Optimal Severance Pay in a Matching Model*

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Abstract

This paper constructs an equilibrium matching model with risk-averse workers and incomplete markets that can be used to study both the optimal private provision of severance pay and the allocational and welfare consequences of government intervention mandating payments in excess of the private optimum. A binding mandate decreases equilibrium employment if unemployment benefits are not too responsive to wages, and increases it otherwise. In the latter case, the increase in employment can be substantial for values of the unemployment benefit replacement rate at the upper end of its range in OECD countries.

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1 Introduction

Employment contracts often contain explicit severance pay provisions.[1] Indeed, in many countries minimum levels of severance pay and other forms of employment protection are enshrined in legislation. This is difficult to understand in the context of standard labour market models in which homogeneous workers maximise expected labour income and wages are perfectly flexible.[2] As observed by Lazear (1990), employment protection measures have no useful role in such a setting, and there is no reason why a firm taking aggregate quantities as given would offer them. Thus, as Pissarides (2001) concludes, "much of the debate about employment protection has been conducted within a framework that is not suitable for a proper evaluation of its role in modern labour markets."

The primary contribution of this paper is to construct a model that can be used to study both the optimal private provision of one form of employment protection, namely severance pay, and the allocational and welfare consequences of government intervention mandating payments that exceed the private optimum. We accomplish this by extending the matching model of Mortensen and Pissarides (1994) to allow for risk-averse workers, incomplete asset markets, and bargaining over contracts rather than the spot wage. Our contracts feature a fixed wage together with a severance payment that can be renegotiated by mutual consent at the time of separation. The only available asset is a risk-free bond tradable without restriction. As in the Mortensen-Pissarides model workers face several sources of risk: Idiosyncratic productivity shocks create wage and job-loss risks, while the uncertain duration of unemployment spells amounts to *re-employment risk*.

The paper's main results can be summarized as follows. First, optimal severance payments insure against job-loss risk. They are positive whenever market wages exceed workers' reservation wages, so that job loss is costly, and their size is bounded below by

[1] For the US, Bishow and Parsons (2004) document that, over the period 1980–2001, roughly 40 per cent of workers in establishments with more than 100 employees, plus 20 per cent in smaller businesses, were covered by severance payment clauses. For the UK, the 1990 *Workplace Industrial Relations Survey* reveals that 51 per cent of union companies bargained over the size of (non-statutory) severance pay for non-manual workers and 42 per cent for manual workers (see Millward et al. 1992). For Spain — a country usually thought of as having high levels of state-mandated employment protection — Lorences et al. (1995) document that, over the period 1978–1991, the proportion of collective bargaining agreements establishing severance pay in excess of the legislated minimum varied between 8 and 18 per cent in the metal manufacturing sector and between 22 and 100 per cent in the construction sector.

[2] See Fella (2005) for a model with heterogeneous workers in which consensual termination restrictions increase firms' investment in the general training of unskilled workers.

the fall in permanent income associated with job loss. Second, mandated severance pay above the privately-optimal level increases both the volume and duration of equilibrium unemployment if unemployment benefits are not too responsive to wages, and otherwise reduces them. In general, the quantitative allocational and welfare consequences of even large mandated severance pay minima are small. However, if unemployment benefits are proportional to wages with a replacement rate at the upper end of its range in OECD countries, mandated minima can substantially reduce unemployment and increase both efficiency and workers' welfare.

Intuitively, mandated severance pay minima overinsure workers against job loss (relative to laissez faire) and induce a fall in wages to reestablish ex-ante profitability. These two effects increase income fluctuations and the cost to firms of providing a given level of utility to new hires. Fixing such a utility level, mandated minima thus reduce job creation and increase unemployment. This partial-equilibrium insight carries over to general equilibrium if unemployment benefits are not too responsive to wages and the utility of new hires in equilibrium does not fall too much as a result of government intervention. On the other hand, if unemployment benefits respond strongly to wages — for example, if they are proportional with a replacement rate above 0.5 — then the fall in benefits resulting from the fall in wages reduces the threat point and equilibrium utility of new hires by so much that firms' profits increase. In such cases the government intervention leads to more job creation and higher employment. When the replacement rate is above 0.8, the increase in employment can be significant for mandated severance payments that are large in comparison to the private optimum.

The quantitative effects of mandated severance payments are generally small because such mandates simply determine the *maximum* transfer in the event of separation. In equilibrium, the legislated payment is made only if productivity is so low that the firm cannot credibly threaten to continue the match at the contracted wage. If the productivity realization is not this low, but is nevertheless below the jointly optimal reservation value, the parties agree to label the separation a quit and to exchange a lower payment ensuring that separation Pareto dominates continuation. Since the mandated payment is renegotiated when the marginal job is destroyed, it has only a minor, general equilibrium impact on the reservation productivity and the job destruction rate. Job creation is also little affected, since the contractual wage falls to rebalance the parties' respective shares of the surplus from a new match. The model thus implies that factors which increase workers' rents or unemployment duration — such as high workers' bargaining power, high costs of posting vacancies, or low matching efficiency — increase the permanent income fall associated with job loss and lead to higher severance pay. And for the same reason, severance pay is negatively related to the level of unemployment benefits.

Government mandates are generally welfare-reducing in our model because optimal private contracts already provide full insurance against wage and job-loss risks under laissez faire. Indeed, mandates interfere with this mechanism by overinsuring workers against job loss, though the welfare loss is small since the contract adjusts in response. Government intervention increases workers' welfare only when unemployment benefits are proportional to wages with a replacement rate above 0.7, and furthermore the unemployment rate is inefficiently low under laissez faire. In this case the increase in net output and the fall in taxes more than compensate workers for the overinsurance.

Formally, the two key features of our model are (i) simple, explicit contracts, and (ii) renegotiation by mutual consent.

Feature (i) rules out time- or state-dependent transfers other than severance payments, and ensures that government mandates are a priori non-neutral. If firms are insensitive to risk, broadening the space of contracts would increase the extent to which they can substitute for complete insurance markets, and therefore the neutrality of mandates.

Whereas feature (i) favours non-neutrality of mandates, feature (ii) imposes the natural, joint-rationality constraint that the firm and worker do not deliberately leave money on the table. Renegotiation allows the parties to circumvent legislation if there are gains from doing so, but only by means of spot payments at the time of separation. Since these ex-post payments are state-dependent, insurance may be imperfect and binding severance pay mandates are a priori non-neutral. But as it turns out, the force of ex-post efficiency prevails and leads to near-neutrality of mandates.

This paper is related to several others in the literature. In contrast to Lazear (1990), we provide microfoundations for the non-neutrality of legislated employment protection measures relating to risk aversion of workers and incomplete contracting, rather than to wasteful firing taxes.[3] Both Alvarez and Veracierto (2001) and Bertola (2004) find that mandated severance payments can improve welfare and efficiency in dynamic models with search frictions and risk-averse workers, though neither paper allows for optimal private contracts. Finally, Pissarides (2004) shows in a partial equilibrium setting that optimal private contracts feature severance pay and (possibly) advance notice.[4]

The remainder of the paper is structured as follows. Section 2 describes the economic environment, while Section 3 proceeds to study the renegotiation game and the value and policy functions. Section 4 characterizes the equilibrium of the model and derives a number of analytical results. Section 5 calibrates the model and assesses its quantitative implications. Section 6 discusses several of our assumptions and offers some concluding comments. All proofs are in the Appendix.

2 Model

2.1 Workers and firms

Time is continuous and the horizon infinite. The economy contains a unit mass of workers, each with an indivisible unit of labour, together with an endogenous mass of (active or inactive) firms that each require one worker to produce. Workers are risk averse, firms are risk neutral, and both have infinite lifespans.

Firms maximize the expected present value of profits discounted at the exogenous, riskfree rate $r > 0$. At a given time t, a worker maximizes the objective function

$$\mathcal{U}_t := \mathbb{E}_t \int_t^\infty e^{-\phi[\xi - t]} U(c_\xi) d\xi, \tag{1}$$

where $\mathbb{E}_t$ is the expectation operator, $\phi > 0$ is the subjective discount rate, U is the felicity function, and c_ξ is consumption at time ξ. While there are no insurance markets,

[3] Garibaldi and Violante (2005) and Fella (2007*b*) argue that firing taxes are unlikely to be quantitatively important.

[4] A related literature studies the optimal size and time path of unemployment benefits in search and matching models with risk-averse workers. See, in particular: Cahuc and Lehmann (2000), Fredriksson and Holmlund (2001), Coles and Masters (2006), and Shimer and Werning (2007). Acemoglu and Shimer (1999) show that unemployment benefits increase efficiency and welfare (relative to laissez faire) in a directed search model without job loss. And Blanchard and Tirole (2008) study the optimal financing of benefits by means of layoff taxes.

the worker can self-insure by borrowing and lending at the rate r. Denoting the stock of assets by a_ξ, its rate of change (i.e., savings) by s_ξ, and income by i_ξ, the maximization of $\mathcal{U}_t$ is thus subject to the dynamic budget identity $s_\xi = ra_\xi + i_\xi - c_\xi$.[5] To eliminate wealth effects we adopt the CARA specification $U(c) = -e^{-\alpha c}$ for felicity, where $\alpha > 0$. Moreover, we set $\phi = r$, so that under complete markets each worker would choose a flat consumption profile.

Unemployed workers and inactive firms meet via a random matching process governed by a strictly concave function M. More precisely, if u represents the mass of unemployed workers and v the mass of vacancies, $M(u, v)$ is the flow of new matches. Defining market tightness $\theta := v/u$ and assuming that the matching technology exhibits constant returns, we have the contact rates $M(u, v)/u = M(1, \theta) =: p(\theta)$ for unemployed workers and $M(u, v)/v = M(1/\theta, 1) =: q(\theta)$ for vacancies. Firms can open vacancies freely, but each entails a flow cost of $m > 0$.

When a worker and firm meet at some time t, the newly-formed match has productivity $y = 1$. At $\xi > t$ this variable is subject to Poisson shocks at rate $\lambda > 0$, with the new values i.i.d. according to a continuous distribution G with support $[y_l, 1]$.[6] Unemployed workers receive a flow $b < 1$ of benefits financed as in Acemoglu and Shimer (1999) by an endogenous, lump-sum tax τ. The benefit program runs a balanced budget at all times.

2.2 Contracts and renegotiation

When a new match is formed the participants negotiate a long-term contract $\sigma = \langle w, F \rangle$, where w is the wage and F the severance payment in the event of a layoff. Featuring simple, state-independent terms, this type of agreement is broadly consistent with observed labour contracts.[7] We assume that the chosen σ is efficient ex ante (i.e., for $y = 1$), and more specifically — in line with the matching literature — that this contract arises from

[5]The worker's consumption plan must also satisfy the no-Ponzi-game condition $\lim_{\xi \to \infty} e^{-r\xi} a_\xi \geq 0$ almost surely.

[6]The assumption that new matches are maximally productive is without loss of generality: What matters is that they have positive surplus.

[7]Proposition 4 will show that even our very simple contracts can deliver full insurance when severance payments are unconstrained. Provided actual contracts are no less flexible, our findings will yield an upper bound on the welfare and efficiency costs of government intervention. (Section 6 discusses the implications of broadening the space of contracts.)

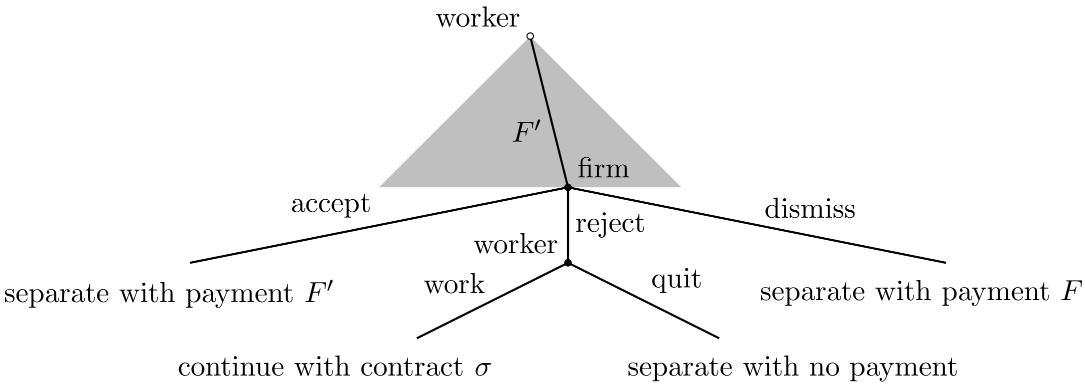

Figure 1: The renegotiation game following a productivity shock, with prevailing contract $\sigma = \langle w, F \rangle$. The worker makes a new severance offer F', after which the firm can accept, reject and propose continuation, or dismiss the worker and pay F. If the firm proposes continuation, then the worker must either return to work or quit and receive no payment.

the Nash bargaining solution with weight $\gamma \in [0, 1)$ on the worker's gain.[8]

Ex post (i.e., for $y < 1$) the agreed contract σ may no longer be efficient, and the two parties are free to reach a new agreement to capture additional surplus. For simplicity we model only the option to adjust the severance payment, since this is what is important for determining the impact of a government mandate.[9]

The renegotiation game is depicted schematically in Figure 1. After a productivity shock, a worker employed under contract $\sigma = \langle w, F \rangle$ makes a new severance offer F'. The firm can accept this offer, reject it and propose that things continue as before, or dismiss the worker outright and make the contractual payment F. Continuation requires the consent of the worker, whose other option is to quit and receive no payment.[10]

Crucially, it is assumed that when separation occurs payments are contingent on which party takes verifiable steps to end the relationship. A separation is deemed a dismissal,

[8]Note that the proof of Rudanko's (2009) Proposition 6 can be adapted to show that in our setting the result of Nash bargaining coincides with that of competitive search when γ equals the elasticity of the probability that a vacancy is filled (see Hosios 1990).

[9]A more elaborate model of renegotiation, allowing changes to the wage as well as the severance payment, is considered in an earlier version of this paper (see Fella 2007*a*). This extra freedom affects neither the equilibrium path nor the resulting payoffs. And in any event artificial constraints on renegotiation can only strengthen findings of (near-)neutrality.

[10]The outcome of this procedure is identical to that of a renegotiation game (analyzed in Fella 2007*a*) in which the worker makes offers repeatedly after vanishingly-small time intervals. Observe also that giving all bargaining power to the worker at the renegotiation stage increases the welfare cost of government intervention by making the (renegotiated) severance payment fluctuate with the productivity of the match (see Section A.2). This is consistent with our aim of bounding the welfare cost from above.

and the worker is entitled to the contractual severance payment, if the firm gives written notice that the worker's services are no longer required. On the other hand, a separation is deemed a quit, and no payment is due, if the worker gives written notice that he or she no longer intends to continue in employment (or simply stops showing up for work without obtaining leave). Any claim by one party that the other has unilaterally severed the relationship must be supported by documentation. This accords with existing practices in most industrialized countries.

We allow for the possibility that the government mandates a minimum severance payment F_m. Such a mandate imposes the constraint $F \geq F_m$ on the determination (by means of the Nash bargaining solution) of the initial contract $\sigma = \langle w, F \rangle$, since a term breaching legislation would not be enforceable in court. But while this is a non-negligible restriction on ex-ante contracting, it does not prevent a firm-worker pair from replacing the contractual payment F by mutual consent with a spot payment $F' < F_m$ upon separation. Indeed, the parties can achieve this outcome in two equivalent ways: They can agree to call the separation a quit (or "voluntary redundancy") rather than a dismissal, in which case transfers between them are unconstrained by legislation. Alternatively, they can describe the separation as a layoff, with the worker rebating to the firm, on the spot, the difference $F - F' > 0$.

3 Analysis

3.1 Renegotiation and job destruction

To analyze the model we shall restrict attention to stationary equilibria and proceed by backward induction. Recalling that y denotes the productivity of a match, $\sigma = \langle w, F \rangle$ the prevailing contract, and a the stock of assets, let us indicate payoffs by $W^{\mathrm{e}}(\sigma, a)$ for an employed worker, $J^{\mathrm{e}}(y, \sigma, a)$ for a producing firm, $W^{\mathrm{u}}(a)$ for an unemployed worker, and V for a firm advertising a vacancy.[11] Since there is free entry by firms we can conclude that $V = 0$ in equilibrium, and to simplify the analysis we impose this condition from the outset. Taking the remaining continuation value mappings as given, our first goal is

[11]To streamline notation we anticipate here that W^{e} will be independent of the match productivity.

to characterize the subgame-perfect equilibrium outcomes of the game in Figure 1. This will yield the payoffs $W^{\mathrm{r}}(y', \sigma, a)$ to the worker and $J^{\mathrm{r}}(y', \sigma, a)$ to the firm *after* a shock (realizing new productivity y') but *before* renegotiation.

Backward induction analysis of the renegotiation game establishes the following result.

Proposition 1. *Given $\langle y', \sigma, a\rangle$, in any subgame-perfect equilibrium of the renegotiation game the payoffs $\langle W^{\mathrm{r}}(y', \sigma, a), J^{\mathrm{r}}(y', \sigma, a)\rangle$ are equal to:*

I. $\langle W^{\mathrm{u}}(a), 0\rangle$ *if* $W^{\mathrm{u}}(a) > W^{\mathrm{e}}(\sigma, a)$;

II. $\langle W^{\mathrm{e}}(\sigma, a), J^{\mathrm{e}}(y', \sigma, a)\rangle$ *if* $W^{\mathrm{u}}(a) < W^{\mathrm{e}}(\sigma, a)$, $J^{\mathrm{e}}(y', \sigma, a) > -F$, *and* $W^{\mathrm{e}}(\sigma, a) > W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a))$;

III. $\langle W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a)), J^{\mathrm{e}}(y', \sigma, a)\rangle$ *if* $W^{\mathrm{u}}(a) < W^{\mathrm{e}}(\sigma, a)$, $J^{\mathrm{e}}(y', \sigma, a) > -F$, *and* $W^{\mathrm{e}}(\sigma, a) < W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a))$;

IV. $\langle W^{\mathrm{u}}(a + F), -F\rangle$ *if* $W^{\mathrm{u}}(a) < W^{\mathrm{e}}(\sigma, a)$ *and* $J^{\mathrm{e}}(y', \sigma, a) < -F$.

The four cases distinguished in Proposition 1 correspond to the four possible outcomes of the renegotiation game in Figure 1. In case I, the worker's outside option is binding and he or she quits. In cases II and III neither party can credibly threaten to unilaterally terminate the match. If the productivity is high enough (case II) then it is optimal to continue the match, so the firm rejects any separation offer and the relationship continues. If the productivity is lower (case III) then the firm accepts the Pareto-improving offer $F' = -J^{\mathrm{e}}(y', \sigma, a)$. In case IV the worker would be willing to continue the match, but the productivity is so low that the firm dismisses and pays F.

To see how the outcome of renegotiation depends on the vector $\langle y', \sigma, a\rangle$ taken as given in Proposition 1, it is useful now to introduce the Hamilton-Jacobi-Bellman equations

$$rW^{\mathrm{e}}(\sigma, a) = \max_c [U(c) + (ra + w - \tau - c)W^{\mathrm{e}}_a(\sigma, a)] + \lambda \left[\int_{y_l}^1 W^{\mathrm{r}}(y', \sigma, a)dG - W^{\mathrm{e}}(\sigma, a)\right] \quad (2)$$

for an employed worker (where $W^{\mathrm{e}}_a(\sigma, a) = \partial W^{\mathrm{e}}(\sigma, a)/\partial a$) and

$$rJ^{\mathrm{e}}(y, \sigma, a) = y - w + \lambda \left[\int_{y_l}^1 J^{\mathrm{r}}(y', \sigma, a)dG - J^{\mathrm{e}}(y, \sigma, a)\right] \quad (3)$$

for a producing firm. The worker's choice of c maximizes the total utility from current consumption and savings — with the shadow price of the latter equal to the marginal value $W^{\mathrm{e}}_a(\sigma, a)$ of wealth — plus the expected gain in utility from a productivity shock.[12] Meanwhile, the flow value of production to the firm equals the profit flow $y - w$ plus the expected capital gain. The match experiences shocks at rate λ, and the integrals in equations (2) and (3) are the expectations over the new productivity realization y' of the corresponding continuation values prior to renegotiation.

Whenever the worker plans to work following a rejection in the renegotiation game (i.e., for cases II–IV in Proposition 1), we have $J^{\mathrm{r}}(y', \sigma, a) = \max\{-F, J^{\mathrm{e}}(y', \sigma, a)\}$. Since also $J^{\mathrm{e}}_y(y, \sigma, a) = [r + \lambda]^{-1} > 0$, for each relevant pair $\langle \sigma, a \rangle$ there exists a unique "layoff threshold" $\bar{y}(\sigma, a)$ that satisfies $J^{\mathrm{e}}(\bar{y}(\sigma, a), \sigma, a) = -F$ and separates case IV from cases II–III.[13] It then follows from equation (3) that

$$J^{\mathrm{e}}(y, \sigma, a) = \frac{y - \bar{y}(\sigma, a)}{r + \lambda} - F \tag{4}$$

for all $y \geq \bar{y}(\sigma, a)$. Substituting for $J^{\mathrm{r}}(y', \sigma, a)$ in equation (3), we obtain

$$rJ^{\mathrm{e}}(y, \sigma, a) = y - w + \lambda \left[\int_{\bar{y}(\sigma,a)}^{1} \frac{y' - \bar{y}(\sigma, a)}{r + \lambda} dG - F - J^{\mathrm{e}}(y, \sigma, a) \right], \tag{5}$$

and setting $y = \bar{y}(\sigma, a)$ yields

$$-rF = \bar{y}(\sigma, a) - w + \lambda \int_{\bar{y}(\sigma,a)}^{1} \frac{y' - \bar{y}(\sigma, a)}{r + \lambda} dG. \tag{6}$$

This relation defines $\bar{y}(\sigma, a)$ implicitly given σ and τ, and since it does not depend on a we can write $\bar{y}(\sigma)$ for the layoff threshold and $J^{\mathrm{e}}(y, \sigma)$ for a producing firm's payoff.

Turning our attention to an employed worker, monotonicity of U will imply that W^{e} is strictly increasing in all its arguments. It follows that for each relevant $\langle F, a \rangle$ there exists a unique reservation wage $\underline{w}(F, a)$ that satisfies $W^{\mathrm{u}}(a) = W^{\mathrm{e}}(\underline{w}(F, a), F, a)$ and separates case I from cases II–IV. Moreover, if W^{u} too is strictly increasing, then for each relevant $\langle \sigma, a \rangle$ there exists a unique reservation productivity $\hat{y}(\sigma, a)$ that satisfies

$$W^{\mathrm{e}}(\sigma, a) = W^{\mathrm{u}}(a - J^{\mathrm{e}}(\hat{y}(\sigma, a), \sigma)) = W^{\mathrm{u}} \left(a + F - \frac{\hat{y}(\sigma, a) - \bar{y}(\sigma)}{r + \lambda} \right) \tag{7}$$

[12] Observe that since these shocks are i.i.d. the function W^{e} is independent of y, as anticipated.

[13] The relevant pairs satisfy $J^{\mathrm{e}}(y_l, \sigma, a) \leq -F \leq J^{\mathrm{e}}(1, \sigma, a)$. Such qualifications are suppressed below.

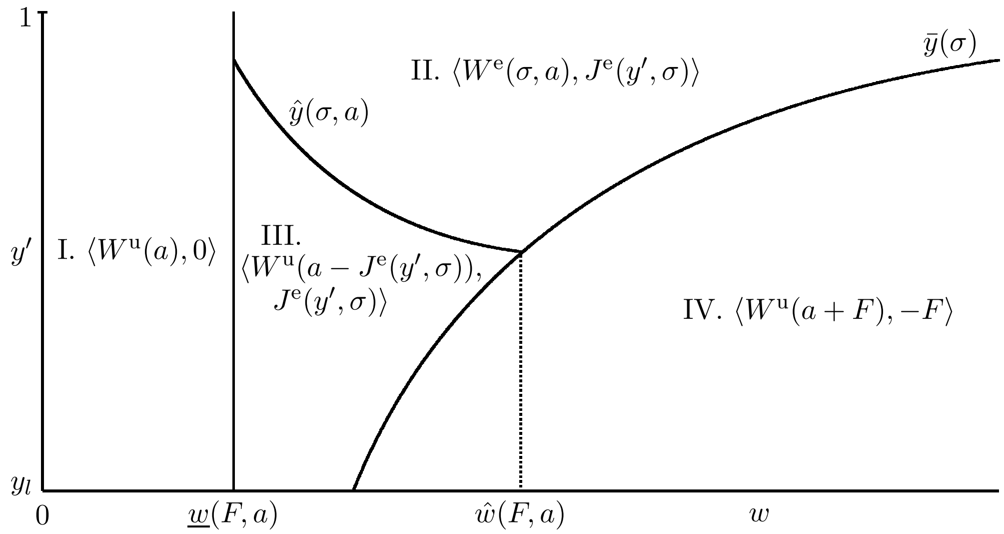

Figure 2: Renegotiation regions and payoffs. Given $\langle F, a\rangle$, Proposition 1 is illustrated in $\langle w, y'\rangle$-space. The worker quits (case I) if his or her wage is below $\underline{w}(F, a)$. The match continues (case II) if productivity exceeds both $\hat{y}(\sigma, a)$ and $\bar{y}(\sigma)$. Renegotiation occurs (case III) if productivity is below $\hat{y}(\sigma, a)$ but above $\bar{y}(\sigma)$. And the firm dismisses (case IV) if productivity is less than $\bar{y}(\sigma)$.

and separates case II from case III.

Given $\langle F, a\rangle$, the above constructions are depicted schematically in Figure 2. Here the contractual wage w is measured on the horizontal axis and the post-shock productivity y' on the vertical axis. Four regions in this space are demarcated by the thresholds $\underline{w}(F, a)$, $\bar{y}(\sigma)$, and $\hat{y}(\sigma, a)$; each corresponding to a case in Proposition 1 and labeled with the associated renegotiation payoffs. Equation (6) implies that $\bar{y}(\sigma)$ is increasing in w, while equation (7) implies that the difference $\hat{y}(\sigma, a) - \bar{y}(\sigma)$ is both positive and decreasing in w as long as $W^{\mathrm{e}}(\sigma, a) > W^{\mathrm{u}}(a + F)$. It follows that there exists a unique wage $\hat{w}(F, a)$ for which $W^{\mathrm{e}}(\hat{w}(F, a), F, a) = W^{\mathrm{u}}(a + F)$ and $\hat{y}(\sigma, a) = \bar{y}(\sigma)$.

As seen in Figure 2, $\underline{w}(F, a)$ is the reservation wage below which the worker quits (case I). When $w > \underline{w}(F, a)$ there are three possibilities: If productivity is sufficiently high the match continues (case II). If productivity is below the layoff threshold $\bar{y}(\sigma)$ the worker is dismissed (case IV). If productivity is above this threshold but below the reservation productivity $\hat{y}(\sigma, a)$, then separation occurs with a renegotiated transfer (case III). Note that for $w \geq \hat{w}(F, a)$ the contractual payment F is never renegotiated.[14] On the other

[14]In such cases the separation is involuntary if $w > \hat{w}(F, a)$ and jointly optimal if $w = \hat{w}(F, a)$.

hand, if $\hat{w}(F,a) > w > \underline{w}(F,a)$ then renegotiation takes place with positive probability.

When the worker's outside option is not binding (i.e., when $W^{\mathrm{e}}(\sigma,a) > W^{\mathrm{u}}(a)$), the above discussion implies that equation (2) can be written as

$$rW^{\mathrm{e}}(\sigma,a) = \max_c [U(c) + (ra + w - \tau - c)W^{\mathrm{e}}_a(\sigma,a)] + \cdots \\ \lambda \int_{y_l}^{y^{\mathrm{d}}(\sigma,a)} [W^{\mathrm{u}}(a + F^{\mathrm{r}}(y',\sigma)) - W^{\mathrm{e}}(\sigma,a)]dG, \quad (8)$$

where

$$y^{\mathrm{d}}(\sigma,a) = \max\{\hat{y}(\sigma,a), \bar{y}(\sigma)\}, \quad (9)$$

$$F^{\mathrm{r}}(y',\sigma) = F - \frac{\max\{y' - \bar{y}(\sigma), 0\}}{r+\lambda}, \quad (10)$$

are the job-destruction threshold and the severance payment after renegotiation.

3.2 The initial contract and outside returns

The initial contract is assumed to arise from Nash bargaining with weight $\gamma \in [0,1)$ on the worker's gain. Given wealth a, and writing the Nash objective function as

$$\Phi(\sigma,a) := [W^{\mathrm{e}}(\sigma,a) - W^{\mathrm{u}}(a)]^{\gamma}[J^{\mathrm{e}}(1,\sigma) - V]^{1-\gamma}, \quad (11)$$

we have that the chosen contract $\sigma^*(a)$ maximizes $\Phi(\sigma,a)$ subject to the participation constraints $W^{\mathrm{e}}(\sigma,a) \geq W^{\mathrm{u}}(a)$ and $J^{\mathrm{e}}(1,\sigma) \geq V = 0$ and the statutory restriction $F \geq F_m$. By assumption there are positive gains from employment, of which each party will receive a non-negative share. Writing λ for the Lagrange multiplier associated with the worker's participation constraint (and noting that the firm's constraint cannot be binding when $\gamma < 1$), the first-order necessary conditions for a maximum are

$$\Phi_w(\sigma^*(a),a) + \lambda W^{\mathrm{e}}_w(\sigma^*(a),a) = 0, \quad (12)$$

$$[F^*(a) - F_m][\Phi_F(\sigma^*(a),a) + \lambda W^{\mathrm{e}}_F(\sigma^*(a),a)] = 0, \quad (13)$$

$$\lambda[W^{\mathrm{e}}(\sigma^*(a),a) - W^{\mathrm{u}}(a)] = 0. \quad (14)$$

Since all new matches lead to employment, the worker's value functions satisfy

$$rW^{\mathrm{u}}(a) = \max_c [U(c) + (ra + b - \tau - c)W_a^{\mathrm{u}}(a)] + p(\theta)[W^{\mathrm{e}}(\sigma^*(a), a) - W^{\mathrm{u}}(a)]. \tag{15}$$

Here the first term on the RHS describes the unemployed worker's consumption-savings choice and the second term is his or her expected gain from finding a job.

While equations (12)–(15) allow the initial contract to depend on a, the CARA specification for felicity ensures that σ^* and a number of other endogenous variables are in fact independent of the worker's wealth.[15] These other variables include the worker's savings policy functions s^{u} and s^{e}, but not the consumption policy functions c^{u} and c^{e}.

Proposition 2. *Given θ and τ:*

A. *The functions σ^*, s^{u}, s^{e}, $\hat{y}$, y^{d}, $\underline{w}$, and $\hat{w}$ are all independent of the worker's wealth. Moreover, $W^{\mathrm{e}}(\sigma^*, a) \geq W^{\mathrm{u}}(a)$ for all asset levels.*

B. *The value functions satisfy*

$$rW^{\mathrm{u}}(a) = U(c^{\mathrm{u}}(a)) = U(ra + b - \tau - s^{\mathrm{u}}), \tag{16}$$

$$rW^{\mathrm{e}}(\sigma, a) = U(c^{\mathrm{e}}(\sigma, a)) = U(ra + w - \tau - s^{\mathrm{e}}(\sigma)). \tag{17}$$

C. *For each σ such that $W^{\mathrm{e}}(\sigma, a) \geq W^{\mathrm{u}}(a)$, the job-destruction threshold is given by*

$$y^{\mathrm{d}}(\sigma) = \bar{y}(\sigma) + \frac{r + \lambda}{r} \max\{c^{\mathrm{u}}(F) - c^{\mathrm{e}}(\sigma, 0), 0\}. \tag{18}$$

D. *The savings policy functions satisfy*

$$rs^{\mathrm{u}} = \frac{p(\theta)}{\alpha} \left[\frac{U'(c^{\mathrm{e}}(\sigma^*, 0))}{U'(c^{\mathrm{u}}(0))} - 1 \right], \tag{19}$$

$$rs^{\mathrm{e}}(\sigma) = \frac{\lambda}{\alpha} \int_{y_l}^{y^{\mathrm{d}}(\sigma)} \left[\frac{U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma)))}{U'(c^{\mathrm{e}}(\sigma, 0))} - 1 \right] dG. \tag{20}$$

Equations (16)–(17) show that consumption has a permanent-income form with savings independent of asset holdings. Equations (19)–(20) highlight that, with the discount

[15] If this were not the case, the state space would include the wealth distribution.

and interest rates equal, saving is driven entirely by a precautionary motive. For unemployed workers, savings is negative if consumption increases upon re-employment, since workers self-insure against this risk by running down their assets. For employed workers, savings is negative if consumption increases upon job loss due to overinsurance.

Finally, since the agreed contract σ^* does not depend on the worker's wealth, the value $J^{\mathrm{e}}(1, \sigma^*, a)$ of a new job to the employer is also independent of a. In consequence the Bellman equation for the value of a vacancy takes the form

$$rV = -m + q(\theta)[J^{\mathrm{e}}(1, \sigma^*) - V]. \tag{21}$$

Free entry implies $V = 0$, and using equation (4) we obtain the job-creation relation

$$\frac{m}{q(\theta)} = \frac{1 - \bar{y}(\sigma^*)}{r + \lambda} - F^*. \tag{22}$$

3.3 Steady-state conditions

Closing the model requires steady-state conditions for unemployment and the government budget. The unemployment condition mandates balanced flows of workers into and out of jobs. Recalling that u is the mass of unemployed workers, this can be expressed as

$$\lambda G(y^{\mathrm{d}}(\sigma^*))[1 - u] = p(\theta)u. \tag{23}$$

And to balance the government budget we impose equality

$$\tau = bu \tag{24}$$

of tax revenues received and unemployment benefits paid.

4 Equilibrium

4.1 Definition

A stationary equilibrium of our model can now be defined formally as follows.

Definition. *Given* $\langle b, F_m \rangle$*, a* stationary equilibrium *consists of value functions* W^{e}*,* W^{u}*,* J^{e}*, and* $V = 0$*; policy functions* s^{u}*,* s^{e}*,* c^{u}*, and* c^{e}*; renegotiation decision rules* $\bar{y}$*,* y^{d}*, and* F^{r}*; and unemployment and tax variables* u*,* θ*, and* τ*; together with a contract* $\sigma^* = \langle w^*, F^* \rangle$*; jointly satisfying*

- *the Bellman equations* (4), (8)*, and* (15)*;*
- *the threshold equations* (6) *and* (18) *and renegotiation equation* (10)*;*
- *the consumption equations* (16)–(17) *and savings equations* (19)–(20)*;*
- *the job-creation equation* (22) *and steady-state conditions* (23)–(24)*; and*
- *the first-order conditions* (12) *and* (14)*, together with either*

$$F^* > F_m \text{ and } \Phi_F(\sigma^*, 0) + \lambda W^{\mathrm{e}}_F(\sigma^*, 0) = 0 \text{ (laissez-faire } equilibrium\text{), or}$$

$$F^* = F_m \text{ and } \Phi_F(\sigma^*, 0) + \lambda W^{\mathrm{e}}_F(\sigma^*, 0) < 0 \text{ (binding-constraint } equilibrium\text{).}$$

From equations (16)–(17) we have that consumption rises upon the worker finding a job, and employed workers enjoy positive quasi-rents, if and only if $\gamma > 0$. In such cases unemployed workers face re-employment risk and run down their savings according to equation (19) to (partially) self-insure against it. Hence we have the following.

Proposition 3. *In either a laissez-faire or binding-constraint equilibrium we have* $s^{\mathrm{u}} \leq 0$*, with equality if and only if* $\gamma = 0$*.*

4.2 Laissez-faire equilibrium

In this section we study the privately-optimal contract without government intervention. Our findings here will be valid whenever the mandated minimum F_m is smaller than its privately-optimal counterpart.

The following lemma establishes a property of all contracts that satisfy the worker's participation constraint.

Lemma 1. *Given* σ *such that* $W^{\mathrm{e}}(\sigma, 0) \geq W^{\mathrm{u}}(0)$*, the quantities* $w - b + s^{\mathrm{u}} - rF$*,* $s^{\mathrm{e}}(\sigma)$*, and* $c^{\mathrm{e}}(\sigma, 0) - c^{\mathrm{u}}(F)$ *all have the same sign.*

This result is important for two reasons. Firstly, it characterizes (in terms of savings and consumption behavior) the set $\{\langle \hat{w}(F), F\rangle : rF = \hat{w}(F) - b + s^{\mathrm{u}}\}$ of contracts such that both (i) the worker is indifferent between continued employment at wage $\hat{w}(F)$ and separation with payment F, and (ii) the severance payment is never renegotiated for any productivity realization. Secondly, since by equations (16)–(17) and the CARA form of U the worker's value function is proportional to marginal utility, such contracts provide full insurance against job-loss risk by ensuring that $c^{\mathrm{e}}(\hat{w}(F), F, 0) = c^{\mathrm{u}}(F)$.[16]

If $rF > w - b + s^{\mathrm{u}}$, then $c^{\mathrm{u}}(F) > c^{\mathrm{e}}(\sigma, 0)$ and the worker strictly prefers separation with the contractual severance payment to working at the contractual wage. It follows from equations (10) and (18) that the marginal worker finds it optimal to separate with a renegotiated payment. And since separation is voluntary, consumption increases upon job loss for all infra-marginal separations — the worker is over-insured — and borrowing is used (i.e., $s^{\mathrm{e}}(\sigma) < 0$) to smooth consumption.

On the other hand, if $rF < w - b + s^{\mathrm{u}}$ then $c^{\mathrm{u}}(F) < c^{\mathrm{e}}(\sigma, 0)$ and the worker strictly prefers continuation to separation. Being underinsured against job loss by the contract, he or she thus saves to self-insure (i.e., $s^{\mathrm{e}}(\sigma) > 0$) and it follows from equations (10) and (18) that the firm dismisses the worker.[17]

Given that contracts with full insurance against job loss exist, it should not be surprising that the initial contract agreed by the firm and worker has this property.

Proposition 4. *If F is unconstrained, then $\sigma^* = \langle w^*, F^*\rangle$ is uniquely determined and satisfies $rF^* = \hat{w}(F^*) - b + s^{\mathrm{u}} = w^* - b + s^{\mathrm{u}}$.*

While the initial contract provides full insurance against job loss, Proposition 3 implies that the equilibrium features *complete* insurance if and only if workers enjoy no rents. Otherwise the increase in income due to re-employment would constitute a risk against which they can only partially self-insure by running down their assets.

Since Lemma 1 and Proposition 4 imply that $s^{\mathrm{e}}(\sigma^*) = 0$, it follows from equations

[16]Without the CARA assumption imperfect insurance against re-employment risk will upset the proportionality between the unemployed worker's value function and marginal utility of consumption. In consequence, no contract will equalize the employed worker's consumption across all states and at the same time ensure no renegotiation.

[17]Since wage renegotiation is ruled out by assumption, the contractual w is rigid ex post and separation is involuntary whenever $rF < w - b + s^{\mathrm{u}}$. But as will soon be clear, this rigidity is inconsequential since the equilibrium contract is always such that $rF \geq w - b + s^{\mathrm{u}}$.

(16)–(17) that $b - s^{\mathrm{u}}$ is the worker's reservation wage. The optimal severance payment is therefore proportional to the difference between the contract and reservation wages, and is strictly positive when the former exceeds the latter.

Setting $F = F^*$ in equation (6) yields

$$b - s^{\mathrm{u}} = \bar{y}(\sigma^*) + \lambda \int_{\bar{y}(\sigma^*)}^{1} \frac{1 - G(y')}{r + \lambda} dy'. \tag{25}$$

Thus the equilibrium layoff threshold $\bar{y}(\sigma^*)$ is fully determined by the reservation wage, as in the model of Mortensen and Pissarides (1994) with risk-neutral workers.

Our next result establishes a lower bound on the agreed severance payment.

Proposition 5. *If F is unconstrained then $F^* \geq [w^* - b]/[p(\theta) + r] =: \underline{F}$, with strict inequality when $\gamma > 0$ and $F^* = \underline{F} = 0$ when $\gamma = 0$.*

Here the bound $\underline{F}$ can be interpreted as the expected loss of lifetime wealth associated with transiting through unemployment, and is equal to the present value of the income loss $w^* - b$ over the (expected) length of an unemployment spell.

If $\gamma = 0$, then $\underline{F} = w^* - b = 0$. If $\gamma > 0$, then employed workers enjoy economic rents and the wealth cost $\underline{F}$ of a job loss is positive. In the latter case F^* exceeds $\underline{F}$, and the intuition for this runs as follows. Under a full-insurance contract the worker's consumption does not fall when he enters unemployment. Since the duration of unemployment is uncertain, however, the variability of future consumption is higher for a job loser than for an employed worker with the same assets. Since the marginal utility of consumption is convex, precautionary saving leads the expected consumption profile of a job loser to be more upward-sloping (i.e., present consumption is further below permanent income) than that of an employed worker. For consumption not to fall upon job loss, the permanent income of the job loser must therefore exceed that of his employed counterpart.

Since severance payments are usually expressed in relation to the last wage, it is useful to define the relative lower bound $\underline{f} = \underline{F}^*/w^*$. Denoting by $\rho = b/w^*$ the replacement rate of unemployment benefits, this bound can be written as

$$\underline{f} = \frac{1 - \rho}{p(\theta) + r}. \tag{26}$$

Equation (26) is used in Appendix A.3 to measure the extent to which mandates exceed privately optimal levels of severance pay.

4.3 Binding-constraint equilibrium

Characterizing analytically the equilibrium effect of a binding mandate is not in general feasible. An exception is the case of $\gamma = 0$, where $W^{\mathrm{e}}(\sigma, 0) = W^{\mathrm{u}}(0)$ and workers enjoy no rents. Here we have both $s^{\mathrm{u}} = 0$ and $w^* - s^{\mathrm{e}}(\sigma^*) = b$ by Proposition 3 and equations (16)–(17). Moreover, the following result shows that the mandated severance payment is renegotiated with positive probability.

Proposition 6. *If $\gamma = 0$ and $F_m > 0$, then the binding-constraint equilibrium has both $y^{\mathrm{d}}(\sigma^*) > \bar{y}(\sigma^*)$ and $w^* < b$.*

When $\gamma = 0$, the worker is indifferent between working and quitting and would prefer to be dismissed with a strictly positive severance payment. In a laissez-faire equilibrium, the contract $\sigma^\circ = \langle b, 0 \rangle$ specifies no payment and the firm fires the worker (efficiently) whenever $J^{\mathrm{e}}(y, \sigma^\circ) < 0$. In a binding-constraint equilibrium, we have $c^{\mathrm{u}}(F_m) > c^{\mathrm{e}}(\sigma^*, 0)$ and the worker would prefer being fired to continuation. The firm, however, is willing to fire the worker only if $-F_m > J^{\mathrm{e}}(y, \sigma^*)$. If, on the other hand, $-F_m \leq J^{\mathrm{e}}(y, \sigma^*) < 0$, or equivalently $y \in (\bar{y}(\sigma^*), y^{\mathrm{d}}(\sigma^*))$, then it is optimal to renegotiate the contractual payment to a level $F \in [0, -J^{\mathrm{e}}(y, \sigma^*)]$ and terminate the match. Crucially, renegotiation reduces the equilibrium transfer to the marginal job loser relative to the mandated minimum. In fact, when $\gamma = 0$ the equilibrium transfer $J^{\mathrm{e}}(y^{\mathrm{d}}(\sigma^*), \sigma^*)$ to the marginal job loser is zero — just as in laissez faire. Yet since the transfer $F^{\mathrm{r}}(y, \sigma^*) = \min\{-J^{\mathrm{e}}(y, \sigma^*), F_m\}$ after renegotiation is increasing in y, government intervention raises the equilibrium payment to infra-marginal job losers relative to laissez faire and reduces firms' ex ante profits. And so the contractual wage falls to achieve the appropriate ex ante surplus shares.

The next result derives allocational and welfare implications of binding mandates.

Proposition 7. *If $\gamma = 0$ and $F_m > 0$, then the binding-constraint equilibrium features higher job destruction and lower job creation, employment, and workers' welfare relative to the laissez-faire equilibrium.*

The intuition for this decrease in job creation is simple. The expected cost to firms of providing workers with the laissez-faire level of expected utility (before taxes) increases with consumption variability. Since the firm's expected payoff $J^{\mathrm{e}}(y, \sigma^*)$ is lower for any value of y, the job-destruction threshold $J^{\mathrm{e}}(y^{\mathrm{d}}(\sigma^*), \sigma^*) = 0$ increases. And it follows that the unemployment and tax rates increase, while workers' welfare falls.

In contrast to Lazear's (1990) conclusions, intervention is non-neutral in our setting with risk-averse workers and incomplete contracts. However, its impact on allocations is dampened by spot renegotiation of the severance payment, as well as by the lower wage.

While the qualitative analysis above provides a useful benchmark, to investigate the case of strictly positive γ and to determine the *quantitative* effects of binding mandates we must proceed numerically.

5 Quantitative effects of mandated severance pay

5.1 Calibration

We calibrate our model to the Portuguese economy. There are several reasons for this choice: First, Portugal has a notoriously high level of employment protection.[18] Second, severance pay mandates matter in our setting only insofar as they exceed private optima. Intuitively, it is the difference between the former and the latter that determines the allocational and welfare effects of government intervention. To gauge the size of these effects in practice, we have computed an upper bound on the payment difference for each of seventeen OECD countries by subtracting the lower bound $\underline{f}$ on the private optimum from an aggregate of legislated severance and notice-period pay.[19] (The data used for our computations and the resulting series are reported in Table 5 in Appendix A.3.) Portugal — together with Belgium — has the largest measured difference between mandated and optimal severance pay, and is also one of the countries where severance pay is the main component of dismissal costs. Thus Portugal seems a natural benchmark case in which to investigate the consequences of excessive mandated severance pay.

[18]See, for example, Blanchard and Portugal (2000) and the sources therein.

[19]The lower bound $\underline{f}$ depends on the unemployment duration in the unobservable laissez-faire equilibrium. However, for parameter values such that the distinction is quantitatively significant both unemployment duration and $\underline{f}$ would be higher in laissez faire, as shown in Section 5.2.

Moments	Portugal	Model
Unemployment rate (%)	6.5	6.5
Average unemployment duration (months)	17	17
Parameters: $U(c) = -\exp[-\alpha c]$, $\alpha = 1.7$; $M(u, v) = Au^{\eta}v^{1-\eta}$, $A = 0.18$, $\eta = 0.5$; G uniform on $[y_l, 1]$, $y_l = 0.32$; $r = 0.01$, $m = 0.33$, $\lambda = 0.014$, $\gamma = 0.5$, $\rho = 0.65$, $f_m = 5.7$		

Table 1: Summary of calibration to Portuguese economy.

We choose parameter values using a combination of external sources and calibration. We adopt the Cobb-Douglas matching function $M(u, v) = Au^{\eta}v^{1-\eta}$, where A controls the efficiency of the matching process. The productivity distribution G is assumed to be uniform on $[y_l, 1]$. Unemployment benefits and mandated severance payments relative to wages are defined respectively as $\rho = b/w$ and $f_m = F_m/w$. Hence the model has a total of ten parameters: r, α, m, λ, y_l, γ, A, η, ρ, and f_m.

All flow variables are per quarter, and the interest rate is $r = 0.01$. The coefficient of absolute risk aversion is set at $\alpha = 1.7$, which implies a value of $\alpha c^{\mathrm{u}}(0) = 1.5$ for the coefficient of relative risk aversion of an unemployed worker with zero wealth. The latter lies in the middle of the range of available estimates (see, e.g., Attanasio 1999). We set the elasticity of the matching function at $\eta = 0.5$, consistent with the evidence supplied in Petrongolo and Pissarides (2001). The workers' bargaining power parameter is chosen to be $\gamma = 0.5$, which implies (see Footnote 8) that the outcome of bargaining coincides with that of competitive search. (This also implies that the decentralized equilibrium is efficient if workers are risk neutral and there are no unemployment benefits.) The lower bound of the productivity interval is set at $y_l = 0.32$ to obtain a coefficient of variation for output shocks of 0.3, as in Blanchard and Portugal (2000). The vacancy cost is chosen to be $m = 0.33$, following Millard and Mortensen (1997).

The remaining parameters are calibrated to Portuguese policies and data, including a benefit rate of $\rho = 0.65$ and a mandated severance payment of $f_m = 5.7$ (or 17 months at the net quarterly wage; see Table 5 in Appendix A.3). The productivity shock rate and matching efficiency parameter are chosen to be $\lambda = 0.014$ and $A = 0.18$, generating an average unemployment duration of 17 months and an unemployment rate of 6.5%. (The former target comes from the OECD unemployment duration database; see Blanchard and Portugal's (2000) Figure 4.[20] Table 1 summarizes the outcome of our calibration.

5.2 Lump-sum unemployment benefits

We now investigate the impact of severance pay mandates relative to laissez faire when unemployment benefits are lump-sum and hence invariant to policy changes.[21] In Table 2, the second and third columns show the allocational and welfare effects in our calibrated economy of mandates corresponding to 17 and 24 months of wages, with the laissez-faire situation in the first column.[22] The privately-optimal severance payment is 6 months, against 17 months in our benchmark case of Portugal and the maximum payment in our dataset (see Appendix A.3) of 24 months. For the sake of comparison, the fourth column reports allocational and welfare outcomes for the constrained efficient equilibrium where (as in Acemoglu and Shimer 1999) a social planner chooses the benefit rate to maximize net output, setting $\rho = 0.05$.[23]

Qualitatively, the effects of introducing severance pay mandates are in line with our theoretical results. Mandates reduce job creation, increase the unemployment rate, and reduce workers' welfare. Quantitatively, though, both the allocational and welfare effects are remarkably small even for mandates dramatically in excess of the private optimum.

Severance pay mandates have an ambiguous effect on net output because of the usual entry/exit externalities on the job creation and job destruction margins. The sign of this effect is the same as (resp., the opposite of) the sign of the employment effect when employment is inefficiently low (resp., high) in laissez-faire equilibrium. With lump-sum

[20]Using the Portuguese Labour Force Survey, Bover et al. (2000) find a slightly higher unemployment duration of 20 months over 1992–97. Despite using the same worker outflow data in their empirical exercise, Blanchard and Portugal (2000) assume a much lower value of 9 months in their calibration.

[21]Recall that lump-sum benefits were assumed in our theoretical analysis. This assumption eliminates the feedback from changes in wages to changes in benefits and workers' bargaining power, allowing us to isolate the main mechanism driving our results. Proportional benefits are considered in Section 5.4.

[22]The quantities with no meaningful unit of measurement, namely net output and welfare, are reported as a percentage of their values in the fourth column (describing the efficient, laissez-faire equilibrium). Welfare is therefore measured as a percentage of permanent consumption in the efficient equilibrium yielding an equivalent level of utility. The present value of output is the shadow value of an unemployed worker, which — as in Acemoglu and Shimer (1999) — is maximized in the efficient equilibrium.

Since allocational and welfare effects are monotonic functions of the size of the severance pay mandate, we report simulations for a small number of values only.

[23]In contrast to Acemoglu and Shimer's (1999) model, here the equilibrium is only constrained efficient since one instrument is insufficient to align both job creation and job destruction. In practice, however, the outcome agrees with the efficient allocation with risk-neutral workers to at least three decimal digits.

	l.f.	Portugal		l.f.		
Months of wages	6	17	24	10	21	28
Value of $\rho = b/w$	0.65	0.65	0.65	0.05	0.05	0.05
Job creation (%)	18.0	17.8	17.7	28.7	28.4	28.2
Job destruction (%)	1.2	1.2	1.2	1.1	1.1	1.1
Unemployment (%)	6.4	6.5	6.6	3.8	3.8	3.8
Gross wage ($\times$100)	93.1	89.4	87.5	89.4	86.2	84.5
Tax ($\times$100)	3.7	3.8	3.8	0.2	0.2	0.2
Net output	98.3	98.3	98.2	100.0	100.0	100.0
Employed welfare	100.2	100.0	99.9	100.0	100.0	99.8
Unemployed welfare	101.4	101.2	101.1	100.0	99.9	99.8

Table 2: Allocational and welfare effects of severance pay mandates in the benchmark ($\rho = 0.65$) and efficient ($\rho = 0.05$) economies.

benefits this is the only externality relevant to efficiency, but with regard to welfare there are two further effects. First, a fall in unemployment reduces taxes and increases welfare. This externality is unambiguously positive and not internalized by the firm-worker pair. And secondly, with risk-averse workers mandates reduce welfare to the extent that they increase the re-employment risk by lengthening unemployment durations.

The fifth and sixth columns in Table 2 show the effects in the efficient economy of introducing mandates that exceed privately-optimal severance pay by the same amounts — 11 and 18 months — as simulated in the benchmark economy. Here the results are qualitatively similar but the magnitude of the effects is even smaller, since starting from the efficient allocation reduces distortions. Moreover, since the lump-sum tax is affected very little in this case, the welfare impact is caused mainly by an increase in risk.

It is also instructive to compare the laissez-faire outcomes across the benchmark and efficient economies. Note in this regard that severance payments are not a perfect substitute for unemployment benefits, even for the purpose of output maximization. Indeed, the benefit rate in the efficient economy is 0.05, rather than zero.[24] In addition, although even mandated payments dramatically above the private optimum have only small allocational and welfare effects, raising the benefit rate from 0.05 to 0.65 increases unemployment by nearly 70 per cent and reduces output by nearly 12 per cent.

[24]Here the intuition is as in Acemoglu and Shimer (1999), and is clearest in the present setting where because of the CARA felicity assumption there are no wealth effects and past severance payments do not affect bargaining power. For given Nash weights, increased concavity of U reduces the worker's effective bargaining strength. Thus, if Hosios's (1990) condition holds and there are no benefits, the firm's share of surplus is inefficiently high provided workers' marginal utility is decreasing.

Observe also that the optimal severance payment is decreasing in the benefit rate — it is 10 months of wages in the efficient economy versus 6 months in the benchmark case. The lower bound in equation (26) reveals the two opposing forces affecting the optimal payment. On the one hand, a smaller ρ exacerbates the fall in income associated with job loss and calls for a higher payment. On the other, this reduces workers' bargaining power and thereby both the average unemployment duration $1/p(\theta)$ and the cost of job loss. As it turns out, the first effect prevails and the relationship between the benefit rate and the optimal payment is negative.

We next investigate whether this negative relationship is a robust feature of the model and whether the magnitude of the allocational and welfare changes is sensitive to the size of the benefit rate. To do this, we repeat the above exercise for values of the benefit rate ranging from zero to 0.9 and with all other parameters as in the benchmark economy. In the spirit of bounding the quantitative effects from above, we impose a mandate that exceeds the privately-optimal, laissez-faire severance pay amount by 11 months — equal to the difference between the first and second columns in Table 2.

The results of these simulations are summarized in Figure 3, where the horizontal axis reports the benefit rate in the laissez-faire equilibrium. Here the heavy solid line plots the privately-optimal severance payment, measured on the right-hand vertical axis. This quantity falls from 10 months when ρ is zero to 3 months when $\rho = 0.9$. The left-hand vertical axis measures the change in the unemployment rate and the percentage changes in net output and welfare (relative to laissez faire).

The simulations confirm the robustness of our finding that the allocational and welfare effects of mandates are small. The change in unemployment increases mildly as the benefit rate rises, while the changes in net output and welfare are close to zero up to a benefit rate of 0.7 and remain modest for higher values of ρ. Note in this regard that only two of the OECD countries in our dataset have rates higher than 0.7; namely, Sweden at 0.8 and Denmark at 0.9 (see Appendix A.3).

The intuition for the small size of these effects is as follows. Firstly, the legislated severance payment is renegotiated by the marginal job loser, so job destruction is barely affected.[25] Secondly, the contractual wage falls as a prepayment for the higher severance

[25]In fact job destruction increases, as per our theoretical results, but the change is too small to show

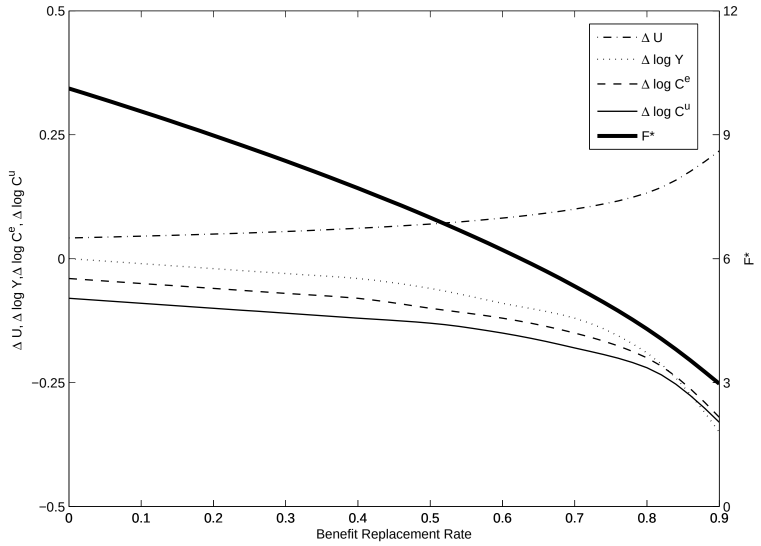

Figure 3: Effects of severance pay mandates for a range of lump-sum benefit rates.

transfer in those states where the parties separate without renegotiation. Even so, the increased income uncertainty associated with government intervention raises the cost to the firm of providing the worker a given level of utility and thereby reduces job creation. But this effect too is small, both because the contractual wage smoothes the prepayment of the severance transfer over employment states, and because the overinsurance against job loss is effectively undone by the employed worker's dissaving.

5.3 No renegotiation or wage rigidity

To better understand the relative importance for our findings of renegotiation and wage flexibility, we now analyze each of these factors separately.

We first rule out renegotiation of the severance pay mandate.[26] In this setting y^{d} no longer satisfies equation (9), but rather coincides with the layoff threshold $\bar{y}$ even outside of laissez faire. The wage, on the other hand, continues to satisfy equation (12).

In Table 3, the second column reports the allocational and welfare effects, absent renegotiation, when severance pay is increased by 11 months relative to the laissez-faire benchmark in the first column (which duplicates the first column of Table 2). Here the separation rate falls by 10 per cent due to Pareto-inefficient labour hoarding. The gross

up in Table 2.

[26]We are grateful to Ioana Marinescu for suggesting that we explore this case.

Exogenous variable	—	F		w
Months of wages	6	17		17
Job creation (%)	18.0	17.7		0.3
Job destruction (%)	1.2	1.1		0.5
Unemployment (%)	6.4	5.7		61.0
Gross wage (×100)	93.1	89.5		93.1
Tax (×100)	3.7	3.3		35.5
Net output	98.3	98.4		18.9
Employed welfare	100.2	100.3	(99.8)	51.1
Unemployed welfare	101.4	101.5	(101.0)	32.1

Table 3: Effects of severance pay mandates with no renegotiation or wage rigidity.

wage, however, is effectively unchanged relative to the second column of Table 2, whereas the job creation rate falls marginally less than in Table 2 as the increase in job duration raises the present value of profits. The fall in job destruction more than offsets the lower rate of job creation, and the unemployment rate decreases markedly.

Net output still increases with the fall in unemployment, though marginally less than in Table 2, and welfare also increases marginally. The figures in parentheses report the hypothetical consumption were the tax to remain at its laissez-faire equilibrium value, showing that the rise in welfare is fully accounted for by the tax decrease.

We next turn to the case of a renegotiable severance payment combined with a (gross) wage that is downward rigid due, perhaps, to some unmodeled institutional constraint. The third column in Table 3 reports the allocational and welfare effects of a mandated payment with the wage kept constant at its level in the laissez-faire benchmark. Increasing the severance payment to 17 months effectively exhausts any return to job creation, and no equilibrium with positive employment exists for higher mandates. Job creation collapses to one-sixtieth of its original value, as wage flexibility cannot reestablish profitability of new jobs. With constant returns in production, the ex-ante value of a job is significantly diminished. The increase in duration makes workers less willing to enter unemployment, and job destruction falls by more than 50 per cent. Both welfare measures also collapse.

Assuming that the exogenous wage is set at its laissez-faire equilibrium value of course maximizes the impact of the policy change. Nevertheless, this exercise clearly shows that sufficient flexibility of the average wage is essential for severance pay mandates to have negligible allocational and welfare effects.

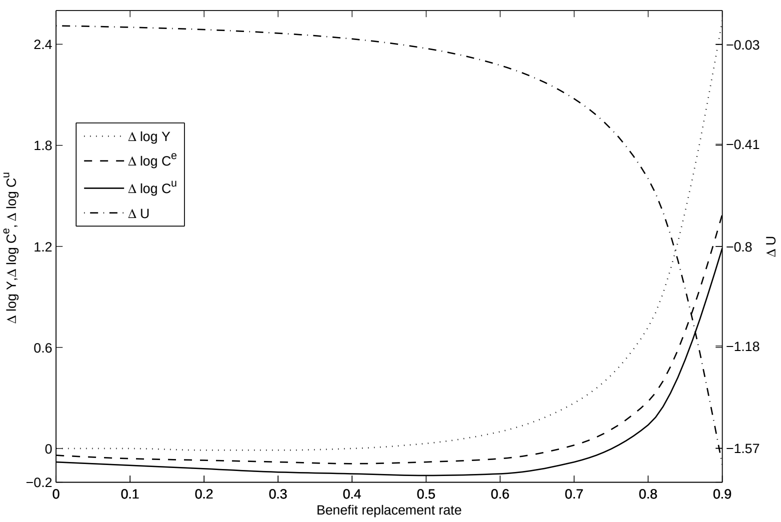

Figure 4: Effects of severance pay mandates for a range of proportional benefit rates.

5.4 Proportional unemployment benefits

In this section we investigate the effects of severance pay mandates when unemployment benefits are proportional to, and therefore vary with, the wage. This adds a new channel by which mandates can affect the equilibrium allocation: As wages fall, unemployment benefits and hence workers' bargaining power move in the same direction.

As in the simulation summarized in Figure 3, we impose a severance pay mandate exceeding the privately-optimal, laissez-faire value by 11 months for values of the benefit rate ranging from zero to 0.9. The difference is that while previously we kept the benefit *level* constant when introducing the mandate, we now keep the *replacement rate* constant.

The results of this exercise are summarized in Figure 4 (where the privately-optimal severance payment remains as in Figure 3). Here the change in unemployment is measured on the right-hand vertical axis and the percentage changes in net output and welfare on the left-hand vertical axis. The first thing to note is that for values of the benefit rate below 0.45, the measured changes are roughly the same as in Section 5.2: The severance pay mandate modestly reduces both employment and welfare. However, when ρ exceeds 0.45, the signs of the unemployment and output changes are reversed, since the response of unemployment benefits to a fall in the wage and the consequent reduction in workers' bargaining power are large enough for workers to accept a lower present value of payments from firms. This effect of course increases with the benefit rate. Moreover, since for higher

Months of wages	l.f. 3	6		9		12	
Job creation (%)	9.2	9.6		10.0		10.4	
Job destruction (%)	1.3	1.3		1.3		1.3	
Unemployment (%)	12.7	12.1		11.7		11.3	
Gross wage (×100)	96.4	95.0		93.8		92.6	
Tax (×100)	11.0	10.4		9.8		9.4	
Net output	67.2	67.8		68.3		68.7	
Employed welfare	76.2	76.6	(75.9)	76.9	(75.7)	77.1	(75.5)
Unemployed welfare	72.8	73.2	(72.5)	73.4	(72.3)	73.6	(72.0)

Table 4: Effects of severance pay mandates when $\rho = 0.9$ (proportional benefits).

values of ρ the unemployment rate is inefficiently low in the laissez-faire equilibrium, the policy change induces an increase in net output.

While the signs of the unemployment and output changes reverse relative to Section 5.2, their magnitudes remain small for benefit rates below 0.8. For even higher values of ρ, increasing severance pay by 11 months has a significantly positive effect on employment, and output also increases substantially. As for workers' welfare, this too begins to climb sharply once ρ reaches approximately 0.7.

To shed more light on the case of high (proportional) unemployment benefits, Table 4 reports the effects when $\rho = 0.9$ of severance pay mandates ranging from the laissez-faire value of 3 months (see Figure 3) to just below the 14 months used in Figure 4. Here the third column, for example, considers a mandate exceeding the private optimum by 6 months — roughly the excess in the only economy in our dataset (namely, Denmark) with a benefit rate of 0.9. Once again the figures in parentheses are the hypothetical consumption were the tax to remain constant.

Observe that at 9 months the effects of the mandate on unemployment and net output are already sizeable, while the effects on welfare are less so. Also worth noting is that the welfare gains come primarily from the fall in the lump-sum tax. Indeed, had the tax remained constant at its laissez-faire value, equilibrium welfare would actually have fallen. And finally, although severance pay mandates do increase welfare in the present case, they are not the preferable (second-best) policy tool to accomplish this goal: Comparing Tables 2 and 4 confirms that much larger efficiency and welfare gains could be achieved by reducing the benefit rate.

6 Discussion and conclusion

With a view towards bounding from above the impact of government intervention, this paper has restricted attention to highly incomplete contracts featuring state-independent wages and severance payments. As we have seen, under the assumption of CARA felicity this class of contracts is rich enough to provide full insurance against job loss in laissez faire. It is not, however, sufficient to sustain full insurance when a severance pay mandate is imposed.

Enriching the space of contracts — for example, by allowing ex-ante agreements on state-contingent rebates of part of the mandated payment (or a state-independent rebate of its excess over the private optimum) — would trivially reestablish full neutrality, as pointed out by Lazear (1990). But since courts are unlikely to enforce contracts designed to circumvent legislation, more complicated agreements would need to be implicit and self-enforcing. However, arrangements such as those just mentioned could not pass this test, as a worker about to be fired would have no ex-post incentive to honour his or her (implicit) ex-ante pledges.[27]

Note that we have also ruled out lump-sum wealth transfers at the beginning of a match. If such transfers were possible, insurance against job loss would not necessarily require a positive severance payment. An optimal contract could then specify a wage equal to the unemployed worker's reservation value $b - s^{\mathrm{u}}$, no severance payment, and an upfront wealth transfer giving the worker the appropriate share of quasi-rents.[28]

From the empirical point of view, this assumption is justified by the observation that upfront wealth transfers are observed only in special circumstances, likely because they can leave firms exposed to opportunistic shirking or quitting. And from the theoretical perspective, our analysis of the laissez-faire equilibrium in Section 4.2 would still be valid, since our modelling choice is just a normalization. (The only caveat here is that the lower bound on the severance payment in Proposition 5 would no longer be determinate.)

Of course, in the binding-constraint equilibrium our choice of contracting margins is no

[27]Privately negotiated severance payment are also unenforceable through reputation alone in the standard matching framework with anonymity in which a firm coincides with one job and, when a job becomes unprofitable, there are no third parties that can punish a firm that reneges on an implicit contract.

[28]It is well known that if agents are not subject to liquidity constraints, then the timing of transfers is indeterminate given enough degrees of freedom; see, e.g., Werning (2002). Our normalization is equivalent to that of Werning, who disallows taxes upon employment.

longer simply a normalization. In this case, absent borrowing constraints, allowing lump-sum transfers of unrestricted sign would once again lead to neutrality. By Proposition 4, full insurance against job loss could still be achieved by *raising* the wage in response to an increase in the mandate F_m to maintain the optimality condition $\hat{w}(F_m) = rF_m + b - s^{\mathrm{u}}$, while at the same time reducing the lump-sum transfer to the worker to reestablish the correct ex-ante shares of surplus. Moreover, our analysis in Sections 4.3 and 5 — which assumes zero hiring transfers — would still apply provided transfers from firms to workers upon hiring cannot be negative.

A robust finding of this paper is that, even with very incomplete markets, severance pay mandates do not cause high unemployment rates, long unemployment durations, or low job destruction rates. In the context of our model, the causation goes from factors that influence unemployment durations, such as matching frictions, unemployment benefits, and workers' bargaining power, to the determination of optimal severance payments. And to the extent that mandates have significant allocational effects, they reduce rather than increase unemployment.

A Appendix

A.1 Proofs

Proof of Proposition 1. If $W^{\mathrm{u}}(a) > W^{\mathrm{e}}(\sigma, a)$ then the worker will quit in the event that the firm rejects. There is then no reason for the firm to make a nonzero severance payment by either accepting or dismissing, so the worker's offer is immaterial and we have payoffs $\langle W^{\mathrm{u}}(a), 0\rangle$.

Suppose now that $W^{\mathrm{u}}(a) < W^{\mathrm{e}}(\sigma, a)$, in which case the worker works following a rejection. If also $J^{\mathrm{e}}(y', \sigma, a) < -F$ then the firm prefers dismissing to rejecting, the worker has no incentive to lower the severance payment, and the payoffs are $\langle W^{\mathrm{u}}(a + F), -F\rangle$. On the other hand, if $J^{\mathrm{e}}(y', \sigma, a) > -F$ then the firm prefers rejecting to dismissing and the outcome hinges on whether continuation of the match (under contract σ) is or is not efficient. Since the worker must offer $F' \leq -J^{\mathrm{e}}(y', \sigma, a)$ to induce the firm to accept, we have that $W^{\mathrm{e}}(\sigma, a) < W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a))$ yields payoffs $\langle W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a)), J^{\mathrm{e}}(y', \sigma, a)\rangle$.

Alternatively, $W^{\mathrm{e}}(\sigma, a) > W^{\mathrm{u}}(a - J^{\mathrm{e}}(y', \sigma, a))$ rules out gains from renegotiation and leads to the payoffs $\langle W^{\mathrm{e}}(\sigma, a), J^{\mathrm{e}}(y', \sigma, a)\rangle$. $\square$

Proof of Proposition 2. We first establish equations (16)–(17) under the assumption that $\sigma^*(a)$ is independent of a. From the worker's sequence problem we have the Euler equation $U'(c_0) = \mathbb{E}_0 U'(c_t)$ for each $t \geq 0$. The CARA felicity function satisfies $U'(c) = -\alpha U(c)$, and it follows that $U(c_0) = \mathbb{E}_0 U(c_t)$. For an unemployed worker equation (1) can then be written as $\mathcal{U}_0 = U(c^{\mathrm{u}}(a_0)) \int_0^\infty e^{-rt} dt = U(c^{\mathrm{u}}(a_0))/r$, and stationarity allows us to drop the time subscript. Thus we have $rW^{\mathrm{u}}(a) = U(c^{\mathrm{u}}(a))$, and similarly for an employed worker $rW^{\mathrm{e}}(\sigma, a) = U(c^{\mathrm{e}}(\sigma, a))$. Differentiating these equations with respect to a and using the first-order conditions $W^{\mathrm{u}}_a(a) = U'(c^{\mathrm{u}}(a))$ and $W^{\mathrm{e}}_a(\sigma, a) = U'(c^{\mathrm{e}}(\sigma, a))$ for the worker's consumption choices, we obtain $c^{\mathrm{u}}_a(a) = r = c^{\mathrm{e}}_a(\sigma, a)$. The dynamic budget identity then ensures that $s^{\mathrm{u}}(a)$ and $s^{\mathrm{e}}(\sigma, a)$ are independent of a and so equations (16)–(17) are valid.

From equations (16)–(17) we see that consumption depends on wealth only through the additively separable term ra. Together with the CARA felicity function this implies that $W^{\mathrm{e}}(\sigma, a) - W^{\mathrm{u}}(a) = e^{-\alpha ra}[W^{\mathrm{e}}(\sigma, 0) - W^{\mathrm{u}}(0)]$ for any $\langle \sigma, a\rangle$. It follows that neither maximization of the Nash objective function $\Phi(\sigma, a) = e^{-\alpha ra\gamma}\Phi(\sigma, 0)$ nor satisfaction of the worker's participation constraint is affected by changes in wealth, so both $\sigma^*(a)$ and $\underline{w}(F, a)$ are independent of a. Moreover, applying equations (16)–(17) to (7) now yields

$$\hat{y}(\sigma, a) = \bar{y}(\sigma) + r^{-1}[r + \lambda][rF + s^{\mathrm{e}}(\sigma) - w + b - s^{\mathrm{u}}], \tag{27}$$

so $\hat{y}(\sigma, a)$, $\hat{w}(F, a)$, and $y^{\mathrm{d}}(\sigma, a) = \max\{\hat{y}(\sigma, a), \bar{y}(\sigma)\}$ are independent of a for all σ such that $W^{\mathrm{e}}(\sigma, 0) \geq W^{\mathrm{u}}(0)$. And equation (18) then follows from (27) and (16)–(17).

Finally, substituting for the value functions in equations (8) and (15), using the first-order conditions for consumption optima, and rearranging terms yields (19) and (20). $\square$

Proof of Proposition 3. In text. $\square$

Proof of Lemma 1. Suppose first that $c^{\mathrm{e}}(\sigma, 0) - c^{\mathrm{u}}(F) \geq 0$. Then $y^{\mathrm{d}}(\sigma) = \bar{y}(\sigma)$ by equation (18), and hence by (10) we have $F^{\mathrm{r}}(y', \sigma) = F$ for all $y' \leq y^{\mathrm{d}}(\sigma)$. For each such y' it follows that $U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) = U'(c^{\mathrm{u}}(F)) \geq U'(c^{\mathrm{e}}(\sigma, 0))$. Equation (20) then implies that $s^{\mathrm{e}}(\sigma) \geq 0$, with equality if and only if $c^{\mathrm{u}}(F) = c^{\mathrm{e}}(\sigma, 0)$. And furthermore we have

$$w - b + s^{\mathrm{u}} - rF = c^{\mathrm{e}}(\sigma, 0) - c^{\mathrm{u}}(F) + s^{\mathrm{e}}(\sigma) \geq 0, \tag{28}$$

again with equality if and only if $c^{\mathrm{u}}(F) = c^{\mathrm{e}}(\sigma, 0)$.

Now suppose that $c^{\mathrm{e}}(\sigma, 0) - c^{\mathrm{u}}(F) < 0$, so that by equation (18) we have $y^{\mathrm{d}}(\sigma) > \bar{y}(\sigma)$. Then $\langle y^{\mathrm{d}}(\sigma), \sigma, 0\rangle$ is on the border of cases III and IV in Proposition 1, so that in view of equations (16)–(17) we have

$$U(c^{\mathrm{e}}(\sigma, 0)) = rW^{\mathrm{e}}(\sigma, 0) = rW^{\mathrm{u}}(F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma)) = U(c^{\mathrm{u}}(F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma))) \tag{29}$$

and $c^{\mathrm{e}}(\sigma, 0) = c^{\mathrm{u}}(F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma))$. Now for all $y' < y^{\mathrm{d}}(\sigma)$ we have $F^{\mathrm{r}}(y', \sigma) > F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma)$ and hence $U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) < U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma))) = U'(c^{\mathrm{e}}(\sigma, 0))$. Finally, equation (20) implies that $s^{\mathrm{e}}(\sigma) < 0$, and it follows that $w - b + s^{\mathrm{u}} - rF < 0$ as well. $\square$

Lemma 2. *The partial derivatives of W^{e} and J^{e} with respect to $\sigma = \langle w, F\rangle$ satisfy*

$$W^{\mathrm{e}}_w(\sigma, a) \leq \frac{W^{\mathrm{e}}_a(\sigma, a) + s^{\mathrm{e}}(\sigma) W^{\mathrm{e}}_{aw}(\sigma, a) + \lambda \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} W^{\mathrm{u}}_a(a + F^{\mathrm{r}}(y', \sigma)) F^{\mathrm{r}}_w(y', \sigma) dG}{r + \lambda G(y^{\mathrm{d}}(\sigma))}, \tag{30}$$

$$W^{\mathrm{e}}_F(\sigma, a) \geq \frac{s^{\mathrm{e}}(\sigma) W^{\mathrm{e}}_{aF}(\sigma, a) + \lambda \int_{y_l}^{y^{\mathrm{d}}(\sigma)} W^{\mathrm{u}}_a(a + F^{\mathrm{r}}(y', \sigma)) F^{\mathrm{r}}_F(y', \sigma) dG}{r + \lambda G(y^{\mathrm{d}}(\sigma))}, \tag{31}$$

$$J^{\mathrm{e}}_w(y, \sigma) = \frac{-1}{r + \lambda G(\bar{y}(\sigma))}, \tag{32}$$

$$J^{\mathrm{e}}_F(y, \sigma) = \frac{-\lambda G(\bar{y}(\sigma))}{r + \lambda G(\bar{y}(\sigma))}, \tag{33}$$

with equality in (30)–(31) *if $rF \geq w - b + s^{\mathrm{u}}$.*

Proof. From equation (6) we have $\bar{y}_F(\sigma) = -r[r + \lambda][r + \lambda G(\bar{y}(\sigma))]^{-1} = -r\bar{y}_w(\sigma)$, and using these relationships to differentiate (4) leads to (32)–(33). Moreover, differentiating equation (8) with respect to w yields

$$\begin{aligned}&[r + \lambda G(y^{\mathrm{d}}(\sigma))] W^{\mathrm{e}}_w(\sigma, a) + \lambda y^{\mathrm{d}}_w(\sigma)[W^{\mathrm{e}}(\sigma, a) - W^{\mathrm{u}}(a + F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma))] = \cdots \\ &\qquad W^{\mathrm{e}}_a(\sigma, a) + s^{\mathrm{e}}(\sigma) W^{\mathrm{e}}_{aw}(\sigma, a) + \lambda \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} W^{\mathrm{u}}_a(a + F^{\mathrm{r}}(y', \sigma)) F^{\mathrm{r}}_w(y', \sigma) dG. \end{aligned} \tag{34}$$

Since $W^{\mathrm{e}}(\sigma, a) \geq W^{\mathrm{u}}(a + F^{\mathrm{r}}(y^{\mathrm{d}}(\sigma), \sigma))$ with equality if $y^{\mathrm{d}}(\sigma) = \hat{y}(\sigma)$, and since $y^{\mathrm{d}}(\sigma) \neq \hat{y}(\sigma)$ implies $y^{\mathrm{d}}_w(\sigma) = \bar{y}_w(\sigma) > 0$, we have (30) with equality if $w \leq \hat{w}(F) = rF + b - s^{\mathrm{u}}$. And (31) is established by a similar argument employing $\bar{y}_F(\sigma) < 0$. □

Lemma 3. *We have that*

$$\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} \geq \frac{J^{\mathrm{e}}_F(y, \sigma)}{J^{\mathrm{e}}_w(y, \sigma)} \tag{35}$$

if and only if $rF \leq w - b + s^{\mathrm{u}}$.

Proof. We first find the marginal rates of substitution of the value functions. Equations (16)–(17) and the CARA specification for felicity together imply that

$$W^{\mathrm{u}}_a(a) = U'(c^{\mathrm{u}}(a)) = -r\alpha \exp\{-\alpha r a\} W^{\mathrm{u}}(0), \tag{36}$$

$$W^{\mathrm{e}}_a(\sigma, a) = U'(c^{\mathrm{e}}(\sigma, a)) = -r\alpha \exp\{-\alpha r a\} W^{\mathrm{e}}(\sigma, 0). \tag{37}$$

Therefore $W^{\mathrm{e}}_{aw}(\sigma, a) = -r\alpha W^{\mathrm{e}}_w(\sigma, a)$ and $W^{\mathrm{e}}_{aF}(\sigma, a) = -r\alpha W^{\mathrm{e}}_F(\sigma, a)$, and it follows that (30)–(31) can be rearranged and combined to yield

$$\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} \geq \frac{\lambda \int_{y_l}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) F^{\mathrm{r}}_F(y', \sigma) dG}{U'(c^{\mathrm{e}}(\sigma, 0)) + \lambda \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) F^{\mathrm{r}}_w(y', \sigma) dG} \tag{38}$$

with equality if $rF \geq w - b + s^{\mathrm{u}}$. Moreover, from (32)–(33) the firm's counterpart is

$$\frac{J^{\mathrm{e}}_F(y, \sigma)}{J^{\mathrm{e}}_w(y, \sigma)} = \lambda G(\bar{y}(\sigma)). \tag{39}$$

Suppose now that $rF \leq w - b + s^{\mathrm{u}}$, so that by Lemma 1 the worker is underinsured (or fully insured) against job loss and $y^{\mathrm{d}}(\sigma) = \bar{y}(\sigma)$. Equation (10) then implies $F^{\mathrm{r}}(y', \sigma) = F$ for all $y' \leq y^{\mathrm{d}}(\sigma)$, so in this case (38) can be simplified to

$$\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} \geq \frac{\lambda G(\bar{y}(\sigma)) U'(c^{\mathrm{u}}(F))}{U'(c^{\mathrm{e}}(\sigma, 0))}. \tag{40}$$

And Lemma 1 ensures that $c^{\mathrm{e}}(\sigma, 0) \geq c^{\mathrm{u}}(F)$ and $U'(c^{\mathrm{e}}(\sigma, 0)) \leq U'(c^{\mathrm{u}}(F))$, so that

$$\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} \geq \lambda G(\bar{y}(\sigma)) = \frac{J^{\mathrm{e}}_F(y, \sigma)}{J^{\mathrm{e}}_w(y, \sigma)} \tag{41}$$

as desired.

Alternatively, if $rF > w - b + s^{\mathrm{u}}$ then the worker is overinsured and $y^{\mathrm{d}}(\sigma) > \bar{y}(\sigma)$. Equations (4) and (10) imply that $F^{\mathrm{r}}(y', \sigma) = F$ for $y' \leq \bar{y}(\sigma)$ and $F^{\mathrm{r}}(y', \sigma) = -J^{\mathrm{e}}(y, \sigma)$ for $\bar{y}(\sigma) < y' \leq y^{\mathrm{d}}(\sigma)$. Here (38) holds with equality, and using Lemma 2 to substitute for the derivatives of F^{r} yields

$$\begin{aligned}
\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} &= \frac{\lambda G(\bar{y}(\sigma)) U'(c^{\mathrm{u}}(F)) + \lambda \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) \frac{\lambda G(\bar{y}(\sigma))}{r + \lambda G(\bar{y}(\sigma))} dG}{U'(c^{\mathrm{e}}(\sigma, 0)) + \lambda \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) \frac{1}{r + \lambda G(\bar{y}(\sigma))} dG} \\
&= \frac{U'(c^{\mathrm{u}}(F)) + \frac{\lambda}{r + \lambda G(\bar{y}(\sigma))} \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) dG}{U'(c^{\mathrm{e}}(\sigma, 0)) + \frac{\lambda}{r + \lambda G(\bar{y}(\sigma))} \int_{\bar{y}(\sigma)}^{y^{\mathrm{d}}(\sigma)} U'(c^{\mathrm{u}}(F^{\mathrm{r}}(y', \sigma))) dG} \lambda G(\bar{y}(\sigma)). \qquad (42)
\end{aligned}$$

Furthermore, in this case $c^{\mathrm{e}}(\sigma, 0) < c^{\mathrm{u}}(F)$ and $U'(c^{\mathrm{e}}(\sigma, 0)) > U'(c^{\mathrm{u}}(F))$, so that

$$\frac{W^{\mathrm{e}}_F(\sigma, a)}{W^{\mathrm{e}}_w(\sigma, a)} < \lambda G(\bar{y}(\sigma)) = \frac{J^{\mathrm{e}}_F(y, \sigma)}{J^{\mathrm{e}}_w(y, \sigma)} \qquad (43)$$

as desired. □

Lemma 4. *Given J, the unique Pareto-optimal contract σ such that $J^{\mathrm{e}}(1, \sigma) = J$ satisfies $rF = w - b + s^{\mathrm{u}}$. Moreover, the Pareto frontier is strictly decreasing, strictly concave, and differentiable.*

Proof. Pareto optimality of σ ensures that $W^{\mathrm{e}}_F(\sigma, a)/W^{\mathrm{e}}_w(\sigma, a) = J^{\mathrm{e}}_F(1, \sigma)/J^{\mathrm{e}}_w(1, \sigma)$, and from Lemma 3 it follows that $rF = w - b + s^{\mathrm{u}}$. Since the locus of contracts satisfying $J^{\mathrm{e}}(1, \sigma) = J$ is downward-sloping in $\langle w, F \rangle$-space, these two conditions characterize the unique Pareto optimum for fixed J.

Substituting $w = \hat{w}(F) = rF + b - s^{\mathrm{u}}$ into equation (6), we obtain

$$0 = \bar{y}(\sigma) - b + s^{\mathrm{u}} - \tau + \lambda \int_{\bar{y}(\sigma)}^{1} \frac{y' - \bar{y}(\sigma)}{r + \lambda} dG. \qquad (44)$$

Hence $\bar{y}(\hat{w}(F), F) = y^{\mathrm{d}}(\hat{w}(F), F)$ is independent of F, and therefore from equation (4) we have $d[J^{\mathrm{e}}(1, \hat{w}(F), F) + F]/dF = 0$. Lemma 1 ensures that $c^{\mathrm{e}}(\hat{w}(F), F, 0) = c^{\mathrm{u}}(F)$, and equations (16)–(17) then yield $W^{\mathrm{e}}(\hat{w}(F), F, 0) = W^{\mathrm{u}}(F)$. Thus we can conclude that the Pareto frontier $\langle W^{\mathrm{e}}(\hat{w}(F), F, 0), J^{\mathrm{e}}(1, \hat{w}(F), F) \rangle$ traced out by F is strictly decreasing, strictly concave, and differentiable. □

Proof of Proposition 4. Since the chosen contract σ^* maximizes the objective function in equation (11), the associated payoff vector $\langle W^{\mathrm{e}}(\sigma^*, a), J^{\mathrm{e}}(1, \sigma^*)\rangle$ is on the Pareto frontier. Moreover, since this frontier is strictly concave by Lemma 4 and the Nash maximand is strictly quasi-concave in the payoffs, the contract σ^* is uniquely determined. Finally, by Lemma 4 we have $rF^* = w^* - b + s^{\mathrm{u}}$ as desired. □

Proof of Proposition 5. From Proposition 4 we have $rF^* = w^* - b + s^{\mathrm{u}}$, in which case $F^* \geq \underline{F}$ is equivalent to $s^{\mathrm{u}} \geq -p(\theta)[w^* - b]/[p(\theta) + r]$ and moreover $s^{\mathrm{e}}(\sigma^*) = 0$. Equation (19) then takes the form

$$\alpha r s^{\mathrm{u}} = p(\theta)\left[\exp\{-\alpha(w^* - b + s^{\mathrm{u}})\} - 1\right]. \tag{45}$$

Since the left-hand and right-hand sides of this equation are respectively increasing and decreasing in s^{u}, it suffices to show that the left-hand side is smaller than the right-hand side when $s^{\mathrm{u}} = -p(\theta)[w^* - b]/[p(\theta) + r]$. But this amounts to

$$1 - \frac{r\alpha(w^* - b)}{p(\theta) + r} \leq \exp\left\{\frac{-r\alpha(w^* - b)}{p(\theta) + r}\right\}, \tag{46}$$

which holds as an equality for $w^* = b$ and strictly for $w^* > b$. Now when $\gamma > 0$ we have that the loss $w^* - b$ from unemployment is strictly positive and hence $F^* > \underline{F}$. And when $\gamma = 0$ we have $w^* - b = 0 = s^{\mathrm{u}}$ and hence $F^* = 0 = \underline{F}$. □

Proof of Proposition 6. Since $\gamma = 0$ we have $W^{\mathrm{e}}(\sigma^*, a) = W^{\mathrm{u}}(a)$. From equations (16)–(17) we then have $w^* - \tau - s^{\mathrm{e}}(\sigma^*) = c^{\mathrm{e}}(\sigma^*, 0) = c^{\mathrm{u}}(0) = b - \tau$, where the last equality follows from Proposition 3, and so $w^* = b + s^{\mathrm{e}}(\sigma^*)$. Also $c^{\mathrm{u}}(F^*) > c^{\mathrm{u}}(0) = c^{\mathrm{e}}(\sigma^*, 0)$ since $F^* = F_m > 0$, and so $y^{\mathrm{d}}(\sigma^*) > \bar{y}(\sigma^*)$ by equation (18). Moreover, since $F^{\mathrm{r}}(y', \sigma^*) > F^*$ for all $y' < y^{\mathrm{d}}(\sigma^*)$, equations (10) and (20) imply $s^{\mathrm{e}}(\sigma^*) < 0$ and hence $w^* < b$. □

Proof of Proposition 7. Since $F^* = F_m > 0$ we have $w^* < b < b + rF^* - s^{\mathrm{u}}$, where the first inequality follows from Proposition 6 and the second from Proposition 3. It follows that $W^{\mathrm{e}}_F(\sigma^*, 0)/W^{\mathrm{e}}_w(\sigma^*, 0) < J^{\mathrm{e}}_F(y, \sigma^*)/J^{\mathrm{e}}_w(y, \sigma^*)$ for all y by Lemma 3. Since these marginal rates of substitution are unequal and yet $W^{\mathrm{e}}(\sigma^*, 0) = W^{\mathrm{u}}(0) = U(b)/r = W^{\mathrm{e}}(\sigma^\circ, 0)$, we can conclude that $J^{\mathrm{e}}(y, \sigma^*) < J^{\mathrm{e}}(y, \sigma^\circ)$ for all y. Equation (21) then yields $q(\theta^*) > q(\theta^\circ)$, so job creation is lower. On the other hand, since $\gamma = 0$ we have $J^{\mathrm{e}}(y^{\mathrm{d}}(\sigma^*), \sigma^*) = 0$ and job destruction is higher, whereupon it follows from equations (23)–(24) that both the unemployment rate and the tax τ are also higher. And finally, from equation (16) we can see that the workers' welfare measures $W^{\mathrm{u}}(a) = W^{\mathrm{e}}(\sigma^*, a)$ have fallen. □

A.2 Alternative bargaining protocols

Our assumption that workers have all of the bargaining power in the renegotiation game ensures that they capture all surplus from separation. Alternatively, one could assume that the renegotiation outcome solves the Nash bargaining problem

$$\max_{F'} \, [W^{\mathrm{u}}(a + F') - W^{\mathrm{e}}(\sigma, a)]^{\gamma}[-F' - J^{\mathrm{e}}(y, \sigma)]^{1-\gamma} \tag{47}$$
$$\text{subject to } W^{\mathrm{u}}(a + F') \geq W^{\mathrm{e}}(\sigma, a) \text{ and } F' \leq \min\{F, -J^{\mathrm{e}}(y, \sigma)\}.$$

It is easy to see that solving this problem will yield the same separation decisions as in the main text. In fact, when $\gamma = 1$ the two cases are identical, and when $\gamma < 1$ the only difference is that the firm captures a strictly positive share of the surplus from separation. Our choice of assumption has two motivations: First, it makes the strategic interaction somewhat more transparent relative to the Nash bargaining implementation. And second, it maximizes the ex-post redistribution resulting from severance pay mandates, further reinforcing our claim that the welfare losses found in Section 5.2 are an upper bound.

Note that the workers' ability to extract positive surplus from separation is necessary for non-neutrality. To see this, imagine that the firm could make a take-it-or-leave-it offer of the renegotiated severance payment F^{r}. The laissez-faire equilibrium would be as in Section 4, since the parties would again have enough instruments to achieve efficiency, and in equilibrium we would have $W^{\mathrm{e}}(\sigma^{\circ}, 0) = W^{\mathrm{u}}(F^{\circ})$. If the government were to impose a mandate F_m strictly larger than F°, then the following would be ex-ante optimal and yield neutrality: The parties set $\sigma^* = \langle w^*, F^* \rangle = \langle w^{\circ}, F_m \rangle$, and in the event that $y' < y^{\mathrm{d}}(\sigma^{\circ})$ the firm proposes $F^{\mathrm{r}}(y', \sigma^*) = F^{\circ}$. Since in laissez-faire the worker is indifferent between working at wage w° and separating with transfer F°, the same is true in the binding-constraint equilibrium. The worker's ex-post bargaining power is zero, so he or she cannot extract a higher payoff in the renegotiation game.

Country	$p(\theta)$	ρ	ACJT	$\underline{f}$	blue collar n.p.	blue collar sev.	white collar n.p.	white collar sev.	$f_m - \underline{f}$
Australia	0.15	36	7.6	4.2	11	2	1	2	8.8
Belgium	0.04	60	24.4	9.2	1.9	—	21[a]	—	11.8
Canada	0.29	59	3.5	1.4	0.5	0.3	0.5	0.3	−0.4
Denmark	0.12	90	11.9	0.8	3	—	6	1	6.2
Finland	0.15	63	10.4	2.4	4	—	4	—	1.6
France	0.05	57	21.1	8	2	1.7	2	1.7	−4.3
Germany	0.13	63	26.5	4.4	2[b]	—	6[b]	—	1.6
Ireland	0.03	37	11.4	19	1.5	1.4	1.5	1.4	−16.1
Italy	0.03	40	41.2	18	0.5	20	4	20	6
Netherlands	0.05	70	15.3	5.6	3.3	—	3.3	—	−2.3
Norway	0.25	65	11.6	1.4	3	—	3	—	−1.6
New Zealand	0.17	30	6.8	4	1	—	1	—	−3
Portugal	0.06	65	14.9	5.7	2	15	2	15	11.3
Spain	0.02	70	26.8	12.9	3	12	3	12	2.1
Sweden	0.25	80	10.6	0.8	4[b]	—	4[b]	—	3.2
UK	0.1	38	4.5	6	1.2	1.2	1.2	1.2	−4.8
USA	0.33	50	3.1	1.5	2[c]	—	2[c]	—	0.5
	per month	%	years	months	months		months		months

[a] ACJT × 0.86; an approximation of the Claeys formula in Grubb and Wells (1993).
[b] Dependent on age and length of service; we assume employment started at age 20.
[c] Applies only to large-scale layoffs covered by the Worker Adjustment and Retraining Notification Act.

Table 5: Legislated and privately-optimal dismissal costs for blue and white collar workers in various countries. Costs include both notice-period (n.p.) and severance (sev.) pay.

A.3 Data and data sources

Table 5 contains the data used to construct the country-specific upper bounds on the excess of mandated over privately-optimal severance pay used in Section 5. These upper bounds, reported in the last column of the table, amount to the difference between the legislated payment f_m and the bound on the privately-optimal payment in equation (26).

The monthly exit rates $p(\theta)$ from unemployment are from the OECD unemployment duration database. The benefit replacement rates ρ come from Nickell (1997), except for the Italian rate which has been updated using U.S. Social Security Administration (2002). The interest rate is set at 4 per cent annually.

Legislated dismissal costs are constructed as the maximum over blue and white collar workers of the sum of notice-period and severance pay. The latter quantities are obtained by applying the formulas for legislated notice-period and severance pay to the average completed job tenure (ACJT) figures in the third column of the table, from the dataset in Nickell et al. (2002), averaged over each country's sample period. The relevant formulas for European countries come from Grubb and Wells (1993), with the exception of those for Austria, Finland, Norway, and Sweden, which are derived from Industrial Relations Service (1989). The size of the legislated severance payment for Italy includes damages workers are entitled to if their dismissal is deemed unfair (5 months) plus the amount they receive if they give up their right to reinstatement (15 months). Our value is consistent with the estimates in Ichino (1996).[29] The data for Portugal and New Zealand come from European Foundation (2002) and CCH New Zealand Ltd (2002), respectively. The data for legislation in Australia, Canada, and the United States are from Bertola et al. (1999).

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[29] Note that the formula in Grubb and Wells (1993) wrongly treats as severance pay the "trattamento di fine rapporto," a form of forced savings workers are entitled to whatever the reason for termination, including voluntary quits and summary dismissal. On this point see Brandolini and Torrini (2002).

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