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**Labor Market Reforms, Job Instability, and the Flexibility  
of the Employment Relationship**

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Frédéric Robert-Nicoud**

## **Abstract**

We endogenize separation in a search model of the labor market and allow for bargaining over the continuation of employment relationships following productivity shocks to take place under asymmetric information. In such a setting separation may occur even if continuation of the employment relationship is privately efficient for workers and firms. We show that reductions in the cost of separation, owing for example to a reduction in firing taxes, lead to an increase in job instability and, when separation costs are initially high, may be welfare decreasing for workers and firms. We furthermore show that, in response to an exogenous reduction in firing taxes, workers and firms may switch from rigid to flexible employment contracts, which further amplifies the increase in job instability caused by policy reform.

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# 1 Introduction

Bargaining between firms and workers often takes place in the presence of private information. As an example, consider a firm that has the opportunity to adopt a new production technology that is effective only if the firm's workers invest in learning how to use it. The firm is likely to be only incompletely informed about the workers' costs of making the investment and the workers are likely to be only incompletely informed about the firm's benefits of adopting the new technology. The presence of this private information will hamper the negotiations over the continuation of the employment relationship and may possibly lead to the firm and the worker separating. In this paper we analyze the functioning of decentralized labor markets under circumstances like these. To this end we endogenize separation in a search model of the labor market and allow for negotiations over separations to take place under private information.

In most existing search models, bargaining between firms and workers takes place under complete information (see e.g. Pissarides 2000). An important implication of this assumption is that bargaining is efficient, in that firms and workers instantaneously agree to form, or continue, employment relationships if there are gains from trade and they instantaneously agree to separate if there are none. In contrast, as a well-established literature has shown, if bargaining takes place under asymmetric information the parties may fail to realize all gains from trade (see Myerson and Satterthwaite 1983, Hall and Lazear 1984, and Hall 1995).<sup>1</sup> Our paper combines the insights of these two literatures. We present a dynamic random matching model in which firms post vacancies and workers search for jobs. We assume that job creation takes place under complete information (like in Pissarides, 2000) but job destruction may be caused by private information. In

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<sup>1</sup>There is also a large experimental literature that supports the view that agents often fail to reach efficient agreements (see Kagel and Roth 1997).

particular, we assume that during the course of their relationship a firm and a worker may experience productivity shocks and that the cost of the adjustments necessary to cope with these shocks is private information. As a consequence, wage renegotiation following productivity shocks may be inefficient and the firm and worker may separate failing to realize gains from trade (like in Myerson and Satterthwaite, 1983). Our analysis of this model provides three main insights.

First, we show that in a labor market in which workers and firms bargain under asymmetric information, a reduction in the cost of separation (e.g. a firing tax) leads to an increase in job instability, i.e. in the probability that workers and firms separate following productivity shocks. The reason for this is that a reduction in separation costs increases the joint value of the workers and the firms' outside options and thus induces them to bargain more aggressively. This, in turn, makes it more likely that firms and workers will separate following productivity shocks and thus makes employment relationships more unstable. In this regard it is important to note that, contrary to what would happen in a model in which workers and firms bargain under complete information, in our model workers and firms may sometimes separate even when it would be efficient for them not to do so, i.e. even when their joint expected utility from continuing the employment relationship is greater than their joint expected utility from separating and returning to the labor market.

Second, we show that, because separations can be privately inefficient, a reduction in the cost of separation can make some groups in society – and possibly society as a whole – worse off by increasing the probability of separation. To see this, consider the effect of a reduction in the firing tax that has to be paid whenever a firm and a worker separate. On the one hand, such a reduction has a direct positive effect on the worker and the firm's expected welfare, because it lowers separation costs when the

productivity shock is so large that separation is actually privately efficient. On the other hand, however, precisely because it becomes less costly to separate, the reduction in the firing tax induces the workers and firms to bargain more aggressively and increases the probability of privately inefficient separation. This negative effect can dominate the direct benefit of a reduction in firing taxes, with the possible consequence that firms and workers can be actually made worse off by a reduction in these taxes. Our analysis allows us to derive precise, and potentially testable, predictions about the conditions under which different groups in society are made worse off by a labor market reform. In this respect, our analysis contributes to the literature that seeks to explain why reforms that reduce labor market frictions have often faced substantial political opposition in spite of their strong support by institutions such as the OECD and the IMF (see, for instance, Saint-Paul 2000 and Pissarides 2001).

Third, our analysis contributes to our understanding of contractual arrangements between firms and workers and of the effects of changes in the labor market environment on these arrangements. In Section 5 of the paper we endogenize contractual arrangements between firms and workers and study the effects of changes in the labor market environment on these arrangements. Specifically, firms and workers often use employment contracts that make it *more* costly for them to separate in the future. For instance, since the mid-1980s firms in Europe have been able to choose between hiring workers on ‘rigid’ permanent contracts for which separation costs are significant or on ‘flexible’ fixed-term contracts for which they are negligible.<sup>2</sup> We provide a novel explanation for why firms and workers may agree to adopt rigid employment contracts that increase future separation costs. In particular, we show that firms and workers that anticipate

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<sup>2</sup>The ‘difficulty of dismissal’ is one of three kinds of employment protection listed by the OECD that increases firing costs but does not involve any transfer from the employer to the employee (see also Footnote 9 below).

future bargaining inefficiencies can use these contracts as a means of committing to less aggressive bargaining behavior and thus ‘stabilize’ their employment relationship. Our model shows that whether or not firms and workers want to use such contracts for this purpose depends crucially on the labor market environment and the workers’ productivity. In particular, it shows that a sufficiently large reduction in exogenously imposed separation costs, such as a reduction in firing taxes, leads to a one-off switch from rigid to flexible employment contracts. This endogenous contractual response to exogenous labor policy changes induces firms and workers to bargain even more aggressively and thus further destabilizes employment relationships.

The rest of the paper is organized as follows. In the next section we discuss the related literature. In Section 3 we present the structure of the model. In Section 4 we solve the model, taking as given the contractually specified separation costs and discuss the effects of a reduction in firing taxes. We then endogenize the contractually specified separation costs in Section 5, check for the robustness of our results in Section 6 and finally conclude in Section 7. All proofs are in the Appendix.

## **2 Related Literature**

Our paper is related to a number of contributions that have identified different mechanisms through which a reduction in market frictions can be welfare reducing. For instance, Kranton (1996) and McLaren and Newman (2002) analyze models in which a reduction in market frictions, by increasing the outside options of agents in a repeated game setting, can hamper cooperation and potentially reduce welfare, whilst Ramey and Watson (2001) consider the adverse effects that reductions in market frictions may have on the investment incentives of agents. A number of papers have identified reasons why market frictions in the form of employment protections can be welfare enhancing.

For instance, Saint Paul (1995, 1996) and Fella (2000) have shown that, when firms rely on efficiency wages to motivate workers, severance payments can mitigate the tendency of the firms to fire workers ‘too often’ and, through this channel, increase welfare. Pissarides (2001) shows that different kinds of employment protection can serve as insurance devices when workers are risk averse and Alvarez and Veracierto (2001) show that severance payments can increase welfare by providing insurance and reducing firings.<sup>3</sup> Our paper is related to these contributions since we show that one consequence of inefficient bargaining between firms and workers is that an increase in separation costs can be welfare enhancing.

While the papers discussed above show that severance payments can be welfare enhancing, less work has been done on whether such payments should be imposed by the government rather than left to private contracts. This issue is, however, addressed by Schmitz (2004) who provides a model of employment relationships with asymmetric information and shows that firms and workers may be better off when the government imposes employment protections than when these protections are stipulated privately by the parties. Although the focus of our paper is different, we also allow for the possibility of private contracting over employment protection.<sup>4</sup>

Bargaining under asymmetric information has been analyzed by a large and well-established literature (see Ausubel, Cramton and Deneckere 2002 for an overview). In a seminal contribution, Myerson and Satterthwaite (1983) analyze bilateral bargaining between two agents with private and independent valuations. They show that if trade is not always efficient and the agents can opt out of the bargaining game after having

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<sup>3</sup>A related literature studies the introduction of fixed-term contracts. See Güell (2005) and Alonso-Borrego, Fernandez-Villaverde and Galdon-Sanchez (2004) and the references therein.

<sup>4</sup>Burguet, Caminal and Matutes (2002) consider private contracting over employment protections (buy-out fees and severance payments) when the incumbent employer has more information about an employee than the labor market has.

learned their valuations, bargaining is necessarily inefficient, that is, the agents will sometimes fail to realize strictly positive gains from trade. They also characterize the second best trading mechanism.<sup>5</sup> Most of the literature on bilateral bargaining under private information assumes that agents are risk neutral and we follow the literature in this respect. An exception is Copic and Ponsati (2006) who consider a setting similar to that adopted by Myerson and Satterthwaite (1983) and allow for risk aversion by the traders. They characterize the optimal mechanism under ex post individual rationality and ex post incentive compatibility. It would be interesting to allow for risk aversion by the workers in a setting such as ours but we do not address this issue in this paper.

Several recent papers study the consequences of asymmetric information in models of competitive search (Shimer and Wright 2004, Faig and Jerez 2005, Moen and Rosen 2007). In this literature the closest complementary paper to ours is Guerrieri (2007), who analyzes a competitive search model in which workers are privately informed about their disutility of labor and shows that, in a dynamic version of the model, the equilibrium can be constrained inefficient. Her paper and ours are related since in both papers the workers' endogenous outside options determine their participation constraints and, through this channel, the cost of information revelation. However, whilst Guerrieri focuses on the constrained efficiency of a competitive search equilibrium, we focus on the consequences of inefficient bargaining for job instability and the types of labor contracts adopted in equilibrium.

Finally, our paper is related to Matouschek and Ramezzana (2007) who develop a model of a matching market in which buyers and sellers can adopt exclusive contracts to reduce future bargaining inefficiencies. Although their paper also studies bargaining inefficiencies in a matching market, it focuses on the search externalities imposed by a

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<sup>5</sup>Williams (1999) extends the results in Myerson and Satterthwaite (1983) to a multilateral setting.



buyer-seller pair on other buyers and sellers when they adopt exclusive contracts rather than on the effects of policy reform and contractual choices on the instability of trade relationships over time like the present paper.

### 3 The Model

We consider a dynamic market in which time is discrete and runs indefinitely. All agents are risk-neutral and discount the future at rate  $r$ .

There are two types of agents: ‘workers’ and ‘firms.’ At the beginning of every period an exogenous and equal number  $n$  of new workers and new firms enter the market. Every worker enters the market as unemployed and searches for a job, while every firm enters the market with an open vacancy and searches for an employee. In every period in which a worker is unemployed he receives utility  $b$  and in every period in which a firm has an open vacancy it incurs costs  $c$ . Unemployed workers and firms with open vacancies can decide to leave the market permanently at any point in time and obtain utility equal to zero for ever. If they instead decide to stay in the market, they are brought together by a random matching process, that we describe further below. If, after having met, a firm and a worker decide to start an employment relationship then, in every subsequent period in which they are still together, the firm produces one unit of a good worth  $p$  and the worker experiences a disutility that, without loss of generality, is set equal to zero. The worker’s disutility and the firm’s marginal product  $p$  are common knowledge and the marginal product is sufficiently large to ensure that all employment relationships are initially formed. The firm and the worker bargain over the wage at the beginning of their employment relationship and renegotiate it in every period until they separate. We assume that when wages are negotiated the firm and the worker each make a take-it-or-leave-it offer with probability  $1/2$ . If the offer is accepted, production takes place,

wages are paid and time moves on to the next period. If the offer is rejected, the worker becomes unemployed and receives  $b$ , the firm reopens the vacancy and incurs costs  $c$  and time moves on to the next period. Employment relationships are subject to random shocks that cause the worker and the firm to renegotiate compensation under private information, as described further below. Furthermore, at the end of every period a worker (regardless of whether he is employed or not) dies or a position (regardless of whether it is filled or not) is destroyed with exogenous probability  $d$ . In order to preserve symmetry, we also assume that if a worker dies while being employed the position that he occupies is also destroyed and, analogously, that if the position who is destroyed is filled, the worker who occupies it must also leave the market. This implies that the effective discount rate faced by workers and firms is given by  $\delta \equiv (1 - d)/(1 + r)$ .

Vacancies and unemployed workers are brought together by a random matching process. In particular, at the beginning of every period the total number of contacts is given by the matching function  $M = am(u, v) \leq \min\{u, v\}$ , where  $u$  and  $v$  denote the number of unemployed workers and of open vacancies, respectively. We assume that this function is increasing, continuous, and homogeneous of degree one in both arguments; we also normalize  $m(1, 1)$  to unity. Since unemployed workers and open vacancies enter the market in equal numbers and they only leave the market in pairs, we have that  $u = v$  and thus that  $M/u = M/v = a$ . In other words, unemployed workers and firms with open vacancies find a counterpart with the same exogenously given probability  $a$ . The parameter  $a$ , therefore, captures the efficiency (or Total Factor Productivity) of the matching process.

The focus of our analysis is on job destruction, which we describe next. At the beginning of every period existing employment relationships are hit by a shock with probability  $\lambda$ . To avoid having to discuss uninteresting cases, we assume that the shock

does not hit very often, in the sense that  $\lambda < (1 - \delta)/(2\delta)$ . When an employment relationship is hit by a shock, the firm and the worker need to decide between making a costly adjustment and continuing their relationship or separating. The type of adjustment that we have in mind is, for instance, a fundamental change in production technology or a reorganization of the firm. If the adjustment is made, the worker experiences a one-off disutility  $\gamma$  and the firm realizes a, potentially negative, one-off benefit  $\rho$ . After  $\gamma$  and  $\rho$  have been incurred, the firm and the worker can continue their employment relationship as described above, i.e. they can produce one unit of a good worth  $p$ , after which time moves on to the next period. If the adjustment is not made, the worker-firm pair becomes unproductive and separates. The worker's disutility,  $\gamma$ , is drawn from a distribution with cumulative function  $G(\gamma)$  and density function  $g(\gamma)$  on some compact support  $\Gamma$ . We denote the inverse of the hazard rate of this distribution by  $H(\gamma) \equiv G(\gamma)/g(\gamma)$  and assume that it is monotonically increasing. Analogously, the firm's realization of  $\rho$  is drawn from a distribution with cumulative function  $F(\rho)$  and density function  $f(\rho)$  on some compact support  $P$ . We denote the inverse of the hazard rate of this distribution by  $K(\rho) \equiv [1 - F(\rho)]/f(\rho)$  and assume that it is monotonically decreasing.<sup>6</sup> Our key assumption is that, although the distributions  $F(\rho)$  and  $G(\gamma)$  are common knowledge, the realizations  $\rho$  and  $\gamma$  are privately observed by the firm and the worker, respectively. Bargaining over the amount that the firm should pay the worker for the adjustment is therefore hindered by the presence of private information. To be consistent with the wage bargaining process in the absence of shocks, we assume that when a shock occurs the firm and the worker can each make a take-it-or-leave-it offer with probability 1/2. If this offer is accepted, the worker and the firm continue their

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<sup>6</sup>The monotone hazard rate conditions imposed on  $H(\cdot)$  and  $K(\cdot)$  are satisfied by many common distributions.

employment relationship and if it is rejected they separate and return to the search pool. We also assume that the  $\gamma$ 's and the  $\rho$ 's are uncorrelated between them and over time. Finally, we assume that  $\Gamma$  and  $P$  are such that for some realizations of  $\gamma$  and  $\rho$  it is efficient for the firm and the worker to make the adjustment while for other realizations it is not.<sup>7</sup> The timing of the bargaining game is summarized in Figure 1.

Whenever a firm and worker who are currently in an employment relationship separate, the firm must bear two types of costs: a firing tax  $\phi$ , which is fixed exogenously by the government, and, possibly, a self-imposed cost  $R \in [0, \bar{R}]$  to which the firm and the worker commit at the beginning of their employment relationship.<sup>8</sup> The upper limit  $\bar{R}$  is exogenously given. Note that  $R$  is not a transfer from the firm to the worker, but a pure cost that detracts from their joint surplus, e.g. costly legal or administrative procedures, an amount paid to an escrow fund, a net loss on retirement income, or investments that are partly specific to the firm worker pair and cannot be fully recovered by either party.<sup>9</sup> As we shall discuss in Section 5, in a world with complete information agents would always set  $R = 0$  but this is no longer the case under private information.

Having outlined the structure of the model, it is worth briefly discussing the reasons for and the implications of two of our simplifying assumptions. First, we rule out free entry by firms and focus on a simple model with an exogenous inflow of firms which is equal to the inflow of workers. This has the advantage of simplifying the analysis, since

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<sup>7</sup>We are ruling out the uninteresting cases in which it is always efficient to make the adjustment and in which it is never efficient to do so.

<sup>8</sup>The results that we derive in this paper would not change if the extra cost  $R$  were incurred not only by the firm but also by the worker.

<sup>9</sup>Pissarides (2001, page 136) discusses the five kinds of employment protection listed by the OECD and argues that three of them (administrative procedures, difficulty of dismissal and additional measures for collective dismissals) “appear to be mainly ways of making it difficult for the employer to dismiss a worker without any apparent immediate financial gain to the employee.” Saint Paul (1995, page 49) argues that firms can use a technology with costly training and specific investment in human capital to make it more costly for themselves to fire workers in the future. Fella (2000) also allows for the possibility that the severance payment that a worker receives is less than the amount paid by the firm.

the market tightness ratio of vacancies to unemployed workers is always unity. It can be shown, however, that our main results would continue to hold in a version of the model with free entry, as discussed in Section 4.5. Second, for most of the paper we assume that workers and firms use a given, simple bargaining game in their negotiations following a shock. A possible concern with this approach is, however, that our results may depend on this particular bargaining game, especially in light of the fact that this is not the most efficient bargaining game that the parties could adopt.<sup>10</sup> To address this concern, in Section 6 we assume that firms and workers adopt the most efficient bargaining game and show that our qualitative results are unaffected by the adoption of this more general framework.

## 4 Equilibrium without Self-imposed Rigidities

In this section we study the equilibrium of our model in the case in which the firm and the worker cannot contract over self-imposed rigidities. Thus, for the time being,  $R$  is taken as an exogenous parameter. We solve the model in Sections 4.1-4.3 and analyze the effect of a fall in the firing tax in Section 4.4.

### 4.1 Job Creation and Wage Setting

A firm and a worker who are matched first negotiate an initial wage and then, in case they agree on a wage and form an employment relationship, renegotiate the wage in every subsequent period in which they are still together. In this section we consider wage bargaining between the firm and the worker at the initial hiring stage and in all subsequent periods in which there is no productivity shock. Note that, in contrast

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<sup>10</sup>The simple bargaining game used in most of the paper is not the most efficient in the sense that if firms and workers were able to contract over the bargaining game when they form their employment relationship, they would choose a different game.

to the bargaining over the adjustment bonus considered in the next subsection, in this section wage bargaining always takes place under complete information.

Consider a firm and a worker that have just been matched. If they start an employment relationship, they can generate a match value  $Z$ . If, instead, they return to the search pool, the worker and the firm realize  $U$  and  $V$ , respectively, where  $U$  is the worker's expected utility when unemployed and  $V$  is the expected value of a firm when it is searching for a worker. Wages are determined by a bargaining game in which the firm and the worker each make a take-it-or-leave-it wage offer with probability  $1/2$ . In this game it is optimal to offer a wage that makes the other party indifferent between accepting and rejecting. Thus, when it is the firm to make an offer, it offers a wage such that the worker's lifetime expected utility from being employed by the firm,  $W$ , is equal to  $U$ , his expected utility when unemployed. Similarly, when it is the worker to make an offer, he demands a wage such that the firm's expected value from employing the worker,  $J$ , is equal to the firm's expected value when searching for a worker  $V$ . It then follows that when a firm and a worker are initially matched, the worker's lifetime expected utility is

$$W_0 = U + \frac{1}{2} [Z - S_0] \quad (1)$$

and the expected value of the firm is

$$J_0 = V + \frac{1}{2} [Z - S_0], \quad (2)$$

where

$$S_0 \equiv U + V \quad (3)$$

is the joint value of search if the firm and the worker do not form an employment relationship.<sup>11</sup>

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<sup>11</sup>Since the dynamic structure of our model is fairly straightforward, we omit time subscripts throughout the paper in order to simplify notation.

Consider next a firm and a worker who are renegotiating the wage in some period after they formed their employment relationship and in which there has not been any productivity shock. When it is the firm's turn to make the offer, it still offers a wage such that  $W = U$ . When it is the worker's turn, however, he will now offer a wage such that  $J = V - \phi - R$ , where  $\phi$  is the firing tax and  $R$  the self-imposed rigidities. This is the case since, once an employment relationship has been formed, the firm can only return to the search pool and realize  $J$  after incurring separation costs equal to  $(\phi + R)$ . In every period in which the worker-firm pair has not been hit by a productivity shock, the worker's lifetime expected utility is then given by

$$W_1 = U + \frac{1}{2} [Z - S] \quad (4)$$

and the expected value of the firm is given by

$$J_1 = V - \phi - R + \frac{1}{2} [Z - S], \quad (5)$$

where  $S \equiv U + V - \phi - R$  is the joint value of search if the firm and the worker terminate their employment relationship. Note that when the separation costs are strictly positive, that is when  $\phi + R > 0$ , the value of the firm is higher at the beginning of the employment relationship than during it, i.e.  $J_0 > J_1$ , while the expected utility of the worker is higher during an employment relationship than at its beginning, i.e.  $W_1 > W_0$ . This is the case since, with strictly positive separation costs, the firm is in a stronger position when it bargains with a new potential worker than when it bargains with an existing employee. Note, however, that this is only a distributive effect, since the total match value does not depend on whether the worker and the firm are at the start or at some later stage of their employment relationship. In particular, using (1) to (5), we have

$$W_0 + J_0 = W_1 + J_1 = Z. \quad (6)$$

The match value  $Z$  is given by

$$Z = p + \delta [\lambda Z^e + (1 - \lambda)Z],$$

where  $\lambda$  is the probability that a shock hits and  $Z^e$  is the expected match value when a shock hits. Rearranging then gives

$$Z = \frac{1}{1 - \delta(1 - \lambda)}(p + \lambda\delta Z^e). \quad (7)$$

## 4.2 Job Destruction

Consider now the implications of the model outlined in Section 3 for job destruction. When the shock occurs, the firm and the worker negotiate over the adjustment bonus  $\beta$  and these negotiations are hindered by the presence of private information. In particular, with probability 1/2 the firm makes a take-it-or-leave-it offer without observing the worker's disutility  $\gamma$  and with probability 1/2 the worker makes a take-it-or-leave-it offer without observing the firm's realization of the adjustment benefit  $\rho$ .

Suppose first that the firm makes the offer. The worker accepts an offer  $\beta$  if and only if the value of continuing with the current employer is greater than or equal to the value of search  $U$ , i.e. if and only if  $\beta - \gamma + W_1 \geq U$ . Rearranging one obtains that the worker continues in the job if and only if

$$\gamma \leq \tilde{\gamma} \equiv \beta + W_1 - U, \quad (8)$$

that is, if the adjustment bonus  $\beta$  and the net continuation payoff  $W_1 - U$  are sufficiently large relative to the adjustment cost  $\gamma$ .

The firm chooses the bonus  $\beta$  in order to maximize its expected value from the time of the shock onward, given by  $G(\tilde{\gamma})(\rho - \beta + J_1) + [1 - G(\tilde{\gamma})](V - \phi - R)$ . Since (8) establishes a



one-to-one relationship between the bonus  $\beta$  offered by the firm and the marginal worker  $\tilde{\gamma}$  who accepts it, in order to solve the firm's expected profit maximization problem we can think of the firm choosing the marginal worker  $\tilde{\gamma}$ . Therefore using (8) to substitute for  $\beta$  and then (6) to substitute  $Z$  for  $(W_1 + J_1)$  in the expression for the expected value of the firm given above, we have that a firm with productivity  $\rho$  solves

$$\max_{\tilde{\gamma}} G(\tilde{\gamma}) (\rho - \tilde{\gamma} + Z - U) + [1 - G(\tilde{\gamma})] (V - \phi - R). \quad (9)$$

The first order condition of this problem is

$$\tilde{\gamma} + H(\tilde{\gamma}) = \rho + Z - S, \quad (10)$$

for all  $\rho$ ; where  $H(\gamma)$  is the inverse of the hazard rate of the distribution of  $\gamma$ . Equation (10) implies that  $\tilde{\gamma}$  is a function of  $\rho$ , although we do not make this explicit in the notation.

Suppose now that the worker makes the offer and demands a bonus  $\beta$  in order to agree to continue in its current job. The firm accepts this offer if and only if the value of continuing with the current worker is greater than or equal to the value of search, i.e. if and only if  $\rho - \beta + J_1 \geq V - \phi - R$ . Rearranging this expression one obtains that the firm continues to employ the worker if and only if

$$\rho \geq \tilde{\rho} \equiv V - \phi - R + \beta - J_1. \quad (11)$$

The worker chooses the bonus  $\beta$  in order to maximize his expected utility from the time of the shock onward, given by  $[1 - F(\tilde{\rho})] (\beta - \gamma + W_1) + F(\tilde{\rho})U$ . Using (11) to substitute for  $\beta$  and then (6) to substitute  $Z$  for  $(W_1 + J_1)$  in the expression above, the worker's offer solves

$$\max_{\tilde{\rho}} [1 - F(\tilde{\rho})] (\tilde{\rho} - \gamma + Z - (V - \phi - R)) + F(\tilde{\rho})U. \quad (12)$$

The first order condition of this problem is

$$\tilde{\rho} - K(\tilde{\rho}) = \gamma - Z + S, \quad (13)$$

for all  $\gamma$ ; where  $K(\rho)$  is the inverse of the hazard rate of the distribution of  $\rho$ . Note that  $\tilde{\rho}$  is a function of  $\gamma$ , although we do not make this explicit in the notation.

Note also that it would be ex post efficient for the worker and the firm to continue their employment relationship whenever

$$\rho - \gamma + Z \geq S. \quad (14)$$

The presence of  $H(\tilde{\gamma}) > 0$  and  $K(\tilde{\rho}) > 0$  in the first order conditions (10) and (13) implies that the firm and the worker sometimes separate when it would be efficient for them to continue their employment relationship, i.e. they separate for some  $\rho$  and  $\gamma$  that satisfy (14). This bargaining inefficiency is at the heart of our analysis.

For the analysis that follows it is useful to derive an expression for the expected match value when the firm-worker pair is hit by a shock, which we denote by  $Z^e$ . Every time a firm-worker pair is hit by a shock they jointly realize  $\rho - \gamma + Z$  if they continue their relationship and they jointly realize  $S$  if they separate. Thus,  $Z^e$  is given by

$$\begin{aligned} Z^e &= S + \frac{1}{2} \int_{\rho \in \mathbb{P}} \int_{\gamma \leq \tilde{\gamma}} (\rho - \gamma + Z - S) dG(\gamma) dF(\rho) \\ &\quad + \frac{1}{2} \int_{\gamma \in \Gamma} \int_{\rho \geq \tilde{\rho}} (\rho - \gamma + Z - S) dF(\rho) dG(\gamma). \end{aligned} \quad (15)$$

### 4.3 Steady-state Market Equilibrium

A steady-state equilibrium of the model without self-imposed rigidities is a tuple  $\langle \tilde{\gamma}, \tilde{\rho}, U, V \rangle$  that satisfies the firms and workers utility maximization problems in (9) and (12), respectively, and equations (1) - (7) and (15).<sup>12</sup>

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<sup>12</sup>A complete definition of a steady-state equilibrium in a random matching model should also include a condition that ensures that the inflows into the unemployment pool are equal to the outflows from

We start by solving for  $U$  and  $V$ . Since an unemployed worker can always drop out of the labor market and obtain a utility equal to zero, his expected utility is the maximum between zero and the value of search, which is given by  $b + \delta[aW_0 + (1 - a)U]$ , that is

$$U = \max \{b + \delta [aW_0 + (1 - a)U], 0\}. \quad (16)$$

where  $a$  is the probability with which firms and workers meet a counterpart and  $W_0$  is given in equation (1). Similarly, the value of a vacancy,  $V$ , must satisfy

$$V = \max \{-c + \delta [aJ_0 + (1 - a)V], 0\}, \quad (17)$$

where  $J_0$  is given in equation (2).

Note that if one side of the market (e.g. workers) decides not to participate in the labor market, then it is an optimal response for the other side (e.g. firms) to also stay out of the market. In what follows we disregard this type of trivial equilibria with no trade – which always exist in any two-sided search model – and focus on equilibria in which both parties participate in the market. In particular, we assume that the parameters of the model are such that there always exist equilibria in which  $U > 0$  and  $V > 0$ .<sup>13</sup>

Adding (16) and (17) we have that the joint value of search,  $S_0$ , for a firm-worker pair who decide not to start an employment relationship satisfies

$$(1 - \delta)S_0 = (b - c) + a\delta [W_0 + J_0 - S_0]. \quad (18)$$

The key to proving that the equilibrium of this model is unique is to show that there exists a unique  $S_0$  that solves equation (18). To show this and to derive the comparative

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this pool, see e.g. Pissarides (2000). However, in the present model in which workers and firms enter the market in equal, exogenously given numbers each period and only leave unemployment in pairs, this condition does not add any useful insight. We therefore chose to omit it from the formal definition of the equilibrium in order to simplify the exposition.

<sup>13</sup>For this to be the case it is sufficient for  $(b - c)$  and/or  $p$  to be sufficiently large.

static results that we discuss in the next section, it is useful to first show that the gains to continuing an employment relationship ( $Z - S$ ) are decreasing in the joint value of search  $S$ . For this purpose, we now establish the following lemma.

**Lemma 1** *The effect of a marginal increase in the joint value of search  $S$  on the match value  $Z$  is given by*

$$\frac{dZ}{dS} = \frac{\delta \lambda m}{(1 - \delta) + \delta \lambda m} < 1, \quad (19)$$

where

$$m \equiv 1 - \frac{1}{2} \left[ \mathbb{E}_\rho [G(\tilde{\gamma})] \left( 1 + \frac{1}{1 + H'(\tilde{\gamma})} \right) - \mathbb{E}_\gamma [1 - F(\tilde{\rho})] \left( 1 + \frac{1}{1 - K'(\tilde{\rho})} \right) \right]. \quad (20)$$

Having established this result, we can now prove that the equilibrium of our model is unique.

**Proposition 1** *In the model without self-imposed rigidities, there exists a unique equilibrium.*

#### 4.4 The Effects of a Reduction in the Firing Tax

We are interested in the effect of a reduction in the firing tax  $\phi$  on the equilibrium of the economy derived in the previous subsections. In this section our primary interest is how such a reduction affects the well being of workers and the profits of firms. We will argue that a reduction in the firing tax leads to more aggressive bargaining behavior between firms and workers which, in turn, leads to an increase in job instability. We show that because of the increase in job instability some groups in society, and under some circumstances society as a whole, can be made worse off.

The firing tax only affects the match value  $Z$  through the joint value of search  $S$ . This follows immediately from the definitions of  $Z$  and  $Z^e$  in (7) and (15) which together

imply that

$$\frac{dZ}{d\phi} = \frac{\delta\lambda}{1 - \delta(1 - \lambda)} \frac{dZ^e}{dS} \frac{dS}{d\phi}. \quad (21)$$

The next lemma shows that the last term on the right hand side of (21),  $dS/d\phi$ , is negative, that is, that a reduction in the firing tax increases the joint value of search. Essentially, such a reduction makes it less costly for firms and workers to separate, simply because alternative trading partners can be found at lower cost.

**Lemma 2** *A reduction in the firing tax  $\phi$  increases the expected joint value of separation for a firm-worker pair  $S$ , that is,  $dS/d\phi < 0$ .*

It then follows from (21) that, in order to determine the effect of a change in the firing tax  $\phi$  on  $Z$ , it is sufficient to study the sign of  $dZ^e/dS$ . Using (A1) and (A2) in the proof of Lemma 1 we have that

$$\frac{dZ^e}{dS} = \frac{1 - \delta + \delta\lambda}{1 - \delta + (1 - q)\delta\lambda} \left( \frac{\partial Z^e}{\partial S} + \frac{\partial Z^e}{\partial \tilde{\gamma}} \frac{d\tilde{\gamma}}{dS} + \frac{\partial Z^e}{\partial \tilde{\rho}} \frac{d\tilde{\rho}}{dS} \right), \quad (22)$$

where  $q = (E_\rho[G(\tilde{\gamma})] + E_\gamma[1 - F(\tilde{\rho})]) / 2$  is the expected probability of agreement. Since  $q \in [0, 1]$ , the first term in the right hand side of (22) is positive which implies that the sign of  $dZ^e/dS$  is determined by the three terms in the parentheses. Equation (A4) in the proof of Lemma 1 shows that the first term is given by

$$\frac{\partial Z^e}{\partial S} = 1 - q \geq 0.$$

Intuitively, whenever the firm and the worker disagree, which happens with probability  $(1 - q)$ , they obtain a higher payoff the higher is  $S$ . For given  $\tilde{\gamma}$  and  $\tilde{\rho}$  his effect is unambiguously positive and represents the marginal benefit of an increase in  $S$ .

The second and the third terms in brackets in (22) represent the marginal cost of an increase in  $S$ . In particular, from the proof of Lemma 1 we know that

$$\frac{\partial Z^e}{\partial \tilde{\gamma}} \frac{d\tilde{\gamma}}{dS} = -\frac{E_\rho[G(\tilde{\gamma})]}{2(1 + H'(\tilde{\gamma}))} \left[ 1 - \frac{dZ}{dS} \right] \leq 0$$

and

$$\frac{\partial Z^e}{\partial \tilde{\rho}} \frac{d\tilde{\rho}}{dS} = -\frac{E_\gamma[1 - F(\tilde{\rho})]}{2(1 - K'(\tilde{\rho}))} \left[ 1 - \frac{dZ}{dS} \right] \leq 0.$$

Intuitively, an increase in  $S$  leads to more aggressive bargaining behavior and increases the probability of separation, that is, it reduces  $\tilde{\gamma}$  and increases  $\tilde{\rho}$ . This increase in the probability of separation, in turn, has a negative effect on the match value of a worker-firm pair that has experienced a productivity shock, that is, it reduces  $Z^e$ . It is important to note that the negative effect of an increase in the probability of separation on the match value is due to firms and workers separating ‘too often’ which, in turn, is due to the negotiations being hampered by the presence of private information. In a standard model in which negotiations over compensation always take place under complete information, an increase in  $S$  also leads to more job instability; however, there such an increase in job instability is *not costly* for the firm and the worker, since the employment relationships that are discontinued have no value.

To see when a reduction in the firing tax can actually make a worker-firm pair worse off, consider the following lemma.

**Lemma 3** (a) *Suppose that the distributions  $G(\gamma)$  and  $F(\rho)$  are such that for some  $\kappa < \infty$*

$$\min \left\{ \lim_{\gamma \rightarrow \sup \Gamma} H'(\gamma), -\lim_{\rho \rightarrow \inf P} K'(\rho) \right\} \leq \kappa.$$

*Then there exists an  $\bar{S}$  and an  $\underline{S} \leq \bar{S}$  such that*

$$\frac{dZ}{dS} = \begin{cases} \leq 0 & \text{if } S < \underline{S} \\ > 0 & \text{if } S > \bar{S}. \end{cases}$$

*If the distributions do not satisfy the foregoing condition,  $\underline{S}$  might not (but still can) exist. For  $\underline{S} \leq S \leq \bar{S}$ , the sign of  $dZ/dS$  is ambiguous and depends on the precise distributions of  $\rho$  and  $\gamma$ .*

**Lemma 1** (b)  $Z$  reaches its global maximum for  $S > \bar{S}$ .

This lemma is key for all the results in the paper. To get a sense for the condition on the distributions in part (a), note first that it rules out situations in which  $f(\underline{\rho}) = g(\bar{\gamma}) = 0$ ,  $f'(\underline{\rho}) > 0$  and  $g'(\bar{\gamma}) < 0$ , where  $\bar{\gamma} = \sup \Gamma$  and  $\underline{\rho} = \inf P$ . The condition is satisfied, for instance, for truncated exponential, normal and Pareto distributions as well as for uniform distributions. To focus on the most interesting case, we assume for the rest of the discussion that this condition is indeed satisfied.

The key insight of the lemma is that the negative effect of an increase in  $S$  dominates when  $S$  is small and the positive effect dominates when  $S$  is large. For intermediate values of  $S$ , the effect of an increase in  $S$  on  $Z$  is ambiguous and depends on the particular distributions of  $\gamma$  and  $\rho$ . The intuition for this result is as follows: when  $S$  is initially small, it is very costly for firms and workers to separate and search for alternative trading partners. As a result, the firm and the worker do not bargain very aggressively with each other and separations are rare in equilibrium. Thus, the marginal benefit of an increase in  $S$  – that is, the higher payoff that the worker and the firm obtain when they separate – is relatively small and is dominated by the marginal cost – that is, the increased probability of inefficient separation. When  $S$  is initially large, however, it is not very costly for firms and workers to separate. They therefore bargain aggressively and separate fairly often. In this case the marginal benefit of an increase in  $S$  is large and dominates the marginal cost. Finally, we note that, although an increase in  $S$  can have a negative effect on  $Z$  for low initial values of  $S$ , the global maximum of  $Z$  is achieved at the upper limit of  $S$ .

Recall from Lemma 2 that  $S$  is decreasing in  $\phi$ . Thus, together Lemmas 2 and 3 imply that a small reduction in firing taxes makes worker-firm pairs worse off if firing taxes are initially high and better off if firing taxes are initially low. To formally state

this and other results, it is useful to introduce the following definition.

**Definition 1** Let  $\underline{\phi}$  denote the unique  $\phi$  that solves  $S(\phi) = \bar{S}$ , where  $S(\phi)$  is the equilibrium value of  $S$  given  $\phi$ . Similarly, let  $\bar{\phi}$  denote the unique  $\phi$  that solves  $S(\phi) = \underline{S}$ .

Note that the existence and uniqueness of  $\underline{\phi}$  and  $\bar{\phi}$  follow from Lemma 2. We can now state the following proposition which summarizes the first set of results in this section.

**Proposition 2 (Comparative statics for insiders)**

(a) *The effect of a marginal change in  $\phi$  on  $Z$  is*

$$\frac{dZ}{d\phi} = \begin{cases} \geq 0 & \text{if } \phi > \bar{\phi} \\ < 0 & \text{if } \phi < \underline{\phi}. \end{cases}$$

(b) *The effect of a marginal change in  $\phi$  on  $W_0$  and  $J_0$  is*

$$\frac{dW_0}{d\phi} = \frac{dJ_0}{d\phi} = \begin{cases} \geq 0 & \text{if } \phi > \bar{\phi} \\ < 0 & \text{if } \phi < \underline{\phi}. \end{cases}$$

(c) *The effect of a marginal change in  $\phi$  on  $W_1$  and  $J_1$  is*

$$\frac{dW_1}{d\phi} \geq 0 \quad \text{if } \phi > \bar{\phi} \quad \text{and} \quad \frac{dJ_1}{d\phi} \leq 0 \quad \text{for all } \phi.$$

Part (a) of the proposition formally describes the effect of a reduction in the firing tax on the match value that was discussed above while parts (b) and (c) investigate its effect on the distribution of the match value. Part (b) shows that a reduction in firing taxes has an adverse effect on firms and workers at the beginning of an employment relationship if firing taxes are initially high and a positive effect if they are initially low. This is again due to the two countervailing effects of a reduction in the firing tax. Finally, part (c) describes the effect of a reduction in the firing tax on firms and workers



during an employment relationship. It shows that such a reduction always increases  $J_1$  since it improves the firm's bargaining position relative to that of the worker. A reduction in firing taxes can also be beneficial for the worker when these taxes are initially low because, although it weakens the worker's bargaining position, it increases the value of the match over which bargaining takes place.

Having discussed the effect of a reduction in the firing tax on workers and firms that are in an employment relationship, we now turn to its effect on workers and firms that are not in an employment relationship.

**Proposition 3 (Comparative Statics Outsiders)**

*The effects of a marginal change in  $\phi$  on  $U$  and  $V$  satisfy*

$$\frac{dU}{d\phi} = \frac{dV}{d\phi} = \frac{1}{2} \frac{dS_0}{d\phi} = \begin{cases} \geq 0 & \text{if } \phi > \bar{\phi} \\ < 0 & \text{if } \phi < \underline{\phi}. \end{cases}$$

*For  $\underline{\phi} \leq \phi \leq \bar{\phi}$ , the sign of  $dU/d\phi$  and  $dV/d\phi$  are ambiguous and depend on the distributions of  $\gamma$  and  $\rho$ .*

Thus, even firms and workers who are currently searching for trading partners can be made worse off by a reduction in the firing tax. In particular, when firing taxes are initially high, a tax reduction reduces the match value  $Z$  without increasing the probability that firms and workers are matched. As a result, unemployed workers and firms with open vacancies are made worse off.

So far the analysis has shown that a reduction in firing taxes can have an adverse effect on firms and workers who are already in an employment relationship and on those who are still searching for potential trading partners. Indeed, Propositions 2 and 3 show that this reduction can make all firms and workers worse off. It can thus reduce overall welfare, as shown in the following proposition.

**Proposition 4** *Assume a utilitarian welfare function in which welfare is given by the sum of the expected utilities of all firms and workers. Then a small reduction in the firing tax reduces welfare when labor market frictions are high, that is, when  $\phi \geq \bar{\phi}$ .*

In summary, this section makes two main points. First, it shows that when firms and workers bargain under asymmetric information, a reduction in the costs of separation (e.g. a reduction in firing taxes) leads to more job instability. Second, it shows that because of the increase in job instability, a small reduction in separation costs can make some groups in society worse off and, when separation costs are initially high, reduce overall welfare. The adverse effects of a small reduction in separation costs are, however, dominated by its positive effects when separation costs are initially low. This suggests that labor market reforms may be harder to implement in continental Europe, where labor market frictions are high, than in the UK or the US, where frictions are already less severe.

It is also important to note that in our model a sufficiently large reduction in labor market frictions is always welfare enhancing. In some situations, therefore, it may be preferable to implement large reforms rather than piece-meal reforms.

## 4.5 Free Entry

Before we move on to analyze self-imposed rigidities in the next section, we briefly digress to discuss free entry by firms and why the main insights of the analysis above are not affected by it.<sup>14</sup>

With free entry the expected value of a vacancy,  $V$ , is equal to zero in equilibrium. The outside option of a firm that is renegotiating the wage of an existing employee,

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<sup>14</sup>A formal derivation of the results on free entry is contained in an appendix available from the authors on request. Free entry by firms is also discussed in a previous, and slightly different, version of our model contained in the working paper version of this article (Matouschek, Ramezzana and Robert-Nicoud, 2004).

however, still depends on the firing tax  $\phi$  that it has to pay if the employment relationship is dissolved. Under free entry it is therefore still the case that a reduction in the firing tax increases the joint expected value of separation  $S$  and, through this channel, leads to more aggressive bargaining behavior and more job instability. As a result, a marginal reduction in the firing tax reduces the match value  $Z$  and the joint value of search  $S_0$  when separation costs are initially high and it increases  $Z$  and  $S_0$  when separation costs are initially low. Moreover, it continues to be the case that a marginal reduction in the firing tax reduces welfare when labor market frictions are high.

Free entry therefore does not change the comparative statics on the match value and on the joint outside options of a worker and firm that are in an employment relationship. It does, however, change the comparative statics on the division of the surplus at the beginning of an employment relationship. This is the case since, with free entry, the value of a vacancy  $V$  is always equal to zero and thus unaffected by changes in  $\phi$ . However, changes in  $\phi$  have an effect on  $U$ . To see the implications of this, consider a reduction in  $\phi$  when the firing tax is initially low. This reduction increases the value of being unemployed  $U$  but does not change  $V$ . As a result, the bargaining position of unemployed workers is strengthened and thus firms may actually be made worse off.

## 5 Self-Imposed Rigidities

In the previous sections we saw that firms and workers may sometimes fail to reach efficient agreements when they renegotiate wages. To the extent that firms and workers anticipate this inefficiency, one would expect them to take contractual actions at the beginning of their relationship to mitigate it. In this section we investigate this possibility. We first show that firms and workers may want to increase future separation costs so as to commit to less aggressive bargaining behavior in the future. In other

words, firms and workers may want to complement the exogenous rigidities that they face with their own, self-imposed rigidities. We assume that firms and workers can commit themselves to these self-imposed rigidities at the beginning of their relationship even though they would prefer not to incur the extra cost when separation actually occurs. In the real world, firms and workers commit to different separation costs in a variety of ways. For instance, separation between a firm and a worker is less costly if the firm uses a fixed-term employment contract than if it uses a permanent contract. In this section we study the conditions under which firms and workers choose to commit to self-imposed rigidities and investigate the effects of a reduction in firing taxes on the optimal level of these rigidities.

In particular, we now analyze the full-fledged model described in Section 2 in which a firm and a worker that have just been matched can contract over the extra cost  $R$  that the firm incurs in case the employment relationship is terminated in the future.<sup>15</sup> To simplify the exposition we now restrict attention to distributions for which  $H''(\gamma)$  is not ‘too positive’ and  $K''(\rho)$  is not ‘too negative,’ in the sense made clear in the following lemma. As the lemma shows, these conditions ensure that  $Z$  is everywhere convex in  $S$ .

**Lemma 4** *Assume that the following conditions hold:  $H''(\cdot) < [1+H'(\cdot)][2+H'(\cdot)]/H(\cdot)$  for all  $\gamma \in \Gamma$  and  $K''(\cdot) > [1 - K'(\cdot)]K'(\cdot)/K(\cdot)$  for all  $\rho \in P$ . Then  $Z$  is everywhere convex in  $S$ , that is,  $\underline{S} = \overline{S}$ .*

These conditions are satisfied by a number of common distributions, including truncated exponential and Pareto distributions as well as uniform distributions.<sup>16</sup>

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<sup>15</sup>The results that we derive in this section would not change if the extra costs  $R$  were incurred not only by the firm but also (in part or in full) by the worker.

<sup>16</sup>Slightly weaker results than those that we present in this section can be proven for more general distributions.

Suppose that a firm and a worker are matched and bargain over  $R$ . Since they are risk neutral and not liquidity constrained they agree on the level of  $R$  that maximizes their match value  $Z$ , as given in (7). Note that in a model in which bargaining over adjustment to productivity shocks takes place under complete information it would never be optimal for workers and firms to commit to a strictly positive  $R$ . When bargaining takes place under private information, however, committing to higher separation costs may indeed be optimal, as shown in the next proposition.

**Proposition 5 (Self-Imposed Rigidities)** *There exists a unique  $\hat{\phi}$  such that*

$$R = \begin{cases} \bar{R} & \text{if } \phi \geq \hat{\phi} \\ 0 & \text{otherwise,} \end{cases}$$

where

$$\frac{\partial \hat{\phi}}{\partial a} > 0 \quad \text{and} \quad \frac{\partial \hat{\phi}}{\partial p} > 0.$$

The intuition for this result is as follows. On the one hand, self-imposed rigidities make it more costly for the firm and the worker to separate, which happens with positive probability in equilibrium. On the other hand, however, precisely because these rigidities make separation more costly, they also make it less likely, since they induce less aggressive bargaining. When labor market frictions are initially high and/or workers are very productive, the benefit of self-imposed rigidities dominate the costs if labor market frictions are large. The opposite holds if labor market frictions are small and/or workers are not very productive.

The proposition provides a novel and intuitive explanation for why firms and workers may commit to higher future separation costs: since firms and workers anticipate that they may bargain ‘too aggressively’ in the future they may find it optimal to commit to high separation costs in order to make the employment relationship more stable.

The proposition also shows that if self-imposed rigidities serve this purpose, then these self-imposed-rigidities *complement* exogenous rigidities: when labor market frictions are high, in the sense that  $\phi$  is large, it is optimal for the firm and the worker to make it even more costly for themselves to separate in the future by setting  $R$  as high as possible. In contrast, when labor market frictions are low it is optimal for the firm and the worker to avoid any additional cost of separation by setting  $R = 0$ . This result is consistent with the observation that in countries such as Japan, in which labor market frictions are relatively high and firms face significant government imposed rigidities, many firms voluntarily commit to additional constraints that make it even more costly for them to separate from their employees.<sup>17</sup>

Finally, we can use Proposition 5 to analyze the effect of a reduction in firing taxes on the employment contracts that firms and workers adopt. For this purpose, suppose that firing taxes are initially high, in the sense that  $\phi > \hat{\phi}$ , and consider the effect of a reduction in the firing tax. If this reduction is sufficiently small, then the firing tax  $\phi$  remains above the cut-off level  $\hat{\phi}$  and firms and workers continue to adopt the most rigid employment contracts. If, however, the reduction is sufficiently large, so that  $\phi$  falls below  $\hat{\phi}$ , firms and workers switch to the most flexible employment contracts, i.e. from  $R = \bar{R}$  to  $R = 0$ . This switch leads to a discrete reduction in the cost of separation and thus induces the firms and workers to bargain more aggressively and to separate more often following productivity shocks. The instability caused by a reduction in firing taxes is therefore amplified by this endogenous contractual response to the original policy change.

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<sup>17</sup>See, for instance, Dore (1996) who states that “*What was not always recognized [...] was the importance of self-imposed rigidities, most fully exemplified in the Japanese firm. By self-imposed rigidities, I mean the acceptance, by managers, of a wide range of constraints on their freedom of action - lifetime employment guarantees, tight seniority constraints on promotion, acceptance of the need to engineer consent, to maintain close consultation with employees or their unions [...].*”

We note that the results in this section still hold if we allow for free entry of firms along the lines of the model discussed in Section 4.5 and in the Appendix. This is the case because the adoption of contractual rigidities discussed in the present section depends on the joint match value  $Z$  and not on how this value is distributed between the worker and the firm. As discussed in Section 4.5, the introduction of free entry does not affect the comparative statics on the joint match value  $Z$  and thus does not affect our conclusions about the implications of changes in firing taxes for self-imposed rigidities.

## 6 Efficient Bargaining

The model introduced in Section 3 assumed that when the firm and the worker renegotiate the wage, they play a simple bargaining game in which each side makes a take-it-or-leave-it offer with probability  $1/2$ . We assumed this particular bargaining game because of its simplicity and because it is consistent with the standard assumption, which we also adopted, that the firm and the worker Nash bargain over the wage when they are first matched. A potential concern, however, is that the results that we derived are not robust and depend crucially on the assumed bargaining game. In this section we address this concern. In particular, we change the model from Section 3 in two ways. First, to simplify the exposition, we assume that each employment relationship is hit by a shock at most once. Second, we now assume that, of all the possible bargaining games that the firm and the worker could play when the shock hits, they play the most efficient, voluntary bargaining game, that is, the bargaining game that maximizes the expected match value  $Z^e$ , subject to the interim participation constraints.<sup>18</sup> In other words, we assume that at the renegotiation stage, the firm and the worker play the

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<sup>18</sup>The interim participation constraints ensure that the firm and the worker are willing to participate in the bargaining game after they have learned the realization of  $p$  and  $\gamma$  respectively.

Myerson and Satterthwaite (1983) bargaining game. This assumption addresses the robustness concern since the firm and the worker would commit to exactly this renegotiation bargaining game if they could contract over it when they are first matched. Also, by assuming that the firm and the worker adopt the most efficient bargaining game we are focusing on the minimum inefficiency that has to arise in a labor market in which wage renegotiations take place in the presence of private information.

It should be stressed that the approach that we adopt in this section is very general since we are allowing for any possible bargaining game including, for instance, alternating offers games. The only restrictive assumption that we maintain is that the firm and the worker can commit to the outcome of the renegotiation game, that is, they can commit not to renegotiate again. Thus, if the firm and the worker disagree on a wage they separate even if it is commonly known that there are still gains from trade. It is important to note that if the firm and the worker were unable to commit to separate if they disagree on a wage, the bargaining inefficiency that we focus on would necessarily be even larger. Thus, by assuming that the firm and the worker are able to commit to separate in the case of disagreement we ensure that we are analyzing the minimum inefficiency that has to arise in a labor market in which wage renegotiations take place in the presence of private information.<sup>19</sup>

In the formal analysis, which we relegate to the appendix, we start by following Myerson and Satterthwaite (1983) to describe the most efficient, voluntary bargaining game. In particular, we adopt the mechanism design approach to describe the bargaining game that maximizes  $Z^e$  subject to the participation constraints  $W(\gamma) \geq U$

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<sup>19</sup>Note also that any complete information model in which wages are determined by take-it-or-leave-it offers makes the same assumption, i.e. it assumes that if an offer is rejected, the firm and the worker separate although it is commonly known that there are gains from trade (see, for instance, Pissarides 2000).



and  $J(\rho) \geq V - \phi - R$ , where  $W(\gamma)$  is the worker's expected payoff from playing the bargaining game given that his costs are  $\gamma$  and  $J(\rho)$  is the firm's expected payoff from playing the bargaining game given that its benefit is  $\rho$  (see Lemma A2 in the Appendix). We then observe that as long as continuation of the employment relationship is not always optimal, bargaining between the firm and the worker is inefficient, in the sense that they sometimes separate although it would be optimal for them to continue their relationship. Next we establish the existence and uniqueness of the equilibrium (see Proposition A1) and then turn to the comparative statics. We argue that, just as in the main model, a liberalization of the labor market makes it less costly for a firm and a worker to separate. We show that this has an ambiguous effect on the match value since, on the one hand, it increases the payoff they realize in case they separate but, on the other hand, also makes separation more likely.<sup>20</sup> The only difference to the analysis of the main model is that we are no longer able to characterize analytically when either effect dominates in the case of general distributions. However, we can show that our results continue to hold for a number of common distributions, in particular the standard normal, standard exponential, and standard uniform distributions. We argue that for these distributions our main results continue to go through.

As an illustration, consider a simple numerical example in which  $\gamma$  and  $\rho$  are uniformly distributed on  $[0, 1]$ ,  $b = c = 0$ ,  $a = 1/2$ ,  $p = \lambda = 1/10$ ,  $d = 5/100$ ,  $r = 5/90$  and  $\delta = 9/10$ . In this example, the optimal mechanism ensures that a firm-worker pair that has been hit by a shock agrees to continue their relationship with probability

$$q(\gamma, \rho) = \begin{cases} 1 & \text{if } p - \gamma \geq \frac{1+\mu}{1+2\mu} (S_0 - \phi - 1) + \frac{\mu}{1+2\mu} \\ 0 & \text{otherwise,} \end{cases}$$

where  $\mu \in [0, \infty)$ . For  $(S_0 - \phi - 1) \leq -1$ ,  $\mu = 0$  and for  $(S_0 - \phi - 1) > -1$ ,  $\mu > 0$

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<sup>20</sup>The formal proof builds on Matouschek (2004). See Appendix for details.

solves the interim participation constraint

$$E_{\gamma,\rho} [(2(\rho - \gamma) + S_0 - \phi - 2)q(\gamma, \rho)] = 0.$$

In the appendix we show how to work out the values of all the endogenous variables for  $\phi = \{0, 0.1, \dots, 1\}$ . The results are in line with Proposition 4, namely, a reduction in the firing tax reduces welfare when the labor market frictions are high and increases it when they are low. Similar comparative statics hold for  $W_0$ ,  $J_0$ ,  $U$  and  $V$ , consistent with Propositions 2 and 3. Finally, in line with Proposition 2, a reduction in the firing tax leads to an increase in  $J_1$  and may lead to a reduction in  $W_1$ .

## 7 Conclusions

When firms and workers bargain over compensation they are often asymmetrically informed about relevant payoffs, such as profits and the workers' opportunity costs. It is well-known that in such situations bargaining is likely to be inefficient, in the sense that firms and workers fail to realize all gains from trade. In this paper we investigate the implications of this type of bargaining inefficiency for the functioning of labor markets.

Our analysis provides three main insights. First, it shows that when bargaining between firms and workers takes place under asymmetric information, a reduction in separation costs leads to an increase in job instability. Essentially, such a reduction makes it less costly for firms and workers to separate which, in turn, induces them to bargain more aggressively. In equilibrium this leads to more job separations. Second, a reduction in separation costs can make firms and workers worse off. In other words, the increase in job instability can outweigh the direct benefit of a reduction in separation costs. Finally, our analysis shows that when wage renegotiations take place under asymmetric information, firms and workers may find it optimal to adopt rigid employment

contracts that make it more costly for them to separate in the future. Moreover, a reduction in firing taxes can lead to a one-off switch from rigid to flexible employment contracts. This contractual response induces firms and workers to bargain even more aggressively and thus further destabilizes employment relationships.

As regards the robustness of our conclusions to alternative modelling choices, we address possible concerns that our results may depend on the assumed bargaining game by allowing firms and workers to play the most efficient bargaining game and show that for a number of common distributions our results continue to hold. In contrast, throughout we maintain the simplifying assumption that productivity shocks are match-specific. We believe that it would be interesting to analyze a model in which shocks are correlated – as this would shed some light on the, possibly different, effects of changes in separation costs on high and low productivity workers and firms. We leave this analysis for future work.

# Appendix

This appendix is divided into two sections. In Section A1 we prove all lemmas and propositions stated in the main text and in Section A2 we allow workers and firms to choose the most efficient game when bargaining over adjustment to productivity shocks.

## A1 Proofs of Lemmas and Propositions

**Proof of Lemma 1:** Differentiating (7) gives

$$\frac{dZ}{dS} = \frac{\delta\lambda}{(1-\delta) + \delta\lambda} \frac{dZ^e}{dS}, \quad (\text{A1})$$

where  $Z^e$  is the expected match value when a shock hits. To obtain  $dZ^e/dS$  we totally differentiate (15):

$$\frac{dZ^e}{dS} = \frac{\partial Z^e}{\partial S} + \frac{\partial Z^e}{\partial \tilde{\gamma}} \frac{d\tilde{\gamma}}{dS} + \frac{\partial Z^e}{\partial \tilde{\rho}} \frac{d\tilde{\rho}}{dS} + \frac{\partial Z^e}{\partial Z} \frac{dZ}{dS}. \quad (\text{A2})$$

Using this expression to substitute for  $dZ^e/dS$  in (A1) and solving for  $dZ/dS$  gives

$$\frac{dZ}{dS} = \frac{\delta\lambda}{(1-\delta) + \delta\lambda(1 - \partial Z^e/\partial Z)} \left( \frac{\partial Z^e}{\partial S} + \frac{\partial Z^e}{\partial \tilde{\gamma}} \frac{d\tilde{\gamma}}{dS} + \frac{\partial Z^e}{\partial \tilde{\rho}} \frac{d\tilde{\rho}}{dS} \right). \quad (\text{A3})$$

This expression reduces to that stated in the lemma. To show this, we first partially differentiate (15) with respect to  $Z$  and  $S$  to obtain

$$\frac{\partial Z^e}{\partial Z} = 1 - \frac{\partial Z^e}{\partial S} = \frac{1}{2} (E_\rho[G(\tilde{\gamma})] + E_\gamma[1 - F(\tilde{\rho})]). \quad (\text{A4})$$

Next, partially differentiating (15) with respect to  $\tilde{\gamma}$  and  $\tilde{\rho}$  and using the first order conditions for  $\tilde{\gamma}$  and  $\tilde{\rho}$  given by (10) and (13) we have that

$$\frac{\partial Z^e}{\partial \tilde{\gamma}} = \frac{1}{2} E_\rho[G(\tilde{\gamma})] \quad \text{and} \quad \frac{\partial Z^e}{\partial \tilde{\rho}} = -\frac{1}{2} E_\gamma[1 - F(\tilde{\rho})]. \quad (\text{A5})$$

Finally, we totally differentiate (10) and (13) to get

$$\frac{d\tilde{\gamma}}{dS} = -\frac{1}{1 + H'(\tilde{\gamma})} \left[ 1 - \frac{dZ}{dS} \right] \quad \text{and} \quad \frac{d\tilde{\rho}}{dS} = \frac{1}{1 - K'(\tilde{\rho})} \left[ 1 - \frac{dZ}{dS} \right]. \quad (\text{A6})$$

Substituting (A4) - (A6) into (A3) and solving for  $dZ/dS$  then gives (19). The fact that  $dZ/dS < 1$  then follows from the assumptions that  $H'(\tilde{\gamma}) > 0$  and  $K'(\tilde{\rho}) < 0$ , which ensure that  $m \in [-1, 1]$  holds for all  $\tilde{\gamma}(\rho) \in \Gamma$  and all  $\tilde{\rho}(\gamma) \in P$ , and that  $\lambda < (1 - \delta)/(2\delta)$ .

■

**Proof of Proposition 1:** As discussed in the main text, we assume that the parameters of the model are such that equilibria with  $U > 0$  and  $V > 0$  always exist and we focus on these equilibria. However, we note that even if these conditions on the parameters did not hold, trivial equilibria with neither party participating in the market always exist.

Noting that  $S = S_0 - R - \phi$  and, from (6), that  $W_0 + J_0 = Z$  we can write (18) as

$$(1 - \delta)(S + R + \phi) = (b - c) + a\delta(Z - S - R - \phi). \quad (\text{A7})$$

Lemma 1 implies that  $dZ/dS < 1$  and thus that the right hand side of (A7) is decreasing in  $S$ . Since the left hand side of this equation is increasing in  $S$  there can only exist a unique equilibrium value for  $S$  and thus for  $S_0$ . From (18), a unique equilibrium value for  $S_0$  implies a unique equilibrium value for  $(Z - S_0)$ . From (10) and (13), a unique equilibrium value for  $(Z - S_0)$  implies unique equilibrium values for  $\tilde{\gamma}$  and  $\tilde{\rho}$ . From (1), (2), (16) and (17) a unique equilibrium value for  $(Z - S_0)$  implies unique equilibrium values for  $U$  and  $V$ . ■

**Proof of Lemma 2:** Using  $S = S_0 - \phi - R$  and totally differentiating (18) gives

$$\frac{dS}{d\phi} = -\frac{1 - \delta + a\delta}{1 - \delta + a\delta[1 - dZ/dS]} < 0, \quad (\text{A8})$$

where the inequality follows from  $dZ/dS < 1$  as shown in Lemma 1. ■

**Proof of Lemma 3:** We make use of the following facts: (i)  $dZ/dS = m/\alpha(m)$ , where  $m$  is given by (20) and  $\alpha \equiv (1 - \delta + \delta\lambda m)/(\delta\lambda) > 1$  by  $m \in [-1, 1]$ . (ii) By (20), we have  $m = 1 - E_\rho[G(\tilde{\gamma})][2 + H'(\tilde{\gamma})]/[2 + 2H'(\tilde{\gamma})] - E_\gamma[(1 - F(\tilde{\rho})][2 - K'(\tilde{\rho})]/[2 - 2K'(\tilde{\rho})]$ . (iii) By the monotone hazard rate conditions,  $[2 + H'(\tilde{\gamma})]/[1 + H'(\tilde{\gamma})] \in [1, 2]$  and  $[2 - K'(\tilde{\rho})]/[1 - K'(\tilde{\rho})] \in [1, 2]$ . (iv) By (10)  $\tilde{\gamma}$  is decreasing in  $S$  and by (13)  $\tilde{\rho}$  is increasing in  $S$ .

(a) We start with the second inequality. Fact (iv) implies that for any  $\varepsilon > 0$ , there exists an  $\bar{S}(\varepsilon)$  such that  $\forall S > \bar{S}(\varepsilon)$ ,  $G(\tilde{\gamma}) < \varepsilon$  and  $1 - F(\tilde{\rho}) < \varepsilon$ . Together with facts (ii) and (iii), we get  $m > 1 - 2\varepsilon$ . Invoking fact (i), this in turn implies

$$\frac{dZ}{dS} = \frac{m}{\alpha} > \frac{1 - 2\varepsilon}{\alpha},$$

which is strictly positive if  $\varepsilon$  is chosen adequately. Thus by continuity of the supports  $\Gamma$  and  $P$  an  $\bar{S}$ , as defined in the lemma, exists.

Consider next the first inequality. Fact (iv) implies that for any  $\xi > 0$  there exists an  $\underline{S}(\xi)$  such that  $G(\tilde{\gamma}) > 1 - \xi$  and  $1 - F(\tilde{\rho}) > 1 - \xi$ . Next, let us impose our assumption  $\min\{\lim_{\gamma \rightarrow \sup \Gamma} H'(\gamma), -\lim_{\rho \rightarrow \inf P} K'(\rho)\} \leq \kappa$ , where  $\kappa$  is some finite real number. In this case, using facts (i), (ii) and (iii), we obtain  $m < -[1 - \xi(2 + \kappa)]/(1 + \kappa)$ . Invoking fact (i), this in turn implies

$$\frac{dZ}{dS} = \frac{m}{\alpha} < -\frac{1 - \xi(2 + \kappa)}{(1 + \kappa)\alpha}$$

which is strictly negative if  $\xi$  is chosen small enough. Thus by continuity of the supports  $\Gamma$  and  $P$  an  $\underline{S}$ , as defined in the lemma, exists. If our assumption above fails, that is, if  $\kappa \rightarrow \infty$ , then such an  $\underline{S}$  *might* not exist.

(b) By part (a),  $Z$  grows unbounded as  $S$  increases since  $dZ/dS > 0$  if  $S$  is large enough. Moreover, by the fact that  $H(\cdot)$  and  $K(\cdot)$  are continuously differentiable  $Z$  is also a continuously differentiable function of  $S$ . The result thus immediately follows. ■

**Proof of Proposition 2:** Part (a) follows immediately from Lemmas 1 and 2.

For part (b) note first that from (16) and (17),  $(1 - \delta)dU = a\delta d(W_0 - U)$  and  $(1 - \delta)dV = a\delta d(J_0 - V)$ . Next, from (1) and (2) we have  $W_0 - U = J_0 - V$ . Substituting  $W_0 - U$  for  $J_0 - V$  in the foregoing equations then shows that  $dU = dV$  and hence  $dU/d\phi = dV/d\phi$ . Differentiating (1) and (2) and substituting  $dV/d\phi$  for  $dU/d\phi$  then gives

$$\frac{dW_0}{d\phi} = \frac{dJ_0}{d\phi} = \frac{1}{2} \frac{dZ}{d\phi}.$$

The signs of  $dW_0/d\phi$  and  $dJ_0/d\phi$  follow readily from part (a).

For part (c) we differentiate (4) and (5) and substitute  $dV/d\phi$  for  $dU/d\phi$  to obtain

$$\frac{dW_1}{d\phi} = \frac{1}{2} \left[ \frac{dZ}{d\phi} + 1 \right] \quad \text{and} \quad \frac{dJ_1}{d\phi} = \frac{1}{2} \left[ \frac{dZ}{d\phi} - 1 \right].$$

Since  $\phi$  affects  $Z$  via  $S$  only, we have

$$\frac{dZ}{d\phi} = \frac{dZ}{dS} \frac{dS}{d\phi}$$

which is negative (respectively positive) if and only if  $dZ/dS > 0$  (respectively  $dZ/dS < 0$ ) by the proof of Lemma 2. Therefore, a sufficient condition for  $dW_1/d\phi$  to be positive is that  $\phi > \bar{\phi}$ , as claimed in the text. Using (A8), we obtain

$$\frac{dJ_1}{d\phi} = -\frac{1}{2} \frac{a\delta + (1 - \delta) [1 + dZ/dS]}{1 - \delta + a\delta [1 - dZ/dS]}$$

which is negative since  $1 > \partial Z/\partial S > -1$ . ■

**Proof of Proposition 3:** In the proof of Proposition 2 we have shown that  $dU/d\phi = dV/d\phi$ . We can therefore focus on the effect of a labor market liberalization on  $S_0 = U + V$ . Using  $S = S_0 - \phi$  and (A8) we have that

$$\frac{dS_0}{d\phi} = -\frac{a\delta dZ/dS}{1 - \delta + a\delta[1 - dZ/dS]}.$$

Thus,  $\text{sign}\{dS_0/d\phi\} = -\text{sign}\{dZ/dS\}$ . From Lemma 3 it then follows that  $dS_0/d\phi \geq 0$  if  $S < \underline{S}$  and  $dS_0/d\phi > 0$  if  $S > \bar{S}$ . The signs of  $dU/d\phi$  and  $dV/d\phi$  then follow from the definition of  $\bar{\phi}(a)$  and  $\underline{\phi}(a)$ . ■

**Lemma A1** (a) *In the model presented in Section 3 the unemployment rate is given by*

$$u = \left[ 1 + \frac{2a}{2\delta + \lambda \{E_\rho[1 - G(\tilde{\gamma})] + E_\gamma[F(\tilde{\rho})]\}} \right]^{-1}. \quad (\text{A9})$$

(b) *The unemployment rate increases as the firing tax decreases, namely  $du/d\phi < 0$  for any  $\phi$ .*

**Proof:** (a) This rate is computed as follows. The dynamics of the number of unemployed workers is  $N_u(t+1) - N_u(t) = n - (a + \delta)N_u(t) + \lambda N_e(t)\{E_\rho[1 - G(\tilde{\gamma})] + E_\gamma[F(\tilde{\rho})]\}/2$  and the dynamics of the number of employed workers is given by  $N_e(t+1) - N_e(t) = aN_u(t) - (\delta + \lambda\{E_\rho[1 - G(\tilde{\gamma})] + E_\gamma[F(\tilde{\rho})]\}/2)N_e(t)$ . In steady state  $N_u(t+1) = N_u(t) = N_u$  and  $N_e(t+1) = N_e(t) = N_e$  and thus the total number of workers in the steady state is  $N = N_u + N_e = n/\delta$  and the unemployment rate  $u \equiv N_u/N$  is as given in (A9).

(b) From (10) and (13),  $\tilde{\gamma}$  decreases and  $\tilde{\rho}$  increases when  $S$  increases. The result then follows from the fact that  $dS/d\phi < 0$ , as shown in Lemma 2. ■



**Proof of Proposition 4:** In steady state, welfare is given by  $uS_0/2 + (1 - u)Z/2$ . Given that  $\phi \geq \bar{\phi}(a)$  we know by Proposition 3 that when  $\phi$  decreases, unmatched firms and workers and matched worker-firm pairs are both made worse off. Also, from Lemma A1,  $du/d\phi < 0$  for any  $\phi$ . Since  $Z > S_0$  it follows that those who lose their jobs and close the job position as a result of  $\phi$  going down are worse off, too. Then the net result of a marginal reduction in the firing tax on welfare is unambiguously negative when labor market frictions are high to start with. ■

**Proof of Lemma 4:** Assume that the following hold:  $H''(\cdot) < [1 + H'(\cdot)][2 + H'(\cdot)]/H(\cdot)$  for all  $\gamma$  and that  $K''(\cdot) > [1 - K'(\cdot)]K'(\cdot)/K(\cdot)$  for all  $\rho$ . Next, consider

$$\begin{aligned} \frac{d^2Z}{dS^2} = & \left[ 1 - \frac{dZ}{dS} \right] \frac{\delta\lambda}{2(1 - \delta(1 - \lambda m))} \times \\ & \left[ \int_{\rho \in P} \left\{ \frac{H(\tilde{\gamma})H''(\tilde{\gamma})}{(1 + H'(\tilde{\gamma}))^2} - \frac{2 + H'(\tilde{\gamma})}{1 + H'(\tilde{\gamma})} \right\} \frac{d\tilde{\gamma}}{dS} g(\tilde{\gamma}) dF(\rho) \right. \\ & \left. + \int_{\gamma \in \Gamma} \left\{ \frac{K(\tilde{\rho})K''(\tilde{\rho})}{(1 - K'(\tilde{\rho}))^2} - \frac{K'(\tilde{\rho})}{1 - K'(\tilde{\rho})} \right\} \frac{d\tilde{\rho}}{dS} f(\tilde{\rho}) dG(\gamma) \right]. \end{aligned}$$

Since  $dZ/dS < 1$ ,  $d\tilde{\gamma}/dS < 0$  and  $d\tilde{\rho}/dS > 0$ , we have that  $Z$  is convex in  $S$  for all  $S$  as long as  $H''(\gamma)$  and  $K''(\rho)$  obey the restrictions above. ■

**Proof of Proposition 5:** We first argue that  $Z$  is quasi-convex in  $R$ . To see this note first that  $Z$  depends on  $R$  only through  $S$ . Thus,  $dZ/dR = (\partial Z/\partial S)(dS/dR)$ . Next note that a change in  $\phi$  has the same effect on  $S$  as a change in  $R$ , i.e.  $dS/d\phi = dS/dR$ . Since we have shown in Lemma 2 that  $dS/d\phi < 0$  it follows that  $dS/dR < 0$ . Thus,  $dZ/dR = 0$  if and only if  $\partial Z/\partial S = 0$ . This, in turn, implies that at any  $R$  for which  $dZ/dR = 0$ , the second derivative is given by  $d^2Z/dR^2 = (\partial^2 Z/\partial S^2)(dS/dR)^2 > 0$ ,

where the inequality follows from the convexity of  $Z$  in  $S$  (by Lemma 4). Thus, any interior extremum of  $Z$  is a minimum so that  $Z$  is quasi-convex in  $R$ .

Since  $Z$  is quasi-convex in  $R$  it can only be maximized by either  $R = 0$  or  $R = \bar{R}$ . Let  $\Omega(R)$  be the equilibrium value of  $Z$  when the self-imposed rigidities take the value  $R$ . Then,  $R = \bar{R}$  is optimal if and only if  $\Omega(\bar{R}) - \Omega(0) \geq 0$  and  $R = 0$  is optimal otherwise.

To show the first part of the proposition, namely that there exists a unique  $\hat{\phi}(p)$  such that  $R = \bar{R}$  is optimal if  $\phi \geq \hat{\phi}(a, p)$  and  $R = 0$  is optimal otherwise, we only need to show that if  $\Omega(\bar{R}) - \Omega(0) = 0$ , then  $\Omega(\bar{R}) - \Omega(0)$  is increasing in  $\phi$ . To see that this is indeed the case note first that

$$\left. \frac{d(\Omega(\bar{R}) - \Omega(0))}{d\phi} \right|_{\Omega(\bar{R}) - \Omega(0) = 0} = \frac{\partial \Omega(\bar{R})}{\partial S} \frac{dS(\bar{R})}{d\phi} - \frac{\partial \Omega(0)}{\partial S} \frac{dS(0)}{d\phi}. \quad (\text{A10})$$

Note next that because  $\Omega(R)$  is quasi-convex in  $R$ , it must be the case that if  $\Omega(\bar{R}) - \Omega(0) = 0$ , then

$$\frac{d\Omega(\bar{R})}{dR} = \frac{\partial \Omega(\bar{R})}{\partial S} \frac{dS(\bar{R})}{dR} > 0 \quad \text{and} \quad \frac{d\Omega(0)}{dR} = \frac{\partial \Omega(0)}{\partial S} \frac{dS(0)}{dR} < 0.$$

Since, as shown above,  $dS/dR < 0$  for all  $R$ , it follows that  $\partial \Omega(\bar{R})/\partial S < 0$  and  $\partial \Omega(0)/\partial S > 0$  if  $\Omega(\bar{R}) - \Omega(0) = 0$ . This, together with the observation that  $dS/d\phi < 0$  for all  $R$ , implies that the expression in (A10) is positive, which proves our claim.

Finally, to see that  $\hat{\phi}(a, p)$  is increasing in  $a$  we only need to show that if  $\Omega(\bar{R}) - \Omega(0) = 0$ , then  $\Omega(\bar{R}) - \Omega(0)$  is decreasing in  $a$ . To see that this is indeed the case note that

$$\left. \frac{d(\Omega(\bar{R}) - \Omega(0))}{da} \right|_{\Omega(\bar{R}) - \Omega(0) = 0} = \frac{\partial \Omega(\bar{R})}{\partial S} \frac{dS(\bar{R})}{da} - \frac{\partial \Omega(0)}{\partial S} \frac{dS(0)}{da}. \quad (\text{A11})$$

We have just shown that if  $(\Omega(\bar{R}) - \Phi(0)) = 0$ , then  $\partial \Omega(\bar{R})/\partial S < 0$  and  $\partial \Omega(0)/\partial S > 0$ . This, together with the observation that  $dS/da > 0$  for all  $R$ , implies that the expression

in (A11) is negative if  $(\Omega(\bar{R}) - \Omega(0)) = 0$ . The comparative statics for  $p$  can be shown in a similar manner. ■

## A2 Efficient Bargaining

In this section we analyze the model described in Section 6. Most of the analysis in Section 4.1. still goes through. In particular,  $W_0$  is still given by (1) and  $J_0$  is still given by (2). The expected utility  $W_1$  of a worker who formed an employment relationship in the past and has not yet been hit by the shock is given by (4) and the corresponding expected value of a firm  $J_1$  is given by (5). Since we are assuming that the shock only hits once, we must now also specify the expected utility of an employed worker after a shock has hit,  $W_2$ , and the value of a firm with a filled vacancy after a shock has hit,  $J_2$ . These values are given by respectively by (4) and (5) for  $\lambda = 0$ , in which case  $Z = p/(1 - \delta)$  by (7).

Next, we need to reconsider the analysis in Section 4.2. To describe the bargaining solution of the bargaining game that takes place when a firm and a worker have been hit by a shock, we can apply the Revelation Principle which allows us to restrict the analysis, without loss of generality, to Bayesian incentive compatible direct mechanisms. Suppose then that, after having learned  $\rho$  and  $\gamma$ , the firm and the worker make announcements  $\hat{\rho}$  and  $\hat{\gamma}$ . A direct mechanism specifies the probability of trade  $q(\hat{\gamma}, \hat{\rho})$  and expected adjustment bonus  $\beta(\hat{\gamma}, \hat{\rho})$  as a function of these announcements. The bargaining game maximizes the match value subject to the interim participation constraints. Thus, it is described by the solution to

$$\max_{q(\cdot), \beta(\cdot)} Z^e = S + E_{\gamma, p} [(\rho - \gamma + W_2 + J_2 - S) q(\gamma, \rho)] \quad (\text{A12})$$

subject to the interim participation and incentive compatibility constraints, where  $Z_2 \equiv$

$(W_2 + J_2)$ .<sup>21</sup> Note that  $Z_2$  and  $S$  do not depend on  $\gamma$  and  $\rho$  and can therefore be treated as constants. The following lemma follows immediately from Myerson and Satterthwaite (1983) and describes the optimal trading rule that solves the maximization problem (A12).

**Lemma A2** *The optimal trading rule that solves maximization problem (A12) is given by*

$$q(\gamma, \rho) = \begin{cases} 1 & \text{if } p - \gamma + Z_2 - S \geq \frac{\mu}{1+\mu} (H(\gamma) + K(\rho)) \\ 0 & \text{otherwise,} \end{cases}$$

where  $\mu \in [0, \infty)$ . For  $S - Z_2 \leq \inf P - \sup \Gamma$ ,  $\mu = 0$  and for  $S - Z_2 > \inf P - \sup \Gamma$ ,  $\mu > 0$  solves the interim participation constraint

$$E_{\gamma, \rho} [(\rho - \gamma + Z_2 - S - K(\rho) - H(\gamma)) q(\gamma, \rho)] = 0. \quad (\text{IR})$$

**Proof:** This lemma follows immediately from Myerson and Satterthwaite (1983) and we refer to their analysis. ■

Thus, even if the firm and the worker play the most efficient bargaining game, bargaining is inefficient if  $S - Z_2 > \inf P - \sup \Gamma$ . Essentially, as long as continuation of the employment relationship is not optimal for all  $\rho$  and  $\gamma$ , the firm and the worker sometimes separate although it would be efficient for them to continue the employment relationship.

Having described the bargaining game at the renegotiation stage, we can proceed and close the model by solving for  $U$  and  $V$  as in Section 4.3. The equations (16) - (18) still hold and we can use them to show the existence and uniqueness of the equilibrium of the model.

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<sup>21</sup>The incentive compatibility constraints ensure that each manager finds it optimal to make truthful announcements of his or her type and the interim individual rationality constraints ensure that, after learning their type, the agents prefer participating in the bargaining game to realizing the disagreement payoffs.

**Proposition A1 (Equilibrium)** *The equilibrium of the model exists and is unique.*

**Proof:** The proof is similar to that in Proposition 1. We only need to show that with the different bargaining that we now assume it is still the case that  $dZ/dS < 1$  as shown in Lemma 1. We can use Lemma A3 and (7) and apply the envelope theorem to get

$$\frac{dZ}{dS_0} = \frac{\delta\lambda}{1 - \delta(1 - \lambda)} \{(1 - E_{\gamma,p}[q(\gamma, \rho)]) - \mu E_{\gamma,p}[q(\gamma, \rho)]\} \leq 1. \quad (\text{A13})$$

For the rest of the proof we refer to the proof of Proposition 1. ■

Next we need to reconsider the analysis in Sections 4.4. Lemma 2 still goes through since its proof does not depend on the assumed bargaining game; indeed, the key step in that lemma requires  $dZ/dS$  to be smaller than unity, which holds by (A13). Thus, it is still the case that a reduction in the firing tax increases  $S$  and therefore makes it less costly for firms and workers to separate. The effect of such a reduction on  $Z$  is also the same as in the main model. In particular, on the one hand, a reduction in the firing tax makes it less costly for firms and workers to separate, which tends to increase  $Z$ , but on the other hand, it also increases the probability of disagreement, which tends to reduce  $Z$ . To see this formally consider (A13). The first term in the squared brackets represents the positive effect of a marginal increase in  $S$ : the firm and the worker realize a higher payoff whenever they disagree, which happens with probability  $(1 - E_{\gamma,p}[q(\gamma, \rho)])$ . The second term represents the costs of a marginal increase in  $S$ : the probability of agreement is reduced since the participation constraint is more binding.

In contrast to the main model, we can no longer characterize analytically when either of the two effects dominates for general distributions. In other words, we can no longer prove something as general as Lemma 3. We can, however, show that for a number of common distributions our key results still hold.

**Lemma A3** *Suppose that the distributions of  $\gamma$  and  $\rho$  are either the standard normal, standard exponential, or standard uniform distributions. Then  $Z$  is quasi-convex in  $S$ , has an interior minimum, and reaches its global maximum as  $S$  goes towards its upper limit.*

**Proof:** This follows from Proposition 3 and Footnote 17 in Matouschek (2004). ■

For these common distributions all the results in Sections 4.4 and 5 then continue to hold. In particular, the proofs of Propositions 2 - 5 still go through.

Finally, we turn to the numerical example described in Section 6. Note first that for this example  $Z_2 = 1$ . It then follows from Lemma A3 that a firm-worker pair that is hit by a shock continues its relationship with probability

$$q(\gamma, \rho) = \begin{cases} 1 & \text{if } p - \gamma \geq \frac{1+\mu}{1+2\mu} (S_0 - \phi - 1) + \frac{\mu}{1+2\mu} \\ 0 & \text{otherwise,} \end{cases} \quad (\text{A14})$$

where  $\mu \in [0, \infty)$ . For  $(S_0 - \phi - 1) \leq -1$ ,  $\mu = 0$  and for  $(S_0 - \phi - 1) > -1$ ,  $\mu > 0$  solves the interim participation constraint

$$E_{\gamma, \rho} [(2(\rho - \gamma) + S_0 - \phi - 2) q(\gamma, \rho)] = 0. \quad (\text{A15})$$

Substituting  $Z^e = \{S + E_{\gamma, \rho} [(\rho - \gamma + 1 - S) q(\gamma, \rho)]\}$  into (7) gives

$$Z = \frac{p + \lambda \delta \{S + E_{\gamma, \rho} [(\rho - \gamma + 1 - S) q(\gamma, \rho)]\}}{1 - \delta(1 - \lambda)}. \quad (\text{A16})$$

We can use equations (18) and (A14) - (A16) to solve for  $\mu$ ,  $S_0$  and  $Z$ . Equations (1) - (5) can then be used to solve for  $W_0$ ,  $J_0$ ,  $W_1$  and  $J_1$ . Finally, equations (16) and (17) give  $U$  and  $V$ .

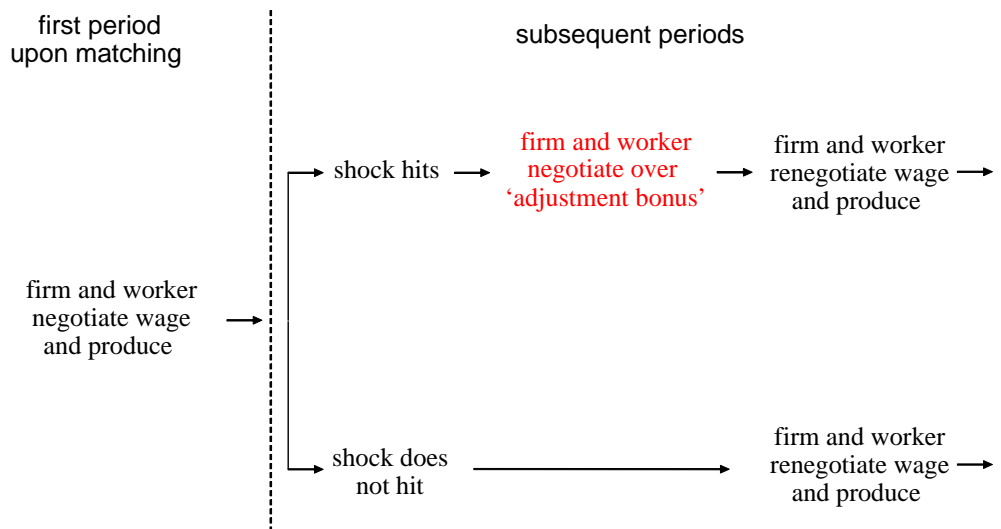


Figure 1: Timing

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