**The effects of firing costs on employment
and hours per employee**

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Abstract

We explore the role of firing costs on labor market outcomes in a search and matching framework with distinct decisions on the intensive (hours per employee) and extensive (employment) margins of labor supply. We show that allowing for two distinct labor supply margins matters for assessing firing costs. When the intensive margin is kept fixed (as is typically done in empirical work on firing costs), the dampening effect of firing costs on employment fluctuations is strongly understated. Further, in a quantitative exercise, we calibrate firing costs to represent the different employment protection regulations across OECD countries. We find that with firing costs of a similar size as in France, the drop in US employment during the Great Recession would have been a third its size.

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Keywords: Search and matching, firing costs, employment protection legislation, labor supply margins.

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1 Introduction

There is a large literature on the role of employment protection legislation (EPL) for labor market outcomes, including the seminal contributions of Garibaldi (1998), Hamermesh (1996), Hopenhayn and Rogerson (1993), Nickell (1986), Oi (1962), Pries and Rogerson (2005), and Veracierto (2008). A shortcoming of this literature is that it typically does not allow for two distinct labor supply choices: an extensive (employment) and an intensive (hours per employee or effort) margin choice. Typically, only variation at the extensive margin is considered, while the intensive margin is implicitly kept fixed.[1] There are reasons to believe that the omission of a flexible intensive margin matters for assessing EPL. For instance, when firing workers becomes more costly, firms may opt to adjust hours instead. Figure 1 presents evidence that this mechanism is quantitatively relevant. The figure shows a positive relationship between the level of employment protection legislation (as measured by the OECD Protection Against Dismissal indicator) and the relative variability of the intensive (h) versus the extensive margin (n) of labor supply.[2]
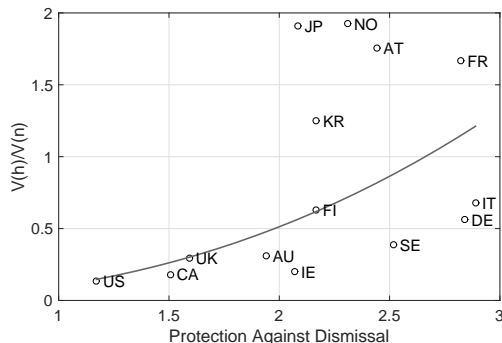

Figure 1: *Protection Against Dismissal and relative intensive-extensive margin variance (HP-filtered). Data source: Ohanian and Raffo (2012), OECD*

In this paper, we explore the role of firing costs on labor market outcomes in a search and matching framework with distinct decisions on the intensive and extensive margins of labor supply. We are particularly interested in the role of a distinct intensive margin for the assessment of EPL. To this end, we compare results between two versions of our model, once with fixed and once with flexible average hours per employee. To further illustrate our mechanism in the context of historical episodes, we calibrate the firing costs of our model to capture differences in EPL across OECD countries. We then analyze how employment protection regulations of different OECD countries would have affected the economic outcome of the US 1990s expansion and the Great Recession.

Our analysis is based on a standard neoclassical growth model with labor market frictions in the spirit of Mortensen and Pissarides (1994). The search and matching framework is particularly useful for our analysis, since it offers a clear distinction between hiring and firing

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[1]The focus on the extensive margin is partly explained by that fact that it is the dominant driver of US total hours (see Hansen (1985)). A recent data set by Ohanian and Raffo (2012) shows that this is a feature specific to US data and e.g. not shared by continental European countries such as France or Germany.

[2]The black line represents the OLS fitted line in logarithms (p-value of the slope coefficient: 0.01). See Section 3.2 for a further discussion of the figure.

and hence allows a tractable way to introduce frictions on the firing margin. In our baseline case, we introduce EPL as *wasteful* firing costs, in the sense that they are costs paid by the employer to a third party, like procedural costs. We also model firing costs as severance payments and evaluate the robustness of our findings.

While most papers in the literature on labor market policies do not distinguish between intensive and extensive margins of labor supply, there are important exceptions. Fang and Rogerson (2009) explain cross-country differences in average employment rates and hours worked by differences in labor market policies. An important difference to our work is their focus on averages of the data, rather than relative volatilities. Wesselbaum (2016) documents an empirical relationship between EPL and the relative variability of the intensive and extensive margins and replicates the relationship within a search and matching model. A crucial difference to our work is his use of official labor market data, which results in different stylized facts. As pointed out by Ohanian and Raffo (2012), using official labor data for cross-country comparison may be problematic due to differences in definition and compilation of the statistics. We use their newly available standardized labor market data to address this critique. The work most closely related to ours is Llosa, Ohanian, Raffo, and Rogerson (2014). Based on the same data set by Ohanian and Raffo (2012), the authors document large differences in labor market fluctuations across OECD countries. They show that an RBC model with distinct intensive and extensive labor supply margins and wasteful firing costs can account for the documented cross-country differences. In their model, firing costs reduce employment variability more strongly with flexible hours. While our goal is similar to theirs, our mechanism differs. In Llosa et al. (2014), firing costs are introduced as adjustment costs on negative employment gross flows. This directly discourages employment fluctuations and shifts the burden of adjustment to the intensive margin. In contrast, the search and matching model offers an explicit distinction between hiring and firing. Then, firing costs do not necessarily reduce the variability in employment but may affect hiring instead.

Our results can be summarized as follows. *First*, the intensive margin matters for the effect of firing costs on labor market outcomes. In particular, when the intensive margin is held fixed, the dampening effect of higher firing costs on employment volatility is strongly understated. In our calibrated model, the reduction in employment volatility is about twice as large when the intensive margin is flexible. Also, the welfare losses caused by firing costs are about 20% smaller. *Second*, the firing cost mechanism matters quantitatively. When we impose firing costs of a similar size as in France, the counterfactual US employment growth over the 1992Q1–1999Q1 period is 2.1%, compared to the realized growth of 6.7%. Imposing the same firing costs in the Great Recession would have dampened the effect of the recession and subsequent recovery on the labor market. For the 2007Q4–2009Q4 period, we find a fall in employment of 2.2%, compared to the realized fall of 6.9%. For 2009Q4–2012Q4, we find a counterfactual employment growth of 0.7% compared to the realized growth of 2.4%.

The remainder is organized as follows. Section 2 introduces the search and matching framework. Section 3 describes our calibration strategy and the data fit. In Section 4, we discuss our firing cost mechanism and highlight the role of a flexible intensive margin. Section 5 presents the counterfactual experiments.

2 Framework

This section introduces our model. In Sections 2.1 and 2.2, we first discuss a simple version of the model that allows a tractable discussion of the key mechanisms in Section 4. Section 2.3 describes two extensions of the benchmark which improve the model's fit with standard business cycle moments. The two extensions are useful for our counterfactual experiments in Section 5.

2.1 The benchmark economy

We consider a variant of the standard neoclassical growth model with labor market frictions in the spirit of Mortensen and Pissarides (1994) that includes distinct intensive and extensive margin decisions. The economy is inhabited by a continuum of infinitely lived identical households and a continuum of firms. Households choose the time path of consumption to maximize lifetime utility. Firms choose the workforce sequence to maximize profits, subject to employment adjustment costs. Endogenous separation between employed household members (workers) and firms arises because of job-specific productivity shocks.

Households. Following Merz (1995) and Andolfatto (1996), each household consists of a continuum of family members of measure one. Income and risk is shared equally across the household. The household's lifetime utility $\mathcal{U}$ is:

$$\mathcal{U} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \xi_h n_t \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1+\nu} \frac{g(a)}{1-G(\tilde{a}_t)} da - \xi_n \frac{n_t^{1+\eta}}{1+\eta} \right) \right\}, \qquad (2.1)$$

where c_t denotes average consumption per household member, n_t denotes the fraction of members that are employed, and $h_t(a)$ denotes the intensive margin, namely the number of hours worked for a worker with job-specific productivity level a. a is drawn from a time-invariant distribution with CDF $G(a)$ and density $g(a)$. Further, $\beta \in (0,1)$ denotes the deterministic discount factor, σ denotes the inverse elasticity of intertemporal substitution, ξ_h and ξ_n are preference shift factors, and ν and η determine the elasticity of labor supply at the intensive and extensive margins, respectively.[3] We use $\tilde{a}_t$ to denote the threshold level of productivity below which firms and workers separate, which we will derive and discuss in more detail later on. With this definition of $\tilde{a}_t$, $1 - G(\tilde{a}_t)$ denotes the fraction of job-worker pairs that engage in production (*i.e.* the matches that remain productive), while $G(\tilde{a}_t)$ denotes the separation rate. Hence, in (2.1), the integral corresponds to the average disutility of hours worked expressed in *per worker terms*.

Households choose consumption c_t and bond holdings b_t to maximize their lifetime

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[3]Household preferences in (2.1) can be motivated as follows. Each worker is assumed to incur convex disutility of hours worked of the form $\frac{h^{1+\nu}}{1+\nu}$. Hours depend on job-specific productivity a. Unemployed household members work zero hours. Then, the average disutility of hours worked per household member is $n_t \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1+\nu} \frac{g(a)}{1-G(\tilde{a}_t)} da$. The last term in the per period utility function (2.1)—namely $\frac{n_t^{1+\eta}}{1+\eta}$—follows Cho and Cooley (1994). This term reflects fixed employment costs across household members.

utility $\mathcal{U}$ subject to the period-by-period budget constraint:

$$c_t + b_t \leq R_{t-1}b_{t-1} + i_t(\tilde{a}_t)n_t + t_t, \ i_t(\tilde{a}_t) = \int_{\tilde{a}_t}^{\infty} w_t(a)h_t(a)\frac{g(a)}{1 - G(\tilde{a}_t)}da, \qquad (2.2)$$

where R_t is a riskless gross interest rate, $i_t(\tilde{a}_t)$ denotes the average labor income per worker, and $w_t(a)$ denotes the hourly wage of a worker with skill a. Optimal consumption and savings behavior of households yields the consumption Euler equation:

$$c_t^{-\sigma} = \beta R_t \mathbb{E}_t[c_{t+1}^{-\sigma}]. \qquad (2.3)$$

The household's labor market decisions are part of its bargaining decisions with firms, which we discuss after we introduce the problem of the firm.

Firms and the labor market. Firms use labor services as the only input to produce goods. Within each firm, there is a continuum of jobs. To accommodate endogenous separation, we follow Mortensen and Pissarides (1994) and allow for heterogeneity in the value of products across jobs. In particular, every period, each job is hit by a job-specific productivity shock a. In addition, all firms are hit by a stationary aggregate productivity shock Z_t. Aggregate production then writes:

$$y_t = n_t \int_{\tilde{a}_t}^{\infty} Z_t h_t(a)a\frac{g(a)}{1 - G(\tilde{a}_t)}da. \qquad (2.4)$$

The integral denotes the average product per worker that engages in production. Each worker with job-specific productivity $a > \tilde{a}_t$ contributes $Z_t h_t(a)a$ to overall production. Workers with $a < \tilde{a}_t$ are separated before production takes place, even if the match is new.

Job creation is subject to matching frictions and depends on aggregate labor market conditions and the hiring effort of firms. The aggregate flow of new matches in period $t - 1$ is given by the matching function $m(u_{t-1}, v_{t-1}) = Bu_{t-1}^{\mu}v_{t-1}^{1-\mu}$, where B is the matching efficiency, $u_{t-1} = (1 - n_{t-1})$ is the number of unemployed household members, and v_{t-1} is the number of vacancies. New matches in period $t - 1$ enter the workforce of a firm in the beginning of period t, *before* production takes place and *before* the job-specific productivity shock a realizes. The probability that a vacancy is filled is given by $q(\theta_t) = \frac{m(u_t, v_t)}{v_t} = B\theta_t^{-\mu}$, where $\theta_t \equiv \frac{v_t}{u_t}$ denotes the labor market tightness. The aggregate law of motion of employment is given by:

$$n_t = (1 - \rho_t)(n_{t-1} + m_{t-1}), \qquad (2.5)$$

where we use $\rho_t = G(\tilde{a}_t)$ to denote the endogenous job separation rate (as all job-worker pairs with a draw $a < \tilde{a}_t$ are separated, irrespective of whether they are existing matches n_{t-1} or new matches m_{t-1}).

Firms can influence the workforce through two margins, either via vacancy posting or firing. The firm's optimization problem is to choose vacancies v_t, employment n_t and the threshold productivity level $\tilde{a}_t$ to maximize the current market value of profits $\mathcal{P}$ subject to the law of motion of employment (2.5) and taking wages and the probability of filling a

vacancy as given. Profits are composed of production net of wage payments $i_t(\tilde{a}_t)n_t$, vacancy posting costs χv_t, and the payment of a fixed cost F per firing:

$$\mathcal{P} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \lambda_t \left[y_t - i_t(\tilde{a}_t)n_t - \chi v_t - \frac{\rho_t n_t}{1 - \rho_t} F \right] \right\}. \tag{2.6}$$

For the expression of profits $\mathcal{P}$, we use (2.5) to rewrite the amount of firings $f_t = \rho_t(n_{t-1} + m_{t-1})$ to $\frac{\rho_t n_t}{1 - \rho_t}$. Also note that we assume firing costs F are wasteful, in the sense that they are not redistributed. The first-order conditions of the firm problem are:

$$\delta n_t : \ \tau_t = \frac{y_t}{n_t} - i_t(\tilde{a}_t) - \frac{\rho_t}{1 - \rho_t} F + \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} (1 - \rho_{t+1}) \tau_{t+1} \right], \tag{2.7}$$

$$\delta v_t : \ \frac{\chi}{q(\theta_t)} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} (1 - \rho_{t+1}) \tau_{t+1} \right], \tag{2.8}$$

$$\delta \tilde{a}_t : \ \tau_t = \frac{y_t}{n_t} - Z_t h_t(\tilde{a}_t) \tilde{a}_t - i_t(\tilde{a}_t) + w_t(\tilde{a}_t) h_t(\tilde{a}_t) - \frac{1}{1 - \rho_t} F, \tag{2.9}$$

where τ_t denotes the marginal value of employment (it is the Lagrange multiplier on the law of motion of employment). Combining equations (2.7) and (2.8) yields the job creation condition:

$$\frac{\chi}{q(\theta_t)} = \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[(1 - \rho_{t+1}) \left(\frac{y_{t+1}}{n_{t+1}} - i_{t+1}(\tilde{a}_{t+1}) + \frac{\chi}{q(\theta_{t+1})} \right) - \rho_{t+1} F \right] \right\}. \tag{2.10}$$

Condition (2.10) states that in equilibrium, the cost of filling a vacancy (left-hand-side) must equal the expected return on a vacancy (right-hand-side). With probability $1 - \rho_{t+1}$, the firm does not separate from the worker—then the return is the additional product plus the continuation value of the filled vacancy, net of wage payments. With probability ρ_{t+1} firm and worker separate, and the firm pays the firing cost F. The higher firing costs, the lower are the incentives to post a vacancy, as firms take into account that firing will later be costly.

Combining conditions (2.7)–(2.9) implicitly defines the optimal productivity threshold $\tilde{a}_t$:

$$w_t(\tilde{a}_t) h_t(\tilde{a}_t) = Z_t h_t(\tilde{a}_t) \tilde{a}_t + \frac{\chi}{q(\theta_t)} + F. \tag{2.11}$$

Equation (2.11) states that in equilibrium, the benefits of firing the marginal worker (*i.e.* the worker with job-specific productivity $\tilde{a}_t$) must equal its costs. The benefits correspond to saved wage payments $w_t(\tilde{a}_t) h_t(\tilde{a}_t)$. The costs are composed of lost production, the value of posting a new vacancy (which equals the missed out expected return of a filled vacancy, see (2.10)), and the payment of the firing cost F.

Wage and hours bargaining. Each firm-worker match generates a rent $S_t(a)$, which is split in individual Nash bargaining. Firms and workers bargain over the hourly wage payment $w_t(a)$ and hours worked $h_t(a)$ by solving:

$$[w_t(a), h_t(a)] = \operatorname{argmax} \left(S_t^W(a) \right)^\zeta \left(S_t^F(a) + F \right)^{1-\zeta}, \tag{2.12}$$

where S_t^W denotes the worker's surplus, S_t^F is the firm's surplus, and $\zeta \in (0,1)$ denotes the worker's relative bargaining power. Importantly, the firing cost F has to be included in the bargaining problem. The firing cost weakens the position of the firm and hence reduces the firm's threat point. The total surplus of a match is defined as $S_t(a) \equiv S_t(a)^W + S_t(a)^F + F$.

The worker's surplus $S_t^W(a)$ corresponds to the difference between the household's asset value of being employed and unemployed, $S_t^W(a) = E_t(a) - U_t$. The relevant objects write:

$$
\begin{aligned}
E_t(a) =& w_t(a)h_t(a) - \frac{1}{\lambda_t}\left(\xi_h \frac{h_t(a)^{1+\nu}}{1+\nu} + \xi_n n_t^\eta\right)... \\
& + \beta \mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty E_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da + \rho_{t+1}U_{t+1}\right)\right], \quad (2.13)
\end{aligned}
$$

$$
\begin{aligned}
U_t =& \beta \mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\theta_t q(\theta_t)\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty E_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da + \rho_{t+1}U_{t+1}\right)... \right. \\
& \left. + (1-\theta_t q(\theta_t))U_{t+1}\right]. \quad (2.14)
\end{aligned}
$$

The value of being employed (2.13) is skill-dependent and is composed of the wage payment, the disutility of work, and the probability-weighted continuation value of staying employed or becoming unemployed. The asset value of being unemployed in (2.14) is identical for all unemployed household members. It is given by the probability-weighted continuation value of remaining unemployed or finding a job. In particular, $1 - \theta_t q(\theta_t)$ denotes the probability of remaining unemployed, and $\theta_t q(\theta_t)$ denotes the probability of being matched with a firm. In the latter case, we further need to distinguish two cases: With probability ρ_{t+1} the match is separated before production takes place, while with probability $1 - \rho_{t+1}$ the match remains intact.

The firm surplus $S_t^F(a)$ corresponds to the difference between the asset value of a filled job and a vacancy, $S_t^F(a) \equiv J_t(a) - V_t^v$. The relevant objects write:

$$
\begin{aligned}
J_t(a) =& Z_t h_t(a)a - w_t(a)h_t(a)... \\
& + \beta \mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty J_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da + \rho_{t+1}(V_{t+1}^v - F)\right)\right],
\end{aligned}
$$
$$(2.15)$$

$$
\begin{aligned}
V_t^v =& -\chi + \beta \mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(q(\theta_t)\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty J_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da...\right.\right.\right. \\
& \left.\left.\left. + \rho_{t+1}(V_{t+1}^v - F)\right) + (1-q(\theta_t))V_{t+1}^v\right)\right]. \quad (2.16)
\end{aligned}
$$

The value of a job $J_t(a)$ defined in (2.15) consists of the revenue, the wage payments, and the probability-weighted continuation value of either keeping a job or having a vacancy. With probability $1 - \rho_{t+1}$, the job remains active, and with probability ρ_{t+1} it becomes a vacancy and firing costs have to be payed. The asset value of a vacancy (2.16) is the same for all firms and depends on the cost of posting a vacancy and the probability-weighted continuation

value of the filled or open vacancy. The vacancy remains unfilled with probability $1 - q(\theta_t)$ and becomes filled with probability $q(\theta_t)$. In the latter case, the match may immediately separate (probability ρ_{t+1}) at the cost F or remain active (probability $1 - \rho_{t+1}$). Importantly, since we assume perfect competition and free entry, the value of a vacancy V_t^v is zero in equilibrium.[4]

To obtain optimal hours worked and wage, we can solve the Nash bargaining using equations (2.13)–(2.16).[5] We obtain:

$$h_t(a) = \left(\frac{Z_t \lambda_t a}{\xi_h} \right)^{\frac{1}{\nu}}, \tag{2.17}$$

$$w_t(a)h_t(a) = (1-\zeta)\frac{1}{\lambda_t}\left(\xi_h \frac{h_t(a)^{1+\nu}}{1+\nu} + \xi_n n_t^{\eta} \right) \dots$$
$$+ \zeta\left(Z_t h_t(a)a + \theta_t \chi + \left(1 - (1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right)F \right). \tag{2.18}$$

According to (2.17), the optimal hours decision increases with aggregate and job-specific productivity and decreases with the marginal value of a unit of wealth (captured by λ). Condition (2.18) states that the individual wage payment increases with higher employment in the family, higher hours worked, higher job-specific and aggregate productivity, tighter labor markets, and higher firing costs.[6]

Combining equations (2.11), (2.17), and (2.18) delivers an explicit expression for the job destruction threshold:

$$\tilde{a}_t = \left(\frac{\xi_n \frac{n_t^{\eta}}{\lambda_t} + \frac{\zeta}{1-\zeta}\theta_t\chi - \frac{1}{1-\zeta}\frac{\chi}{q(\theta_t)} - \left(1 + \frac{\zeta}{1-\zeta}(1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right)F}{\frac{\nu}{1+\nu}Z_t^{1+\nu}\left(\frac{\lambda_t}{\xi} \right)^{\nu}} \right)^{\frac{1}{1+\nu}}. \tag{2.19}$$

Condition (2.19) shows that firing costs reduce the productivity threshold $\tilde{a}_t$.[7] As firing becomes costly, firms become more reluctant to separate, and less productive jobs remain intact.

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[4]From equations (2.15), (2.16), and the free entry condition follows $S_t^F(a) = Z_t h_t(a)a - w_t(a)h_t(a) + \frac{\chi}{q(\theta_t)}$. Using (2.11), this shows that firms separate from workers when $S_t^F(a) + F < 0$.

[5]Equations (2.17) and (2.18) are expressed in terms of job-specific productivity a. Weighting with the distribution of idiosyncratic productivity, we obtain the following expressions of average hours worked per worker $H_t(\tilde{a}_t)$ and average labor income per worker $i_t(\tilde{a}_t)$:

$$H_t(\tilde{a}_t) = \left(\frac{Z_t \lambda_t}{\xi_h} \right)^{\frac{1}{\nu}} \int_{\tilde{a}_t}^{\infty} a^{\frac{1}{\nu}} \frac{g(a)}{1 - G(\tilde{a}_t)}da,$$

$$i_t(\tilde{a}_t) = (1-\zeta)\frac{1}{\lambda_t}\left(\xi_h \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1+\nu}\frac{g(a)}{1 - G(\tilde{a}_t)}da + \xi_n n_t^{\eta} \right) + \zeta\left(\frac{y_t}{n_t} + \theta_t\chi + \left(1 - (1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right)F \right).$$

[6]The last part of the statement assumes $(1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t} \right] < 1$.

[7]This statement assumes $(1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t} \right] > -\frac{\zeta}{1-\zeta}$.

2.2 Equilibrium and model solution

In equilibrium, all markets clear. The aggregate resource constraint is given by:

$$y_t = c_t + \chi v_t + \frac{n_t}{1 - \rho_t} \rho_t F. \tag{2.20}$$

To close the model, we assume that a follows a log-normal distribution with standard deviation σ_a and mean $\mu_a = -\frac{\sigma^2}{2}$ ($\mathbb{E}[a] = 1$). The aggregate productivity shock Z_t follows an AR(1) process of the form $\log(Z_t) = \rho_z \log(Z_{t-1}) + \sigma_z$, $\sigma_z \sim N(0, \sigma_z^2)$. Appendix Section A.1 contains an overview of all conditions that characterize the equilibrium of this economy. To solve the model, we first log-linearize the general equilibrium equations around the non-stochastic steady state. We then apply standard techniques for solving linear rational expectation models.

2.3 Model extensions

We now turn to versions of our benchmark model that improve its empirical performance. We augment the benchmark along two dimensions: discount factor shocks and a hiring cost function in the spirit of Yashiv (2000a, 2000b, 2006) and Merz and Yashiv (2007).

Discount factor shocks. Hall (2017) argues that business cycle variation in financial discounts plays an important role for unemployment fluctuations. In particular, he observes that in the data, discount rates implicit in stock markets are strongly positively correlated with unemployment. This finding is in line with the standard Mortensen and Pissarides (1994) model: From the employer's perspective, an increase in the discount rate reduces the net present value of the benefit of hiring a new worker. In turn, the lower incentives to create jobs lead to an increase in unemployment.

We follow Hall (2017) and augment our benchmark model with discount factor shocks as an additional source of business cycle fluctuations. In particular, we assume discount factor shocks d_t follow an AR(1) process of the form $d_t = \rho_d d_{t-1} + \varepsilon_{d,t}$ and enter the household and firm maximization problems as follows:

$$\mathcal{U} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \exp(-d_t) \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \xi_h n_t \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1+\nu} \frac{g(a)}{1-G(\tilde{a}_t)} da - \xi_n \frac{n_t^{1+\eta}}{1+\eta} \right) \right\}, \tag{2.21}$$

$$\mathcal{P} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \exp(-d_t) \beta^t \lambda_t \left[y_t - i_t(\tilde{a}_t) n_t - \chi v_t - \frac{n_t}{1-\rho_t} \rho_t F \right] \right\}. \tag{2.22}$$

Appendix Section A.1.2 depicts all relevant equations characterizing general equilibrium.

Yashiv hiring cost function. In our benchmark model, hiring costs are a linear function of the number of vacancies posted. Alternatively, Yashiv (2000a, 2000b, 2006) and Merz and Yashiv (2007) suggest a convex hiring cost function, which offers a better fit in capturing costs such as the advertising of vacancies, the screening of candidates, or the training of new workers.

We assume the following hiring cost function, which we refer to as *Yashiv hiring cost function*:

$$\psi\Gamma_t = \psi\frac{\left(\phi v_t + (1-\phi)m_t\right)^2}{2}\bar{y}_t. \tag{2.23}$$

Total hiring costs $\psi\Gamma_t$ (which replace the linear vacancy cost function χv_t) are quadratic in a weighted average of the number of vacancies and new matches, where ϕ is the relative weight given to vacancies. The costs are measured in terms of aggregate output $\bar{y}_t$, which the firm takes as given. Appendix Section A.1.3 contains a full overview of all relevant equations characterizing the general equilibrium.

3   Calibration and fit

We now turn to the model calibration and examine its empirical performance. We consider three variants of our model: our benchmark (model 1), the benchmark augmented with discount factor shocks (model 2), and the benchmark augmented with both discount factor shocks and Yashiv's hiring cost function (model 3).

3.1   Calibration and parametrization

Table 1 summarizes the calibration and parametrization values for all three model variants. We first introduce the calibration and parametrization of model 1 and then highlight the key differences for models 2 and 3. The model is calibrated to US data. One model time-period reflects one quarter. The discount rate β matches an annual real rate of 4%. We set the constant relative risk aversion parameter to 0.5, which represents an intermediate value between (1) the risk neutrality assumption used for instance in Shimer (2005), Hall (2005), Hagedorn and Manovskii (2008), or Pissarides (2009), and (2) the logarithmic utility case considered in Merz (1995) or Andolfatto (1996). The employment and hours disutility curvature parameters η and ν are critical in determining the fluctuations of employment and hours worked. We set $\eta = 0$, consistent with the assumption that each employed household member incurs the same fixed costs. ν fits the empirical volatility between US employment and hours worked, based on data by Ohanian and Raffo (2012). Regarding the matching function, we set the matching elasticity μ to 0.4, in line with empirical estimates by Blanchard and Diamond (1989). The matching efficiency B implies a quarterly probability of filling a vacancy of 0.9, in line with Merz (1995) and Andolfatto (1996). The bargaining power of workers ζ is set to ensure the Hosios (1990) condition, *i.e.* $\zeta = \mu$. Following Sedláček (2014), the variance of the job-specific productivity shock σ_a is 0.155. The vacancy posting costs χ and preference shift parameters ξ_h and ξ_n are chosen to imply (1) a steady state separation rate of 0.1 in line with the evidence presented in Shimer (2005), (2) a steady state intensive margin of 0.33 in line with average hours worked from Ohanian and Raffo (2012), and (3) a steady state unemployment rate of 0.1 in line with Krause and Lubik (2007).[8] The

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[8] We follow Krause and Lubik (2007) and choose an unemployment rate which is higher than in the data. The underlying idea is to allow for participants in the matching market that are not registered as unemployed.

persistence of the technology shock process ρ_z is estimated using linearly detrended data on utilization-adjusted total factor productivity (TFP), constructed as in Fernald (2014). We obtain $\rho_z = 0.95$ and $\sigma_z = 0.0077$.

As we focus on the effect of firing costs F, a range of values for F is considered, which is meant to capture the different regulatory frameworks across OECD countries. We set $F = 0$ in our benchmark to reflect the low regulatory framework in the US. We then use data on the OECD *Protection Against Dismissal* indicator to calibrate F for the other countries. The OECD indicator gives us a synthetic cardinal measure of various costs involved in firing workers. To relate the OECD indicator to F, we use the empirical relation (an OLS regression) between the OECD indicator and the relative variance of average hours worked to employment shown in Figures 1 and 2. More precisely, we set the highest value of firing costs F_{max} in our model such that—for the highest value of the OECD indicator—our calibrated model fits the OLS regression line in terms of the relative hours per employee to employment variance. This procedure yields an F_{max} of roughly 9% of steady state average

Table 1: *Model parameters*

Parameter	Role	Model 1	Model 2	Model 3
Preferences				
β	Discount rate	0.99	0.99	0.99
σ	CRRA	0.5	0.5	0.5
ν	Hours disutility curvature	1.65	0.90	0.84
η	Employment disutility curvature	0	0	0
ξ_h	Preference shift parameter	11.55	5.03	4.69
ξ_n	Preference shift parameter	0.33	0.24	0.23
Matching, bargaining, separation, hiring and firing costs				
B	Matching efficiency	0.94	0.94	0.94
μ	Match elasticity	0.40	0.40	0.40
ζ	Bargaining power	0.40	0.40	0.40
σ_a	Standard deviation a	0.16	0.16	0.16
χ	Vacancy posting costs	0.03	0.03	–
ψ	Hiring cost scale parameter	–	–	1.05
ϕ	Hiring cost weighting parameter	–	–	0.38
F	Firing costs	[0; 0.09]	[0; 0.10]	[0; 0.11]
Shock processes: technology shock (Z) and discount factor shock (d)				
$\bar{Z}$	Steady state	1	1	1
ρ_z	Persistence	0.95	0.95	0.95
σ_z	Standard deviation	0.0077	0.0077	0.0077
$\bar{d}$	Steady state	–	0	0
ρ_d	Persistence	–	0.75	0.75
σ_d	Standard deviation	–	0.3810	0.6169

wage payments. We then linearly map the OECD indicator to the space $F = [0, F_{max}]$.[9,10]

For models 2 and 3, we follow the same calibration and parametrization strategy as outlined above. Compared to model 1, all parameter values which were chosen to match moments change—namely the values for ν, ξ_h, ξ_n and χ.[11] Further, models 2 and 3 have two additional parameters related to the discount factor shock, ρ_d and σ_d. In line with Albertini and Poirier (2014), we assume $\rho_d = 0.75$ for both models. We then calibrate σ_d relative to σ_z by minimizing the equally weighted distance between standard business cycle moments implied by the model and the data (namely, standard deviations of vacancies, employment, unemployment, and hours worked relative to the standard deviation of output; the correlation between unemployment and vacancies). For F, we use the calibration strategy outlined above and obtain $F_{max} = 10\%$ and $F_{max} = 11\%$ for models 2 and 3, respectively. Finally, for model 3, we additionally calibrate the hiring cost parameter ϕ to fit the standard business cycle moments.

3.2 Model-data fit

We now examine the model-data fit along two main dimensions: *First*, we focus on the US (meaning $F = 0$) and explore the empirical plausibility of the business cycles moments generated by the three model variants. *Second*, we turn to all countries of our sample and compare the model- and data-implied relative hours to employment variance for different values of firing costs F.

Table 2 summarizes standard US business cycle moments (first column) and the model-implied moments. The data moments are taken from Krause and Lubik (2014) and Ohanian and Raffo (2012). The data is in logs and HP-filtered. The table shows that our technology-shock-only specification (model 1) suffers from the Shimer puzzle (Shimer, 2005). That is, the model is not able to generate enough volatility in unemployment and vacancies. Adding discount factor shocks (model 2) helps to fix this problem, as it raises the volatility of labor market variables relative to output. Adding the Yashiv hiring cost formulation (model 3) improves the fit further, especially with regard to the strong negative correlation between

Table 2: *Data moments vs. model moments (HP-filtered)*

	Data	Model 1	Model 2	Model 3
$\sigma(v)/\sigma(y)$	9.52	0.64	11.28	9.71
$\sigma(u)/\sigma(y)$	8.77	2.25	5.16	7.70
$\sigma(n)/\sigma(y)$	0.80	0.25	0.57	0.86
$\sigma(h)/\sigma(y)$	0.30	0.10	0.21	0.32
corr(u,v)	-0.92	-0.42	-0.39	-0.90

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[9]The calibration of the range of F is easiest understood when looking at Figure 2. The figure shows the model's implied relationship between firing costs (x-axis) and the relative variance between hours worked and employment (y-axis). F is set such that the model's implied relative hours-to-employment variance for Italy (which corresponds to the country with the highest EPL in our sample) exactly fits our OLS regression line.

[10]We cannot calibrate F using empirical estimates of firing costs incurred by firms. For tractability reasons, we assume job-specific productivity to be *iid*. In our model, there is no persistence in job-specific productivity and already small firing costs prevent firms from firing low productivity workers.

[11]For model 3, we use the hiring cost ψ instead of χ to match the moments considered.
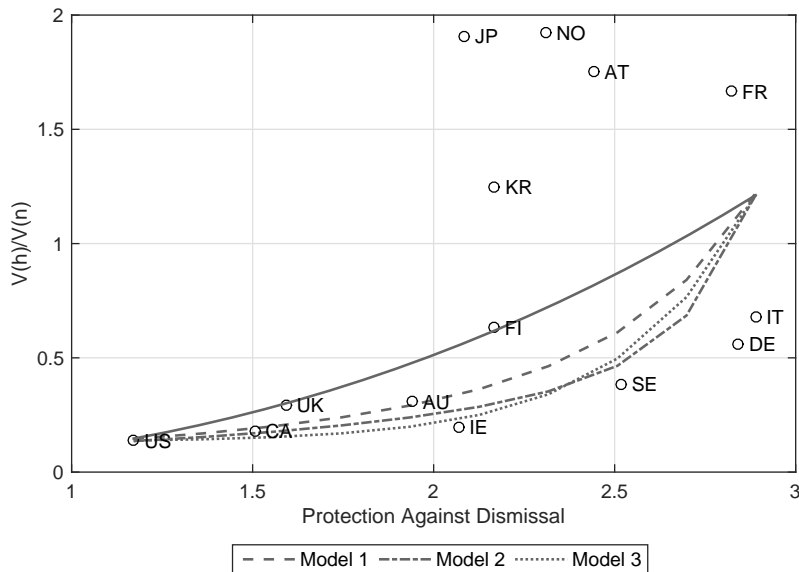
Figure 2: *Protection Against Dismissal and relative intensive-extensive margin variance: model vs. data (HP-filtered)*

unemployment and vacancies.

Figure 2 shows the models' implied relationships between firing costs (x-axis) and the relative hours-to-employment variance (y-axis) across 14 OECD countries.[12] As in Figure 1, the OLS regression line of the relative hours to employment variance for different levels of the OECD indicator is depicted as a solid black line. The dashed, dash-dotted and dotted lines represent the implied relationship by our models 1–3, respectively. For all model variants, the figure shows a positive association between firing costs and the relative hours-to-employment variance. Our chosen mapping between F and the OECD indicator allows to fit relatively well the observed relative variance of Canada, the United Kingdom, Australia, Sweden, Finland, Ireland, Germany, Italy and France. To fit the relative variance of countries like Japan, Korea, Norway or Austria, we have to either adjust the calibration of F or other parameter values.

4   The underlying mechanism

This section describes our quantitative results. In Section 4.1, we analyze the role of firing costs for the steady state and business cycle moments of our model. Our focus is on the mechanism that underlies the fit in Figure 2. In Section 4.2, we describe the role of a flexible intensive margin for our results. In Section 4.3, we examine how the mechanism is affected if firing costs enter as severance payments. For ease of exposition, all results are based on

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[12]The variances in Figure 2 are computed based on the maximum sample reported by Ohanian and Raffo (2012). The sample spans 1960Q1–2013Q4 except Australia and Korea (starting 1970Q1), Sweden (1974Q1), and the UK (1971Q1). For the OECD index, values for 2013 are depicted. The OECD index is available on a yearly basis between 1985–2013. Overall, the ranking is relatively stable across time. The biggest movers are Australia, Japan, and Korea. Appendix A.2 shows that excluding them does not change the stylized fact.

our benchmark model (model 1) introduced in 2.1. Results for the other model variants are discussed in Appendix Section A.3 and are similar.

4.1 The effect of firing costs

4.1.1 Steady state

Table 3a shows the effect of an increase in firing costs on the steady state of output, employment, average hours worked per employee, the separation rate, the number of vacancies posted, and the number of fired and hired workers. The firing costs are increased from 0 to 5% and 10% of steady state average wage payments per worker.

The table shows that firing costs have a strong influence on the steady state separation rate $\bar{\rho}$. An increase in firing costs from 0 to 10% leads to a reduction in the steady state separation rate from 10% to 1%. Also, firing costs reduce steady state average hours worked $\bar{h}$ and raise the steady state employment rate $\bar{n}$. The reduction in average hours worked can be explained by the effect of firing costs on the separation rate: As firing costs lead firms to lower the separation rate, workers with lower productivity remain at the firm. The lower the productivity of a worker, the lower is the optimal amount of hours worked (see equation (2.17)).[13] In turn, the decrease in average hours worked reduces the average disutility of being employed. The lower average disutility leads to lower average wage payments per worker, which raises firms' demand for workers and hence equilibrium employment $\bar{n}$. More specifically, the lower average disutility of being employed dampens the decrease in hirings $\bar{m}$ such that in equilibrium, the fall in firings dominates over the fall in hirings. Overall, the rise in employment is larger than the reduction in average hours worked and consequently total hours and output rise.

The last row in Table 3a shows the steady state welfare loss resulting from increased firing costs. The welfare loss is measured as proportion of steady state consumption the representative agent is willing to sacrifice to avoid the introduction of firing costs, compared to the baseline case with with $F = 0$. Since we satisfy the Hosios (1990) condition, the allocation in the economy without firing costs is constrained Pareto efficient and an increase in firing costs causes a welfare loss.[14] The table shows that the welfare effects of firing costs are small: Raising firing costs from 0 to 10% of steady state average wage payments leads to a welfare loss equivalent to 0.6% of steady state consumption. Roughly speaking, the small effect can be explained by the fact that our model does not capture any distributional costs arising from firing costs. The model assumes perfect consumption insurance across household members, so household members consume the same irrespective of their employment status. It follows that our model only captures aggregate costs of unemployment.

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[13]Overall, this explains why the reduction in aggregate productivity goes along with a reduction in average hours worked. Firing costs also entail a negative wealth effect for the households, which is however weak in our model.

[14]The allocation with firing costs is no longer constrained Pareto efficient as firms do not take the effect of reducing the separation rate on labor market tightness into account. The Hosios condition is not sufficient to internalize this externality.

Table 3: *Effect of firing costs*

	(a) Steady state			(b) Relative std.			(c) Absolute std.[i]		
	$F=0\%$	$F=5\%$	$F=10\%$	$F=0\%$	$F=5\%$	$F=10\%$	$F=0\%$	$F=5\%$	$F=10\%$
y	0.31	0.31	0.32	1.46	1.40	1.32	0.45	0.44	0.42
n	0.90	0.94	0.98	0.36	0.28	0.15	0.33	0.26	0.14
h	0.33	0.32	0.32	0.14	0.17	0.20	0.05	0.05	0.07
ρ	0.10	0.04	0.01	1.84	2.36	3.06	0.18	0.10	0.03
v	0.11	0.04	0.01	0.94	2.56	5.65	0.10	0.09	0.04
f	0.10	0.04	0.01	1.75	2.29	3.01	0.17	0.10	0.03
m	0.10	0.04	0.01	1.19	1.92	3.38	0.12	0.08	0.04
Welfare cost[ii]	-	0.41%	0.59%	-	0.41%	0.58%			

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The absolute standard deviations (part *c*) are obtained by multiplying the relative standard deviations (part *b*) by the corresponding steady state values (part *a*). (ii): The welfare cost is measured as proportion of consumption the representative agent would sacrifice to avoid the increase in firing costs (compared to $F = 0$).

4.1.2 Business cycle fluctuations

Tables 3b and 3c show the effect of firing costs on various standard deviations, measured based on HP-filtered simulations. As discussed in the previous section, firing costs have a strong influence on steady states values. We therefore have to be careful in the measurement of the variability of variables. Two different standard deviations are reported: *First*, Table 3b depicts *relative* standard deviations, *i.e.* the variability of variables measured as percentage of their respective steady states. For instance, the relationship between EPL and the relative variability of the intensive-extensive margin presented in Figures 1 and 2 as well as the moments reported in Table 2 are based on variables measured as percentage of the steady state. *Second*, Table 3c depicts *absolute* standard deviations, *i.e.* numbers measured in absolute units.

Table 3b shows that firing costs decrease the relative volatility of employment and increase the relative volatility of hours. The reduction in the relative volatility of employment is easiest understood when looking at absolute movements in firings and hirings (Table 3c) relative to the steady state employment level.[15] Both the absolute volatility of firings and hirings decrease. For firings, the reason is immediate—firings costs discourage firings. For hirings, there is a direct and an indirect channel at work: The direct channel is that with higher firing costs, filling a vacancy will, in later periods, lead to a costly firing. The indirect channel is that firing costs stabilize absolute variations in the separation rate and, thereby, the average productivity of workers. The more stable average productivity of workers stabilizes absolute variations in the amount of vacancies. Overall, the decrease in absolute variations in firings and hirings joint with a higher steady state employment level explains the reduction in the relative volatility of employment.[16]

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[15]Higher firing costs 1) increase the relative standard deviations of firings and hirings and 2) reduce the correlation between the two. Both of these observations cannot account for the observed increase in the relative standard deviation of employment—it is caused by changes in the steady state of firings and hirings.

[16]To explain the strong increase in the relative standard deviations of firings and hirings, we conjecture that the same mechanism as in Ljungqvist and Sargent (2017) is at work. In the standard search and matching framework, an increase in layoff costs decreases the fundamental surplus (the share of a job's output that is used by the competitive firm to post vacancies). The lower the steady state fundamental surplus,

The intuition for the increase in the standard deviation of hours worked per employee follows directly from the argumentation above. In contrast to the separation and vacancy posting decision, firing costs have no direct influence on the optimal hours choice. Hence, firing costs move the burden of adjustment in labor to the intensive margin.

The last line in Table 3b depicts the *total* welfare costs of introducing firing costs relative to the benchmark model with $F = 0$. Again, the welfare cost is measured as the proportion of consumption that the representative agent would sacrifice to avoid the increase in firing costs. The total welfare costs are very similar to the steady state welfare costs depicted in Table 3a. Hence, the effect of firing costs on the volatility of aggregates has only a small impact on welfare. This finding can be explained by two modeling assumptions, namely the moderate risk aversion of households and the fact that disutility of work is linear in employment.

4.2 The role of the intensive margin

We now evaluate the role of a flexible intensive margin for the analysis of firing costs. We compare the effect of a change in firing costs across two models: (1) our benchmark model and (2) a variant of our benchmark in which hours per employee h are fixed irrespective of the idiosyncratic productivity level of workers. Appendix Section A.4 contains all details on the computation and calibration of the model with fixed hours.

Table 4 depicts our results. Part *a* shows the percentage change in the steady state when we raise firing costs from 0 to 10% of steady state average wage payments. Parts *b* and *c* depict the percentage change in the relative and absolute standard deviations for the same increase in firing costs. Focusing first on the steady state results, the table shows that holding the intensive margin fixed leads to understate the effects of firing costs on almost all variables. In particular, keeping hours fixed reduces the negative effect of firing costs on the steady state separation rate and on vacancy postings. In addition, the positive effect of firing costs on employment is understated. The intuition for the differences in steady states is as follows. With flexible hours, higher firing costs cause a fall in hours per employee. The reduction in hours reduces the disutility of being employed (which decreases equilibrium wages and hence the cost of workers) and reduces workers' average production (which decreases the gain of having an additional worker). For the separation rate, the first effect dominates, as the separation rate drops more strongly with flexible hours. This drop in the separation rate has a mixed effect on vacancies: On the one hand, it makes vacancies more valuable due to longer lasting employment relationships. On the other hand, by decreasing workers average productivity, it decreases the gain of having an additional worker. Overall, the reduction in average production per worker due to the lower separation rate and the lower hours worked dominates: Firms reduce vacancy posting more strongly under flexible than under fixed hours. As to the steady state welfare analysis, Table 4a shows that with a fixed intensive margin, the negative welfare effects of firing costs are overstated. This is intuitive, as allowing

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the larger is the percentage change in the fundamental surplus in response to a technology shock. Hence, vacancy postings react more strongly to technology shocks in relative terms. In turn, the stronger relative reaction of vacancy postings affects firms' separation decisions.

Table 4: *The role of the intensive margin: effect of increasing firing costs from 0 to 10%*

	(a) $\Delta\%$ **Steady state**[(i)]		(b) $\Delta\%$ **Relative std.**[(ii)]		(c) $\Delta\%$ **Absolute std.**[(iii)]	
	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed
y	3.35%	4.04%	-9.93%	-9.43%	-6.91%	-5.76%
n	8.41%	6.17%	-59.92%	-29.95%	-56.55%	-25.62%
h	-2.72%	–	46.43%	–	42.45%	–
ρ	-88.73%	-79.60%	66.37%	88.16%	-81.25%	-61.62%
v	-93.39%	-88.34%	504.10%	689.65%	-60.05%	-7.93%
f	-88.88%	-80.10%	71.94%	93.26%	-80.88%	-61.54%
m	-88.88%	-80.10%	222.24%	132.27%	-64.16%	-53.77%
Welf.[(iv)]	0.58%	0.70%	0.58%	0.70%		

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The values correspond to the percentage change in steady state between F=10% and F=0 for two different models: "flexible" corresponds to the benchmark model; "fixed" corresponds to the adjusted benchmark with fixed hours. (ii), (iii): Same as (i), but for the percentage change in relative and absolute standard deviations. (iv): Part *a* reports the percentage change in steady state welfare costs, part *b* the percentage change in total welfare costs.

hours to adjust offers an additional choice variable with which the negative effects of firing costs can be absorbed.

We now turn to the business cycle moments in Table 4b and Table 4c. Our main result is that holding the intensive margin fixed leads to a strong understatement of the dampening effect of firing costs on the volatility of employment. One way to explain this is through absolute changes in hirings and firings (Table 4c) relative to the steady state employment level (Table 4a). When firms adjust total labor input with a fixed intensive margin, they have a margin less over which they can avoid firing costs. Hence, firing costs lead to a lower reduction in the variation of hirings and firings when the intensive margin is fixed. At the same time, firing costs lead to a lower increase in the steady state level of employment. As the effect on the steady state level is quantitatively small, overall, the stabilizing effect on the absolute volatility of hirings and firings dominates. With respect to the welfare analysis reported in the last row of Table 4, the findings are similar to Section 4.1.2. The welfare effect caused by the changes in dynamics are negligible compared to the steady state welfare effects.

4.3 Firing costs as severance payments

Severance payments are part of the employment protection framework of many countries.[17] In the following, we investigate how our results change if firing costs are no longer wasteful, but instead enter as severance payments directly paid to the fired worker. Compared to the benchmark model, the probability of receiving a transfer F improves the household's asset values of being employed E_t or unemployed U_t:

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[17]For instance, more than half of the countries in the 2016 "Doing Business" report of the World Bank use severance payments to protect workers from dismissal.

$$E_t(a) = w_t(a)h_t(a) - \frac{1}{\lambda_t}\left(\xi_h\frac{h_t(a)^{1+\nu}}{1+\nu} + \xi_n n_t^\eta\right)...$$
$$+ \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty E_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da + \rho_{t+1}(U_{t+1}+F)\right)\right], \tag{4.1}$$

$$U_t = \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\theta_t q(\theta_t)\left((1-\rho_{t+1})\int_{\tilde{a}_{t+1}}^\infty E_{t+1}(a)\frac{g(a)}{1-G(\tilde{a}_{t+1})}da + \rho_{t+1}(U_{t+1}+F)\right)...$$
$$+ (1-\theta_t q(\theta_t))U_{t+1}\right]. \tag{4.2}$$

Modeling firing costs as severance payments also affects the bargaining problem between firms and workers. Severance payments improve the worker's outside option when bargaining with the firm over hourly wages and hours worked. The Nash bargaining problem now writes:

$$[w_t(a), h_t(a)] = \text{argmax}\left(S_t^W(a) - F\right)^\zeta\left(S_t^F(a) + F\right)^{1-\zeta}. \tag{4.3}$$

The full list of equations characterizing general equilibrium is printed in Appendix Section A.5.1. Appendix Section A.5.2 containts our results.[18],[19] Overall, the results of our benchmark model with firing costs and the alternate model with severance payments are broadly similar. There are two main differences in our steady state results and in the welfare effects. *First*, an increase in firing costs raises steady state employment and total hours worked (employment times average hours per worker) less strongly when firing costs are modeled as severance payments. *Second*, welfare losses are smaller. These differences can by explained by the fact that in our benchmark model, firing costs represent a destruction of resources. This destruction of resources represents a negative wealth effect which induces households to supply more labor. Further, the destruction of resources directly affects welfare because less resources for consumption are available. As to the role of the intensive margin, our results suggest that there are only minor quantitative differences. Qualitatively, the role of the intensive margin is similar to the one presented in Section 4.2: In the absence of a flexible hours choice, both, wasteful firing costs and severance payments move the burden of adjustment onto vacancy posting. Also, holding hours per employee fixed leads to a strong underestimation of the dampening effect of firing costs on employment volatility, irrespective of whether we model firing costs as wasteful or as severance payments.

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[18]We follow the same calibration approach as we have outlined in Section 3. In particular, the values for ν, χ, ξ_h and ξ_N change to 1.7, 0.03 12.21 and 0.33.

[19]In particular, Appendix Table 9 reports the effect of severance payments on the steady state, on business cycle fluctuations, and on welfare. Appendix Table 10 reports the role of a flexible intensive margin for the evaluation of severance payments.

5   Counterfactuals

In this section we illustrate our model's firing cost mechanism by revisiting two historical events. We first look at the US 1990s to show how firing costs impede employment growth during an episode of economic upswing. We then turn to the Great Recession and illustrate how firing costs can be helpful in stabilizing employment in a downturn—at the cost of a slower recovery.

5.1   The US 1990s boom

The US 1990s are generally considered a period of extended economic prosperity with steady job creation. We are interested in the quantitative implications of firing restrictions. The underlying thought experiment is a counterfactual simulation of how employment and average hours per employee would have evolved had US firing costs been of similar size as in other OECD countries.

Our counterfactual exercise is based on model 3, *i.e.* the benchmark model augmented with discount factor shocks and the Yashiv hiring cost function (the "best-fit model"). We use data on employment and hours worked from Ohanian and Raffo (2012) for the 1980Q1–2013Q4 period to estimate the historical structural innovations. Based on the identified innovations, we then compute different counterfactual paths by imposing a change in the firing cost F. To ensure that the convergence to the new steady state does not play a role in our counterfactuals, we assume the policy change studied took place some years before our episode of interest.[20]

Figure 3 depicts our results. The corresponding numbers are summarized in Appendix Table 11. The figure shows the evolution of employment (left) and hours per employee (right) for different counterfactual values of firing costs. In particular, the figure shows counterfactuals for firing costs of 2.5% (dashed line) and 10% (dash-dotted line) of steady state average wage payments per worker. These values correspond roughly to the UK and France/Italy—based on our calibration approach introduced in Section 3.1. Both the data and counterfactuals are normalized to equal 1 in 1992Q1. The figure shows that with firing costs of similar size as in France, the employment growth over the 1992Q1–1999Q1 period is less than a third as large (2.1% compared to the realized employment growth of 6.7%). For hours per employee, we estimate an increase by 3.9% compared to the observed 1.9%. With regard to total hours, the effect of employment dominates. Overall, with higher firing costs, we find an increase in total hours of 6.1% compared to the effective increase of 8.8%. In our model, higher firing costs impede the economic upswing.

5.2   The US Great Recession

The US Great Recession has been characterized by an unusual large drop in labor input—unusual both in comparison to its own past as well as in comparison to the Great Recession

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[20]The results are robust to the date of the change in firing costs, as long as the change occurs before 1988Q1. The results depicted in Figure 3 are based on a change in firing costs in 1985Q1.
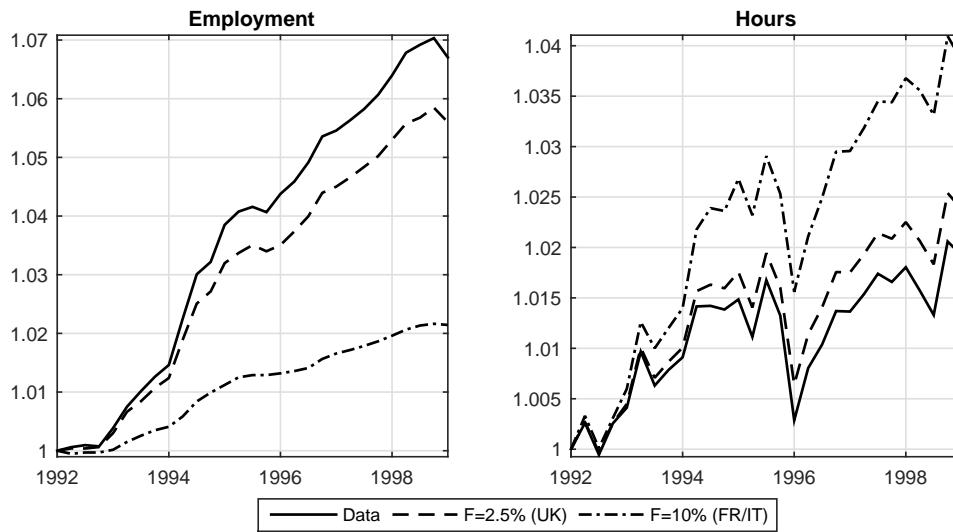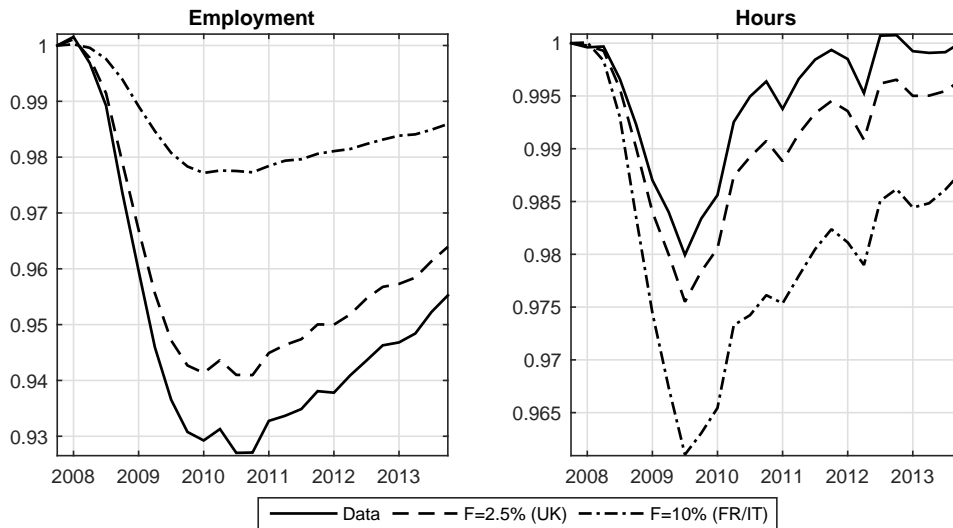
Figure 3: *Counterfactual US 1990s*

Figure 4: *Counterfactual US Great Recession*

in other OECD countries.[21] In the following, we quantitatively assess the labor market implications of our firing restrictions using the same counterfactual experiment as for the US 1990s boom.

Figure 4 summarizes counterfactual paths of employment and hours per employee for the 2007Q4–2013Q4 period. The corresponding numbers are depicted in Appendix Table A.6. Again, our computations are based on the assumption that the policy reform took place some years before our episode of interest, such that the convergence to the new steady state

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[21]US employment fell by 6.9% over the 2007Q4–2009Q4 period. For comparison, over the same episode, employment fell by roughly 2.8% in Canada, 1.9% in France, 5.1% in Italy, and 2.8% in the UK.

plays no role for our results.[22] The figure shows that with US firing costs similar in size as in France, the drop in employment over the 2007Q4–2009Q4 period is less than a third as large (namely, -2.2% instead of the observed -6.9%). At the same time, the drop in hours per employee is almost double (-3.7% instead of -1.7%). Looking at the overall effect on aggregate hours worked, just like in the previous exercise, the effect of employment dominates: With firing costs similar to France, we find that the overall drop in total hours between 2007Q4 to 2009Q4 is about 30% smaller. The underlying intuition follows from our discussion of the mechanism in Section 4.1: Higher firing costs move the burden of adjustment to fluctuations in the intensive margin, while hiring and firing are stabilized. With smaller employment in- and outflows, the fall in employment is stabilized. However, the smaller variability in employment also holds for the recovery: The lower employment fall in recession comes at the cost of a slower recovery. With firing costs as in France, we find an employment growth of 0.7% for 2009Q4–2013Q4, compared the realized employment growth of 2.4%.

6   Concluding remarks

We explore the role of firing costs on labor market outcomes in a search and matching framework. To evaluate the role of a distinct intensive margin, we compare results of two versions of our model, once with fixed and once with flexible average hours per employee. In both versions of our model, higher firing costs dampen employment in- and outflows. The reduction in employment volatility is about twice as large when the intensive margin is flexible. In terms of welfare, the difference between the two model variants is sizable. In particular, with flexible hours, the welfare loss caused by higher firing costs is about 20% smaller.

We contribute to a recent line of research that shifts attention to the intensive margin. Typically, existing research on the link between labor market policies and labor market outcomes focuses on employment only. Our main finding is that the intensive margin matters for understanding the effect of firing costs. While our results are obtained in the context of a search and matching model, Llosa et al. (2014) find similar effects in an RBC setting. Overall, this indicates that the role of the intensive margin should be addressed in any model that studies labor market policies.

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[22]The results are robust to the date of the change in firing costs, as long as the change occurs before 2005Q1. The results in Figure 4 are based on a change in firing costs in 2000Q1.

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A Appendix

A.1 General equilibrium

A.1.1 Benchmark model

$$\rho_t = G(\tilde{a}_t) \tag{A.1}$$

$$c_t^{-\sigma} = \beta R_t \mathbb{E}_t[c_{t+1}^{-\sigma}] \tag{A.2}$$

$$y_t = Z_t n_t \int_{\tilde{a}_t}^{\infty} h_t(a) a \frac{g(a)}{1 - G(\tilde{a}_t)} da = n_t Z_t^{\frac{1+\nu}{\nu}} \left(\frac{\lambda_t}{\xi_h}\right)^{\frac{1}{\nu}} \int_{\tilde{a}_t}^{\infty} a^{\frac{1+\nu}{\nu}} \frac{g(a)}{1 - G(\tilde{a}_t)} da \tag{A.3}$$

$$n_t = (1 - \rho_t)(n_{t-1} + m_{t-1}) \tag{A.4}$$

$$m(u_t, v_t) = B u_t^{\mu} v_t^{1-\mu} = B \theta_t^{1-\mu} \underbrace{(1 - n_t)}_{\equiv u_t} \tag{A.5}$$

$$q(\theta_t) = \frac{m(u_t, v_t)}{v_t} = B \theta_t^{-\mu} \tag{A.6}$$

$$\lambda_t = c_t^{-\sigma} \tag{A.7}$$

$$\frac{\chi}{q(\theta_t)} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} (1 - \rho_{t+1}) \left(\frac{y_{t+1}}{n_{t+1}} - i_{t+1}(\tilde{a}_{t+1}) - \frac{\rho_{t+1}}{1 - \rho_{t+1}} F + \frac{\chi}{q(\theta_{t+1})} \right) \right] \tag{A.8}$$

$$y_t = c_t + c^c V_t + \frac{\rho_t}{1 - \rho_t} n_t F \tag{A.9}$$

$$h_t(a) = \left(\frac{Z_t \lambda_t a}{\xi_h} \right)^{\frac{1}{\nu}} \tag{A.10}$$

$$H_t(\tilde{a}_t) = \left(\frac{Z_t \lambda_t}{\xi_h} \right)^{\frac{1}{\nu}} \int_{\tilde{a}_t}^{\infty} a^{\frac{1}{\nu}} \frac{g(a)}{1 - G(\tilde{a}_t)} da \tag{A.11}$$

$$w_t(a) h_t(a) = (1 - \zeta) \frac{1}{\lambda_t} \left(\xi_h \frac{h_t(a)^{1+\nu}}{1 + \nu} + \xi_n n_t^{\eta} \right) \dots$$
$$+ \zeta \left(Z_t h_t(a) a + \theta_t \chi + \left(1 - (1 - \theta_t q(\theta_t)) \beta \mathbb{E} \left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right) F \right) \tag{A.12}$$

$$i_t(\tilde{a}_t) = (1 - \zeta) \frac{1}{\lambda_t} \left(\xi_h \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1 + \nu} \frac{g(a)}{1 - G(\tilde{a}_t)} da + \xi_n n_t^{\eta} \right) \dots$$
$$+ \zeta \left(\frac{y_t}{n_t} + \theta_t \chi + \left(1 - (1 - \theta_t q(\theta_t)) \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right) F \right) \tag{A.13}$$

$$\tilde{a}_t = \left(\frac{\xi_n \frac{n_t^{\eta}}{\lambda_t} + \frac{\zeta}{1-\zeta} \theta_t \chi - \frac{1}{1-\zeta} \frac{\chi}{q(\theta_t)} - \left(1 + \frac{\zeta}{1-\zeta} (1 - \theta_t q(\theta_t)) \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \right] \right) F}{\frac{\nu}{1+\nu} Z_t^{1+\nu} \left(\frac{\lambda_t}{\xi} \right)^{\nu}} \right)^{\frac{1}{1+\nu}} \tag{A.14}$$

$$\log(Z_t) = \rho_z \log(Z_{t-1}) + \sigma_z, \ z \sim N(0, \sigma_z^2) \tag{A.15}$$

A.1.2 Including discount factor shocks (model 2)

Compared to the benchmark model, equations (A.2), (A.8), and (A.12)–(A.14) change:

$$\exp(-d_t) c_t^{-\sigma} = \beta R_t \mathbb{E}_t[\exp(-d_{t+1}) c_{t+1}^{-\sigma}] \tag{A.16}$$

$$\frac{\chi}{q(\theta_t)} = \beta \mathbb{E}_t \left[\frac{\exp(-d_{t+1}) \lambda_{t+1}}{\exp(-d_t) \lambda_t} (1 - \rho_{t+1}) \left(\frac{y_{t+1}}{n_{t+1}} - i_{t+1}(\tilde{a}_{t+1}) - \frac{\rho_{t+1}}{1 - \rho_{t+1}} F + \frac{\chi}{q(\theta_{t+1})} \right) \right] \tag{A.17}$$

$$w_t(a) h_t(a) = (1 - \zeta) \frac{1}{\lambda_t} \left(\xi_h \frac{h_t(a)^{1+\nu}}{1 + \nu} + \xi_n n_t^{\eta} \right) \dots$$

$$+ \zeta \left(Z_t h_t(a) a + \theta_t \chi + \left(1 - (1 - \theta_t q(\theta_t)) \beta \mathbb{E} \left[\frac{\exp(-d_{t+1}) \lambda_{t+1}}{\exp(-d_t) \lambda_t} \right] \right) F \right) \tag{A.18}$$

$$i_t(\tilde{a}_t) = (1 - \zeta) \frac{1}{\lambda_t} \left(\xi_h \int_{\tilde{a}_t}^{\infty} \frac{h_t(a)^{1+\nu}}{1+\nu} \frac{g(a)}{1-G(\tilde{a}_t)} da + \xi_n n_t^{\eta} \right) \ldots$$

$$+ \zeta \left(\frac{y_t}{n_t} + \theta_t \chi + \left(1 - (1 - \theta_t q(\theta_t)) \beta \mathbb{E}_t \left[\frac{\exp(-d_{t+1}) \lambda_{t+1}}{\exp(-d_t) \lambda_t} \right] \right) F \right) \tag{A.19}$$

$$\tilde{a}_t = \left(\frac{\xi_n \frac{n_t^{\eta}}{\lambda_t} + \frac{\zeta}{1-\zeta} \theta_t \chi - \frac{1}{1-\zeta} \frac{\chi}{q(\theta_t)} - \left(1 + \frac{\zeta}{1-\zeta}(1 - \theta_t q(\theta_t)) \beta \mathbb{E}_t \left[\frac{\exp(-d_{t+1}) \lambda_{t+1}}{\exp(-d_t) \lambda_t} \right] \right) F}{\frac{\nu}{1+\nu} Z_t^{1+\nu} \left(\frac{\lambda_t}{\xi} \right)^{\nu}} \right)^{\frac{1}{1+\nu}} \tag{A.20}$$

A.1.3 Including Yashiv's formulation (model 3)

$$h_t(a_t) = \left(\frac{Z_t \lambda_t a_t}{\xi_h} \right)^{\frac{1}{\nu}} \tag{A.21}$$

$$z_t h_t(\tilde{a}_t) \tilde{a}_t = \frac{1}{c_t^{-\sigma}} \left(\xi_h \frac{h_t(\tilde{a}_t)^{1+\nu}}{1+\nu} + \xi_N n_t^{\eta} \right) - \frac{1 - \mu B \theta_t^{1-\mu}}{(1-\mu)B} \theta_t^{\mu} \chi \Gamma'_{t,v} + \Gamma'_{t,n} - F \tag{A.22}$$

$$\frac{\chi}{B} \theta_t^{\mu} \Gamma'_{t,v} = \beta \mathbb{E}_t \left\{ \frac{c_{t+1}^{-\sigma} \exp(-d_{t+1})}{c_t^{-\sigma} \exp(-d_t)} (1 - \rho_{t+1})(1 - \mu) \times \ldots \right.$$

$$\left[\left(\frac{y_{t+1}}{n_{t+1}} - z_{t+1} h_{t+1}(\tilde{a}_{t+1}) \tilde{a}_{t+1} \right) \ldots \right.$$

$$\left. \left. - \frac{\xi_h}{\lambda_{t+1}} \left(\int_{\tilde{a}_{t+1}}^{\infty} \frac{h_{t+1}(a)^{1+\nu}}{1+\nu} \frac{g(a)}{1-G(\tilde{a}_{t+1})} da - \frac{h_{t+1}(\tilde{a}_{t+1})^{1+\nu}}{1+\nu} \right) \right] \right\} \ldots$$

$$- \beta \mathbb{E}_t \left[\frac{c_{t+1}^{-\sigma} \exp(-d_{t+1})}{c_t^{-\sigma} \exp(-d_t)} (1 - \mu) F (1 - \rho_x) \right] \tag{A.23}$$

A.2 Stylized facts

(a) *Full sample (0.01)* **(b)** *1985Q1-2013Q4 (0.03)* **(c)** *2000Q1-2013Q4 (0.08)*
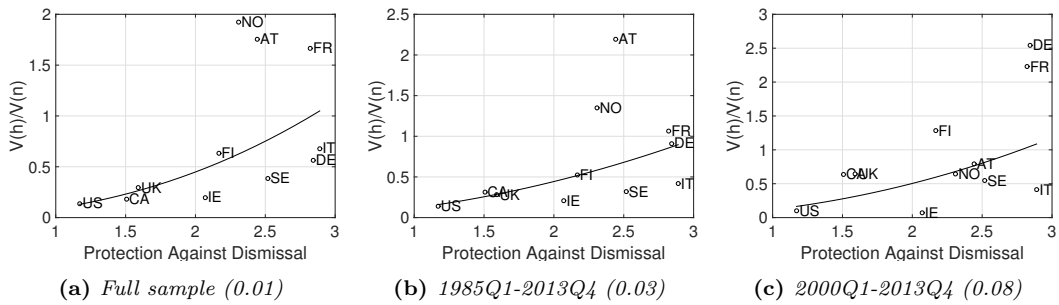
Figure 5: *Robustness exercise: Protection Against Dismissal and relative intensive-extensive margin variance*

Figure 5 presents robustness checks for the stylized fact illustrated in Figures 1 and 2. The figure depicts the relative intensive-extensive margin variability against the OECD measure of "Protection Against Dismissal" for different data samples. Data is HP-filtered and in logs. The black line represents the fitted line of an OLS regression. The corresponding p-value is shown in parentheses in the caption of each panel. All figures exclude Australia, Japan, and Korea, as they are the biggest movers in terms of the OECD index over time. For all three samples, we find a statistically significant positive relation between the relative intensive-extensive margin variance and the OECD index.

A.3   Additional results for models 2 and 3

A.3.1   The effect of firing costs in model 2

Table 5 depicts the effect of an increase in firing costs on the steady state (part *a*) and the relative (part *b*) and absolute (part *c*) standard deviations of various aggregates for model 2 (the benchmark model augmented with discount factor shocks). As in the main body of the paper, firing costs are raised from 0 to 5% and 10% of steady state average wage payments per worker. The table also depicts the steady state (part *a*) and total (part *b*) welfare loss of firing costs, based on HP-filtered simulations. Qualitatively, the results are similar to those of the benchmark model presented in Section 4.1. The most interesting difference is that firing costs do no longer monotonically raise the volatility of average hours worked. An increase in firing costs from 0 to 5% raises the volatility, while an increase from 0 to 10% leaves it roughly unchanged. In terms of absolute standard deviations, firing costs move the burden of adjustment to the intensive margin, as both, the absolute standard deviations of both hirings and firings decrease strongly. Overall, the basic intuition gained from the benchmark model is unchanged.

Table 5: *Effect of firing costs in model 2*

	(a) Steady state			(b) Relative std.			(c) Absolute std.[i]		
	F=0%	*F*=5%	*F*=10%	*F*=0%	*F*=5%	*F*=10%	*F*=0%	*F*=5%	*F*=10%
y	0.31	0.31	0.32	1.69	1.53	1.39	0.53	0.48	0.45
n	0.90	0.95	0.99	0.97	0.77	0.34	0.87	0.73	0.34
h	0.33	0.32	0.31	0.36	0.39	0.37	0.12	0.13	0.12
ρ	0.10	0.04	0.01	4.76	5.26	24.04	0.48	0.19	0.12
v	0.11	0.03	0.00	19.07	19.26	24.99	2.11	0.58	0.09
f	0.10	0.03	0.01	6.10	5.42	23.93	0.61	0.19	0.12
m	0.10	0.03	0.01	10.58	11.18	21.12	1.06	0.39	0.11
Welfare cost[ii]	-	0.38%	0.49%	-	0.41%	0.53%			

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The absolute standard deviations are obtained by multiplying the relative standard deviations (part *b*) by the corresponding steady state values (part *a*). (ii): The welfare cost is measured as proportion of consumption the representative agent would sacrifice to avoid the increase in firing costs.

A.3.2   The role of the intensive margin in model 2

Table 6 shows the effect of firing costs on the steady state (part *a*) and the relative (part b) and absolute (part c) standard deviations of various aggregates for model 2 and a version of model 2 with fixed hours. The last row reports the steady state (part *a*) and total (part b) welfare loss of firing costs. For the fixed hours version of the model, we use the same calibration approach as outlined in Section 3.1. Compared to the flexible hours version of model 2, the following parameters change: $\sigma_d = 0.3993$, $\chi = 0.0346$ and $\xi_N = 0.2349$. Overall, the role of the intensive margin for the evaluation of firing costs in model 2 is qualitatively similar to the benchmark model outlined in Section 4.2.

Table 6: *The role of the intensive margin in model 2: effect of increasing firing costs from 0 to 10%*

	(a) Δ% Steady state[(i)]		(b) Δ% Relative std.[(ii)]		(c) Δ% Absolute std.[(iii)]	
	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed
y	2.72%	4.06%	-17.52%	-13.19%	-15.28%	-9.67%
n	9.89%	6.19%	-64.65%	-11.97%	-61.15%	-6.52%
h	-4.71%	–	4.76%	–	-0.18%	–
ρ	-94.83%	-79.73%	405.05%	87.44%	-73.88%	-62.01%
v	-96.89%	-88.44%	31.06%	22.49%	-95.92%	-85.85%
f	-94.86%	-80.23%	292.34%	55.18%	-79.83%	-69.31%
m	-94.86%	-80.23%	99.71%	34.90%	-89.73%	-73.33%
$Welf.$	0.49%	0.70%	0.53%	0.75%		

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The values correspond to the percentage change in steady state between F=10% and F=0 for two different models: "flexible" corresponds to the benchmark model; "fixed" corresponds to the adjusted benchmark with fixed hours. (ii), (iii): Same as (i), but for the percentage change in relative and absolute standard deviations.

A.3.3 The effect of firing costs in model 3

Table 7 repeats Table 5, but for model 3. Overall, the results are broadly similar to the ones of the benchmark model presented in Section 4.1. A noteworthy difference is that firing costs decrease rather than increase the variability of average hours worked. Nevertheless, in terms of absolute standard deviations, the burden of adjustment is still moved onto the intensive margin, as both, the firing and hiring margin' absolute standard deviations decrease even more than the absolute standard deviation of the intensive margin. Hence, the basic intuition gained from the benchmark model still applies.

Table 7: *Effect of firing costs in model 3*

	(a) Steady state			(b) Relative std.			(c) Absolute std.[(i)]		
	F=0%	F=5%	F=10%	F=0%	F=5%	F=10%	F=0%	F=5%	F=10%
y	0.31	0.31	0.32	1.86	1.62	1.48	0.58	0.51	0.47
n	0.90	0.92	0.95	1.59	0.86	0.41	1.43	0.79	0.39
h	0.33	0.33	0.32	0.59	0.38	0.36	0.20	0.12	0.12
ρ	0.10	0.07	0.04	9.37	7.98	7.08	0.94	0.55	0.25
v	0.11	0.07	0.03	18.01	17.73	17.21	2.00	1.21	0.54
f	0.10	0.07	0.04	10.51	8.91	7.62	1.05	0.60	0.27
m	0.10	0.07	0.04	6.21	7.59	8.23	0.62	0.51	0.29
Welfare cost[(ii)]	-	0.52%	0.86%	-	0.56%	0.90%			

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The absolute standard deviations are obtained by multiplying the relative standard deviations (part *b*) by the corresponding steady state values (part *a*). (ii): The welfare cost is measured as proportion of consumption the representative agent would sacrifice to avoid the increase in firing costs.

A.3.4 The role of the intensive margin in model 3

Table 8 repeats Table 6 for model 3. For the fixed hours version of the model, we use the same calibration approach as outlined in Section 3.1. Compared to the flexible hours version of model 3, the following parameters change: $\sigma_d = 1.0615$, $\phi = 0.4947$, $\psi = 1.1313$ and $\xi_N = 0.2236$.

In contrast to the results of our benchmark model discussed in Section 4.2, the omission of the flexible hours margin in model 3 leads firing costs to have a *stronger* dampening effect on the variability of output. This stronger dampening effect occurs although under flexible hours, the variability of employment and hours is dampened more strongly. The reason behind the stronger dampening effect is that in model 3, firing costs raise the correlation

between employment and hours worked. The larger correlation counteracts the effect of a reduction in the variability of employment and hours worked on the variability of output. More precisely, firing costs weaken the negative correlation between employment and average hours worked in model 3. The negative correlation arises because of the discount factor shocks.

Apart from the difference in the effect on the variability of output, the role of the intensive margin for the evaluation of firing costs in model 3 is broadly similar to the benchmark model outlined in Section 4.2.

Table 8: *The role of the intensive margin in model 3: effect of increasing firing costs from 0 to 10%*

	(a) Δ% **Steady state**[i]		(b) Δ% **Relative std.**[ii]		(c) Δ% **Absolute std.**[iii]	
	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed
y	1.41%	2.19%	-20.49%	-38.11%	-19.37%	-36.75%
n	5.60%	3.52%	-74.50%	-53.62%	-73.08%	-51.98%
h	-2.75%	–	-39.38%	–	-41.05%	–
ρ	-64.77%	-53.67%	-24.41%	-13.31%	-72.98%	-58.94%
v	-71.96%	-64.23%	-4.45%	2.24%	-73.20%	-63.43%
f	-64.77%	-53.67%	-27.57%	-15.69%	-74.48%	-60.94%
m	-64.77%	-53.67%	32.49%	35.89%	-53.33%	-37.05%
Welf.[iv]	0.86%	0.98%	0.90%	1.21%		

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The values correspond to the percentage change in steady state between F=10% and F=0 for two different models: "flexible" corresponds to the benchmark model; "fixed" corresponds to the adjusted benchmark with fixed hours. (ii), (iii): Same as (i), but for the percentage change in relative and absolute standard deviations. (iv): Part a reports the percentage change in steady state welfare costs, part b the percentage change in total welfare costs.

A.4   Alternative model with fixed hours

The alternative model with fixed hours does not differ much from our benchmark model. The choice of hours is fixed, irrespective of the idiosyncratic productivity level of the worker. In comparison to the benchmark model, only the preferences of the household, the definition of the wage payment per employee and the production function change:

Household preferences:
$$\mathcal{U} = \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \xi_h n_t \frac{\bar{h}^{1+\nu}}{1+\nu} - \xi_n \frac{n_t^{1+\eta}}{1+\eta} \right), \quad \text{(A.24)}$$

Wage payment per employee:
$$i_t(\tilde{a}_t) = \bar{h} \int_{\tilde{a}_t}^{\infty} w_t(\tilde{a}_t) \frac{g(a)}{1-G(\tilde{a}_t)} da, \quad \text{(A.25)}$$

Production function:
$$y_t = Z_t n_t \bar{h} \int_{\tilde{a}_t}^{\infty} a \frac{g(a)}{1-G(\tilde{a}_t)} da. \quad \text{(A.26)}$$

In contrast to the benchmark model, each firm-worker match only bargains over the hourly wage payment $w_t(a)$. The full list of general equilibrium equations is as follows:

$$\rho_t = \rho^x + (1-\rho^x)G(\tilde{a}_t) \quad \text{(A.27)}$$

$$n_t = (1-\rho_t)(n_{t-1} + m_{t-1}) \quad \text{(A.28)}$$

$$m_t = B\theta_t^{1-\mu}(1-n_t) \quad \text{(A.29)}$$

$$q(\theta_t) = B\theta_t^{-\mu} \quad \text{(A.30)}$$

$$\lambda_t = c_t^{-\sigma} \quad \text{(A.31)}$$

$$y_t = Z_t n_t \bar{h} \int_{\tilde{a}_t}^{\infty} a \frac{g(a)}{1-G(\tilde{a}_t)} da \quad \text{(A.32)}$$

$$\frac{\chi}{q(\theta_t)} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t}(1-\rho_{t+1}) \left[\frac{y_{t+1}}{n_{t+1}} - i_{t+1}(\tilde{a}_{t+1}) - \frac{\rho_{t+1}-\rho^x}{1-\rho_{t+1}}F + \frac{\chi}{q(\theta_{t+1})} \right] \right] \quad \text{(A.33)}$$

$$y_t = c_t + \chi v_t + \frac{\rho_t - \rho_x}{1-\rho_t} n_t F \quad \text{(A.34)}$$

$$i_t(\tilde{a}_t) = (1-\zeta)\frac{1}{\lambda_t}\left(\xi_h\frac{\bar{h}^{1+\nu}}{1+\nu} + \xi_n n_t^\eta\right) + \zeta y_t/n_t + \zeta\theta_t\chi + \dots$$

$$\zeta\left(1 - (1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}(1-\rho^x)\right]\right)F \tag{A.35}$$

$$Z_t\bar{h}\tilde{a}_t = \frac{\zeta}{1-\zeta}\theta_t\chi - \frac{1}{1-\zeta}\frac{\chi}{q(\theta_t)} + \frac{1}{\lambda_t}\left(\xi_h\frac{\bar{h}^{1+\nu}}{1+\nu} + \xi_n n_t^\eta\right)\dots$$

$$\dots - \left(1 + \frac{\zeta}{1-\zeta}(1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}(1-\rho^x)\right]\right)F \tag{A.36}$$

To calibrate the alternative model, we use the same calibration procedure as outlined in section [3.1]. As hours are fixed, we use the same values for ν and ξ_h as in the benchmark model. Hence, only the parameters χ and ξ_n change and are set to 0.0346 and 0.3259.

A.5 Alternative model with severance payments

A.5.1 General equilibrium

$$\rho_t = F(\tilde{a}_t) \tag{A.37}$$

$$c_t^{-\sigma} = \beta R_t\mathbb{E}_t[c_{t+1}^{-\sigma}] \tag{A.38}$$

$$y_t = Z_t n_t \int_{\tilde{a}_t}^\infty h_t(a)a\frac{g(a)}{1-G(\tilde{a}_t)}da = n_t Z_t^{\frac{1+\nu}{\nu}}\left(\frac{\lambda_t}{\xi_h}\right)^{\frac{1}{\nu}}\int_{\tilde{a}_t}^\infty a^{\frac{1+\nu}{\nu}}\frac{g(a)}{1-G(\tilde{a}_t)}da \tag{A.39}$$

$$n_t = (1-\rho_t)(n_{t-1} + m_{t-1}) \tag{A.40}$$

$$m(u_t, v_t) = Bu_t^\mu v_t^{1-\mu} = B\theta_t^{1-\mu}\underbrace{(1-n_t)}_{\equiv u_t} \tag{A.41}$$

$$q(\theta_t) = \frac{m(u_t, v_t)}{v_t} = B\theta_t^{-\mu} \tag{A.42}$$

$$\lambda_t = c_t^{-\sigma} \tag{A.43}$$

$$\frac{\chi}{q(\theta_t)} = \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}(1-\rho_{t+1})\left(\frac{y_{t+1}}{n_{t+1}} - i_{t+1}(\tilde{a}_{t+1}) - \frac{\rho_{t+1}}{1-\rho_{t+1}}F + \frac{\chi}{q(\theta_{t+1})}\right)\right] \tag{A.44}$$

$$y_t = c_t + c^c V_t \tag{A.45}$$

$$h_t(a) = \left(\frac{Z_t\lambda_t a}{\xi_h}\right)^{\frac{1}{\nu}} \tag{A.46}$$

$$H_t(\tilde{a}_t) = \left(\frac{Z_t\lambda_t}{\xi_h}\right)^{\frac{1}{\nu}}\int_{\tilde{a}_t}^\infty a^{\frac{1}{\nu}}\frac{g(a)}{1-G(\tilde{a}_t)}da \tag{A.47}$$

$$w_t(a)h_t(a) = (1-\zeta)\frac{1}{\lambda_t}\left(\xi_h\frac{h_t(a)^{1+\nu}}{1+\nu} + \xi_n n_t^\eta\right)\dots$$

$$+ \zeta\left(Z_t h_t(a)a + \theta_t\chi\right) + \left(1 - (1 - \theta_t q(\theta_t))\beta\mathbb{E}\left[\frac{\lambda_{t+1}}{\lambda_t}\right]\right)F \tag{A.48}$$

$$i_t(\tilde{a}_t) = (1-\zeta)\frac{1}{\lambda_t}\left(\xi_h\int_{\tilde{a}_t}^\infty\frac{h_t(a)^{1+\nu}}{1+\nu}\frac{g(a)}{1-G(\tilde{a}_t)}da + \xi_n n_t^\eta\right)\dots$$

$$+ \zeta\left(\frac{y_t}{n_t} + \theta_t\chi\right) + \left(1 - (1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\right]\right)F \tag{A.49}$$

$$\tilde{a}_t = \left(\frac{\xi_n\frac{n_t^\eta}{\lambda_t} + \frac{\zeta}{1-\zeta}\theta_t\chi - \frac{1}{1-\zeta}\frac{\chi}{q(\theta_t)} - \frac{1}{1-\zeta}(1 - \theta_t q(\theta_t))\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\right]F}{\frac{\nu}{1+\nu}Z_t^{1+\nu}\left(\frac{\lambda_t}{\xi}\right)^\nu}\right)^{\frac{1}{1+\nu}} \tag{A.50}$$

$$\log(Z_t) = \rho_z\log(Z_{t-1}) + \sigma_z, \; z \sim N(0, \sigma_z^2) \tag{A.51}$$

A.5.2 Results

Table 9 depicts the effect of an increase in firing costs on the steady state (part a) and the relative (part b) and absolute (part c) standard deviations of various aggregates. The firing costs are raised from 0 to 5% and 10% of steady state average wage payments per worker. Furthermore, the table depicts the steady state (part a) and the total welfare loss of firing costs. Both, the standard deviation and the total welfare loss computations are based on HP-filtered simulations.

Table 9: *Effect of firing costs modeled as severance payments*

	(a) Steady state			(b) Relative std.			(c) Absolute std.[i]		
	F=0%	F=5%	F=10%	F=0%	F=5%	F=10%	F=0%	F=5%	F=10%
y	0.31	0.30	0.31	1.46	1.45	1.35	0.45	0.44	0.42
n	0.90	0.89	0.93	0.37	0.34	0.21	0.33	0.30	0.19
h	0.33	0.33	0.32	0.14	0.16	0.20	0.04	0.05	0.06
ρ	0.10	0.06	0.02	1.85	1.59	1.09	0.19	0.10	0.03
v	0.11	0.05	0.01	0.93	2.97	6.55	0.10	0.14	0.07
f	0.10	0.06	0.02	1.77	1.61	1.25	0.18	0.10	0.03
m	0.10	0.06	0.02	1.20	1.53	3.72	0.12	0.09	0.08
Welfare cost[ii]	-	0.20%	0.49%	-	0.20%	0.48%			

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The absolute standard deviations are obtained by multiplying the relative standard deviations (part (b)) times the corresponding steady state values (part (a)). (ii): The welfare cost is measured as proportion of consumption the representative agent would sacrifice to avoid the increase in firing costs. Part (a) depicts the steady state welfare cost, part (b) the total welfare costs including fluctuations.

Table 10 shows the role of the intensive margin for the evaluation of firing costs. The table depicts the percentage change in the steady state (part a), in the relative (part b) and the absolute (part c) standard deviation of various aggregates as firing costs are raised from 0 to 10% of steady state average wage payments. Also, the percentage change in the steady state (part a) and total (part b) welfare loss for the same increase in firing costs is shown. Both, results for the flexible and the fixed hours version of the model with severance payments are shown. The standard deviations and the total welfare loss of firing costs are based on HP-filtered simulations.

Table 10: *The role of the intensive margin with severance payments: effect of increasing firing costs from 0 to 10%*

	(a) Δ% Steady state[i]		(b) Δ% Relative std.[ii]		(c) Δ% Absolute std.[iii]	
	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed
y	0.16%	-0.20%	-7.62%	-7.27%	-7.47%	-7.46%
n	3.51%	1.55%	-43.17%	-22.09%	-41.18%	-20.89%
h	-1.55%	–	47.12%	–	44.84%	–
ρ	-76.95%	-69.24%	-41.06%	2.07%	-86.42%	-68.61%
v	-89.70%	-85.96%	604.81%	750.60%	-27.38%	19.46%
f	-78.03%	-71.00%	-29.45%	8.74%	-84.50%	-68.46%
m	-78.03%	-71.00%	210.57%	93.63%	-31.75%	-43.84%
Welf.[iv]	0.49%	0.53%	0.48%	0.52%		

Note: The standard deviations (std.) are based on HP-filtered simulations. (i): The values correspond to the percentage change in steady state between F=10% and F=0 for two different models: "flexible" corresponds to the benchmark model; "fixed" corresponds to the adjusted benchmark with fixed hours. (ii), (iii): Same as (i), but for the percentage change in relative and absolute standard deviations. (iv): Part a reports the percentage change in steady state welfare costs, part b the percentage change in total welfare costs.

A.6 US counterfactuals

Table 11: *Counterfactual US labor market 1992Q1-1999Q1*

	Data	$F = 2.5\%$ (UK)	$F = 5\%$ (AU)	$F = 7.5\%$ (SE)	$F = 10\%$ (FR)
ΔN	6.70%	5.60%	4.49%	3.36%	2.14%
ΔH	1.92%	2.38%	2.84%	3.33%	3.86%
ΔTH	8.76%	8.11%	7.46%	6.80%	6.08%

Table 12: *Counterfactual US labor market 2007Q4-2009Q4*

	Data	$F = 2.5\%$ (UK)	$F = 5\%$ (AU)	$F = 7.5\%$ (SE)	$F = 10\%$ (FR)
ΔN	-6.92%	-5.73%	-4.56%	-3.39%	-2.17%
ΔH	-1.66%	-2.16%	-2.66%	-3.17%	-3.69%
ΔTH	-8.47%	-7.77%	-7.10%	-6.45%	-5.78%