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► **To cite this version:**

Tristan-Pierre Maury, Fabien Tripier. Intrafim Bargaining, Worker Flows, and Employment Protection. 2011. hal-00566168v1

HAL Id: hal-00566168

<https://hal.science/hal-00566168v1>

Preprint submitted on 15 Feb 2011 (v1), last revised 13 Jul 2012 (v2)

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Intrafirm Bargaining, Worker Flows, and Employment Protection

Tristan-Pierre Maury* and Fabien Tripier†

Very preliminary

February 15, 2011

Abstract

This paper provides a rationale for employment protection based on the interaction between the firm's decision on firing and the wage bargaining process with its workers. We develop a matching and intrafirm bargaining model where large firms hire workers on a frictional labor market and decide to destroy low productivity jobworker matches. The coexistence of entry and exit worker flows gives rise to a specific interaction between the firing decision and the wage bargaining process. This interaction causes inefficient decisions for hiring and firing and numerical simulations show that a combination of firing taxes and severance payments leads to an efficient labor market.

Keywords: Matching; Employment Protection; Intrafirm Bargaining; Worker Flows.

JEL Classification: J3; J6.

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1 Introduction

Search and matching frictions do not *per se* rationalize the existence of employment protection legislation since the labor contract can efficiently internalize these frictions in the core model of this literature.¹ Given the prevalence of this legislation around the world², this literature has been enriched with additive features that justify employment protection and therefore allow to define its optimal design. Examples of these features are imperfections in the insurance of workers, e.g. Alvarez and Veracierto (2001) and Pissarides (2001), externalities associated with human capital and skill, e.g. Zoega and Booth (2003) or Belot et al. (2007), and the need to finance other labor market policies, e.g. Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008). In this paper, we provide a new rationale for employment protection, which doesn't result from one of these features, and arises in the core matching model once worker flows in large firms are considered. This conclusion stands in contrast with previous theoretical contributions on job flows between large firms that report welfare costs from employment protection; e.g. Bertola and Caballero (1994) and Koeniger and Prat (2007).

The empirical literature on labor market flows has stressed the importance of the distinction between job flows and workers flows. The first is associated with the net variation of the mass of jobs at the establishment's level: job destruction occurs in contracting establishments, in which the mass of jobs falls, whereas job creation occurs in expanding establishments, in which it rises; see Davis and Haltiwanger (1992). Job destruction and job creation cannot coexist within establishments, and job reallocation is the outcome of the establishment's heterogeneity. The picture is different for worker flows, which coexist in firms. Burgess et al. (2000) among others demonstrate that worker flows exceed largely job flows and that in general both

¹Hosios (1990) and Pissarides (2000) define formally the efficient labor contract in a matching model with exogenous job destruction. It corresponds to the outcome of a Nash bargaining program, where the bargaining power of workers is equal to the elasticity parameter of the matching function with respect to unemployed workers that measures the contribution of workers to the trading externality on the labor market. Mortensen and Pissarides (1994) demonstrate that the Hosios-Pissarides condition of efficiency applies in the context of endogenous match destruction. Mortensen and Pissarides (1999) and Ljunqvist (2002) introduce employment protection detrimental to welfare in this model.

²Freeman (2007) provide an international comparison of labor market institutions, including the employment protection legislation.

entry and exit worker flows coexist within establishments, whatever the size of the establishment and its growth rate of employment. The authors report measures of labor market flows for the state of Maryland. For nonmanufacturing, the average worker flow rate, defined as the sum of hiring and firing divided by the employment, is about 32% against 9.5% for the job reallocation rate, defined as the sum of job created and job destroyed divided by the employment. The associated churning rate defined as the difference between these two rates is equal to 22.8%. The churning rate is about 26% for establishment with less than 50 employed, about 30% for establishment with employment between 50 and 500, and 12.5% and 22.3% for the with employment above 500 and 1000, respectively. For manufacturing, the job average rates of reallocation is 7.4%, of worker flow rate is 19.4%, and of churning is 12.1% (that varies between 6.3% to 17.1 according to the firm sizes)³. In this paper, we develop a matching and bargaining model consistent with this specificity of worker flows (that coexist inside firms, on the contrary to job flows) and use this model to assess the (potential usefulness) of employment protection.

To study worker flows within large firms, we cannot use the traditional matching and bargaining model of the labor market developed by Diamond (1982), Pissarides (2000), and Mortensen and Pissarides (1994) in which firms are small and composed of one single job.⁴ We need to consider the decisions of large firms composed of heterogeneous job-worker matches. As it is widely-known, considering large firms with a non-trivial production function (that is a concave technology) has strong normative implications. While there exists a condition of efficient bargaining when firms are small⁵, the wage negotiation is generally inefficient

³With similar data, Lane et al. (1996) show that one in five hires can be attributed to firms that are reducing employment and that one in four exits to firms that are expanding employment. Accordingly, Anderson and Meyer (1994) conclude that permanent job reallocation account for one-third of worker reallocation in several US states. Using a panel of Dutch Firms, Hamermesh, Hassink and van Ours (1996) report that 20% of firms simultaneously hire and fire workers whereas only 2.6% of firms fire without hiring. Hence, the authors' conclusion that firing is mainly done by firms that are also hiring. For the danish manufacturing sector, Albaek and Sorensen (1998) report that job reallocation flows is about 40% of worker reallocation flows and that 28% of hires takes place in plants with decreasing or constant employment and 30% of separations takes place in expanding firms. Abowd et al. (1999) depict similar facts for the french economy.

⁴Kiyotaki and Lagos (2007) and Burgess and Turon (2010) make the distinction between job flows and worker flows in matching models with small firms by assuming that a job can survive to a separation with a worker and be filled with another worker.

⁵The efficient labor contract of Hosios (1990) and Pissarides (2000) has been defined in matching models with small firms.

in large firms. It proceeds from the strategic interactions between the firm's decisions on the organizational design of production and the processes of wage bargaining with workers originally described by Stole and Zwiebel (1996a,b) and known as *intrafirm bargaining*. One of the key results of the authors is that *intrafirm bargaining* leads firms to over employ workers in order to reduce their individual marginal productivities and so on the individual wage bargained with each worker. Smith (1999), Cahuc and Wasmer (2001), and Cahuc et al. (2008) study the implications of *intrafirm bargaining* on hiring in the matching model.⁶ Our approach extends this literature to the case of endogenous worker reallocation. The novelty of our approach is to address the issue of *intrafirm bargaining* in a setup where firms simultaneously hire and fire workers. This contrasts with the literature that has considered the *intrafirm bargaining* issue in models of heterogeneous firms that either create or destroy jobs in the tradition of Bertola and Caballero (1994) as done by Bertola and Garibaldi (2001), Koeniger and Prat (2007), Fujita and Nakajima (2009), Cosar et al. (2010), and Elsby and Michaels (2010).

In models *à la* Bertola and Caballero (1994), contracting firms destroy jobs when hit by an adverse idiosyncratic shocks at the origin of fall in the demand of labor. An important property of this class of models is that workers in contracting firms are unable to extract a positive rent from the Nash bargaining program on wages since the marginal value of a job is zero or negative for the firm. The wage is consequently set to the worker's reservation level that makes its utility equal to that of an unemployed worker. Therefore, wages in contracting firms are independent of firms' decision and there is no room for strategic interactions between the job destruction decision and the wage bargaining.

For worker flows, since firms simultaneously hire and fire workers, our setup allows for new interactions between the firing decision and the wage bargaining. Existing matching models with large firms that simultaneously hire and fire workers⁷ are not suitable for our purpose since they generally assume a trivial production technology with constant marginal productivity of labor that makes the individual wage independent of the firm's decision and consequently remove the strategic interactions from the model. The

See also the footnote 1.

⁶The strategic interaction between the firm's decision on job creation and the wage bargaining process leads firms to post an excessive number of vacancies or equivalently to over hire workers.

⁷See in particular Merz (1999), Krause and Lubick (2007), Krause et al. (2008) and Faia et al. (2010).

only exception is Helpman et al. (2010) who study the consequences of globalization in a model where heterogeneous firms screen workers. They analyze the welfare impact of trade-opening but do not exhibit the regulation that could restore the economic efficiency as we do here. In addition, we depart from several assumptions of Helpman et al. (2010) to develop a model closer than the literature and to focus on labor market imperfections. First, we assume perfect competition on the good market whereas the authors consider imperfection competition. Therefore, the usefulness of regulation in our model results only from the labor market imperfections. Second, we solve a dynamic and not a static labor market search model. Third, we consider idiosyncratic productivity of matches at the origin of job destruction instead of the screening technology introduced by the authors. Four, we model explicitly the utility of unemployed workers, which is normalized to zero in Helpman, Itskhoki, and Redding (2010). This point matters since at the equilibrium, the labor market tightness impacts the wage through the endogenous value of unemployed worker utility.

Our model put together several pieces of the literature on the matching and bargaining models. The process of hiring is modeled as in the standard matching model of the labor market; e.g. Pissarides (2000). Firms post costly vacancies on the labor market and unemployed workers search passively for a job. An aggregate matching function determines the flow of new hires according to the masses of vacancies and unemployed workers. The processes of worker-job matches destruction is taken from den Haan et al. (2000). The productivity of matches is heterogenous due to non persistent idiosyncratic shocks. The distribution of productivity is the same for newly created matches than for existing ones. If the match productivity is too low, the worker is fired by the firm. This corresponds to the endogenous firing of firms. In addition, there is an exogenous firing rate in firms that is independant of the match productivity. This structure of shocks is considered by den Haan et al. (2000) in a model with small firms. We follow Krause and Lubik (2007) who apply the same structure of shocks for large firms, but we depart from these authors by considering a non-constant marginal productivity of labor. The concavity of the production technology gives rise to the intrafirm bargaining issue. The process of bargaining on wages is solved using the solution proposed by Cahuc et al. (2008) for matching and intrafirm bargaining model.

The employment protection legislation is introduced by firing taxes and severance payments, which are included in the definition of the threat points of agents in the bargaining process as in Mortensen and

Pissarides (1999). We depart from the literature on one point: we assume that employment protection is the same for all workers and not only for workers previously employed by the firm. This assumption is necessary to preserve a homogenous production function consistent with the solution of the intrafirm bargaining process developed by Cahuc et al. (2008). Otherwise, it would be necessary to consider two type of labor inputs, which would be paid differently but perfectly substitutable in the production function. Ljungqvist (2002) assumes too that an identical bargaining process for new and old workers and show that it has few impact on the model's predictions, except for the distribution of wages in the economy.

We show that these mechanisms induce inefficient hiring and firing rules in the economy. We use numerical simulations to quantify the effects of intrafirm bargaining. For our benchmark calibration, intrafirm bargaining induces an excess supply of vacancies and a too low quality of matches. This result is in the line of the classical overemployment result of Stole and Zwiebel (1996ab). Cahuc et al. (2008) give the condition under which this result occurs in matching models with exogenous destruction of job-worker matches as the consequence of an excessive supply of vacancies. Our model shows that with endogenous firing, overemployment is also the outcome of an excessive supply of vacancies but it is also induced by a too low firing rate. The problem of the economy is not only the excessive number of filled jobs, it is as well the insufficient quality of jobs selected by firms.

We then investigate the consequences of employment protection through a firing tax and severance payments. We show that there a combination of these two tools that restore the labor market efficiency and conclude that intrafirm bargaining provides a rational for employment protection. This conclusion stands in contrast with Bertola and Caballero (1994) and Koenig and Prat (2007) who both report substantial welfare losses associated with firing costs in labor market search models.

The remainder is as follows. Section 2 presents the model. Section 3 shows the resolution of the intrafirm bargaining process on wage and gives a formal definition of the equilibrium and its normative properties. Section 4 is devoted to the numerical simulations of the model. Section 5 briefly concludes.

2 The Model

2.1 Hiring, Firing, and Production

Firms are composed of an endogenous number of job-worker matches, which are subject to idiosyncratic productivity shocks denoted a . At the beginning of each period, existing matches and newly formed matches draw a value for a from the cumulative distribution function $G(\cdot)$, which density function is denoted $g(\cdot)$. The firm i chooses its reservation value for idiosyncratic productivity \bar{a}_{it} : all matches below this value are destroyed. The endogenous firing rate is $\bar{\rho}_{it} = G(\bar{a}_{it})$ and the total separation rate is

$$\rho_{it} = \rho^* + (1 - \rho^*) G(\bar{a}_{it}) \quad (1)$$

where ρ^* is the exogenous firing rate. The surviving rate to both exogenous and endogenous separation processes is

$$(1 - \rho_{it}) = (1 - \rho^*) (1 - G(\bar{a}_{it})) \quad (2)$$

The aggregate matching function is $m(u_t, v_t) = mu_t^\gamma v_t^{1-\gamma}$ with $v_t = \int_0^1 v_{it} di$ the mass of vacancies posted by all firms, v_{it} the mass of vacancies posted by the firm i , and u_t the mass of unemployed workers. $\theta_t = v_t/u_t$ is the labor market tightness with $q(\theta_t) = m(u_t, v_t)/v_t = m(1/\theta_t, 1)$ the probability a vacancy get filled in next period.

The evolution of intrafirm employment is

$$n_{it+1} = (1 - \rho_{it+1}) (n_{it} + v_{it}q(\theta_t)) \quad (3)$$

where we assume that each firm gets a linear proportion v_{it}/v_t of total matches $m(u_t, v_t)$. Idiosyncratic productivity shocks are the same for newly created jobs ($v_{it}q(\theta_t)$) and for existing jobs (n_{it}), therefore a same portion ρ_{it+1} of jobs is destroyed at the beginning of the period $t + 1$.

Total output of firm i at date t is

$$y_{it} = f(h_{it}) = h_{it}^\alpha \quad (4)$$

with $0 \leq \alpha < 1$ and h_{it} the amount of effective labor input. The effective labor input is equal to

$$h_{it} = h(n_{it}, \bar{a}_{it}) = zn_{it} \int_{\bar{a}_{it}}^{\infty} a \frac{g(a)}{1 - G(\bar{a}_{it})} da \quad (5)$$

with z the productivity of workers common to all firms and n_{it} the level of employment in firm i .

2.2 The firm's program

The firm's problem is to choose its supply of vacancies v_{it} , its reservation value for idiosyncratic productivity \bar{a}_{it} , and its employment level n_{it} to maximise the following discounted sum of profits

$$\max_{v_{it}, \bar{a}_{it}, n_{it+1}} \Pi_{it} = \sum_{k=t}^{\infty} \beta_{k,t} \left\{ \begin{aligned} & \left(z n_{ik} \int_{\bar{a}_{ik}}^{\infty} a \frac{g(a)}{1-G(\bar{a}_{ik})} da \right)^{\alpha} - w_{ik} (n_{ik}, \bar{a}_{ik}, \bar{a}_{ik+1}) n_{ik} - \kappa v_{ik} \\ & - [\rho^* + (1 - \rho^*) G(\bar{a}_{ik})] (n_{ik-1} + v_{ik-1} q(\theta_{k-1})) \tau \end{aligned} \right\} \quad (6)$$

where $\beta_{k,t} = \beta^{(k-t)}$ is the discount factor at date k (the reference date is denoted t). Two costs are taken in consideration. First, recruiting new workers is costly and the per-period of vacancy is κ . Second, there is a cost of separation, τ , which is made from a firing costs τ^f and a severance payments to the workers τ^s : $\tau = \tau^f + \tau^s$. We assume that these costs apply for all matches in the firm: both existing and newly formed.⁸ The average wage bill per employee is a function of the firm's decision on employment and separation: $w_{it} = w_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1})$. As will be shown below, firing costs introduce a intertemporal relation between current wage bargained and futur reservation productivity. The average wage bill per employee, defined by

$$w_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) = \int_{\bar{a}_{it}}^{\infty} \tilde{w}_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a) \frac{g(a)}{1-G(\bar{a}_{it})} da \quad (7)$$

where $\tilde{w}_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a)$ is the individual earning of an employee with productivity a .

The asset value of a match with productivity a for firm i is

$$\begin{aligned} J_{it}(a) &= z a \alpha h (n_{it}, \bar{a}_{it})^{\alpha-1} - \tilde{w}_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a) - w_{it}^1(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) n_{it} \\ &+ \beta \left[(1 - \rho_{it+1}) \int_{\bar{a}_{it+1}}^{\infty} J_{it+1}(a) \frac{g(a)}{1-G(\bar{a}_{it+1})} da - \rho^* \tau_1 - (1 - \rho^*) G(\bar{a}_{it+1}) \tau_2 \right] \end{aligned} \quad (8)$$

this expression is used to solve the Nash bargaining process on wage.

⁸This assumption is restrictive, since these costs are increasing with tenure in most OECD labor markets. However, making the distinction between old and new workers would make the production function non-homogenous and would prevents us to apply the solution of Cahuc et al. (2008) to the intrafirm bargaining process.

2.3 The Nash Bargaining on Wages

To solve the Nash bargaining process on wage, we first define the value of being employed or unemployed for a worker. The asset value of a match for a worker with productivity a is denoted $W_{it}(a)$ and defined by

$$W_{it}(a) = \tilde{w}_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a) + \beta(1 - \rho^*) [1 - G(\bar{a}_{it+1})] \int_{\bar{a}_{it+1}}^{\infty} W_{it+1}(a) \frac{g(a)}{1 - G(\bar{a}_{it+1})} da \quad (9)$$

$$+ \beta \rho_{it+1} U_{t+1} + \beta [\rho^* + (1 - \rho^*) G(\bar{a}_{it+1})] \tau^s$$

where U_t is the expected return of being unemployed defined by

$$U_t = b + \beta \theta_t q(\theta_t) (1 - \rho_{t+1}) \int_{\bar{\mathbf{a}}_{t+1}}^{\infty} W_{t+1}(a) \frac{g(a)}{1 - G(\bar{\mathbf{a}}_{t+1})} da + \beta [1 - \theta_t q(\theta_t) (1 - \rho_{t+1})] U_{t+1} \quad (10)$$

where b measures home production and the variables in bold show the average values of these variables in the economy. The wage solution of the Bargaining program within firm i solves

$$W_{it}(a) - U_t - \tau^s = \frac{\chi}{1 - \chi} (J_{it}(a) + \tau) \quad (11)$$

where χ is the bargaining power for the worker and $(1 - \chi)$ for the firm.

3 Equilibrium

We first exhibit the wage solution of the intrafirm bargaining process and then define the equilibrium.

3.1 The Wage Solution

3.1.1 The resolution of the intrafirm bargaining process

To ease the interpretation of the results, we introduce the following function

$$\mathcal{T}_{it}(\bar{a}_{t+1}) = \beta \chi \theta_t q(\theta_t) [\rho^* + (1 - \rho^*) G(\bar{\mathbf{a}}_{t+1})] (\tau^s + \tau^f) \quad (12)$$

$$- [\rho^* + 2(1 - \rho^*) G(\bar{a}_{it+1}) - \theta_t q(\theta_t) (1 - \rho^*) G(\bar{\mathbf{a}}_{t+1}) - \beta^{-1}] \beta (\tau^s + \chi \tau^f)$$

which is zero in absence of employment protection legislation ($\tau^s = \tau^f = 0$) and depends upon the firm's reservation productivity (\bar{a}_{t+1}) and the aggregate labor market equilibrium ($\bar{\mathbf{a}}_{t+1}, \theta_t$). The solution of the

Nash program (11) is the individual wage function $\tilde{w}_{it}(\cdot)$ that satisfies

$$\tilde{w}_{it}(n_{it}, \bar{a}_{it}, a, \bar{a}_{it+1}) + \chi w_{it}^1(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) n_{it} = (1 - \chi)b + \chi \kappa \theta_t + \mathcal{T}_{it}(\bar{a}_{t+1}) + \chi z a \alpha h(n_{it}, \bar{a}_{it})^{\alpha-1} \quad (13)$$

As it is common in intrafirm bargaining models, there is a partial derivative of the wage function with respect to employment in the equation solution of the bargaining process. However, in our setup the partial derivative is for the average wage $w_{it}(\cdot)$ whereas the solution is for the individual wage $\tilde{w}_{it}(\cdot)$. Therefore, we first to compute the average wage by aggregating the wages defined by the equation (13) using the definition (7) of the average wage. The average wage solution of the Nash program (11) solves the partial derivative equation

$$w_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) = (1 - \chi)b + \chi \kappa \theta_t + \mathcal{T}_{it}(\bar{a}_{t+1}) + \chi \left[\frac{\partial f(h(n_{it}, \bar{a}_{it}))}{\partial n_{it}} - (1 + \tau_w) w_{it}^1(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) n_{it} \right] \quad (14)$$

which solution is

$$w_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) = (1 - \chi)b + \chi \kappa \theta_t + \mathcal{T}_{it}(\bar{a}_{t+1}) + \frac{\alpha \chi}{1 - \chi(1 - \alpha)} \frac{h(n_{it}, \bar{a}_{it})^\alpha}{n_{it}}$$

Using this expression of the average wage gives the following expression for the individual wage solution of the equation (13)

$$\tilde{w}_{it}(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a) = (1 - \chi)b + \chi \kappa \theta_t + \mathcal{T}_{it}(\bar{a}_{t+1}) + \alpha \chi \frac{h(n_{it}, \bar{a}_{it})^\alpha}{n_{it}} \left[\frac{a}{\int_{\bar{a}_{it}}^{\infty} a \frac{g(a)}{1 - G(\bar{a}_{it})} da} - \frac{\chi(\alpha - 1)}{1 - \chi(1 - \chi)} \right] \quad (15)$$

3.1.2 The Impact of Firm's Decisions on Wages

The average wage is impacted by the firm's decisions on hiring and firing through two channels. The first channel is associated with the employment protection legislation and corresponds to the partial derivative of the wage function with respect to \bar{a}_{it+1}

$$w_{it}^3(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}) = \mathcal{T}_{it}^1(\bar{a}_{t+1}) = -2(1 - \rho^*)g(\bar{a}_{it+1})\beta(\tau^s + \chi\tau^f) < 0 \quad (16)$$

an increase in the tomorrow productivity reservation diminishes the wage bargained inside the firm. The productivity reservation determines the probability of firing, that is to pay the firing costs. Since higher expected costs of separation go down the value of the match for the firm, see equation (8), all other things being equal, a lower wage is required to satisfy the bargaining rule (11).

The second channel is associated with the concavity of the production function and corresponds to the partial derivative of the wage functions with respect to \bar{a}_{it} and \bar{n}_{it} . To clarify this mechanism, let us first consider the case of a linear production function ($\alpha = 1$), the marginal productivity of a worker is equal to a and the individual wage \tilde{w}_{it} becomes independent on \bar{a}_{it} and \bar{n}_{it} ; see equation (15). The average wage $w_{it}(\cdot)$ becomes also independent on n_{it} , but still depends on \bar{a}_{it} , which impact the quality of matches selected for production as in Krause and Lubik (2007). Let us now allow for diminishing marginal productivity ($\alpha < 1$)

$$w_t^1(n_t, \bar{a}_t, \bar{a}_{t+1}) = -\frac{\alpha\chi(1-\alpha)}{1-\chi(1-\alpha)} \frac{h(n_t, \bar{a}_t)^\alpha}{n_t^2} < 0 \quad (17)$$

$$w_t^2(n_t, \bar{a}_t, \bar{a}_{t+1}) = \frac{\alpha^2\chi}{1-\chi(1-\alpha)} \frac{g(\bar{a}_t)}{1-G(\bar{a}_t)} \frac{h(n_t, \bar{a}_t)^\alpha}{n_t} \left[1 - \frac{\bar{a}_t}{\int_{\bar{a}_{it}}^{\infty} a \frac{g(a)}{1-G(\bar{a}_{it})} da} \right] > 0 \quad (18)$$

The negative impact of employment on the average wage measured by $w_t^1(n_t, \bar{a}_t, \bar{a}_{t+1})$ corresponds to the classical result of "overemployment" originally described by Stole and Zwiebel (1996ab) and afterward restated in the context of matching frictions by Cahuc et al. (2008) among others. The second relationship between the wage and the productivity separation is specific to our setup of endogenous firing. This property makes our setup different than models with intrafirm and job destruction in the line of Bertola and Caballero (1994). In these models of job destruction, the wage solutions depend only on the firm's level of employment, but not on the firm's productivity threshold under which it destroys jobs or exits from the market.⁹ Our wage equation is also different from Helpman et al. (2010) who solve a static model where the screening ability cutoff decided by the firm determines simultaneously the quality and the number of workers. Therefore, the wage equation has only argument in Helpman et al. (2010), namely the screening ability cutoff. The novelty of our approach is to provide a wage equation solution of the intrafirm bargaining process that depends both on the employment's level of the firm and its firing rate.

⁹Bertola and Caballero (1994) give the explicit expressions for the wage in contracting firms that does not depend only on firm's employment, see equation (19) in their paper, and the wage in expanding firms that depends on the firm's hiring effort, see equation (21) in their paper. For similar wage solutions in models of job destruction see the equation (11) of Bertola and Garibaldi (2001), the equation (10) of Elsby and Michaels (2010), the equation (9) Koeninger and Prat (2007), and the equation (22) of Fujita and Nakajima (2009).

3.1.3 The consequences of intrafirm bargaining

To highlight the consequences of intrafirm bargaining, it is useful to solve the model under a myopic Nash Bargaining where the firm doesn't take into account the consequence of its decisions on bargained wages.

We use the symbol * for these wages. The individual and average wages are

$$\tilde{w}_{it}^*(a) = (1 - \chi) b + \chi \kappa \theta_t + \chi z a \alpha h(n_{it}, \bar{a}_{it})^{\alpha-1} \quad (19)$$

$$w_{it}^*(n_{it}, \bar{a}_{it}) = (1 - \chi) b + \chi \kappa \theta_t + \mathcal{T}_{it}(\bar{a}_{t+1}) + \chi \alpha \frac{h(n_{it}, \bar{a}_{it})^\alpha}{n_{it}} \quad (20)$$

The intrafirm and myopic bargaining outcomes are related as follows

$$w_t^2(n_t, \bar{a}_t, \bar{a}_{t+1}) = \frac{\alpha}{1 - \chi(1 - \alpha)} w_{it}^{*2}(n_{it}, \bar{a}_{it}) \leq w_{it}^{*2}(n_{it}, \bar{a}_{it}) \quad (21)$$

The partial derivatives of the wage function with respect to \bar{a}_t are equal for constant marginal productivity ($\alpha = 1$). For a decreasing marginal productivity of labor ($\alpha < 1$), the positive impact of \bar{a}_{it} on the average wage is smaller with intrafirm bargaining than without. With intrafirm bargaining, the firm takes into account the negative impact of \bar{a}_t on the all the individual wages bargained inside the firm, which is given by

$$\int_{\bar{a}_{it}}^{\infty} \tilde{w}_{it}^2(n_{it}, \bar{a}_{it}, \bar{a}_{it+1}, a) \frac{g(a)}{g(\bar{a}_{it})} da = -\frac{\chi \alpha (1 - \alpha) (1 - \chi) h(n_{it}, \bar{a}_{it})^\alpha}{1 - \chi(1 - \alpha) n_{it}} \left[1 - \frac{\bar{a}_{it}}{\int_{\bar{a}_{it}}^{\infty} a \frac{g(a)}{1 - G(\bar{a}_{it})} da} \right] < 0 \quad (22)$$

using the definition (15) of the individual wage. The increase in the average wage associated with a higher productivity reservation is reduced by this fall in individual wages.

3.2 Efficiency

Definition 1 *The steady-state equilibrium with intrafirm bargaining is defined by (\bar{a}, θ, n) solution of*

$$\frac{\kappa}{q(\theta)} \frac{1}{(1 - \rho^*)(1 - G(\bar{a}))\beta} = \left[\begin{array}{l} OE \cdot \alpha (1 - \chi) \left(z n(\theta, \bar{a}) \int_{\bar{a}}^{\infty} a \frac{g(a)}{1 - G(\bar{a}_{it})} da \right)^\alpha \frac{1}{n(\theta, \bar{a})} \\ - (1 - \chi) b - \chi \kappa \theta - \mathcal{T}(\theta, \bar{a}) + \frac{\kappa}{q(\theta)} - \frac{\rho^* + (1 - \rho^*)G(\bar{a})}{(1 - \rho^*)(1 - G(\bar{a}))} (\tau^s + \tau^f) \end{array} \right] \quad (H)$$

and

$$\begin{aligned}
& \beta \left[\begin{aligned} & OE \cdot \alpha (1 - \chi) \left(zn(\theta, \bar{a}) \int_{\bar{a}}^{\infty} a \frac{g(a)}{1-G(\bar{a}_t)} da \right)^\alpha \frac{1}{n(\theta, \bar{a})} \\ & - (1 - \chi) b - \chi \kappa \theta - \mathcal{T}(\theta, \bar{a}) + \frac{\kappa}{q(\theta)} + \tau^s + \tau^f \end{aligned} \right] \tag{F} \\
= & \left[\int_{\bar{a}}^{\infty} a \frac{g(a)}{1-G(\bar{a})} da - \bar{a} \right] \left(zn(\theta, \bar{a}) \int_{\bar{a}}^{\infty} a \frac{g(a)}{1-G(\bar{a})} da \right)^{\alpha-1} OE \cdot \beta z \alpha (1 - \chi) \\
& + \beta (1 - \rho^*) [1 - G(\bar{a})] \left[(1 - \chi) \tau^s + \chi (\tau^s + \tau^f) + \tau^s + \chi \tau^f \right]
\end{aligned}$$

where the term OE is

$$OE = \frac{1}{1 - \chi (1 - \alpha)} \tag{OE}$$

and the functions $\mathcal{T}(\theta, \bar{a})$ and $n(\theta, \bar{a})$ are given by

$$\begin{aligned}
\mathcal{T}(\theta, \bar{a}) &= \beta \chi \theta q(\theta) [\rho^* + (1 - \rho^*) G(\bar{a})] (\tau^s + \tau^f) \tag{T} \\
&- [\rho^* + 2(1 - \rho^*) G(\bar{a}) - \theta q(\theta) (1 - \rho^*) G(\bar{a}) - \beta^{-1}] \beta (\tau^s + \chi \tau^f)
\end{aligned}$$

and

$$n(\theta, \bar{a}) = \left[\frac{1 - (1 - \rho^*) (1 - G(\bar{a}))}{(1 - \rho^*) (1 - G(\bar{a}))} \frac{1}{\theta q(\theta)} + 1 \right]^{-1} \tag{n}$$

We define two equilibria with or without the mechanism of intrafirm bargaining. In the model without intrafirm bargaining, the firm doesn't internalize the impact of its hiring and firing decisions on wages bargained with its employees.

Proposition 1 *Under the Hosios's condition and without employment protection, the steady-state equilibrium without intrafirm bargaining is efficient contrary to the steady-state equilibrium with intrafirm bargaining.*

Proof. *The steady-state equilibrium solution of the social planner's problem is defined by (\bar{a}, θ, n) solution of (H), (F), and (n) for $OE = 1$, $\tau^s = \tau^f = 0$ and $\chi = \varepsilon_m^u$, where ε_m^u the elasticity of the matching function with respect to the mass of unemployed workers. This steady-state equilibrium is the outcome of the competitive economy when the Hosios condition holds ($\chi = \varepsilon_m^u$) and without intrafirm bargaining, that is when wages are bargaining independently on firm's decisions on hiring and firing. ■*

Without intrafirm bargaining, the single distortion of the economy (namely the trading externality associated with matching function) is efficiently internalized in the labor contract if the bargaining power of agents correspond to their contribution to the trading activities; see Hosios (1990) and Pissarides (2000). Intrafirm bargaining prevents the labor contract to internalize this externality since it is manipulated by firms to increase profits; see Stole and Zwiebel (1996ab). To explain the underlying mechanisms, let us consider the case of no employment protection: $\tau^s = \tau^f = 0$.

Intrafirm bargaining creates a distortion in the economy because it shifts the valuation of marginal workers by firms, which take into account the impact of the marginal worker on all the bargained wages with its employees. Without intrafirm bargaining the firm takes into account the fraction $(1 - \chi)$ of the marginal productivity of labor against $OE \cdot (1 - \chi)$ with intrafirm. The term OE corresponds to the inefficiency induced by intrafirm bargaining. It appears in the hiring equation as in existing models of matching and intrafirm bargaining models with exogenous separation; e.g. Cahuc et al. (2008). The term OE in (H) means that firms give a higher value to the marginal hired worker with intrafirm bargaining. Therefore, they are motivated to post more vacancies than without intrafirm bargaining. The originality of our model is to show that this term appears too in the firing equation (F) . In this equation OE appears both at the LHS and RHS terms. The LHS term is the expected value of the match and measures the marginal cost of firing that is increasing the productivity reservation. The RHS term is the variation of the current firm's wealth associated with an increase in the productivity reservation through its impact on average productivity and wage in the firms. On the one hand, intrafirm bargaining increases the value of the marginal worker for the firm (motivating the firm to keep low productive workers) and on the other hand intrafirm bargaining increases the payoff of firing since it leads to revise downward the increase in average wage associated with a higher firing rate (motivating the firm to fire low productive workers). To assess the consequences of intrafirm bargaining on the labor market, we use numerical simulation to quantify these opposite effects.

4 Numerical Simulations

To study the normative properties of our setup, we now turn to numerical simulations.

4.1 Calibration

As a benchmark, we choose the model with intrafirm bargaining and without firing costs. According to Koeninger and Prat (2007), this assumption is quite feasible for the US economy where lay-off costs are close to zero compared to continental Europe. The model period is one quarter. We set the discount factor $\beta = 0.99$, making the annual interest rate close to 4%. Labor income share is set to its standard value, $\alpha = 0.6$. Without any loss of generality, z is set to 1. For the other calibration constraints, we follow den Haan et al. (2000). We choose an overall separation rate $\rho = 0.1$ and set the exogenous job destruction rate $\rho^* = 0.068$. Hence, the endogenous separation rate is $G(\bar{a}) = (\rho - \rho^*) / (1 - \rho^*) = 0.034$. As in den Haan et al. (2000), the average matching rate q is set to 0.7. The unemployment rate $u = 1 - n$ is set to 0.12. This rate is higher than its official US empirical counterpart, since it also includes out-of-the-labor-force workers still looking for a job (see Cole & Rogerson, 1999). To ensure optimality of the no intrafirm setup, we suppose that workers and firms share of the bargaining surplus are similar and equal to $1/2$, $\chi = \gamma = 0.5$. Finally, we assume that idiosyncratic productivity \bar{a} is iid lognormally distributed, with mean $E[\ln(a)] = 0$ and standard error $\sigma_a = 0.1$.

Table 1 gives the values of parameters and steady-state interest variables of the intrafirm bargaining model deduced from the calibration procedure. As previously explained, in the intrafirm bargaining model, we set firing taxes and severance payments to zero (i.e. $\tau^f = \tau^s = 0$). The labor market tightness θ is derived from the dynamic equation for the employment rate. The endogenous separation rate directly gives \bar{a} . Finally, the values of κ , real cost per vacancy, and b , home production utility flow, are respectively deduced from the hiring and firing equations. The optimal values of interest variables (here noted θ^* , \bar{a}^* and n^*) are deduced from the no-intrafirm model; equations (H) and (F) for $OE = 1$, $\tau^s = \tau^f = 0$ and $\chi = \varepsilon_m^u$. Proposition 1 ensures the optimality of this setup.

4.2 Comparison of the Intrafirm and Optimal Equilibria

Figure 1 provides a steady-state comparison of the hiring (H) and firing (F) curves in the intrafirm and optimal models. For both models, the hiring locus is decreasing and the firing locus is decreasing as in

Mortensen and Pissarides (1994) where the Job Destruction locus stands for the firing one and the Job Creation locus for the hiring one. This pattern of locus ensures the uniqueness of the equilibria for both models. As can be seen, the labor market tightness is higher in the suboptimal intrafirm setup due to an upward positioning of both hiring and firing curves. Simultaneously, the reservation productivity is lower in the intrafirm case. Consequently, the overall impact of intrafirm negotiation on the employment rate (see Table 1) is positive due to a joint overposting of vacancies and too low firing rate. This "overemployment" result is in line with the standard intrafirm literature, considering exogenous job destruction, but is worsened due to a low quality of jobs selected by firms.

To decompose the effects of intrafirm bargaining, let us first start at the optimal equilibrium (marked by the square symbol in Figure 1). The intrafirm hiring locus is always above the optimal hiring locus. The gap between the two hiring curves is due to the "standard" intrafirm effect: the internalization of firm size n in individual wages bargaining. Intrafirm bargaining induces the presence of the term $w^1(\cdot)$ in the RHS of equation (14) that pushes the hiring curve upward. This can be easily interpreted: for a given value of the reservation productivity \bar{a} , the average wage is lower because of the intrafirm effect: this explains the OE term in the first part of the bracket in the RHS of equation (H). Consequently, the probability a vacancy is filled drops, since jobs are more attractive for firms, which means a higher labor market tightness.

The analysis of the impact of intrafirm effects on the firing curve is more complex since the interaction of intrafirm negotiation and endogenous destruction adds a new term: the standard intrafirm (linked to firm size n) is still present in the LHS of equation (F), however the $w_t^2(n_t, \bar{a}_t, \bar{a}_{t+1})$ in the RHS of the (F) equation now encompasses the intrafirm specific effect presented in equation (22), which is null in the no-intrafirm case. In the intrafirm case, the impact of \bar{a} on each individually negotiated wage is also taken into account and reduce the average wage for a given firm size n and reservation productivity \bar{a} compared to the optimal case as explained above. Hence, this term mitigates the otherwise positive impact of \bar{a} on the average wage $w_t^2(n_t, \bar{a}_t, \bar{a}_{t+1})$. This should then conduct to push the firing curve downward (higher firing rate \bar{a} for a given value of θ). However this effect is dampened by a stronger one in our numerical experiments: the total reduction of the average wage in the intrafirm case. The standard intrafirm effect $w_t^1(n_t, \bar{a}_t, \bar{a}_{t+1})$ lowers the average wage and then increases the value of a supplementary job. Firms prefer

to keep workers of low productivity, since they contribute to the firm's size and consequently to the wage reduction through the intrafirm mechanism. Overall, intrafirm bargaining pushes upward the firing locus which explains the overall negative impact of intrafirm bargaining on the reservation productivity \bar{a} and gives rise to overemployment.

Before investigating the usefulness of employment protection, we first check that the labor contract can not solve the efficiency issue implied by intrafirm bargaining. Figure 2 reports the deviation between intrafirm and optimal equilibria for a wide range of values for χ , the bargaining power of workers. There is clearly no value for χ that ensures the labor market efficiency. While a low value of χ brings the productivity reservation to its optimal value, a high value is required for the labor market tightness. Besides, none of these case leads to efficient employment that is always above its optimal value.

4.3 The Consequences of Employment Protection

We now allow firing taxes τ^f and severance payments τ^s to be strictly positive. We first run a simple numerical optimization experiment: we estimate the numerical values of τ^f and τ^s that counterbalance the intrafirm effect, that is cancel the single distortion between the intrafirm bargaining and the optimal models. This amounts to solve a two-equations non-linear system defined by equations (H) and (F). We find evidence that this system has a solution for large set of parameters values and, in particular, we find that $\tau^s = 0.0647$ and $\tau^f = 0.0407$ delivers the optimum with the benchmark calibration detailed in Table 1. This result suggests that intrafirm bargaining provides a rationale for employment protection in an endogenous destruction context.

Figures 3, 4 and 5 provide simulations of the equilibrium values of \bar{a} , θ and n for different value ranges of the firing taxes τ^f and severance payments τ^s . First, it is crucial to note that for low values of firing costs (i.e. τ^f close to zero), \bar{a} is growing with τ^s . The reverse is also true (\bar{a} grows with τ^f when τ^s is zero). This unexpected result is linked to the $(\tau^s + \tau^f)$ term in the RHS of equation (F): an increase in \bar{a} immediately raises taxes bills, but also dampens the standard intrafirm effect on w^1 . As we said earlier, the latter effect overwhelms the former one for plausible calibrations. Differently said, an increase in \bar{a}

raises firing taxes and severance payments per employee $(1 - \rho^*) G(\bar{a}) (\tau^s + \tau^f)$, but reduces the total bill $(1 - \rho^*) G(\bar{a}) (n + vq(\theta)) (\tau^s + \tau^f)$ due to the huge reaction of n . This explains that \bar{a} paradoxically grows with τ^s (resp. τ^f), when τ^f (resp. τ^s) is null.

When both τ^s and τ^f are strictly positive, their impact on reservation productivity is no longer monotone. As shown in Figure 2, for large values of the firing costs, the long run equilibrium value of the reservation productivity declines with severance payments. This result is linked to the internalization of future firing rate in the JD destruction (i.e. the $\mathcal{T}_{it}(\bar{a}_{t+1})$ term in equation 16). This effect is null in the tax free case, but creates a further source of distortion between the intrafirm model and the optimal one for positive tax values and depends in a non-monotone way on the pair (τ^f, τ^s) .

As evidenced by Figure (3), θ is monotonically decreasing with both τ^f and τ^s . This result was to be expected since both τ^f and τ^s dampen the distortion in equation (H) induced by the standard intrafirm effect. Consequently the employment rate is also decreasing in both taxes (see Figure 4). Notice the joint homogenous response of θ and differentiated response of \bar{a} is a key point to reach the optimum with only a couple of taxes as instrument. τ^f or τ^s considered separately cannot permit to recover the optimal case.

5 Conclusion

We develop a matching and intrafirm bargaining model of the labor market to study the efficiency of hiring and firing by large firms. The novelty of our approach is to consider firms that simultaneously hire and fire workers as suggested by numerous empirical studies. This approach gives rise to specific interactions between the wage bargaining process and the decision on firing. We exhibit a negative impact on bargained wages of the productivity threshold under which workers are fired and show how this impact is included in the firm's choice of this threshold. Because of these interactions, the equilibrium is inefficient. We use numerical simulations to assess the usefulness of the employment legislation protection and show that a combination of positive severance payments and firing taxes can restore the labor market efficiency.

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7 Table and Figures

Table 1: Calibration and steady-state equilibria

Parameters	$\beta = 0.99, \chi = 0.5, \alpha = 0.6, \gamma = 0.5, \sigma_0 = 0.1$ $\rho^* = 0.068, \bar{m} = 0.75, \kappa = 0.04, b = 0.72$
Equilibrium with intrafirm bargaining	$\theta = 1.164, \bar{a} = 0.834, n = 0.88$
Optimum values	$\theta^* = 0.334, \bar{a}^* = 0.915, n^* = 0.57$

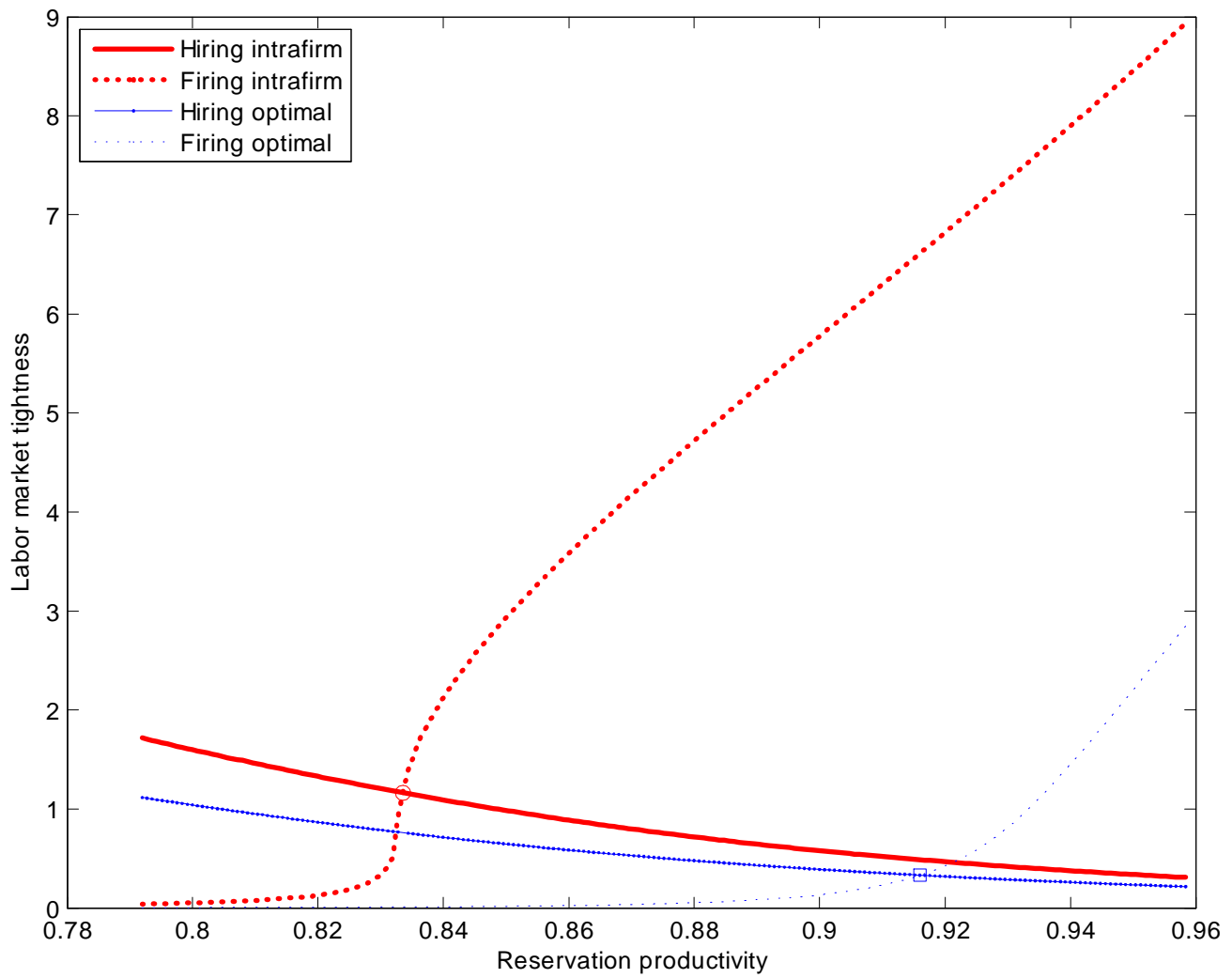


Figure 1: Hiring and firing curves for the intrafirm and optimal models.

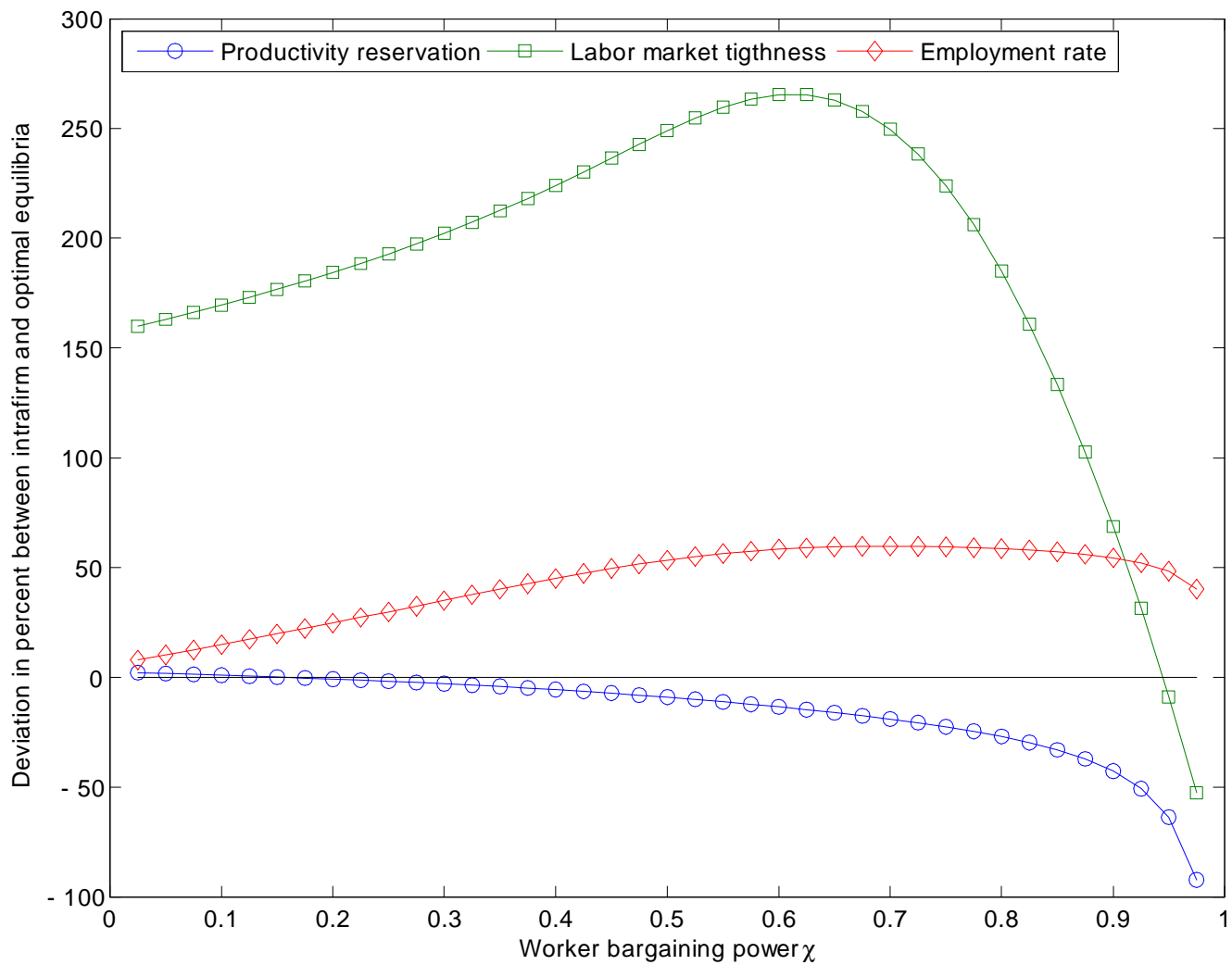


Figure 2: Deviation in percent of endogenous variables between the intrafirm and optimal equilibria for various values of χ the bargaining power of workers.

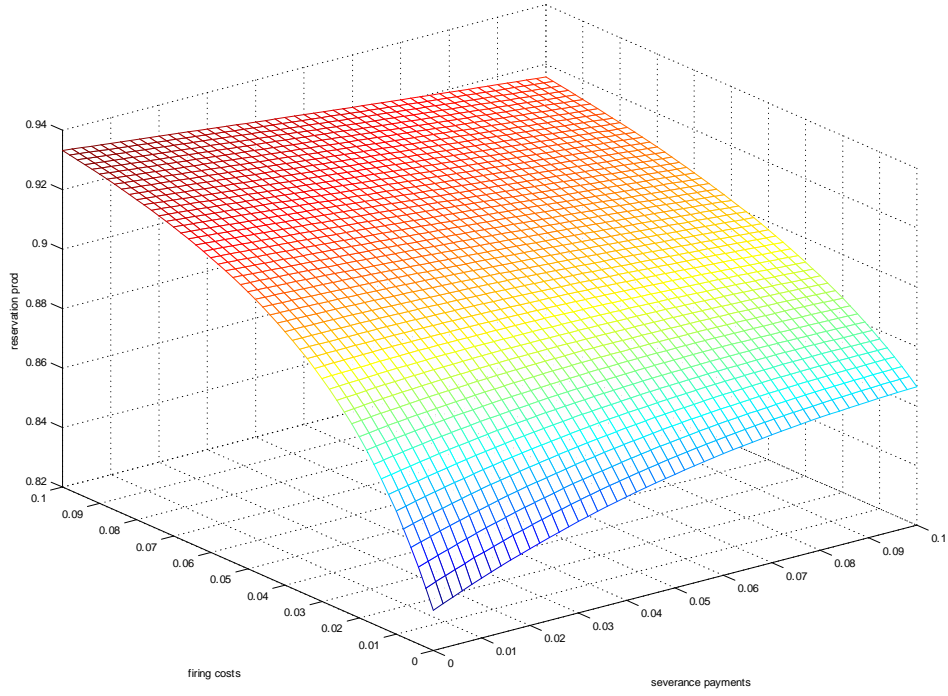


Figure 3: Impact of τ^s and τ^f on the reservation productivity \bar{a}

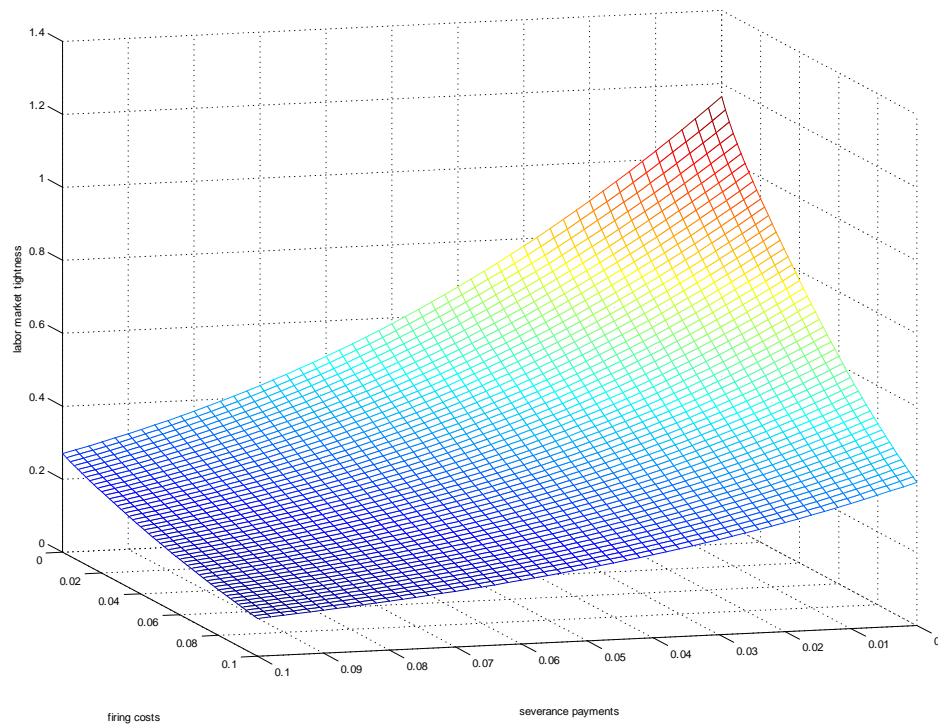


Figure 4: Impact of τ^s and τ^f on the labor market tightness θ .

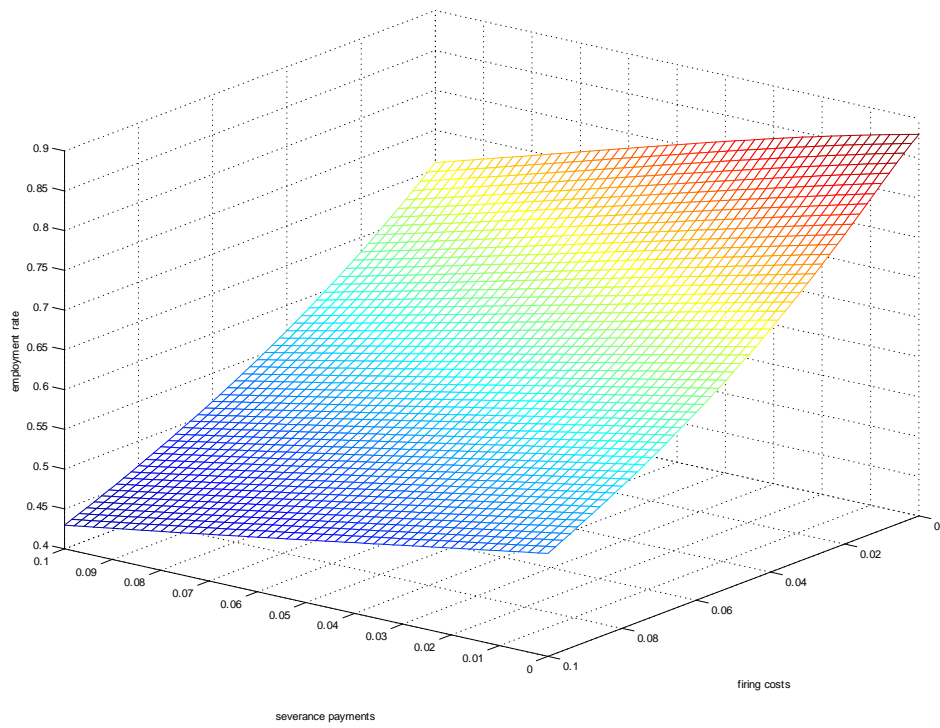


Figure 5: Impact of τ^s and τ^f on the employment rate n .