498	0.913498	0.913498
u	0.0859692	0.0865025	0.0865018	0.086502	0.0865018
v	0.088068	0.0864981	0.0865002	0.0864996	0.0865002
θ	1.02441	0.999949	0.999982	0.999972	0.999981
W	0.900417	0.899873	0.900288	0.898504	0.898507
Y	0.914031	0.913497	0.913498	0.913498	0.913498
		Parameters			
μ	0	0.54303	0.56801	0.53623	0.53643
γ	0.79892	0.79892	0.80871	0.76077	0.76721
σ_ω	0.067708	0.067708	0.23858	0.022196	0.023512

Table 6: Steady state values corresponding to model variations in the simulation Table 5.

A.6.2 Impulse-response plots

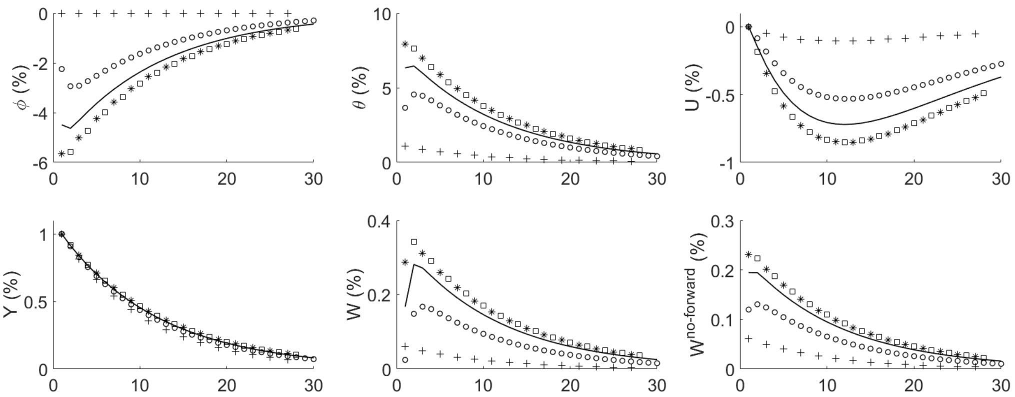

Figure 2: Impulse responses to a one-standard deviation increase in productivity (X), all in percent deviations from steady state. Solid line: baseline, ○: special case I, □: special case II, $*$: special case III, $+$: no financial frictions.

A.6.3 Derivation of $\frac{\beta_5}{\beta_6}$

From Equation (A.74), we have:

$$\frac{\beta_5}{\beta_6} = \frac{X \frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{\omega}}}{\gamma\theta \frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}}} \tag{A.75}$$

From Equations (A.20) and (A.28), we have: $\frac{\partial \frac{\Omega}{\chi^w}}{\partial \bar{\omega}} = \frac{(1-\lambda_w)\left[\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega\right]}{(\chi^w)^2}$ and $\frac{\partial \frac{\chi^v}{\chi^w}}{\partial \bar{\omega}} = \frac{(\lambda_v-\lambda_w)\left[\frac{\partial \Omega}{\partial \bar{\omega}}\phi - \frac{\partial \phi}{\partial \bar{\omega}}\Omega\right]}{(\chi^w)^2}$. Inserting these two equations in Equation (A.75), we have:

$$\frac{\beta_5}{\beta_6} = \frac{X(1-\lambda_w)}{\gamma\theta(\lambda_v - \lambda_w)} \tag{A.76}$$

A.6.4 Simulation decomposition

To derive equation (21), we differentiate equation (16) with respect to X_t. We omit the index i and the index j in the following.

$$\begin{aligned}
\frac{\partial W_t}{\partial X_t} = \eta\Big[& \frac{\Omega_t}{\chi_t^w} + \frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial (\frac{\phi_t}{\Omega_t})} \frac{\partial (\frac{\phi_t}{\Omega_t})}{\partial X_t} X_t \\
& + \big((1-\delta) - (1-\delta - f(\theta_t)) \frac{\chi_t^w}{E_t \chi_{t+1}^w}\big) \frac{\gamma}{p(\theta_t)} \frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial (\frac{\phi_t}{\Omega_t})} \frac{\partial (\frac{\phi_t}{\Omega_t})}{\partial X_t} \\
& - \big((1-\delta) - (1-\delta - f(\theta_t)) \frac{\chi_t^w}{E_t \chi_{t+1}^w}\big) \frac{\chi_t^v}{\chi_t^w} \frac{\gamma}{p^2(\theta_t)} \frac{\partial p(\theta_t)}{\partial \theta_t} \frac{\partial \theta_t}{\partial X_t} \\
& + \frac{\chi_t^w}{E_t \chi_{t+1}^w} \frac{\gamma}{p(\theta_t)} \frac{\chi_t^v}{\chi_t^w} \frac{\partial f(\theta_t)}{\partial \theta_t} \frac{\partial \theta_t}{\partial X_t} \\
& - (1-\delta - f(\theta_t)) \frac{E_t \chi_{t+1}^w \frac{\partial \chi_t^w}{\partial X_t} - \chi_t^w \frac{\partial E_t \chi_{t+1}^w}{\partial E_t X_{t+1}} \frac{\partial E_t X_{t+1}}{\partial X_t}}{{E_t \chi_{t+1}^w}^2} \big) \frac{\gamma}{p(\theta_t)} \frac{\chi_t^v}{\chi_t^w} \Big]
\end{aligned} \tag{A.77}$$

We now use that $\frac{\partial E_t Z_{t+1}}{\partial E_t Y_{t+1}} = \frac{\partial Z_t}{\partial Y_t}$ for any variables $\{Z, Y\}$ and that $\frac{\partial E_t X_{t+1}}{\partial X_t} = \rho_x$. Further, $\epsilon_{W_t,X_t} = \frac{\partial W_t}{\partial X_t} \frac{X_t}{W_t}$. We then evaluate the above expression at steady state which yields

$$\begin{aligned}
\frac{W}{X} \epsilon_{W_t,X_t} = \eta\Big[& \frac{\Omega}{\chi^w} + \frac{\partial \frac{\Omega_t}{\chi_t^w}}{\partial (\frac{\phi_t}{\Omega_t})} \frac{\partial (\frac{\phi_t}{\Omega_t})}{\partial X_t} X + f(\theta) \frac{\gamma}{p(\theta)} \frac{\partial \frac{\chi_t^v}{\chi_t^w}}{\partial (\frac{\phi_t}{\Omega_t})} \frac{\partial (\frac{\phi_t}{\Omega_t})}{\partial X_t} \\
& + [-\frac{f(\theta)}{p^2(\theta)} \frac{\partial p(\theta)}{\partial \theta} + \frac{1}{p(\theta)} \frac{\partial f(\theta)}{\partial \theta}] \gamma \frac{\chi_t^v}{\chi_t^w} \frac{\partial \theta_t}{\partial X_t} - (1-\delta - f(\theta)) \frac{(1-\rho_x) \frac{\partial \chi_t^w}{\partial X_t}}{\chi^w} \frac{\gamma}{p(\theta)} \frac{\chi^v}{\chi^w} \Big]
\end{aligned} \tag{A.78}$$

Use that $-\frac{f(\theta)}{p^2(\theta_t)} \frac{\partial p(\theta)}{\partial \theta} + \frac{1}{p(\theta_t)} \frac{\partial f(\theta_t)}{\partial \theta_t} = 1$ and $\frac{\partial \chi_t^w}{\partial X_t} = \lambda^w \frac{\partial \Omega_t}{\partial X_t} + (1-\lambda^w) \frac{\partial \phi_t}{\partial X_t}$. Then re-arrange to arrive at equation (21).

To derive equation (22), we rewrite equation (13) as follows, omitting the index i and the index j as well as the expectation operator in the following.

$$\frac{\gamma}{p(\theta_t)} = \frac{\chi_{t+1}^v}{\chi_t^v} \beta \left[\frac{\Omega_{t+1}}{\chi_{t+1}^w} \frac{\chi_{t+1}^w}{\chi_{t+1}^v} X_{t+1} - \frac{\chi_{t+1}^w}{\chi_{t+1}^v} W_{t+1} + (1-\delta) \frac{\gamma}{p(\theta_{t+1})} \right] \tag{A.79}$$

We then differentiate this equation with respect to X_t.

$$
\begin{aligned}
&-\frac{\gamma}{p^2(\theta_t)}\frac{\partial p(\theta_t)}{\partial \theta_t}\frac{\partial \theta_t}{\partial X_t} = \\
&\quad \frac{\frac{\partial \chi^v_{t+1}}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t}\chi^v_t - \frac{\partial \chi^v_t}{\partial X_t}\chi^v_{t+1}}{{\chi^v_t}^2}\beta\Big[\frac{\frac{\Omega_{t+1}}{\chi^w_{t+1}}}{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}X_{t+1} - \frac{1}{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}W_{t+1} + (1-\delta)\frac{\gamma}{p(\theta_{t+1})}\Big] \\
&\quad + \frac{\chi^v_{t+1}}{\chi^v_t}\beta[\frac{\frac{\Omega_{t+1}}{\chi^w_{t+1}}}{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}\frac{\partial X_{t+1}}{\partial X_t}] \\
&\quad + \frac{\chi^v_{t+1}}{\chi^v_t}\beta[\frac{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}\frac{\partial \frac{\Omega_{t+1}}{\chi^w_{t+1}}}{\partial(\frac{\phi_{t+1}}{\Omega_{t+1}})}\frac{\partial(\frac{\phi_{t+1}}{\Omega_{t+1}})}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t} - \frac{\Omega_{t+1}}{\chi^w_{t+1}}\frac{\partial \frac{\chi^v_{t+1}}{\chi^w_{t+1}}}{\partial(\frac{\phi_{i,t+1}}{\Omega_{i,t+1}})}\frac{\partial(\frac{\phi_{i,t+1}}{\Omega_{i,t+1}})}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t}}{{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}^2}X_{t+1}] \qquad \text{(A.80)} \\
&\quad + \frac{\chi^v_{t+1}}{\chi^v_t}\beta[\frac{\frac{\partial \frac{\chi^v_{t+1}}{\chi^w_{t+1}}}{\partial(\frac{\phi_{t+1}}{\Omega_t})}\frac{\partial(\frac{\phi_{t+1}}{\Omega_{t+1}})}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t}}{{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}^2}W_{t+1}] \\
&\quad - \frac{\chi^v_{t+1}}{\chi^v_t}\beta[\frac{1}{\frac{\chi^v_{t+1}}{\chi^w_{t+1}}}\frac{\partial W_{t+1}}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t}] \\
&\quad - \frac{\chi^v_{t+1}}{\chi^v_t}\beta[(1-\delta)\frac{\gamma}{p^2(\theta_{t+1})}\frac{\partial p(\theta_{t+1})}{\partial \theta_{t+1}}\frac{\partial \theta_{t+1}}{\partial X_{t+1}}\frac{\partial X_{t+1}}{\partial X_t}
\end{aligned}
$$

We now use that $\frac{\partial Z_{t+1}}{\partial Y_{t+1}} = \frac{\partial Z_t}{\partial Y_t}$ for any variables $\{Z, Y\}$ and that $\frac{\partial X_{t+1}}{\partial X_t} = \rho_x$. We then evaluate the above expression at steady state which yields

$$
\begin{aligned}
-\frac{\gamma}{p(\theta)^2}\frac{\partial p(\theta)}{\partial \theta}\frac{\partial \theta}{\partial X} &= \frac{(\rho_x - 1)\frac{\partial \chi^v}{\partial X}}{\chi^v}\beta\Big[\frac{\frac{\Omega}{\chi^w}}{\frac{\chi^v}{\chi^w}}X - \frac{1}{\frac{\chi^v}{\chi^w}}W + (1-\delta)\frac{\gamma}{P(\theta)}\Big] \\
&\quad + \beta[\frac{\frac{\Omega}{\chi^w}}{\frac{\chi^v}{\chi^w}}\rho_x] + \beta[\frac{\frac{\chi^v}{\chi^w}\frac{\partial \frac{\Omega}{\chi^w}}{\partial(\frac{\phi}{\Omega})}\frac{\partial(\frac{\phi}{\Omega})}{\partial X}\rho_x - \frac{\Omega}{\chi^w}\frac{\partial \frac{\chi^v}{\chi^w}}{\partial(\frac{\phi}{\Omega})}\frac{\partial(\frac{\phi}{\Omega})}{\partial X}\rho_x}{{\frac{\chi^v}{\chi^w}}^2}X] \qquad \text{(A.81)} \\
&\quad + \beta[\frac{\frac{\partial \frac{\chi^v}{\chi^w}}{\partial(\frac{\phi}{\Omega})}\frac{\partial(\frac{\phi}{\Omega})}{\partial X}\rho_x}{{\frac{\chi^v}{\chi^w}}^2}W] - \beta[\frac{1}{\frac{\chi^v}{\chi^w}}\frac{\partial W}{\partial X}\rho_x] - \beta[(1-\delta)\frac{\gamma}{P(\theta)^2}\frac{\partial P(\theta)}{\partial \theta}\frac{\partial \theta}{\partial X}\rho_x
\end{aligned}
$$

Now use that $\epsilon_{\theta,X} = \frac{\partial \theta}{\partial X}\frac{X}{\theta}$, $\beta\Big[\frac{\frac{\Omega}{\chi^w}}{\frac{\chi^v}{\chi^w}}X - \frac{1}{\frac{\chi^v}{\chi^w}}W + (1-\delta)\frac{\gamma}{p(\theta)}\Big] = \frac{\gamma}{p(\theta)}$, $\frac{\partial \chi^v}{\partial X} = \lambda^v\frac{\partial \Omega}{\partial X} + (1-\lambda^v)\frac{\partial \phi}{\partial X}$ and $\frac{\partial p(\theta)}{\partial \theta} = -\frac{\epsilon p(\theta)}{\theta} \Rightarrow \frac{\gamma}{p(\theta)^2}\frac{\partial p(\theta)}{\partial \theta}\frac{\partial \theta}{\partial X} = -\frac{\gamma \epsilon}{X p(\theta)}\varepsilon_{\theta,X}$. Then re-arrange to arrive at equation (22).

A.6.5 Robustness for simulations

	no financial frictions	baseline $\lambda^w = 0.756$ $\lambda^v = 0.33$	case I $\lambda^w = 1$ $\lambda^v = 0$	case II $\lambda^w = 0$ $\lambda^v = 0$	case III $\lambda^w = 0$ $\lambda^v = 1$
		Financial terms			
1. $\epsilon_{\phi,X}$	0	-1.149	-1.190	-1.148	-1.152
2. $\epsilon_{\Omega,X}$	0	-1.091	-0.898	-1.131	-1.134
3. $\epsilon_{\frac{\phi}{\Omega},X}$	0	-0.058	-0.292	-0.017	-0.018
		Wage elasticity $\epsilon_{W,X}$			
4. W_0	0.4238	0.4246	0.4238	0.4271	0.4271
5. W_{level}	1	0.9980	1	0.9916	0.9916
6. W_{FLW}	0	0.0141	0	0.0170	0.0178
7. W_{hiring}	0	-0.0197	-0.1341	0	0.0081
8. W_θ	0.4132	0.7477	0.8251	0.7285	0.7197
9. $W_{forward}$	0	0.5209	0.3853	0.5361	0.5387
10. $4(5+6+7)$	0.4238	0.4214	0.3670	0.4308	0.4346
11. $4(5+6+7+8)$	0.5989	0.7389	0.7167	0.7419	0.7420
12. $4(5+6+7+8+9) = \epsilon_{W,X}$	0.5989	0.9601	0.8801	0.9709	0.9720
		Tightness elasticity $\epsilon_{\theta,X}$			
13. Θ_0	2.3030	2.3226	2.3122	2.3463	2.3266
14. Θ_{level}	0.8979	0.8908	0.8921	0.8904	0.8979
15. Θ_{FLW}	0	0.0126	0	0.0153	0.0161
16. Θ_{hiring}	0	0.0022	0.0147	0	-8.9e-04
17. Θ_W	-0.5076	-0.8009	-0.7266	-0.8106	-0.8184
18. $\Theta_{forward}$	0	0.6294	0.6549	0.6228	0.6202
19. $13(14+15+16)$	2.0679	2.1032	2.8963	2.1250	2.1246
20. $13(14+15+16+17)$	0.8989	0.2429	0.4165	0.2232	0.2204
21. $13(14+15+16+17+18) = \epsilon_{\theta,X}$	0.8989	1.7047	1.9306	1.6846	1.6634

Table 7: Simulation results for $b = 0.6$ and $\eta = 0.4$. The table shows average wage, $\epsilon_{W,X}$, and tightness elasticities, $\epsilon_{\theta,X}$, over the business cycle and their decomposition. Columns show simulations across different model specifications. Without financial constrains, we set $\mu = 0$ and keep all parameters from the baseline. The cases I-III keep the parameters b and η and are otherwise re-calibrated to keep the default rate the same as in the baseline economy. The rows decompose the elasticities according to the decomposition in Equation (21) and Equation (22).

A.6.6 Model with subsidy to vacancy posting costs

Introducing a subsidy to vacancy posting costs T_t to the baseline model delivers the following job creation condition:

$$\frac{\chi^v_{it}((1-T_t)\gamma)}{p(\theta_t)} = \beta\left[E_t\Omega_{i,t+1}X_{i,t+1} - E_t\chi^w_{i,t+1}W_{i,t+1} + (1-\delta)E_t\frac{\chi^v_{i,t+1}((1-T_{t+1})\gamma)}{p(\theta_{t+1})}\right]. \quad \text{(A.82)}$$

The resulting wage equation is then described by

$$W_{it} = \eta \left[\frac{\Omega_{it}}{\chi^w_{it}} X_{it} + \big[(1-\delta) - (1-\delta - f(\theta_t)) \frac{\chi^w_{it}}{E_t \chi^w_{i,t+1}} \big] \frac{\chi^v_{it}}{\chi^w_{it}} \frac{(1-T_t)\gamma}{p(\theta_t)} \right] + (1-\eta) b. \qquad \text{(A.83)}$$

	no financial frictions	baseline $\lambda^w = 0.756$ $\lambda^v = 0.33$	case I $\lambda^w = 1$ $\lambda^v = 0$	case II $\lambda^w = 0$ $\lambda^v = 0$	case III $\lambda^w = 0$ $\lambda^v = 1$
	Financial terms				
1. $\epsilon_{\phi,X}$	0	-4.618	-1.850	-6.449	-6.703
2. $\epsilon_{\Omega,X}$	0	-4.280	-1.483	-6.314	-6.552
3. $\epsilon_{\frac{\phi}{\Omega},X}$	0	-0.338	-0.367	-0.135	-0.152
	Wage elasticity $\epsilon_{W,X}$				
4. W_0	0.0322	0.0322	0.0322	0.0323	0.0323
5. W_{level}	1	0.9981	1	0.9917	0.9917
6. W_{FLW}	0	0.0827	0	0.1337	0.1503
7. W_{hiring}	0	-0.1154	-0.2989	0	0.1153
8. W_θ	4.7611	6.7481	5.4060	7.5154	7.5661
9. $W_{forward}$	0	0.2029	0.0372	0.3309	0.3535
10. $4(5+6+7)$	0.0322	0.0311	0.0226	0.0363	0.0406
11. $4(5+6+7+8)$	0.1855	0.2486	0.1967	0.2789	0.2848
12. $4(5+6+7+8+9) = \epsilon_{W,X}$	0.1855	0.2551	0.1979	0.2896	0.2962
	Tightness elasticity $\epsilon_{\theta,X}$				
13. Θ_0	7.0710	7.1952	7.1079	7.5558	7.4924
14. Θ_{level}	0.9877	0.9825	0.9813	0.9795	0.9877
15. Θ_{FLW}	0	0.0815	0	0.1320	0.1497
16. Θ_{hiring}	0	0.0139	0.0359	0	-0.0141
17. Θ_W	-0.1650	-0.1910	-0.1449	-0.2251	-0.2343
18. $\Theta_{forward}$	0	0.4344	0.1805	0.5918	0.6063
19. $13(14+15+16)$	6.9842	7.7555	7.2305	8.3986	8.4168
20. $13(14+15+16+17)$	5.8174	6.3815	6.2008	6.6980	6.6617
21. $13(14+15+16+17+18) = \epsilon_{\theta,X}$	5.8174	9.5068	7.4838	11.1697	11.2046

Table 8: Simulation results for $\rho_x = 0.99$. The table shows average wage, $\epsilon_{W,X}$, and tightness elasticities, $\epsilon_{\theta,X}$, over the business cycle and their decomposition. Columns show simulations across different model specifications. Without financial constrains, we set $\mu = 0$ and keep all parameters from the baseline. The cases I-III keep the parameters b and η and are otherwise re-calibrated to keep the default rate the same as in the baseline economy. The rows decompose the elasticities according to the decomposition in Equation (21) and Equation (22).

B Data appendix

B.1 Robustness for empirical results

B.1.1 Specification with county-level export exposure

	(1)	(2)
Log ILTD $_{t-1}$	0.032^{***}	0.0022^{***}
	(0.00062)	(0.00066)
Log export share (county) $_t$	0.048^{***}	0.025^{***}
	(0.00061)	(0.00095)
Log export share (county) $_t$ $\times$ Log ILTD $_{t-1}$	-0.0041^{***}	-0.00058^{***}
	(0.00019)	(0.00021)
Log θ	0.052^{***}	0.017^{***}
	(0.00032)	(0.00028)
Log ILTD $_{t-1}$ $\times$ Log ILTD $_{t-1}$	0.0020^{***}	0.000084^{***}
	(0.000020)	(0.000027)
Log ILTD $_{t-1}$ $\times$ Log θ	0.0025^{***}	0.00065^{***}
	(0.00011)	(0.000098)
Δ log ILTD $_{t/t-1}$ $\times$ Log ILTD $_{t-1}$	0.0014^{***}	0.00010^{**}
	(0.000038)	(0.000040)
Log employment	0.043^{***}	0.014^{***}
	(0.00066)	(0.00061)
Log employment $_{t-1}$	-0.0071^{***}	-0.016^{***}
	(0.00065)	(0.00057)
Δ log ILTD $_{t/t-1}$	0.0094^{***}	0.0015^{***}
	(0.00032)	(0.00027)
Δ log ILTD $_{t/t-1}$ $\times$ Δ log ILTD $_{t/t-1}$	0.00089^{***}	0.000066^{***}
	(0.000023)	(0.000024)
Δ log ILTD $_{t/t-1}$ $\times$ Log θ	0.0012^{***}	0.00076^{***}
	(0.00013)	(0.00011)
Constant	3.66^{***}	3.87^{***}
	(0.0032)	(0.0047)
Observations	4516525	4516525
R^2	0.34	0.62
Year fixed effects	Yes	Yes
Fixed effects	None	Firm

Table 9: Export regression in the spirit of Giroud and Mueller (2017): Dependent variable is the log real wage at the worker level. The export share at the county-level is the aggregate export share of GDP over time weighted by the average county-level export-exposure. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.2 Different measures of financial constraints

	(1)	(2)	(3)	(4)
Log ILTD	0.014***	0.00057**	0.00013	0.000016
	(0.00023)	(0.00023)	(0.000091)	(0.000090)
Log sales t	0.070***	0.013***	0.017***	0.017***
	(0.00038)	(0.00050)	(0.00016)	(0.00017)
Log sales t $\times$ Log ILTD	0.00040***	−0.00034***	−0.00034***	−0.00033***
	(0.000056)	(0.000059)	(0.000020)	(0.000020)
Log θ	0.051***	0.019***	0.0076***	0.0074***
	(0.00030)	(0.00027)	(0.00016)	(0.00016)
Log ILTD $\times$ Log ILTD	0.0015***	0.000044**	0.000039***	0.000020***
	(0.000014)	(0.000018)	(0.0000060)	(0.0000059)
Log ILTD $\times$ Log θ	0.0031***	0.00076***	0.00022***	0.00018***
	(0.000092)	(0.000084)	(0.000037)	(0.000037)
Log sales $t-1$	0.024***	0.0029***	0.0050***	0.0046***
	(0.00036)	(0.00043)	(0.00014)	(0.00014)
Log employment	0.031***	0.014***	0.025***	0.026***
	(0.00064)	(0.00062)	(0.00028)	(0.00030)
Log employment $t-1$	0.0041***	−0.014***	−0.0097***	−0.0097***
	(0.00063)	(0.00059)	(0.00022)	(0.00022)
Constant	3.91***	3.96***	3.15***	3.19***
	(0.0029)	(0.0042)	(0.0056)	(0.0070)
Observations	3558873	3558873	3558873	3558873
R^2	0.39	0.63	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 10: Dependent variables is the log real wage at the worker level. No controls for the change in financial constraints. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

	(1)	(2)	(3)	(4)
Log ILTD t	0.017^{***}	0.00083^{***}	0.0015^{***}	0.0013^{***}
	(0.00029)	(0.00031)	(0.00013)	(0.00013)
Log sales t	0.062^{***}	0.013^{***}	0.018^{***}	0.017^{***}
	(0.00044)	(0.00056)	(0.00018)	(0.00019)
Log sales t $\times$ Log ILTD t	-0.00020^{***}	-0.00046^{***}	-0.000077^{***}	-0.000062^{**}
	(0.000073)	(0.000087)	(0.000029)	(0.000029)
Log θ	0.051^{***}	0.019^{***}	0.0084^{***}	0.0081^{***}
	(0.00034)	(0.00030)	(0.00018)	(0.00018)
Log ILTD t $\times$ Log ILTD t	0.0022^{***}	0.000055^{*}	0.00011^{***}	0.000084^{***}
	(0.000022)	(0.000031)	(0.000010)	(0.000010)
Log ILTD t $\times$ Log θ	0.0038^{***}	0.0012^{***}	0.00052^{***}	0.00048^{***}
	(0.00012)	(0.00011)	(0.000051)	(0.000050)
Δ log ILTD $t/t-1$ $\times$ Log ILTD t	-0.0032^{***}	-0.000024	0.0000049	0.000039^{***}
	(0.000043)	(0.000047)	(0.000015)	(0.000015)
Log sales $t-1$	0.030^{***}	0.0021^{***}	0.0048^{***}	0.0042^{***}
	(0.00041)	(0.00050)	(0.00016)	(0.00016)
Log employment	0.030^{***}	0.012^{***}	0.026^{***}	0.027^{***}
	(0.00070)	(0.00066)	(0.00030)	(0.00032)
Log employment $t-1$	0.0061^{***}	-0.013^{***}	-0.010^{***}	-0.010^{***}
	(0.00069)	(0.00063)	(0.00023)	(0.00023)
Δ log ILTD $t/t-1$	-0.010^{***}	0.00061^{**}	-0.00046^{***}	-0.00031^{***}
	(0.00035)	(0.00031)	(0.00011)	(0.00011)
Δ log ILTD $t/t-1$ $\times$ Δ log ILTD $t/t-1$	0.0015^{***}	0.000029	-0.000040^{***}	-0.000047^{***}
	(0.000025)	(0.000027)	(0.0000089)	(0.0000088)
Δ log ILTD $t/t-1$ $\times$ Log θ	-0.0029^{***}	-0.00013	-0.00023^{***}	-0.00019^{***}
	(0.00015)	(0.00013)	(0.000047)	(0.000046)
Constant	3.91^{***}	3.97^{***}	3.15^{***}	3.18^{***}
	(0.0031)	(0.0045)	(0.0062)	(0.0074)
Observations	3170722	3170722	3170722	3170722
R^2	0.40	0.63	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 11: Dependent variables is the log real wage at the worker level. Using interest over long-term debt in period t as measure of financial constraints. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

	(1)	(2)	(3)	(4)
Log interest $_{t-1}$	0.032^{***}	-0.0066^{***}	-0.00056^{**}	-0.00010
	(0.00055)	(0.00064)	(0.00024)	(0.00023)
Log sales $_t$	0.068^{***}	0.014^{***}	0.017^{***}	0.017^{***}
	(0.00052)	(0.00061)	(0.00020)	(0.00020)
Log sales $_t$ $\times$ Log interest $_{t-1}$	0.0010^{***}	-0.000089	-0.00025^{***}	-0.00024^{***}
	(0.000079)	(0.000081)	(0.000028)	(0.000027)
Log θ	0.018^{***}	0.012^{***}	0.0077^{***}	0.0079^{***}
	(0.00073)	(0.00066)	(0.00031)	(0.00031)
Log interest $_{t-1}$ $\times$ Log interest $_{t-1}$	0.0050^{***}	-0.00014^{**}	-0.000038^{**}	-0.000034^{*}
	(0.000042)	(0.000054)	(0.000018)	(0.000018)
Log interest $_{t-1}$ $\times$ Log θ	-0.0069^{***}	-0.0015^{***}	0.000099	0.00019^{**}
	(0.00019)	(0.00017)	(0.000077)	(0.000076)
Δ log interest $_{t/t-1}$ $\times$ Log interest $_{t-1}$	0.0016^{***}	-0.00022^{***}	0.000054^{***}	0.000050^{***}
	(0.000051)	(0.000051)	(0.000017)	(0.000016)
Log sales $_{t-1}$	0.032^{***}	0.0023^{***}	0.0049^{***}	0.0043^{***}
	(0.00041)	(0.00050)	(0.00016)	(0.00016)
Log employment	0.032^{***}	0.012^{***}	0.026^{***}	0.027^{***}
	(0.00070)	(0.00067)	(0.00030)	(0.00032)
Log employment $_{t-1}$	0.0047^{***}	-0.013^{***}	-0.010^{***}	-0.010^{***}
	(0.00070)	(0.00063)	(0.00023)	(0.00023)
Δ log interest $_{t/t-1}$	0.0045^{***}	-0.000061	0.00056^{***}	0.00061^{***}
	(0.00036)	(0.00032)	(0.00011)	(0.00011)
Δ log interest $_{t/t-1}$ $\times$ Δ log interest $_{t/t-1}$	0.00045^{***}	-0.000016	-0.0000018	0.0000020
	(0.000019)	(0.000019)	(0.0000062)	(0.0000061)
Δ log interest $_{t/t-1}$ $\times$ Log θ	-0.0013^{***}	0.00034^{***}	0.000064	0.000093^{**}
	(0.00014)	(0.00012)	(0.000042)	(0.000041)
Constant	3.93^{***}	3.96^{***}	3.14^{***}	3.18^{***}
	(0.0035)	(0.0048)	(0.0062)	(0.0074)
Observations	3168371	3168371	3168371	3168371
R^2	0.40	0.63	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 12: Dependent variables is the log real wage at the worker level. Using interest over total debt in period $t-1$ as measure of financial constraints. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

	(1)	(2)	(3)	(4)
Log leverage	0.037^{***}	0.014^{***}	0.011^{***}	0.014^{***}
	(0.0012)	(0.0019)	(0.00065)	(0.00066)
Log sales $_t$	0.040^{***}	0.017^{***}	0.023^{***}	0.021^{***}
	(0.00071)	(0.0011)	(0.00038)	(0.00038)
Log sales $_t$ $\times$ Log leverage	0.0068^{***}	-0.0017^{***}	-0.0019^{***}	-0.0018^{***}
	(0.00017)	(0.00027)	(0.000094)	(0.000094)
Log θ	-0.00035	0.0086^{***}	0.0044^{***}	0.0048^{***}
	(0.00093)	(0.00086)	(0.00043)	(0.00043)
Log leverage $\times$ Log leverage	-0.0086^{***}	-0.0025^{***}	-0.0028^{***}	-0.0031^{***}
	(0.00015)	(0.00027)	(0.000090)	(0.000091)
Log leverage $\times$ Log θ	0.013^{***}	0.0026^{***}	0.00039^{***}	0.00022^{**}
	(0.00024)	(0.00023)	(0.00011)	(0.00011)
Δ log leverage $_{t/t-1}$ $\times$ Log leverage	-0.0095^{***}	-0.0024^{***}	-0.0027^{***}	-0.0030^{***}
	(0.00035)	(0.00038)	(0.00013)	(0.00013)
Log sales $_{t-1}$	0.027^{***}	0.0025^{***}	0.0045^{***}	0.0037^{***}
	(0.00028)	(0.00031)	(0.00010)	(0.00010)
Log employment	0.022^{***}	0.012^{***}	0.022^{***}	0.023^{***}
	(0.00050)	(0.00048)	(0.00021)	(0.00022)
Log employment $_{t-1}$	0.0014^{***}	-0.012^{***}	-0.0086^{***}	-0.0086^{***}
	(0.00049)	(0.00045)	(0.00017)	(0.00016)
Δ log leverage $_{t/t-1}$	0.030^{***}	0.0057^{***}	0.0093^{***}	0.011^{***}
	(0.0017)	(0.0017)	(0.00058)	(0.00057)
Δ log leverage $_{t/t-1}$ $\times$ Δ log leverage $_{t/t-1}$	0.00072^{***}	-0.0012^{***}	-0.00036^{***}	-0.0011^{***}
	(0.00027)	(0.00027)	(0.000092)	(0.000095)
Δ log leverage $_{t/t-1}$ $\times$ Log θ	0.0032^{***}	-0.00056	0.00084^{***}	0.00080^{***}
	(0.00053)	(0.00045)	(0.00016)	(0.00016)
Constant	3.93^{***}	3.93^{***}	3.17^{***}	3.22^{***}
	(0.0036)	(0.0053)	(0.0042)	(0.0050)
Observations	5319075	5319075	5319075	5319075
R^2	0.38	0.62	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 13: Dependent variables is the log real wage at the worker level. Using leverage in period $t-1$ as measure of financial constraints. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.3 Different measure of labor market tightness

	(1)	(2)	(3)	(4)
Log ILTD $t-1$	0.011^{***}	-0.0023^{***}	0.0017^{***}	0.0014^{***}
	(0.00058)	(0.00069)	(0.00025)	(0.00025)
Log sales t	0.060^{***}	0.013^{***}	0.017^{***}	0.017^{***}
	(0.00042)	(0.00053)	(0.00017)	(0.00017)
Log sales t × Log ILTD $t-1$	-0.000046	-0.00065^{***}	-0.00037^{***}	-0.00034^{***}
	(0.000060)	(0.000063)	(0.000020)	(0.000020)
Log θ (by county)	-0.0016^{***}	0.0054^{***}	0.0016^{***}	0.0015^{***}
	(0.00058)	(0.00069)	(0.00027)	(0.00027)
Log ILTD $t-1$ × Log ILTD $t-1$	0.0023^{***}	0.00014^{***}	0.00012^{***}	0.00011^{***}
	(0.000022)	(0.000030)	(0.0000098)	(0.0000097)
Log ILTD $t-1$ × Log θ (by county)	0.00046^{***}	-0.00019	0.00055^{***}	0.00049^{***}
	(0.00018)	(0.00020)	(0.000076)	(0.000075)
Δ log ILTD $t/t-1$ × Log ILTD $t-1$	0.0013^{***}	0.00017^{***}	0.00023^{***}	0.00023^{***}
	(0.000041)	(0.000044)	(0.000014)	(0.000014)
Log sales $t-1$	0.035^{***}	0.0032^{***}	0.0051^{***}	0.0046^{***}
	(0.00040)	(0.00048)	(0.00015)	(0.00015)
Log employment	0.030^{***}	0.012^{***}	0.026^{***}	0.026^{***}
	(0.00068)	(0.00064)	(0.00029)	(0.00031)
Log employment $t-1$	0.0062^{***}	-0.012^{***}	-0.0095^{***}	-0.0095^{***}
	(0.00067)	(0.00061)	(0.00022)	(0.00022)
Δ log ILTD $t/t-1$	-0.013^{***}	0.00093	0.0032^{***}	0.0031^{***}
	(0.00069)	(0.00064)	(0.00022)	(0.00021)
Δ log ILTD $t/t-1$ × Δ log ILTD $t/t-1$	0.00066^{***}	0.000075^{***}	0.000059^{***}	0.000063^{***}
	(0.000025)	(0.000026)	(0.0000084)	(0.0000083)
Δ log ILTD $t/t-1$ × Log θ (by county)	-0.0056^{***}	0.00032	0.00081^{***}	0.00078^{***}
	(0.00021)	(0.00019)	(0.000065)	(0.000064)
Constant	3.78^{***}	3.95^{***}	3.11^{***}	3.15^{***}
	(0.0034)	(0.0049)	(0.0061)	(0.0072)
Observations	3290259	3290259	3290259	3290259
R^2	0.39	0.63	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	None	Firm	Worker	Match

Table 14: Dependent variables is the log real wage at the worker level. Tightness at the county level. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.4 Using firm-year fixed effects

	(1)	(2)
Log ILTD $t-1$	0.017^{***}	
	(0.00029)	
Log sales t	0.061^{***}	
	(0.00043)	
Log sales t $\times$ Log ILTD $t-1$	-0.00097^{***}	
	(0.000063)	
Log θ	0.051^{***}	0.020^{***}
	(0.00034)	(0.00032)
Log ILTD $t-1$ $\times$ Log ILTD $t-1$	0.0023^{***}	
	(0.000022)	
Log ILTD $t-1$ $\times$ Log θ	0.0039^{***}	0.0014^{***}
	(0.00012)	(0.00012)
Δ log ILTD $t/t-1$ $\times$ Log ILTD $t-1$	0.0013^{***}	
	(0.000041)	
Log sales $t-1$	0.030^{***}	
	(0.00041)	
Log employment	0.030^{***}	0.0092^{***}
	(0.00070)	(0.0011)
Log employment $t-1$	0.0061^{***}	-0.0096^{***}
	(0.00069)	(0.0011)
Δ log ILTD $t/t-1$	0.0072^{***}	
	(0.00034)	
Δ log ILTD $t/t-1$ $\times$ Δ log ILTD $t/t-1$	0.00057^{***}	
	(0.000025)	
Δ log ILTD $t/t-1$ $\times$ Log θ	0.00086^{***}	0.0018^{***}
	(0.00014)	(0.00015)
Constant	3.91^{***}	4.00^{***}
	(0.0031)	(0.011)
Observations	3170722	3166717
R^2	0.40	0.64
Year fixed effects	Yes	Yes
Fixed effects	None	Firm-Year

Table 15: Dependent variables is the log real wage at the worker level. Adding firm-year fixed effects. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.5 Baseline estimation by job complexity

	(1) Low	(2) Trained	(3) Skilled	(4) High-skilled
Log ILTD $t-1$	-0.0023^{***}	0.0017^{***}	-0.0016^{***}	-0.00086^{*}
	(0.00060)	(0.00016)	(0.00033)	(0.00049)
Log sales t	0.0061^{***}	0.021^{***}	0.011^{***}	0.0094^{***}
	(0.00059)	(0.00022)	(0.00048)	(0.00062)
Log sales t × Log ILTD $t-1$	-0.00052^{***}	-0.00012^{***}	-0.00087^{***}	-0.00054^{***}
	(0.00017)	(0.000028)	(0.000051)	(0.000091)
Log θ	-0.0079^{***}	0.013^{***}	0.0037^{***}	0.0034^{***}
	(0.0016)	(0.00023)	(0.00060)	(0.00087)
Log ILTD $t-1$ × Log ILTD $t-1$	0.00031^{***}	0.000054^{***}	0.00013^{***}	0.00013^{***}
	(0.000040)	(0.000013)	(0.000025)	(0.000036)
Log ILTD $t-1$ × Log θ	-0.00028	0.00068^{***}	-0.000027	0.00013
	(0.00025)	(0.000062)	(0.00016)	(0.00021)
Δ log ILTD $t/t-1$ × Log ILTD $t-1$	0.00027^{***}	0.00021^{***}	0.00015^{***}	0.00031^{***}
	(0.000058)	(0.000018)	(0.000035)	(0.000050)
Log sales $t-1$	0.0070^{***}	0.0033^{***}	0.0043^{***}	0.0051^{***}
	(0.00063)	(0.00019)	(0.00042)	(0.00058)
Log employment	0.027^{***}	0.029^{***}	0.021^{***}	0.015^{***}
	(0.0016)	(0.00038)	(0.00089)	(0.0011)
Log employment $t-1$	-0.0018^{**}	-0.011^{***}	-0.0065^{***}	-0.0094^{***}
	(0.00074)	(0.00027)	(0.00066)	(0.00089)
Δ log ILTD $t/t-1$	-0.00085^{*}	0.0011^{***}	0.00038	0.00056
	(0.00045)	(0.00013)	(0.00028)	(0.00041)
Δ log ILTD $t/t-1$ × Δ log ILTD $t/t-1$	0.00013^{***}	0.000069^{***}	0.000054^{**}	0.00016^{***}
	(0.000035)	(0.000010)	(0.000021)	(0.000030)
Δ log ILTD $t/t-1$ × Log θ	-0.00032^{*}	0.00030^{***}	0.000036	0.000016
	(0.00019)	(0.000056)	(0.00014)	(0.00019)
Constant	3.06^{***}	3.26^{***}	2.98^{***}	2.99^{***}
	(0.086)	(0.0090)	(0.025)	(0.032)
Observations	231247	2267378	420432	251665
R^2	0.99	0.98	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match

Table 16: Dependent variable is the log real wage at the worker level. Regressions by worker's job complexity. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

	(1) Low	(2) Trained	(3) Skilled	(4) High-skilled
Log ILTD $t-1$	0.0019^{*}	0.0042^{***}	-0.00035	0.00081
	(0.00098)	(0.00034)	(0.00069)	(0.0010)
Log sales t	0.0060^{***}	0.021^{***}	0.011^{***}	0.0094^{***}
	(0.00059)	(0.00023)	(0.00048)	(0.00062)
Log sales t × Log ILTD $t-1$	-0.00055^{***}	-0.00017^{***}	-0.00088^{***}	-0.00054^{***}
	(0.00016)	(0.000028)	(0.000051)	(0.000092)
Log θ (by county)	-0.0010	0.0047^{***}	0.0019^{**}	0.0042^{***}
	(0.0014)	(0.00033)	(0.00077)	(0.0012)
Log ILTD $t-1$ × Log ILTD $t-1$	0.00028^{***}	0.000048^{***}	0.00013^{***}	0.00015^{***}
	(0.000040)	(0.000013)	(0.000025)	(0.000036)
Log ILTD $t-1$ × Log θ (by county)	0.0012^{***}	0.0013^{***}	0.00036^{*}	0.00059^{*}
	(0.00031)	(0.000099)	(0.00021)	(0.00030)
Δ log ILTD $t/t-1$ × Log ILTD $t-1$	0.00028^{***}	0.00017^{***}	0.00015^{***}	0.00032^{***}
	(0.000058)	(0.000018)	(0.000035)	(0.000050)
Log sales $t-1$	0.0066^{***}	0.0036^{***}	0.0044^{***}	0.0051^{***}
	(0.00063)	(0.00019)	(0.00042)	(0.00059)
Log employment	0.026^{***}	0.029^{***}	0.020^{***}	0.015^{***}
	(0.0016)	(0.00039)	(0.00089)	(0.0011)
Log employment $t-1$	-0.0022^{***}	-0.011^{***}	-0.0062^{***}	-0.0093^{***}
	(0.00075)	(0.00027)	(0.00066)	(0.00090)
Δ log ILTD $t/t-1$	0.0018^{**}	0.0053^{***}	0.0040^{***}	0.0033^{***}
	(0.00076)	(0.00028)	(0.00060)	(0.00091)
Δ log ILTD $t/t-1$ × Δ log ILTD $t/t-1$	0.00011^{***}	0.000029^{***}	0.000048^{**}	0.00016^{***}
	(0.000036)	(0.000010)	(0.000021)	(0.000030)
Δ log ILTD $t/t-1$ × Log θ (by county)	0.00066^{***}	0.0015^{***}	0.0011^{***}	0.00085^{***}
	(0.00024)	(0.000081)	(0.00018)	(0.00027)
Constant	3.08^{***}	3.23^{***}	2.97^{***}	3.00^{***}
	(0.086)	(0.0091)	(0.026)	(0.033)
Observations	229656	2203303	413567	246785
R^2	0.99	0.98	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match

Table 17: Dependent variable is the log real wage at the worker level. Regressions by worker's job complexity using tightness by county. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.6 Baseline estimation by firm size

	(1) 1-9	(2) 10-49	(3) 50-199	(4) 200+
Log ILTD $t-1$	0.0030^{**}	-0.00040	-0.0014^{***}	0.0019^{***}
	(0.0012)	(0.00044)	(0.00027)	(0.00015)
Log sales t	0.014^{***}	0.017^{***}	0.020^{***}	0.017^{***}
	(0.0017)	(0.00057)	(0.00034)	(0.00025)
Log sales t $\times$ Log ILTD $t-1$	0.000017	0.00027^{**}	-0.00059^{***}	-0.00047^{***}
	(0.00028)	(0.00011)	(0.000078)	(0.000024)
Log θ	0.014^{***}	0.0060^{***}	0.0065^{***}	0.0089^{***}
	(0.0016)	(0.00057)	(0.00034)	(0.00023)
Log ILTD $t-1$ $\times$ Log ILTD $t-1$	0.00046^{***}	0.00031^{***}	-0.000019	0.000034^{***}
	(0.00012)	(0.000038)	(0.000022)	(0.000013)
Log ILTD $t-1$ $\times$ Log θ	0.0011^{**}	-0.00024	-0.00034^{***}	0.0011^{***}
	(0.00047)	(0.00017)	(0.00010)	(0.000063)
Δ log ILTD $t/t-1$ $\times$ Log ILTD $t-1$	0.00053^{***}	0.00041^{***}	0.000011	0.00025^{***}
	(0.00017)	(0.000054)	(0.000030)	(0.000018)
Log sales $t-1$	0.0074^{***}	0.0038^{***}	0.0032^{***}	0.0046^{***}
	(0.0014)	(0.00046)	(0.00032)	(0.00021)
Log employment	0.0093^{***}	0.028^{***}	0.056^{***}	0.049^{***}
	(0.0022)	(0.0011)	(0.00085)	(0.00062)
Log employment $t-1$	0.0039^{**}	-0.0059^{***}	-0.012^{***}	-0.011^{***}
	(0.0016)	(0.00074)	(0.00053)	(0.00029)
Δ log ILTD $t/t-1$	0.0036^{***}	-0.000083	0.000014	0.0016^{***}
	(0.0011)	(0.00037)	(0.00022)	(0.00014)
Δ log ILTD $t/t-1$ $\times$ Δ log ILTD $t/t-1$	0.00024^{**}	0.00022^{***}	0.000091^{***}	0.000075^{***}
	(0.000095)	(0.000033)	(0.000017)	(0.000011)
Δ log ILTD $t/t-1$ $\times$ Log θ	0.0010^{**}	-0.00017	-0.00030^{***}	0.00064^{***}
	(0.00044)	(0.00015)	(0.000093)	(0.000059)
Constant	3.17^{***}	3.05^{***}	3.20^{***}	3.12^{***}
	(0.070)	(0.024)	(0.057)	(0.013)
Observations	69322	503912	1049014	1548474
R^2	0.99	0.99	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match

Table 18: Dependent variable is the log real wage at the worker level. Regressions by establishment size. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.7 Baseline estimation by capital-intensity

	(1) 0-5	(2) 5-25	(3) 25-50	(4) 50-75	(5) 75-95	(6) 95-100
Log ILTD $t-1$	0.0015	0.0018***	0.0035***	−0.0012***	0.000057	0.0023***
	(0.0014)	(0.00059)	(0.00050)	(0.00033)	(0.00023)	(0.00032)
Log sales t	0.029***	0.015***	0.031***	0.035***	0.025***	−0.00028
	(0.0034)	(0.0013)	(0.0010)	(0.00059)	(0.00031)	(0.00051)
Log sales $t \times$ Log ILTD $t-1$	0.00052*	0.000098	0.0011***	−0.00062***	−0.0014***	−0.0015***
	(0.00030)	(0.00014)	(0.00018)	(0.000053)	(0.000078)	(0.000096)
Log θ	0.0086***	0.0037***	0.0044***	0.0078***	0.0072***	0.0093***
	(0.0024)	(0.00094)	(0.00064)	(0.00042)	(0.00028)	(0.00045)
Log ILTD $t-1 \times$ Log ILTD $t-1$	−0.00025	0.00036***	0.00025***	−0.00019***	−0.00020***	−0.000029
	(0.00015)	(0.000045)	(0.000045)	(0.000029)	(0.000019)	(0.000036)
Log ILTD $t-1 \times$ Log θ	0.00033	0.000086	0.00014	0.00079***	0.00072***	0.0012***
	(0.00050)	(0.00023)	(0.00016)	(0.00012)	(0.000085)	(0.00014)
Δ log ILTD $t/t-1 \times$ Log ILTD $t-1$	−0.00030*	0.00031***	0.00023***	−0.00031***	0.00016***	−0.00059***
	(0.00018)	(0.000052)	(0.000061)	(0.000046)	(0.000025)	(0.000055)
Log sales $t-1$	−0.0031	0.0011	0.0043***	0.0018***	0.0060***	0.0070***
	(0.0023)	(0.00090)	(0.00069)	(0.00043)	(0.00027)	(0.00040)
Log employment	0.016***	0.020***	0.020***	0.024***	0.039***	0.014***
	(0.0048)	(0.0018)	(0.0011)	(0.00069)	(0.00055)	(0.00081)
Log employment $t-1$	0.0079**	−0.0075***	−0.0066***	−0.0066***	−0.015***	−0.012***
	(0.0040)	(0.0012)	(0.00095)	(0.00039)	(0.00040)	(0.00063)
Δ log ILTD $t/t-1$	0.00084	0.0010**	0.0017***	0.00031	0.0014***	0.00094***
	(0.00093)	(0.00045)	(0.00037)	(0.00029)	(0.00019)	(0.00030)
Δ log ILTD $t/t-1 \times \Delta$ log ILTD $t/t-1$	−0.00014	0.00033***	0.000096**	−0.00019***	0.0000032	−0.00036***
	(0.00011)	(0.000027)	(0.000038)	(0.000026)	(0.000015)	(0.000031)
Δ log ILTD $t/t-1 \times$ Log θ	0.00060	−0.000053	0.00051***	0.00061***	0.00017**	0.00059***
	(0.00038)	(0.00017)	(0.00015)	(0.00012)	(0.000081)	(0.00013)
Constant	2.69***	3.14***	3.08***	3.29***	3.22***	3.12***
	(0.14)	(0.10)	(0.021)	(0.018)	(0.011)	(0.032)
Observations	38989	177231	367929	726284	1417678	433996
R^2	0.99	0.99	0.99	0.99	0.98	0.98
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match	Match	Match

Table 19: Dependent variable is the log real wage at the worker level. Regressions by capital-labor intensity. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

B.1.8 Baseline estimation by sector

	(1) Manufacturing	(2) Construction	(3) Tranport/communication/electric/gas/water	(4) Wholesale/retail	(5) Other services
Log ILTD $t-1$	0.00019	0.00056	−0.00021	−0.00024	0.0048***
	(0.00018)	(0.00053)	(0.00029)	(0.00039)	(0.00040)
Log sales t	0.020***	0.011***	0.0025***	0.011***	0.011***
	(0.00025)	(0.00070)	(0.00061)	(0.00055)	(0.00064)
Log sales t × Log ILTD $t-1$	−0.00026***	−0.00023***	−0.00031***	−0.00037***	0.00084***
	(0.000062)	(0.000057)	(0.000035)	(0.000088)	(0.00011)
Log θ	0.011***	0.0048***	0.0014***	0.0017***	0.0019***
	(0.00025)	(0.00069)	(0.00045)	(0.00046)	(0.00055)
Log ILTD $t-1$ × Log ILTD $t-1$	0.000055***	0.00031***	−0.000068**	0.00042***	0.00028***
	(0.000014)	(0.000042)	(0.000029)	(0.000034)	(0.000033)
Log ILTD $t-1$ × Log θ	0.00057***	−0.00033	−0.00018	−0.00042***	0.00067***
	(0.000071)	(0.00020)	(0.00013)	(0.00014)	(0.00014)
Δ log ILTD $t/t-1$ × Log ILTD $t-1$	0.00027***	0.00026***	−0.00029***	0.00053***	0.00040***
	(0.000019)	(0.000065)	(0.000045)	(0.000045)	(0.000045)
Log sales $t-1$	0.0050***	0.0045***	−0.00096*	0.0069***	−0.00039
	(0.00021)	(0.00060)	(0.00055)	(0.00051)	(0.00048)
Log employment	0.060***	0.032***	0.0096***	0.013***	0.016***
	(0.00059)	(0.0013)	(0.00076)	(0.00063)	(0.00091)
Log employment $t-1$	−0.016***	−0.0066***	−0.0035***	−0.0053***	−0.0090***
	(0.00041)	(0.00062)	(0.00044)	(0.00053)	(0.00067)
Δ log ILTD $t/t-1$	0.00024*	−0.00022	0.0012***	0.0017***	0.0017***
	(0.00015)	(0.00050)	(0.00031)	(0.00033)	(0.00038)
Δ log ILTD $t/t-1$ × Δ log ILTD $t/t-1$	0.000019*	0.00018***	−0.00033***	0.00031***	0.00026***
	(0.000011)	(0.000041)	(0.000030)	(0.000024)	(0.000028)
Δ log ILTD $t/t-1$ × Log θ	0.00018***	−0.00046**	0.00024*	0.00027**	0.00041***
	(0.000066)	(0.00020)	(0.00014)	(0.00013)	(0.00014)
Constant	3.18***	3.21***	2.79***	3.13***	3.09***
	(0.016)	(0.045)	(0.042)	(0.013)	(0.026)
Observations	1536979	253652	327758	696239	356094
R^2	0.98	0.98	0.98	0.98	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match	Match

Table 20: Dependent variable is the log real wage at the worker level. Regressions by sector. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

	(1) Manufacturing	(2) Construction	(3) Tranport/communication/electric/gas/water	(4) Wholesale/retail	(5) Other services
Log ILTD $t-1$	0.0027^{***}	0.0020^{*}	0.0021^{**}	-0.0029^{***}	-0.00088
	(0.00036)	(0.0011)	(0.00084)	(0.00065)	(0.00083)
Log sales t	0.020^{***}	0.011^{***}	0.0012^{**}	0.011^{***}	0.012^{***}
	(0.00023)	(0.00066)	(0.00060)	(0.00053)	(0.00063)
Log sales t × Log ILTD $t-1$	-0.00058^{***}	-0.00018^{***}	-0.00035^{***}	-0.00037^{***}	0.0011^{***}
	(0.000059)	(0.000051)	(0.000034)	(0.000085)	(0.000100)
Log θ (by county)	0.0030^{***}	0.000051	0.0063^{***}	-0.0026^{***}	-0.0044^{***}
	(0.00035)	(0.0011)	(0.00087)	(0.00069)	(0.00092)
Log ILTD $t-1$ × Log ILTD $t-1$	0.000077^{***}	0.00031^{***}	-0.000086^{***}	0.00029^{***}	0.00029^{***}
	(0.000013)	(0.000039)	(0.000028)	(0.000033)	(0.000032)
Log ILTD $t-1$ × Log θ (by county)	0.0012^{***}	0.00017	0.00058^{**}	-0.0011^{***}	-0.0012^{***}
	(0.00011)	(0.00030)	(0.00025)	(0.00019)	(0.00023)
Δ log ILTD $t/t-1$ × Log ILTD $t-1$	0.00025^{***}	0.00026^{***}	-0.00036^{***}	0.00035^{***}	0.00043^{***}
	(0.000019)	(0.000061)	(0.000044)	(0.000044)	(0.000046)
Log sales $t-1$	0.0060^{***}	0.0046^{***}	-0.0016^{***}	0.0071^{***}	-0.000021
	(0.00020)	(0.00059)	(0.00055)	(0.00049)	(0.00048)
Log employment	0.057^{***}	0.031^{***}	0.010^{***}	0.013^{***}	0.017^{***}
	(0.00056)	(0.0013)	(0.00076)	(0.00061)	(0.00090)
Log employment $t-1$	-0.013^{***}	-0.0071^{***}	-0.0036^{***}	-0.0045^{***}	-0.0090^{***}
	(0.00036)	(0.00062)	(0.00044)	(0.00051)	(0.00066)
Δ log ILTD $t/t-1$	0.0062^{***}	0.00039	-0.0014^{*}	-0.0068^{***}	0.00044
	(0.00029)	(0.00089)	(0.00086)	(0.00055)	(0.00077)
Δ log ILTD $t/t-1$ × Δ log ILTD $t/t-1$	-0.000032^{***}	0.00016^{***}	-0.00035^{***}	0.00029^{***}	0.00028^{***}
	(0.000011)	(0.000040)	(0.000029)	(0.000023)	(0.000027)
Δ log ILTD $t/t-1$ × Log θ (by county)	0.0019^{***}	-0.00014	-0.00066^{***}	-0.0024^{***}	-0.000045
	(0.000086)	(0.00026)	(0.00025)	(0.00016)	(0.00022)
Constant	3.15^{***}	3.16^{***}	2.74^{***}	3.10^{***}	3.04^{***}
	(0.016)	(0.045)	(0.038)	(0.013)	(0.026)
Observations	1612406	259731	328966	724617	364539
R^2	0.98	0.98	0.98	0.98	0.99
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Fixed effects	Match	Match	Match	Match	Match
Sector state interaction	Yes	Yes	Yes	Yes	Yes

Table 21: Dependent variable is the log real wage at the worker level. Regressions by sector using regional tightness. Standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.