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Giulio Fella

Universiteit Utrecht

Utrecht School of Economics

Tjalling C. Koopmans Research Institute
Utrecht School of Economics
Utrecht University

Janskerkhof 12
3512 BL Utrecht
The Netherlands
telephone +31 30 253 9800
fax +31 30 253 7373
website www.koopmansinstitute.uu.nl

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How to reach the authors

Please direct all correspondence to the first author.

Giulio Fella
Queen Mary, University of London
Mile End Road
London El NS
E-mail: g.fella@qmul.ac.uk

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Optimal Severance Pay in a Matching Model

Giulio Fella[a]

[a]Queen Mary, University of London

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Abstract
This paper uses an equilibrium matching framework to study jointly the optimal private provision of severance pay and the allocational and welfare consequences of government intervention in excess of private arrangements. Firms insure risk-averse workers by means of simple explicit employment contracts. Contracts can be renegotiated ex post by mutual consent. It is shown that the lower bound on the privately optimal severance payment equals the fall in lifetime wealth associated with job loss. Simulations show that, despite contract incompleteness, legislated dismissal costs largely in excess of such private optimum are effectively undone by renegotiation and have only a small allocational effect. Welfare falls. Yet, for deviations from *laissez faire* in line with those observed for most OECD countries, the welfare loss is small.

Keywords: Severance Pay, Contracts, Renegotiation

JEL classification: J23, J64, J65

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1 Introduction

Employment contracts often contain explicit severance payments provisions[1]. Furthermore, in many countries minimum levels of severance payments and other forms of employment protection are enshrined in legislation. The existence of such measures is difficult to understand in the light of standard labour market models in which homogeneous[2] workers maximise expected labour income and wages are perfectly flexible.

From a general equilibrium perspective, risk-neutral behaviour requires perfect insurance or complete asset markets. Together with wage flexibility and unconstrained side-payments, perfect insurance implies that any spillover between a worker and her current employer is internalised and the market equilibrium is constrained efficient. As pointed out by Lazear (1990), employment protection measures have no useful role to play in such environment and there is no reason why a firm which takes aggregate quantities as given should offer them. In brief, it is hard for models based on risk-neutral labour market behaviour to provide a role for job security measures when wages can adjust freely. As argued in Pissarides (2001), this implies that "...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."

This paper studies the optimal private provision of one form of employment protection, severance pay, in an environment in which it plays an economic role as risk-averse workers can only imperfectly insure against idiosyncratic labour income shocks. This optimal contracting problem is cast within Mortensen and Pissarides's (1994) equilibrium matching model. Using an equilibrium framework, the paper can explore jointly the privately optimal size of severance pay and the allocational and welfare effects of a mandated discipline which deviates from it.

[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, and 20 per cent in establishments below such threshold, were covered by severance payment clauses. For the UK, the 1990 *Workplace Industrial Relations Survey* reveals that 51 per cent of union companies bargain over the size of non-statutory severance pay for non-manual workers and 42 per cent for manual workers (Millward et al. 1992). Even for Spain, a country usually associated with high level of state-mandated employment protection, Lorences et al. (1995) document that between 8 and 100 per cent of collective agreements in a given sector establish levels of severance pay in excess of legislated measures.

[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 two key features of this exercise are: (i) simple explicit contracts, and (ii) renegotiation by mutual consent.

Feature (i) rules out reputation-based complete implicit contracts and ensures that excessive mandated severance pay is non-neutral. This would not be the case with risk-neutral firms and complete contracting, as the latter would be a substitute for complete insurance markets. Excessive severance pay legislation would also be undone by a simple intertemporal contract mandating that workers rebated to firms the excess of the legislated termination pay over its privately optimal level. Since courts are unlikely to enforce contracts aimed at circumventing legislation, though, such an arrangement would be feasible only if supported by a self-enforcing implicit agreement. Yet the arrangement cannot be self-enforcing as a worker about to be fired would have no ex post incentive to honour such an ex ante pledge[3].

While feature (i) stakes the odds in favour of non-neutrality, feature (ii) imposes the natural, joint-rationality constraint that a firm-worker pair do not leave money on the table if they can avoid it. It allows the parties to potentially circumvent legislation, if there are mutual gains from doing so, but only by means of ex post, spot side payments. Since such ex post side payments are state-dependent, insurance is possibly imperfect and excessive mandated severance pay is a priori non-neutral.

The paper establishes a lower bound for the optimal severance payment size. This equals the fall in lifetime wealth associated with job loss. Hence, job security in the form of positive redundancy pay is part of an optimal contract whenever workers enjoy positive rents. Positive workers' rents imply costly mobility and call for insurance against job loss.

By yielding a closed-form lower bound for the optimal severance pay the model provides a metric against which to assess the extent to which observed legislated measures are excessive. Such a metric is used to construct a series for the lower bound on optimal severance pay for a sample of OECD countries and compare it to the corresponding series for legislated payments. It turns out that for a large proportion of these countries mandated payments do not significantly exceed, and are often significantly lower than, their optimal lower bound. Even for those countries for which this is not the case, the observed

[3]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.

deviation from the private optimum is inconsistent with quantitatively important changes in the allocation of labour in the light of the model's numerical results. Therefore, the model implies a direction of causation from factors which generate high workers' rents and unemployment duration to high severance pay but rules out the reverse. The same causation also goes from low unemployment benefits to large severance payments, coeteris paribus.

The reason why, despite their *a priori* non-neutrality, legislated severance payments above private optima have quantitatively small allocational effects is the following. A legislated severance payment in excess of the private optimum just determines the *maximum* transfer in case of separation. In equilibrium, the firm pays it only if the productivity shock is so low that the firm cannot credibly threat to continue the match at the contract wage. If the productivity realization is not so negative, yet below its reservation value, the parties agree to label the separation a quit and exchange a lower severance payment which equals the firm's present value of profits at the contract wage and current productivity realization. This is Pareto optimal as it makes the worker strictly better off and leaves the firm indifferent between continuation and separation. As the legislated severance 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. The wage component of the contract falls to rebalance the parties' respective shares of the surplus from a new match.

While the allocation of labour is hardly affected, very large deviations from the private optimum may have considerable negative effects on workers' welfare as, by overinsuring against job loss, they increase income fluctuation relative to *laissez-faire.* Yet, for only two countries in our dataset are observed deviations large enough to imply an upper bound on the welfare loss equal to a third of a percentage point fall.

The model is related to a number of papers in the literature. MacLeod and Malcomson (1993) is the closest antecedent to the contracting framework studied in the paper. In a risk-neutral framework they show how incomplete contracts of the fixed price and severance payment variety can solve the hold up problem, as they are infrequently renegotiated. Severance payments reduce the probability of renegotiation of the fixed-price component of the contract. This paper applies MacLeod and Malcomson's insight about the infrequent renegotiation of simple, explicit, fixed-price contracts to the optimal private provision of insurance. This contrasts with the implicit contract literature pioneered by Azariadis (1975) and Baily (1974). That literature was mainly concerned with establishing minimal restrictions on contracts or information that could generate a deviation from the first-best, full-insurance outcome and a trade-off between risk sharing and productive efficiency. By assuming that reputational considerations ruled out firm-initiated renegotiation of implicit agreements that literature resolved the trade-off in favour of risk sharing. Instead, by allowing for renegotiation by mutual consent our paper emphasises the constraint that ex post efficiency imposes on insurance provision by means of simple, explicit contracts.

Recently, Alvarez and Veracierto (2001), Bertola (2004) and Pissarides (2004) have explored the role of employment protection within a fully dynamic framework with risk-averse workers. Alvarez and Veracierto (2001) show that exogenously-imposed severance payments can have large positive effects on employment and welfare in a model with costly frictions and self-insurance. Bertola (2004) shows, within a competitive equilibrium environment, that collectively administered income transfers may improve welfare and efficiency by reducing the consumption fluctuation associated with job mobility. Both papers do not allow for optimal private contracts. We show that allowing for optimal private contracting implies there is no welfare-improving role for legislated employment protection. Yet, Pareto optimal renegotiation implies that the allocational effects and welfare costs of excessive government intervention are small.

Pissarides (2004) shows that optimal private contracts feature severance pay and, possibly, advance notice. Being partial equilibrium though, his model cannot address the allocational effects of excessive government intervention. On the other hand, contrary to this paper, Pissarides (2004) allows for dismissal delays (advance notice). He shows that, as long as state-provided unemployment insurance is low enough for it not to make it worthwhile for the parties to take advantage of such third-party income transfer, dismissal delays provide additional (imperfect) insurance against the uncertain length of unemployment spells at a lower cost to the firm than severance pay.

A related literature studies the optimal size and time path of unemployment benefits in search and matching models with risk-averse workers. For tractability, it studies environment in which severance pay has little or no role. Acemoglu and Shimer (1999) show that positive unemployment benefits increase efficiency and welfare relative to *laissez faire* in a directed search model without job loss. The matching models with wage bargaining and hand-to-mouth consumers of Cahuc and Lehmann (2000), Fredriksson and Holmlund (2001) and Coles and Masters (2006) also imply that the optimal size of unemployment benefits is strictly positive.

Finally, Blanchard and Tirole (2005) study the optimal joint design of unemployment insurance and employment protection in a static, partial-equilibrium setup. Because the model is static, it blurs the distinction between severance pay and unemployment benefits and the analysis emphasises the optimal financing of benefits by means of layoff taxes.

Common to all these papers is the result that, in a dynamic context, moral hazard implies that efficient and/or optimal insurance by means of unemployment benefits is imperfect and job loss costly. This paper shows that severance pay complements unemployment insurance and derives a lower bound for the optimal severance payment as a function of unemployment duration and benefits. It shows that costly job loss calls for positive severance pay. The same insight underpinning Acemoglu and Shimer (1999) also implies that severance payments are not a perfect substitute for unemployment benefits either. We show that productive efficiency still requires the latter to be positive.

The paper is structured as follows. Section 2 introduces the economic environment. Section 3 derives the equilibrium of the renegotiation game and derives the agents' Bellman equation. Section 4 characterises the optimal contract. Section 5 calibrates the model and derives empirical implications. Section 6 considers some extensions and Section 7 concludes.

2 Environment

2.1 Description

Time is continuous and the horizon infinite. The economy is composed by an endogenous number of risk-neutral establishments (or firms) and a unit mass of risk-averse workers with infinite lifetimes. Workers are endowed with an indivisible unit of labour and maximise the present value of utility from consumption

$$\mathbb{E}\int_{t}^{\infty} u(c_s)e^{-\phi(s-t)}ds \tag{1}$$

where $\mathbb{E}$ is the expectation operator conditional on the information set at time t, ϕ is the subjective discount rate, c_s is consumption at time s and $u(.)$ is the increasing and strictly concave felicity function.

There are no insurance markets, but agents can self-insure by investing in the only, riskless, asset available. Therefore, workers' maximisation problem is subject to the dynamic budget identity

$$da_t = (ra_t + z_t - c_t)dt, \tag{2}$$

where r is the exogenous riskless rate, a_t the stock of wealth and z_t is the net-of-tax flow of non-capital income. Disposable non-capital income z_t equals the wage w_t for an employed worker and the unemployment benefit b for an unemployed one. Borrowing is subject to a no-Ponzi-game or tighter constraint to specify.

The riskless rate of return r is assumed to equal the subjective discount rate. Hence, if markets were complete workers would choose a flat consumption profile.

Firms maximize the expected present value of profits discounted at the market interest rate. Each establishment requires one worker in order to produce. Because of search frictions, it takes time for a firm with a vacant position to find a worker. Such frictions are captured by a constant returns to scale, strictly concave, matching technology $M(U, V)$, where U is the number of unemployed workers and V the number of vacancies. With constant returns instantaneous matching rates depend only on market tightness $\theta = V/U$. Contact rates are denoted $q(\theta) = M(U, V)/V$, for vacant firms, and $p(\theta) = M(U, V)/U$, for unemployed workers.

Keeping an open vacancy entails a flow cost $m > 0$. If a firm and worker meet and form a match, they negotiate an initial contract σ. At time t_0, when the contract is signed, the worker starts producing a unit flow of output. At any time $t > t_0$, the job may be hit by a shock with instantaneous probability λ and the parties decide, after observing the productivity realization, whether to continue or end the match and on which terms.

Following a shock the match-specific value of productivity takes a new value[4] $y \in [y_l, 1]$, with y distributed according to a continuous cumulative density function $G(y)$.

A worker who becomes unemployed receives a net-of-tax flow of unemployment benefits b independently from the reason for separation. We assume $b < 1$ to ensure a non-degenerate equilibrium with positive employment exists. As in Acemoglu and Shimer (1999), benefits are assumed to be financed by a lump-sum tax τ. The unemployment benefit fund is balanced at all times.

The paper focuses on simple, realistic employment contracts featuring state-independent wages and termination pay. Namely, we assume that a long-term, initial contract $\sigma = (w_c, F_c)$ only specifies a, post-tax, wage w_c in case production takes place and a layoff payment F_c from the firm to the worker in case of layoff[5].

Crucially it is assumed that termination payments can be conditioned on who takes verifiable steps to end the relationship. A separation is deemed a dismissal if and only if the firm gives the worker written notice that it no longer wishes to continue the employment relationship. The end of the relationship is deemed a quit if the worker gives written notice that she no longer intends to continue in employment[6]. That is, neither party can claim the counterpart has unilaterally severed the relationship unless they can produce a written document, signed by the other party, proving their claim. This seems broadly consistent with existing practices in most countries. A separation is consensual if both parties sign a written document stating their agreement to terminate the relationship and exchange any termination payment specified in the document. Until one of these actions is taken the employment relationship is considered in existence.

At any time the parties can renegotiate the terms of the ruling contract (w_c, F_c). This ensures that mutual gains which are not exhausted by the ex ante contract can be reaped ex post. If the initial contract is renegotiated, there are two possibilities. Either the contract wage is renegotiated and the match continues or the parties agree to renegotiate the severance payment and separate.

[4]The assumption that new jobs are created at the top of the productivity distribution is without loss of generality. What matters is that a new match has positive surplus.

[5]This is broadly consistent with the form of observed labour contracts. Proposition 5 shows that even such a simple contract delivers full insurance in the benchmark economy.

[6]Alternatively, not showing up for work without providing a medical certificate could be interpreted as a signal that the worker has quit.

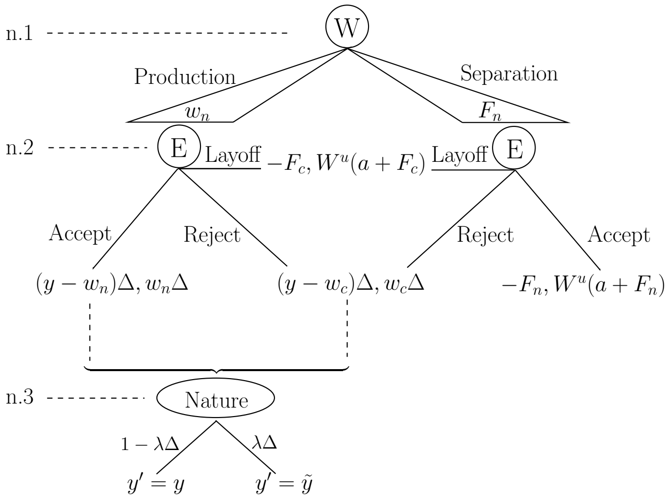

Figure 1: Renegotiation game

We allow for the possibility that the government mandates a minimum layoff payment F^m. Such a minimum standard imposes a constraint $F^c \geq F^m$ on the contracted layoff payment F^c, since a contract in breach of existing legislation would not be upheld in court. Although the mandated minimum constraints *ex ante* contracting, it does not prevent a firm-worker pair from negotiating a lower *spot* side payment upon separation if doing so is Pareto optimal. The parties can achieve this in two equivalent ways. They can label the separation a quit or a voluntary redundancy rather than a layoff, in which case transfers between them are unconstrained by legislation. Alternatively, they can label the separation a layoff with the worker rebating to the firm, on the spot, the difference between the legislated payment F_c and the ex post Pareto optimal one.

3 Contracts and renegotiation

In order to solve for the optimal contract, one has to work backwards from the moment a contract is already in place.

3.1 Contract renegotiation

After the parties match and a contract is signed at time t_0, the parties play an infinite horizon renegotiation game along the lines of MacLeod and Malcomson (1993). The game is illustrated in Figure 1.

The first offer of renegotiation is made at t_0 and subsequent offers follow at intervals of length Δ. Let $W^u(a)$ denote the lifetime expected utility of an unemployed worker with wealth a and let $\Omega_w \subset \{w \in \mathbb{R}\}$ and $\Omega_F \subset \{F \in \mathbb{R}\}$ denote respectively the set of possible wage and severance-pay offers. The two sets are assumed to be continuous and bounded. There is a potentially infinite number of bargaining rounds, each of them characterized by the following sequence of moves.

(n.1) Given the current state $s = (y, w_c, F_c, a) \in S$, the worker chooses one of the following two types of action: 1) proposing to produce at some wage $w_n \in \Omega_w$; 2) proposing to separate with a side payment $F_n \in \Omega_F$. If the worker quits unilaterally, the game ends and the worker's and firm payoffs equal respectively $W^u(a)$ and zero.

(n.2) Given the state and the worker's choice of action, the firm chooses among the following three actions: 1) laying the worker off; 2) accepting the worker's proposal; 3) rejecting the worker's proposal.

If it lays off the worker the game ends and the firm has to pay the contracted severance payment[7]. Its payoff is $-F_c$ and the worker's $W^u(a + F_c)$.

If F_n is proposed at n.1 and the firm accepts, the game ends and the firm and worker obtain respectively payoffs $-F_n$ and $W^u(a + F_n)$.

If w_n has been proposed at n.1 then the state transits to (y, w'_c, F_c, a) with $w'_c = w_n$ if the firm accepts and $w'_c = w_c$, the current contract wage, if the firm rejects. Trade takes place in the current round at the contract wage w'_c for a time interval of length of time Δ, generating income flows $(y - w'_c)$ and w'_c for the firm and worker respectively. The worker chooses her optimal consumption level $\hat{c}^t$. At the end of Δ, the game moves to n.3.

(n.3) With probability $1 - \lambda\Delta$ the match productivity is unchanged and $y' = y$. With probability $\lambda\Delta$ a new realization $\tilde{y}$ is drawn from $[y_l, 1]$ and $y' = \tilde{y}$. The game moves to stage n+1.1 characterized by (y', w'_c, F_c, a'), with $a' = a + (ra + w'_c - \hat{c}^t)\Delta$.

This extensive form is meant to capture the following three aspects. First, the insight of MacLeod and Malcomson (1993) that if trade takes place over time, rather than at a

[7] Since the initial contract satisfies any legislated lower bound by assumption, it is a sufficient statistics for the severance payment in case of unilateral layoff.

fixed date, simple fixed-price contracts are not necessarily renegotiated. If trade under the terms of the current contract is profitable for both parties, refusing to revise the contract is a credible threat for the party who opposes renegotiation. This is captured by the fact that trade takes place at the ruling wage unless the match ends or the contract is renegotiated[8]. Second, the threat to refuse renegotiation is constrained by either party's option to unilaterally end the match. The threat to end the match, when credible, limits a fixed-price contract ability to provide insurance against productivity fluctuations in case the match continues. Third, the parties can renegotiate existing arrangement when this is Pareto optimal.

The renegotiation game above is a stochastic bargaining game. Merlo and Wilson (1995) derive a sufficient condition for a stochastic, alternating offer bargaining game to have a unique stationary equilibrium. Such condition is violated if agents are risk-averse. Removing the alternating offer assumption, by giving the worker all the bargaining power, is sufficient to guarantee uniqueness of a stationary equilibrium[9].

The equilibrium concept used is stationary subgame perfect equilibrium (SSP) in pure strategies. A subgame perfect equilibrium is a strategy profile such that no player can benefit from deviating from her strategy at any stage. A strategy profile is stationary if it depends only on the current state and offer. A strategy profile is SSP if it is stationary and subgame perfect. It follows that SSP payoffs are also stationary.

Let $\beta_f = 1 - r\Delta$ and $\beta_w = 1 - \phi\Delta$ denote the firm and worker's discount factors over a time interval Δ and let $\mathbb{E}$ denote the expectation operator over the future realization of y' conditional on its current value y; i.e. given a generic function $h(y')$ it is $\mathbb{E}h(y') = (1-\lambda\Delta)h(y) + \lambda\Delta\int h(\tilde{y})dG(\tilde{y})$. Finally, let $\Gamma_w = \{\text{quit}\} \cup \Omega_w \cup \Omega_F$ denote the worker's action set.

Proposition 1. *Let w_c, F_c and Δ be given and finite.*

1. *If the renegotiation game at $t \geq t_0$ has a SSP equilibrium, the associated equilibrium*

[8] It would be straightforward to allow the parties to choose optimally whether to trade or not at the ruling wage in case the match survives. If lockouts are illegal and the ruling contract exceeds the disutility of labour (zero in this case) trade always takes place if the match survives. Lockouts are indeed illegal in a number of countries. Furthermore, if legal lockouts destroyed insurance with positive probability by allowing the firm to renegotiate the contract, the parties could negotiate a Pareto improving clause ruling them out.

[9] As it turns out, Proposition 5 shows that giving all bargaining power to the worker is without loss of generality in the absence of government intervention as payoffs are always determined by outside options.

payoff profile is a pair of functions $W^e(s), J^e(s) : S \to R$ *satisfying*

$$W^e(y, w_c, F_c, a) =$$

$$\max_{j\in\{0,1\}} (1-j) \max_F W^u(a+F) + j \max_w W^t(y, w, F_c, a) \tag{3}$$

$$\text{s.t.} - (1-j)F + jJ^t(y, w, F_c, a) = \max\{-F_c, J^t(y, w_c, F_c, a)\}, \tag{4}$$

with

$$W^t(y, w_c, F_c, a) = \max_{c^t} u(c^t)\Delta + \beta_w \mathbb{E} W^e(y', w_c, F_c, a') \tag{5}$$

$$\text{s.t. } a' = a + (ra + w_c - c^t)\Delta \tag{6}$$

and

$$J^t(y, w_c, F_c, a) = (y - w_c - \tau)\Delta + \beta_f \mathbb{E} J^e(y', w_c, F_c, a'), \tag{7}$$

$$J^e(y, w_c, F_c, a) = -(1-\hat{j})\hat{F} + \hat{j} J^t(y, \hat{w}, F_c, a), \tag{8}$$

where $\hat{j}, \hat{w}, \hat{F}$ *are the maximizers of the above programme.*

2. *If a pair of functions* $W^e(s), J^e(s) : S \to R$ *satisfy equations* (3)-(8), *they are a SSP payoff profile for the renegotiation game at* $t \geq t_0$*.*

Proof. We prove point 1. in the main text below, while also introducing the notation. The proof of point 2. is in the Appendix A.1. □

Let $W^e(s), J^e(s)$, be the present values of the expected worker's and firm payoffs, in state s and as of stage n.0, along the equilibrium path. Be $W^t(s), J^t(s)$ the corresponding equilibrium payoffs at stage n.2 conditionally on trade taking place at the equilibrium ruling wage. We need to show that these payoffs functions satisfy the above Bellman equations and that the associated policy functions are consistent with best response strategies at any stage.

Equations (5) and (7) just imply that W^t, J^t equal the respective maximized utility flows associated with trading at the ruling wage plus the discounted expected continuation payoff in the next round. The firm's flow cost of labour is the pre-tax wage $w + \tau$.

The right hand side of constraint (4) is the firm's reservation payoff when confronted with a proposal at stage n.2. The firm can secure a payoff of $-F_c$ by unilaterally firing the worker. Alternatively, it can obtain a payoff $J^t(y, w_c, F_c, a)$ by rejecting the worker's proposal, in which case trade takes place in the current round at the unchanged contract wage w_c. Perfection requires the firm to accept only if the worker's proposal gives her a payoff greater or equal than the one associated with the firm's optimal choice between the two alternative actions. The left hand side of equation (4) is the payoff to the firm if it accepts a worker's proposal to either separate - $j = 0$ - with a transfer F or to produce - $j = 1$ - at some wage w.

Turning to equation (3), at stage n.1 the worker can either propose to separate - $j = 0$ - with a side payment F or to trade - $j = 1$ - at some wage w. In either case, perfection requires the worker to choose the proposed F or w so as to maximize her own payoff subject to the firm receiving at least its reservation payoff. The latter constraint must therefore always be binding in equilibrium, hence equation (4).

Finally, unconditionally, the worker's choice at stage n.1 between quitting, proposing to produce and proposing to separate must be optimal.

If payoffs do not satisfy the above system of functional equations, it is possible to improve on them at some stage by a deviation consistent with the policy functions which implies that the original strategy profile cannot be SSP. This completes the proof.

It is worth pointing out that the policy functions imply that trade takes place in all rounds as long as the match survives and the parties immediately agree on separation whenever it is Pareto optimal to do so.

We can now prove the following result.

Proposition 2. *Given finite w_c, F_c and Δ, the renegotiation game at $t \geq t_0$ has a unique SSP payoff profile.*

Proof. See Appendix A.1. □

We can now characterise the firm's and worker's value functions in the limit as bargaining frictions become negligible.

Proposition 3. *Let w_c, F_c be given. As the interval between offers goes to zero ($\Delta \to 0$), the firm's and worker's unique SSP payoffs at any $t \geq t_0$ converge to*

$$J^e(y, w_c, F_c) = \max\left\{-F_c, \frac{y - w_c - \tau + \lambda \int_{y_l}^{1} J^e(y', w_c, F_c)\, dG}{r + \lambda}\right\}, \tag{9}$$

$$W^e(y, w_c, F_c, a) = \max\left\{W^u(a - J^e(y, w_c, F_c)), W^t(\min\{w_c, \bar{w}\}, F_c, a)\right\}, \tag{10}$$

with

$$W^t(w, F_c, a) = \frac{\max_{c^t} u(c^t) + (ra + w - c^t)W_a^t + \lambda \int_{y_l}^{1} W^e(y', w, F_c, a)\, dG}{\phi + \lambda} \tag{11}$$

and

$$\bar{w}(y, F_c) = y - \tau + rF_c + \lambda \int_{y}^{1} \frac{1 - G(y)}{r + \lambda} dy. \tag{12}$$

Proof. See Appendix A.1. □

The system of equations (9)-(11) are just the continuous-time limit, and compacted, counterpart of the corresponding system in Proposition 2. Equation (9) obtains from equations (4), (7) and (8) and just restates that in the unique equilibrium the firm receives its reservation payoff, i.e. the higher between the return associated with firing the worker at cost F_c and continuing the relationship at the current wage contract w_c. Since both F_c and w_c are independent of the worker's current stock of wealth, so is the firm value function.

If the match continues the equilibrium wage equals the lower between the initial contract wage w_c and the firm's reservation wage $\bar{w}$ in equation (12). This is the wage that equates the two terms inside the maximum operator in equation (9). The associated worker's value function - the second term inside the maximum operator in equation (10) - coincides with the expected utility $W^t(.)$ from continuing the match at the equilibrium ruling wage $\min\{w_c, \bar{w}\}$.

If instead the match ends, also the equilibrium severance payment must be such as to give the firm its reservation payoff. The worker cannot force the firm to unilaterally terminate the match and pay F_c if the firm payoff from continuing the match at w_c exceeds $-F_c$. Therefore, the worker's payoff in case of separation is $W_u(a - J^e(y, w_c, F_c))$.

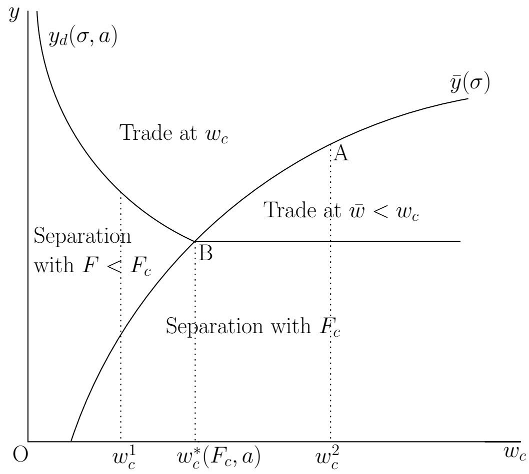

Figure 2: Renegotiation and separation

Equation (10) characterizes the, Pareto optimal, separation decision. Finally, equation (11) is the Hamilton-Jacobi-Bellman equation for the worker's value function in case trade takes place with W_a^t denoting the partial derivative of W^t with respect to wealth a. Finally, note that since shocks are i.i.d., the firm's productivity realization affects the expected utility W^t only through the wage in those states in which the match survives.

Equation (12) can be inverted to solve for the firm's reservation productivity

$$w_c = \bar{y}(\sigma) - \tau + rF_c + \lambda \int_{\bar{y}(\sigma)}^{1} \frac{1 - G(y)}{r + \lambda} dy. \tag{13}$$

For given F_c, $\bar{y}(\sigma)$ is an increasing and concave function of w_c. The corresponding curve is drawn in Figure 2.

Consider now the joint reservation productivity y_d below which the match is destroyed. This is the value of y which equates the two terms inside the maximum operator in equation (10) - the worker's utility from separation at the equilibrium severance pay and from continuation at the equilibrium wage.

Equation (10) implies that the joint reservation productivity is a function $y_d(\sigma, a)$ of the ruling contract σ and the worker's stock of wealth. Figure 2 draws $y_d(\sigma, a)$ as a function of w_c, for given (F_c, a). To understand the shape of the associated curve consider the following thought experiment. For w_c large enough it is $\min\{w_c, \bar{w}\} = \bar{w}$, as the firm's outside option is binding - $J^e(y, \sigma) = -F_c$ - and the contract wage is renegotiated for any possible productivity realization. Therefore, the worker's expected utility from continuing the match W^t in equation (10) is independent of w_c. For the same reason, also the worker's return from separation in equation (10) is independent of w_c. It follows that y_d is also independent of w_c and strictly smaller than $\bar{y}$. Reducing w_c has no effect on y_d but reduces $\bar{y}$. Therefore there exists a unique critical value $w_c^*(F_c, a)$ of w_c at which the two curves cross.

Given (F_c, a), the two curves partition the set of possible (y, w_c) pairs into the four, mutually exclusive, subsets labelled in Figure 2. The contract σ and worker's wealth stock determined whether $y_d < \bar{y}$ or not. The contract is never renegotiated and the ex ante transfers it establishes are realized ex post in all states if and only if $w_c = w_c^*(F_c, a)$.

Consider instead the case in which $w_c < w_c^*(F_c, a)$, or equivalently $y_d(w_c, F_c, a) > \bar{y}(w_c, F_c)$; - e.g. $w_c = w_c^1$ in Figure 2. The firm has an incentive to fire the worker and pay F_c if an only if $y < \bar{y}(w_c^1, F_c)$. If not, the firm prefers to continue trading at w_c^1. It follows that the contract wage is never renegotiated, but the parties renegotiate F_c down and separate efficiently if $\bar{y}(w_c^1, F_c) < y < y_d(w_c^1, F_c, a)$.

Finally, suppose $w_c > w_c^*(F_c, a)$, or equivalently $y_d(w_c, F_c, a) < \bar{y}(w_c, F_c)$; - e.g. $w_c = w_c^2$ in Figure 2. Unless w_c is not renegotiated, the firm is better off paying F_c and firing the worker whenever $y < \bar{y}(w_c^2, F_c)$. Therefore, the contractual severance payment is never renegotiated, but the wage is renegotiated down to $\bar{w}(y, F_c)$ - the inverse image of $\bar{y}$ along the segment AB - whenever $y_d(w_c^2, F_c, a) < y < \bar{y}(w_c^2, F_c)$.

We summarize the state-dependent equilibrium outcomes in the following remark.

Remark 1. *Given (σ, a) one of two possible cases applies.*

a. *It is $y_d(\sigma, a) \geq \bar{y}(\sigma)$ and: 1) trade takes place at the ruling wage w_c in the current round if $y \geq y_d$; 2) the parties agree immediately to separate with a severance payment $F = -J(y, \sigma) < F_c$ if $\bar{y} < y < y_d$; 3) the parties agree immediately to separate with a severance payment F_c if $y \leq \bar{y}$; 4) y_d satisfies*

$$W^t(\sigma, a) = W^u(a - J^e(y_d, \sigma)). \tag{14}$$

b. *It is $y_d(\sigma, a) < \bar{y}(\sigma)$ and: 1) trade takes place at the ruling wage w_c in the current round if $y \geq \bar{y}$; 2) the parties agree immediately to renegotiate w_c down to $\bar{w}(y, F_c)$*

and trade in the current round if $y_d \leq y < \bar{y}$; 3) the parties agree immediately to separate with a severance payment F_c if $y < y_d$; 4) y_d satisfies

$$W^t(\bar{w}(y_d, F_c), F_c, a) = W^u(a + F_c). \tag{15}$$

The remark applies independently from whether the severance payment F_c born by the firm is embodied in a private contract or mandated by legislation.

3.2 Initial contract

An optimal initial contract maximises the present value of the firm's expected profits at t_0 subject to the worker receiving a given level of utility. Alternative (efficient) bargaining solutions just select different values for the worker's utility level. Among these, the axiomatic Nash bargaining solution is the most used in the matching literature. Furthermore, it is straightforward to adapt the proof of Proposition 2.4 in Rudanko (2006) to show that, in the environment of Section 4, the random matching equilibrium with Nash bargaining coincides with the competitive search equilibrium if Hosios's (1990) condition, requiring workers' Nash bargain share to coincide with the elasticity of the probability of filling a vacancy, is satisfied.

We therefore assume without much loss of generality that the initial contract satisfies the axiomatic Nash bargaining solution, or

Assumption 1. *The initial contract solves*

$$\begin{aligned} \max_{\sigma} N = & J(1, \sigma)^{1-\gamma} \left[W^e(1, \sigma, a) - W^u(a)\right]^{\gamma} \\ s.t.\ & W^e(1, \sigma, a) \geq W^u(a) \\ & J(1, \sigma) \geq 0 \end{aligned} \tag{16}$$

The two constraints are the participation constraints for the worker and firm respectively.

The maximisation problem in equation (16) is continuous and differentiable in $\sigma = (w_c, F_c)$ on $[-\infty, \infty]^2$. This, together with the fact that the Nash maximand is zero if either participation constraint is binding, implies that an optimal contract has to lie on the contract curve

$$\frac{\partial W^e(1,.)/\partial F_c}{\partial W^e(1,.)/\partial w_c} = \frac{\partial J(1,.)/\partial F_c}{\partial J(1,.)/\partial w_c} \tag{17}$$

and satisfy the surplus sharing condition

$$\frac{1-\gamma}{\gamma}\frac{W^e(1,.) - W^u(a)}{J(1,.)} = -\frac{\partial W^e(1,.)/\partial w_c}{\partial J(1,.)/\partial w_c}. \tag{18}$$

The following Lemma ensures that the two conditions are also sufficient for a unique global maximum.

Lemma 1. *Given worker's wealth, the Nash bargaining programme has a unique local and global maximum.*

Proof. See Appendix A.1. □

Uniqueness of the mapping from workers' wealth to the optimal contract is necessary for equilibrium analysis, to which we now turn.

4 Equilibrium with CARA preferences

4.1 Steady state

We can now characterize market returns. To streamline notation we anticipate here that if workers' have CARA preferences both the ex ante optimal contract σ^* and the joint reservation productivity y_d are independent of the worker's stock of wealth a.

Denote by $(y, \sigma) \in [y_l, 1] \times R^2$ the state of an establishment. The asset value of an unfilled job V_c satisfies the Bellman equation

$$rV_c = -m + q(\theta)\max\{J^e(1, \sigma^*) - V_c, 0\} = 0, \tag{19}$$

where $J(1, \sigma^*)$ is the value to the firm of forming a new productive match with initial productivity equal to one and optimal contract σ^*. The second equality follows from free entry.

The value function of an unemployed worker W^u is defined in a similar way. Given the structure of uncertainty, W^u satisfies the Hamilton-Jacobi-Bellman equation

$$\phi W^u(a) = \max_{c^u} u(c^u) + W^u_a(a)[ra + b - c^u] + p(\theta) \max\{W^e(1, \sigma^*, a) - W^u(a), 0\}. \quad (20)$$

The flow equivalent of being unemployed with wealth a equals the flow of utility from current consumption plus the expected capital gain. The latter has two components. First, the value of unemployment changes because the stock of wealth changes. The associated gain equals the change in wealth $ra + b - c^u$ times the marginal utility of wealth $W^u_a(a)$, where W^u_a denotes the partial derivative of $W^u(a)$ with respect to wealth. Second, the worker meets a firm at rate $p(\theta)$. If she accepts to form a match with a contract σ^*, her lifetime expected utility is $W^e(1, \sigma^*, a)$.

As in Mortensen and Pissarides (1994), the unemployment steady-state flow equilibrium condition is

$$\lambda G(y_d)(1 - u) = p(\theta) u. \quad (21)$$

Finally, balancing of the government budget requires

$$\tau = (b + \tau)u. \quad (22)$$

The total *gross* unemployment benefit bill must equal total tax revenues.

In order to determine the firm and worker's expected returns from matching, $J(1, \sigma^*)$ and $W^e(a, 1, \sigma^*)$, we need to solve for the optimal contract.

The equilibrium can be formally defined as follows.

Definition (Stationary equilibrium). *Assume CARA preferences and no borrowing constraints. Be* $i = u, t$. *A stationary equilibrium is a set of policy functions* $\{c^i\}$, *value functions* $\{W^i, W^e, J^e, V_c\}$, *an optimal contract* σ^*, *reservation productivity functions* $\{\bar{y}(\sigma), y_d(\sigma, a)\}$, *market tightness* θ, *unemployment rate* u *and tax* τ *such that:* 1) c^u *and* s^t *maximise* (20) *and* (11)*;* 2) $\{W^i, W^e, J^e\}$ *satisfy* (9)-(12)*;* 3) *free entry implies* $V_c = 0$ *and* $J^e(1, \sigma^*) = m/q(\theta)$; 4) $\bar{y}$ *satisfies* (13) *and* y_d *satisfies either* (14) *or* (15)*;* 5) σ^* *satisfies* (16)*;* 6) u *is given by* (21)*;* 7) τ *satisfies* (22)*.*

In what follows we specialise the felicity function to the CARA form

$u(c_t) = -\exp\{-\alpha c_t\}$. We also assume that workers can freely borrow and lend at the riskless rate r subject to a no-Ponzi game condition[10]. The two assumptions imply that there is no lower bound on workers' stock of wealth and that workers' attitude towards lotteries over non-capital income is independent of wealth. Together they make the problem tractable as the following proposition highlights.

Proposition 4. *Assume CARA preferences and no borrowing constraints. Given $i = u, c$*

1. *workers' value functions satisfy*

$$W^i = \frac{u(c^i)}{r}; \tag{23}$$

2. *the saving functions s^i, the optimal contract σ^* and the joint reservation productivity y_d are independent of wealth.*

Proof. See Appendix A.1. □

The dynamic constraint implies $c^i = ra + w^i - s^i$. Since s^i is independent of wealth, the latter enters the worker's value function only through the multiplicative term $\exp\{-\alpha(ra)\}$ which is independent of the employment status. Therefore, workers' wealth does not affect the maximand of the Nash product in (16) and the separation rules (14) and (15). It follows that all jobs have the same optimal contract and separation rule[11].

Finally, we can characterise the optimal contract.

Proposition 5. *Assume CARA preferences and no borrowing constraints. The optimal contract is never renegotiated and implies $c^c(\sigma, a) = c^u(a + F_c)$ and $s^c(\sigma, a) = 0$.*

Proof. See Appendix A.1. □

With CARA preferences an optimal contract is never renegotiated and provides full insurance against job loss. As discussed in Section 6.5, the full insurance result is actually knife-edged and specific to CARA preferences. Since such preferences imply that instantaneous utility is proportional to its first derivative, it follows from Proposition 4 that

[10] This requires debt to grow at a rate below the interest rate, $\lim_{t\to\infty}(1+r)^{-t}a_t \geq 0$, with probability one.

[11] If this were not the case, contracts and the joint reservation productivity y_d would be indexed by wealth and the whole wealth distribution would be a state variable.

equalising the marginal utility of a worker employed at wage w_c and that of a job loser receiving F_c equates their value functions and implies that the worker never renegotiates either component of the contract since she is indifferent between being fired and being employed at the original wage. More importantly, Proposition 5 implies the following corollary which provides a lower bound for the optimal severance payment.

Corollary 1. *The privately optimal F_c is zero if and only if $\gamma = 0$ and exceeds $F^* = (w_c - b)/[r + p(\theta)]$ if $\gamma > 0$.*

Proof. See Appendix A.1. □

Insurance against job loss requires a positive severance payment whenever employed workers enjoy rents over their unemployed counterparts. The optimal size of severance pay is bounded below by F^*, the expected loss in lifetime income associated with transiting through unemployment. This equals the expected present value of the income loss $w_c - b$ over the expected length of an unemployment spell. The intuition is the following. Proposition 5 implies that consumption does not fall upon entering unemployment. Since the duration of unemployment is uncertain, the variability of future consumption for a job loser is higher than for her employed counterpart. The existence of a precautionary saving motive implies that, for consumption not to fall upon losing one's job, the permanent income of a job loser has to exceed that of an employed worker.

If employed workers enjoy no rents over their unemployed counterparts, their participation constraint is binding, and a contract featuring $w_c = b$ and no severance payment provides full insurance. Only in such case, the optimal severance payment coincides with the lower bound F^*.

Clearly, mandated employment protection matters only in so far as it exceeds privately optimal levels. In such a case the following proposition applies.

Proposition 6. *If F_c is set marginally above its privately optimal value, the unique optimal contract features $y_d > \bar{y}$.*

Proof. See Appendix A.1. □

Proposition 6 implies that if somebody, e.g. the government, imposes on the parties a severance payment in excess of the optimal one then the parties adjust (reduce) wages in such a way that point a. of Remark 1 applies for $y \geq \bar{y}$. The wage component of the contract w_c is never renegotiated, while the parties agree to renegotiate the mandated severance payment down to $-J(y, \sigma) > 0$ for $y \in (\bar{y}, y_d)$. Excessive mandated intervention, overinsures job losers and calls for a fall in wages to reestablish ex ante shares. Furthermore, the ability of the government to impose higher than *laissez-faire* job security is limited by renegotiation.

5 Quantitative implications

5.1 Actual versus optimal severance pay

Corollary 1 summarises the main message of the paper: when labour reallocation is a time-consuming process, severance payments are a necessary part of an optimal insurance contract whenever employed workers enjoy rents over their unemployed counterparts.

A key prediction of the model is the functional relationship between the lower bound F^* on the optimal severance pay on the one hand and wages, benefits and unemployment duration on the other. Severance payments are usually expressed as a function of the last wage. For this reason it is useful to define the variable $f^* = F^*/w_c$ which measures the severance payment in units of per-period wage. The fact that in reality unemployment benefits b are a function ρw_c of the last wage imply that in *laissez-faire* equilibrium it is

$$f^* = (1 - \rho) / (r + p(\theta)), \tag{24}$$

where ρ is the replacement rate.

Equation (24) implies that, as a share of wages, the lower bound on the optimal severance payment is fully determined by just three variables, the unemployment benefit replacement rate, the interest rate and unemployment duration. This implies that f^* is an increasing function of all exogenous factors which increase equilibrium unemployment duration such as training and search costs, workers' bargaining power and frictions in the matching process.

In expressing the lower bound on optimal severance pay as a function of observable quantities, equation (24) provides an operational metric which can usefully inform the

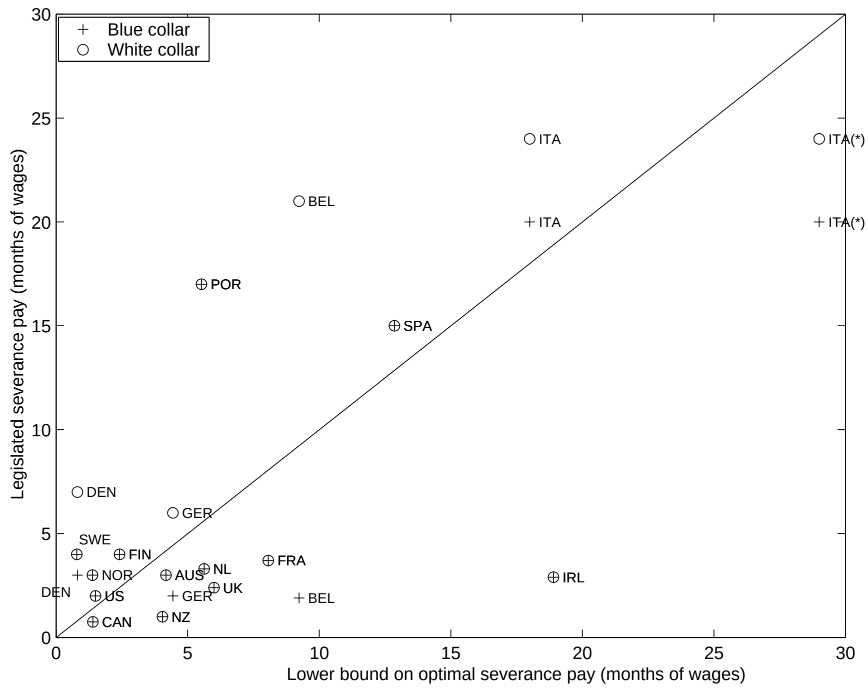

Figure 3: f^* versus actual severance payments

debate on whether observed legislated job security measures are excessive.

To this effect, we choose an annual interest rate of 4 per cent and use data on unemployment duration and benefit replacement rates [12] for seventeen OECD countries to construct a series for f^*. The data with details of their sources are reported in Table 5 in Appendix A.2. For comparison, we have also constructed series for actual legislated dismissal payments and notice periods for blue and white collar workers assuming a representative worker with job tenure equal to the average completed job tenure derived from the worker-flow data in Nickell, Nunziata, Ochel and Quintini (2002). The resulting four series are reported in Table 5 in Appendix A.2. Since in a number of countries notice periods constitute the main bulk of dismissal costs for firms, our series for observed legislated severance payments add up dismissal payments and notice periods. The result are two series for legislated severance payments for white and blue collar workers.

Figure 1 plots the lower bound f^* on the horizontal axis against the two series for legislated severance payment for a worker of average tenure. In interpreting Figure 1 it

[12]The lower bound f^* should be a function of unemployment duration in the counterfactual *laissez-faire* equilibrium which is unobservable. Yet, as shown in Section 5.2, the distinction is not quantitatively important.

is worth keeping in mind, that not only is f^* a lower bound, but our series for legislated payments constitute an upper bound for actual legislated dismissal payment to the extent that the actual cost to firms of notice requirements falls short of total wage payments over the mandated notice period in so far as workers find a new job before the expiration of their notice. Hence, if legislated severance payments were in line with optimal private arrangements one should observe most data points to lie above the forty-five degree line.

The figure highlights that, for a number of countries, legislated payments are significantly below the level consistent with optimal insurance. In particular, legislated severance payments for all workers in Ireland and for blue collar workers in Belgium are significantly below their optimal level. Given the high duration of unemployment in these two countries over the sample period, legislated payments underinsure workers. The same is also true for France and New Zealand. Spain and Italy, two countries which are normally deemed to have extreme levels of employment protection, turn out to have legislated payments which exceed their optimal lower bound by respectively one and at most six months. This is not so surprising in the light of an average unemployment duration in excess of thirty months for Italy and forty months for Spain. The two starred observations for Italy refer to the period before 1991, the year in which the replacement rate was raised from three to forty per cent. They make clear the extent to which despite the very high levels of dismissal costs Italian workers were underinsured before the reform.

Portugal presents the most extreme case. The mandated level of severance payments exceeds its optimal lower bound by slightly more than eleven months. With effectively the same replacement rate but an unemployment duration roughly one third of the Spanish one, its optimal severance payment should also be roughly one third. Yet, observed legislated payment in Portugal are higher than in Spain. Also severance payments for white collar workers in Belgium exceed their optimal lower bound by eleven months. It is worth keeping in mind, though, that in the latter case, as for countries such as Denmark and Sweden, notice periods constitute the bulk of the legislated severance payment reported in the figure[13]. Hence, the actual cost to firms and transfer to workers is likely to be lower.

[13]See the table in section A.2.

The above discussion makes clear that if one judges legislated employment protection measures by how much insurance against the cost of job loss they imply then, with the possible exception of Portugal, there is little support for the view that Mediterranean countries, or indeed most OECD countries, feature levels of employment protections significantly in excess of privately optimal levels. There is an important caveat, though. Since our series for optimal severance payments has been constructed using *observed* unemployment duration the above comparison does not allow for the widely-debated possibility that the positive relationship between legislated employment protection measures and unemployment duration reflects the reverse causation going from high mandated job security to low job creation. We tackle this possibility in the next subsection.

5.2 Quantitative impact of excessive mandated job security.

We have been able to characterise the features of an optimal contract and obtain insight into the rationale for the existence of severance payments in an effectively partial equilibrium set up. Yet, the question of the allocational and welfare impact of excessive mandated job security is of an equilibrium nature and, given the model complexity, can only be answered numerically.

To this effect we calibrate our model economy to the Portuguese one. As noted in Section 5.1 Portugal is characterised by legislated dismissal costs dramatically in excess of the optimal lower bound predicted by the model. It is also one of the countries where severance pay constitutes the main bulk of dismissal costs. Therefore, it appears a natural benchmark to investigate the consequences of excessive government intervention.

We choose a Cobb-Douglas matching function $m(U, V) = AU^{\eta}V^{1-\eta}$, where A indexes the efficiency of the matching process. The productivity distribution is assumed uniform on $[y_l, 1]$. With benefits equal to $b = \rho w_c$ where ρ is the replacement ratio, the model has ten parameters: $\{r, y_l, \rho, \alpha, \eta, \lambda, \gamma, f_c, m, A\}$.

All flow variables are per quarter. The interest rate is $r = \phi = 0.01$. The lower support of the distribution is set to $y_l = 0.32$ to obtain a coefficient of variation for output shocks of 0.3 as in Blanchard and Portugal (2000). The Portuguese benefit replacement rate is $\rho = 0.65$. The ratio between the legislated severance pay and the net quarterly wage is

Table 1: Summary of calibration

	Portugal	Model
Moments		
Unemployment rate (%)	6.5	6.5
Avg. unemployment duration (months)	17	17
Parameters		
G(y) uniform on $[y_l,1]$, $m(U,V) = AU^{\eta}V^{1-\eta}$, $u(c) = \exp\{-\alpha c\}$.		
$r = .01,\ \gamma = \eta = .5,\ \rho = .65,\ f_c = 17,\ m = 10,\ \lambda = .014,\ \ y_l = .32,\ A = 0.18,\ \alpha = 1.7.$		

set to 5.7 which corresponds to its value of 17 months in Table 5[14]. The chosen value for the coefficient of absolute risk aversion is $\alpha = 1.7$ which implies a coefficient of relative risk aversion of $\sigma = \alpha c^u(0) = 1.5$ for an unemployed worker with zero wealth. A value of 1.5 is in the middle of the range of available estimates for the coefficient of relative risk aversion. Results are reported also for $\alpha = 3.5$ which corresponds to $\sigma = 3$. The elasticity of the matching function α is set to 0.5 consistently with the evidence in Petrongolo and Pissarides (2001). The chosen value for the coefficient of workers' bargaining power γ is also 0.5. As noted in Section 3.2 this implies that the bargaining equilibrium coincides with the competitive search one. If workers are risk neutrals, it also implies that the decentralised equilibrium is efficient in the absence of unemployment benefits.

The cost of posting a vacancy m is set to 0.33 following Millard and Mortensen (1997). The remaining two parameters λ and A are set to 0.014 and 0.18 to match an average unemployment duration of 17 months and an unemployment rate of 6.5 per cent. The chosen value for unemployment duration comes from the OECD unemployment duration database[15] (see Blanchard and Portugal (2000), figure 4). Table 1 summarises the calibration procedure .

We can now tackle the question of the employment and welfare costs of mandated employment protection. Table 2 summaries our findings for the benchmark case in which the coefficient of relative risk aversion equals 1.5 and for the more extreme one in which

[14]The government budget constraint (22) implies that the tax born by the worker equals the total benefit bill net of taxes divided by the size of the employment pool. Therefore, it is legitimate to equate the net wage in the model with the wage net of payroll taxes in the data.

[15]Bover, García-Perea and Portugal (2000) calculate a slightly higher value of 20 months for the period 1992-1997 using the Portuguese Labour Force Survey. Despite using the same worker outflow data in their empirical part, Blanchard and Portugal (2000) assume a much lower value of 9 months in their calibration.

Table 2: Mandated severance payments (in months of net wages)

	$\sigma = 1.5$			$\sigma = 3$		
	Laissez-faire	**Mandated**		**Laissez-faire**	**Mandated**	
Severance pay	6	17	30	6	17	30
Job finding rate (%)	17.4	17.8	18.1	17.7	17.8	17.9
Job destruction (%)	1.2	1.2	1.2	1.2	1.2	1.2
Unemployment rate (%)	6.7	6.5	6.4	6.6	6.5	6.4
Gross wage × 100	93.3	89.4	85.9	93.3	89.4	85.9
Net wage × 100	89.0	85.4	82.1	89.0	85.4	82.1
Net output	100.0	100.2	100.3	100.0	100.1	100.1
Welfare (employed)	100.0	100.0	99.8	100.0	99.9	99.3
Welfare (unemployed)	100.0	99.9	99.6	100.0	99.7	99.1
Welfare (avg. job loser)	100.0	103.4	106.2	100.0	103.2	105.7

it equals 3. It shows the allocational and welfare impact of imposing mandated severance payments of respectively 17 and 30 months, against a privately optimal value of 6 months in the calibrated economy[16]. 17 months is the legislated value in Portugal used in our calibration. 30 months is an upper bound obtained by adding the size of the largest mandated severance payments in our dataset - 24 months - to the privately optimal value.

Clearly legislated severance payments below private optima are not binding and have no effect. Instead, rows three to ten in Table 2 report the labour allocation, wages and the percentage change, relative to *laissez-faire,* in the present value of net output, and workers' welfare[17] associated with the three levels of severance pay considered.

The effect of legislated severance payment widely in excess of private optima on job destruction is negligible, as the legislated severance payment is renegotiated. As for the job finding rate, with $\sigma = 1.5$, it increases by 0.4 and 0.7 percentage points when severance payments exceed their *laissez-faire* value by respectively 11 and 24 months. The corresponding fall in the unemployment rate is 0.2 and 0.5 of a percent. The fall in unemployment duration is due to a fall in the gross (producer) wage $w_c + \tau$ equal to 4

[16]This is five per cent larger than 5.7 months, the value of the optimal lower bound f^* in our calibration.

[17]The values of quantities with no meaningful unit of measurement have been normalised to 100 in the decentralised equilibrium. The present value of output is the shadow value of an unemployed worker which, as in Acemoglu and Shimer (1999), is maximised at a social optimum in the risk-neutral case. Workers' welfare is measured in terms of the percentage of permanent consumption in the *laissez faire* equilibrium which would give worker the same level of utility as in the equilibrium with government intervention.

and 12 percent respectively.

This fall in unemployment duration may appear surprising at first sight. Even if wages fall in response, government intervention by increasing income uncertainty should increase the cost to the firm of providing a given level of utility and reduce, rather than increase, job creation. A second, offsetting, effect is at play, though. At given benefit replacement rate, the reduction in wages reduces steady state unemployment benefits and workers' threat point in bargaining thus increasing firms' return to job creation. If the benefit replacement rate is sufficiently high the second effect prevails.

Net (consumer) wages fall slightly less than gross wages due to the fall in the payroll tax stemming from the fall in unemployment.

The fall in wages, unemployment duration and the unemployment rate is smaller in the case in which $\sigma = 3$. Higher risk aversion implies that workers' are less willing to trade off a wage cut for overinsurance in case of job loss.

Independently from the degree of risk aversion, the increase in unemployment duration increases net output in our calibration, as unemployment benefits are inefficiently high and, job creation inefficiently low, in the calibrated economy. While the sign of the change in net output is specific to the choice of calibration parameters, though, its absolute value is not. In general, the change is very small, reflecting the marginal nature of the change in the allocation.

Turning to welfare, as legislated payments increase, the average job loser's welfare increases significantly as the increase in the expected severance pay more than offsets the increased consumption variability. On the other hand, welfare falls for employed workers and unemployed job seekers. The fall in welfare is no larger than respectively one tenth ($\sigma = 1.5$) and one third ($\sigma = 3$) of one per cent for the case in which mandated payments equal 17 months of wages. If $\sigma = 3$ though, the maximum welfare loss is nearly one per cent when mandated payments equal 30 months.

It is instructive to conduct the same experiment starting from the constrained efficient equilibrium in which, as in Acemoglu and Shimer (1999), the social planner chooses one instrument, the replacement rate, to maximise net output[18].

[18] Unlike in Acemoglu and Shimer's (1999) benchmark model, the equilibrium considered is only *constrained* efficient as one instrument is insufficient to hit both active margins - job creation and job destruction. In practice, though, the allocation turns out to coincide with the efficient allocation of the

Table 3: Mandated severance payments (in months of net wages): efficient benefits

	$\sigma = 1.5,\ \rho = 0.05$			$\sigma = 3,\ \rho = 0.1$		
	Laissez-faire	**Mandated**		**Laissez-faire**	**Mandated**	
Severance pay	9.8	21	34	9.6	21	34
Job finding rate (%)	28.7	28.3	28.1	28.6	28.0	27.5
Job destruction (%)	1.1	1.1	1.1	1.2	1.1	1.1
Unemployment rate (%)	3.8	3.8	3.9	3.8	3.9	3.9
Gross wage $\times$ 100	89.4	86.2	83.3	89.5	86.3	83.4
Net wage $\times$ 100	89.2	86.0	83.1	89.1	85.9	83.0
Net output†	101.9	101.9	101.9	101.9	101.9	101.9
Welfare (employed)†	100.3	100.2	100.0	100.2	100.1	99.6
Welfare (unemployed)†	99.0	98.9	98.6	99.0	98.8	98.3
Welfare (avg. job loser)†	100.3	103.4	106.1	100.2	103.3	105.8

† Relative to the corresponding value in *laissez-faire* equilibrium with $\rho = 0.65$ in Table 2.

The results of such experiment are reported in Table 3. Net output and welfare are reported as proportion of their corresponding value in the *laissez-faire* equilibrium in Table 2.

The first interesting result is that, as far as efficiency is concerned, severance payments are no perfect substitute for unemployment benefits. The efficient replacement rate is respectively 0.05 and 0.1 depending on the risk aversion coefficient. The intuition is the same as in Acemoglu and Shimer (1999) and is clearest in the present CARA setup[19], where given the absence of wealth effects, severance pay have no partial equilibrium effect on the bargaining outcome. Decreasing marginal utility implies that wages increase a worker's surplus by less than they reduce a firm's one. Therefore, if Hosios's (1990) condition is satisfied, the firm's share of surplus is inefficiently high in the absence of benefits. This result applies as long as workers marginal utility of consumption is decreasing.

Second, the optimal severance payment size is decreasing in the replacement rate. It is now roughly 10 months of wages against 6 months in Table 2. The larger income fall, relative to the calibrated benchmark economy, is less than offset by the general equilibrium fall in unemployment duration.

Third, increasing severance payments by the same amount as in Table 2 - respectively

model with risk-neutral workers to at least the third decimal digit.

[19]The optimal replacement rate is roughly half than in Table 1 in Acemoglu and Shimer (1999) as their calibration features an average unemployment duration of 6.5 years against 17 months here.

11 and 24 months - above their privately optimal value still has hardly any allocational effect, although the sign of the change in the duration of unemployment and its level is now reversed relative to Table 2. Given the small replacement rate, the fall in wages has now a smaller effect on the worker's threat point relative to the previous case. Therefore the higher cost of providing a given level of utility to the worker is less than offset by the fall in her bargaining power. Job creation falls as a consequence, but the absolute value of the change is still negligible. The associated reduction in net output is less than second order (lower than a thousandth of a per cent) with respect to the change in unemployment while the fall in welfare is roughly the same as in Table 2.

Conversely, the efficiency cost of raising the replacement rate from its efficient level to 0.65 is large. Net output in the *laissez-faire* equilibrium with efficient benefits is 1.9% higher than in the corresponding equilibrium when $\rho = 0.65$. As for welfare, the increase in the replacement rate redistributes from employed, whose net wage falls due to the increase in the unemployment pool and the payroll tax, to unemployed workers.

Summing up, the robust insight of the paper is that, if firms and workers can write optimal contracts, however simple, legislated dismissal costs have very small allocational effects. The result implies that even in the absence of complete markets there is no causal relationship from legislated dismissal costs to high unemployment rates and duration and low job destruction. On the contrary, our findings imply that the causation goes the other way round, from factors, such as high workers' bargaining power, or high matching frictions, that result in high unemployment duration to optimal severance payments. Also, the optimal severance payment is larger, the lower the amount of insurance provided by the state through unemployment benefits.

It is worth emphasising that the comparisons involve alternative steady states. So, while employed workers would be better off in the steady state of the *laissez faire* economy, they would lose if at a point in time excessive legislated job security measures were scrapped. Since contract wages are not renegotiated up as long as they remain above reservation wages in the post-reform equilibrium, employed workers would suffer a negative windfall given that their contract wages were fixed at a lower level in the past, reflecting higher expected layoff payments. This is consistent with the fact that employed workers are often very opposed to reduction in mandated job security.

It also has to be pointed out that the size of the welfare losses derived reflects two extreme deviations from *laissez faire.* Figure 3 shows that for all but two countries in our dataset the difference between the lower bound f^* and legislated severance payments is 5 months or less, rather than 11 months.

It is obviously of interest to know how sensitive the results are to changes in the key parameters. It turns out that, for a given difference between optimal and mandated severance pay, the result is remarkably robust to alternative parameterisations being driven by the optimal nature of contracts rather than any other features[20].

6 Extensions and discussion

This paper has relied on a number of simplifying assumptions to derive a closed form lower bound for the optimal severance pay wage ratio as a function of observable quantities. In what follows we discuss how relaxing such assumptions alters the main conclusions. The broad message can be anticipated here. The lower bound we have derived is remarkably robust. Also, provided wages are flexible and separation jointly optimal, the welfare losses derived in Section 5.2 are an upper bound on the corresponding losses under less restrictive assumptions.

6.1 Wage rigidity and no renegotiation[21]

To better understand the near-neutrality result derived in the paper it may be useful to disentangle the relative role played by wage flexibility and ex post renegotiation of mandated severance payment.

Consider first the case in which the contract wage is rigid, but the severance payment is renegotiated. Standard manipulation of equation (9) allows writing the value of a new job as

$$J(1,\sigma) = \frac{1-\bar{y}}{r+\lambda} - F_c, \tag{25}$$

where $\bar{y}$ satisfies (13).

[20]Calibrating the model to the US economy produces very similar results. They are available upon request.

[21]I am grateful to an anonymous referee and Ioana Marinescu for suggesting to explore respectively the rigid-wage and no-renegotiation cases.

Table 4: Mandated severance payments (months of wages): $\sigma = 1.5$.

	Laissez-faire	**Mandated**		**Mandated**
		Exog. F_c		Exog. w_c
Severance pay	5.7	17	30	15
Job finding rate (%)	17.4	17.7	17.8	2.5
Job destruction (%)	1.2	1.1	0.9	1.0
Unemployment rate (%)	6.7	5.7	4.8	28.5
Gross wage $\times$ 100	93.3	89.5	86.0	93.3
Net wage $\times$ 100	89.0	85.9	83.2	69.2
Net output	100.0	100.1	100.2	54.8
Welfare (employed)	100.0	100.3	99.8	72.8
Welfare (unemployed, $f_c = 0$)	100.0	100.2	99.6	64.4
Welfare (average job loser)	100.0	103.9	107.3	67.9

It follows that, for given w_c, the contractual or mandated severance payment F_c fully determines the firm's return from job creation and, through equation (19), market tightness. An increase in F_c, at given w_c, reduces job creation. Importantly, since (19), (13) and (25) do not depend on workers' preferences, the result applies to *any* matching model in which wages are exogenous.

The last column in Table 4 reports the allocation and welfare associated with increasing F_c while keeping w_c constant at its level in the *laissez-faire* benchmark in Section 5.2 in the case in which the coefficient of relative risk aversion equals 1.5. Increasing F_c to 17 months effectively exhausts any return to job creation and no equilibrium exists for higher values of the mandated severance payment. Job creation collapses to a fifth of its original value as the wage is prevented from reestablishing profitability of new jobs. Given constant returns in production, mandated severance payments have a large negative impact on the ex ante value of a job. Job destruction fall by 20 per cent as the increase in duration makes workers less willing to enter unemployment. All welfare measures also collapse. It follows that the flexibility of the average wage in response to policy parameters is crucial not only for mandated severance pay to have negligible welfare costs, but, much more generally, for the ability of calibrated matching models to generate reasonable changes in allocation and welfare in response to observed cross-country variation in policies.

Let us now turn to the opposite case in which the wage is endogenous, but the excessive mandated severance payment is not renegotiated. In such a case y_d no longer satisfies equation (14), but instead coincides with the firm's reservation productivity $\bar{y}$ even outside *laissez faire.* The wage is instead still determined by equation (18).

Columns 3 and 4 in Table 4 report the allocational and welfare changes when severance pay is increased relative to its *laissez-faire* value. The separation rate falls significantly as there is now (jointly) suboptimal labour hoarding. The producer wage, though, is effectively unchanged relative to Table 2. In fact, it falls marginally with higher severance pay as, given the increase in job duration, a given wage cut implies a bigger fall in a worker's permanent income and welfare. It follows that job creation is hardly affected and the unemployment rate falls significantly.

Net output still increases with the fall in unemployment, though marginally less than in the case in which separation is Pareto optimal. More surprising is the marginal increase in welfare for unemployed and employed workers when F_c is increased to 17 months of wages. The increase is fully accounted for by the fall in the lump sum tax, a positive externality, stemming from the lower unemployment level. Were it not for the tax reduction, consumption and welfare would actually fall. When F_c equals 30 months of wages though, the welfare loss is comparable to the corresponding one in Table 2, with the fall in taxes still accounting for the difference. Basically, the larger fall in taxes offsets the welfare cost associated with the private inefficiency of separation.

While less crucial than wage flexibility, the ability of the parties to negotiate Pareto optimal side payments is an important ingredient of the near-neutrality result, though it hardly matters for welfare.

There are numerous examples suggesting that negotiation of Pareto optimal transfers upon separation is more than a theoretical construct. One such instance is the frequency with which one reads or hears about voluntary redundancy packages and/or early retirement incentives offered by downsizing firms. By revealed preferences, these must be jointly optimal (if workers accept them) and if contracting firms make the effort to negotiate such packages the associated cost must be smaller than the, possibly shadow, cost of unilaterally laying workers off. Also, in Germany firms cannot legally carry out mass redundancies (i.e. the mandated layoff cost is infinite) unless they agree with workers' representatives on a social plan covering procedures and compensation packages. For Italy, a country usually associated with extreme levels of employment protection, IDS

(2000) reports that employers often negotiate incentive payments to induce employees to take voluntary redundancy and sign agreements waiving their right to take legal proceedings[22]. Finally, Toharia and Ojeda (1999) document that it is common for Spanish firms to agree with workers to label economic dismissals as disciplinary ones to economise on advance notice and procedural costs. Between 60 and 70 per cent of all dismissals, over the 1987-97 period, took this form and involved bargaining over the size of termination payments.

6.2 Alternative preferences

CARA preferences and no lower bound on consumption, while analytically convenient, are unappealing for well-known reasons. The following proposition generalises the result in Proposition 4 to a larger class of preferences.

Proposition 7. *If $u''' > 0$, it is ex ante optimal to trade a higher F_c for a lower w_c at the actuarially fair rate as long as $c^c(1, \sigma, a) > c^u(a + F_c)$.*

Proof. See Appendix A.1. □

If consumers are prudent, the optimal contract requires that consumption in those states in which the worker enters unemployment and the severance payment is not renegotiated is no smaller than consumption in those states in which the worker is employed at the contract wage.

The proof of Proposition 7 assumes $\phi = r$, but the result easily generalises to the case in which $\phi > r$ and marginal utility is not strictly convex as long as a lower bound on consumption generates a precautionary saving motive[23].

A formal proof that the permanent income of a job loser receiving F_c exceeds the permanent income of a worker employed at the contract wage is not available for the general case. Yet, the intuition behind Corollary 3 that, given that the contract provides insurance, the future consumption of an employed worker is less variable than that of a

[22] The same source reports a total cost for individual redundancy of 10-12 months of wages for a worker paid around 2 million ITL a month.

[23] It is straightforward to adapt the arguments in Aiyagari (1994) to show that, in a stationary equilibrium with a precautionary saving motive, the saving of a newly matched worker is positive even if $\phi > r$.

job loser suggests that the permanent income of the job loser must be higher for $c^u(a+F_c)$ not to be smaller than $c^c(1,\sigma,a)$.

Allowing for borrowing constraints is also unlikely to significantly change the results in Section 5. A previous version of this paper featuring hand-to-mouth consumers (but allowing for annuitization of severance payments) obtained similar results with only fractionally larger welfare costs.

6.3 Non-stationary benefits

With CARA preferences, allowing for the, realistic, possibility that workers entitlement to benefits falls over an unemployment spell or for the kind wage of losses in new occupations documented for example by Topel (1990) and Farber (2003) would leave unchanged the functional forms for the value functions and the first order condition for an optimal contract[24]. Proposition 5 and Corollary 1 would still apply. The fall in lifetime wealth associated with job loss would be larger though. The associated lower bound on the optimal severance payment would also be larger than in expression (24), if, as in our dataset, ρ denotes the replacement rate upon job loss rather than its average[25] value over an unemployment spell and benefits fall over time.

In fact, our argument that the privately optimal size of severance pay is strictly positive just relies on the *average* replacement rate being smaller than one. Not only is the latter the case in practice. The moral hazard associated with the conditional nature of benefits implies that the maximum, let alone the average, replacement rate along a socially optimal path is below one even when consumers cannot borrow or lend and the optimal time profile of benefits is non-stationary, as in Fredriksson and Holmlund (2001) and Coles and Masters (2006).

6.4 Alternating offer bargaining

The assumption that workers have got all the bargaining power in the renegotiation game implies that workers capture all the surplus from separation. If instead firms capture a

[24]Cohen, Lefranc and Saint-Paul (1997) and Rosolia and Saint-Paul (1998) document even larger losses respectively for France and Spain.

[25]Where the average replacement rate is defined as the constant rate whose expected present value over an unemployment spell coincides with the present value of the path of actual replacement rates.

positive share of the surplus from separation, the agreed severance payment when F_c is renegotiated is lower for given w_c and y. Hence, the redistribution associated with excessive job security is smaller. This further reinforces the conclusion that the welfare loss derived in Section 5.2 is a upper bound.

6.5 Imperfect insurance

In the above analysis, the optimal contract is never renegotiated in the *laissez-faire* equilibrium and insurance against match productivity shocks is perfect. As noted in Section 4 this is not true in general, though.

Consider, for example, the case in which the utility of leisure is positive. If the utility function is separable in consumption and leisure the contract curve is unchanged. Furthermore, it is easily shown that Proposition 4 still applies with the only difference that $W^u > u(c^u)/r$ if the utility of leisure is positive. It follows from Proposition 7 that under the optimal contract the lifetime utility of being employed at the contract wage is smaller than that of entering unemployment receiving the contracted severance payment F_c. Therefore, the latter must be renegotiated down with positive probability - $y_d > \bar{y}$ - and insurance is imperfect.

The same insight is likely to apply if workers have DARA preferences. Provided the optimal w_c and F_c are non-decreasing in wealth[26] it can be shown that DARA preferences imply $y_d > \bar{y}$ even if leisure yields no utility.

7 Conclusion

This paper characterises firms' optimal provision of insurance by means of simple employment contracts when asset markets are incomplete and searching for a job is a costly activity. It establishes that positive severance payments are part of an optimal contract whenever employed workers enjoy positive rents. More importantly, the paper derives a lower bound on the optimal severance payment as a function of observable quantities.

[26] DARA preferences do imply that the bargained wage is increasing in wealth in the static case. While the absence of a wealth effect on the bargaining outcome generalises from the static to dynamic case with CARA preferences, one can only conjecture that, with DARA preferences, the sign of the wealth effect is preserved in going from the static to the dynamic case.

Such bound equals the fall in lifetime wealth associated with job loss and is therefore decreasing in unemployment benefit replacement rates and increasing in unemployment duration.

The paper makes no attempt to explain if and why severance payments should be enshrined in legislation rather than in written private, explicit contracts. In fact, firms have the same incentives to evade both legislated and privately contracted severance payments and courts face the same informational asymmetries in enforcing both types of measures. One possible explanation for excessive government intervention, along the lines of Saint-Paul (2002), is that it reflects the ability of a majority of employed insiders to extract a one-off welfare gain at the expense of the present and future generations of unemployed[27]. Nevertheless, if the assumption is made that observed legislated measures reflect, to some extent, the degree to which private arrangements call for them the model predicts that there should be a direct relationship, *coeteris paribus*, between job security measures and the expected income loss associated with transiting through unemployment.

Indirect evidence consistent with the above assumption comes from Boeri, Borsch-Supan and Tabellini (2001) who find a negative correlation between an index of employment protection and a measure of benefit coverage. More direct evidence can be obtained by regressing observed legislated dismissal costs against the expected income cost of job loss f^*. Estimating such relationship for blue and white collar workers separately yields[28]

$$f^{BC} = \underset{(1.90)}{1.84} + \underset{(0.23)}{0.55} f^*, \qquad \bar{R}^2 = 0.23 \qquad s.e. = 5.20$$

and

$$f^{WC} = \underset{(2.34)}{2.74} + \underset{(0.28)}{0.70} f^*, \qquad \bar{R}^2 = 0.24 \qquad s.e. = 6.39.$$

There is a positive and statistically significant relationship between the series for f^* and those for legislated dismissal costs for blue and white collar workers f^{BC} and f^{WC} in Table 5.

In principle, such positive correlation may reflect the reverse causation from high

[27]The outcome is self-sustaining as new generations of insiders, whose contract wage was determined on the basis of the excessive mandated severance pay, would suffer a windfall be hurt by a subsequent reform which reduced the latter.

[28]Standard errors in parenthesis.

legislated job security to high unemployment duration which has been most emphasised in the literature on employment protection. Numerical simulations of our model, though, indicate that such reverse causation is unwarranted despite the lack of perfect insurance. Furthermore, optimal private contracting undoes the effects of excessive mandate job security to a great extent.

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A Appendix

A.1 Proofs

Proof of Point 2. in Proposition 1. Assume a solution to the system of functional equations (3)-(8) exists and be $\hat{j}, \hat{w}, \hat{F}$ the associated policy functions.

Let $A_w : S \to \Gamma_w$ and $A_f : S \times \Gamma_w \to \{accept,\ layoff,\ reject\}$ denote respectively the worker's and firm stationary strategies. Consider the strategy profile

$$A_w = \begin{cases} w \geq \hat{w} & \text{if } \hat{j}(s) = 0, \hat{w} = w_c, \\ w = \hat{w} & \text{if } \hat{j}(s) = 0, \hat{w} < w_c, \\ F = \hat{F} & \text{if } \hat{j}(s) = 1, \end{cases}$$

and

$$A_f = \begin{cases} \textit{accept} & \text{if } w \leq \hat{w} \text{ or } F \leq \hat{F}, \\ \textit{layoff} & \text{if } J^t(y, w_c, F_c, a) < -F_c \text{ and} \\ & \text{either } w > \hat{w} \text{ or } F > \hat{F}, \\ \textit{reject} & \text{otherwise.} \end{cases}$$

It is straightforward to check that the profile satisfies the one-stage-deviation condition and is therefore SSP. □

Proof of Proposition 2. As in Merlo and Wilson (1995) we prove uniqueness by showing that the system of functional equations (3)-(8) has a unique fixed point. Let H denote the space of bounded continuous functions on S taking values in R. The system (3)-(8) defines an operator T mapping a pair of functions $W^e, J^e \in H$ into a new pair also in H. Replacing on the right hand side of (8) using constraint (4) yields

$$J^e(y, w_c, F_c, a) = \max\left\{-F_c, (y - w_c - \tau)\,\Delta + \beta_f \mathbb{E} J^e(y', w_c, F_c, a')\right\}. \tag{26}$$

Since the set S is a convex Borel subset of $\mathbb{R}^4$, $[y_l, 1]$ is compact and the transition function for y has the Feller property, equation (26) defines an operator T' mapping a function $J^e \in H$ into a new function in H. It is straightforward to verify that T' satisfies Blackwell's sufficient conditions and is therefore a contraction. This proves uniqueness of J^e. By definition the Pareto frontier is strictly decreasing in payoff space. Therefore, there is a unique mapping from the firm's to the worker's payoff in all states. Given that J^e is unique so is W^e. $\square$

Proof of Proposition 3. Taking expectations over y' yields $\mathbb{E}J^e(y', w_c, F_c, a') = (1-\lambda\Delta) J^e(y, w_c, F_c, a') + \lambda\Delta \int J^e(y', w_c, F_c, a') \, dG$. Replacing in (26) and taking the limit as $\Delta \to 0$ yields (9) where the dependence on a has been dropped. It is straightforward to check that there exists one solution J^e to (9) which is independent of wealth. Given that (9) defines a contraction mapping, this is the only solution. If $j = 1$, the highest w' that satisfies (9) is $w' = \min\{w_c, \bar{w}(y, F_c)\}$ where $\bar{w}(y, F_c)$ equates the two terms inside the maximum operator in (9). Integrating by parts in (9) yields (12). It follows that (10) is just an alternative way of writing (3)-(4). Finally, consider equation (5). It is $\mathbb{E}W^e(y', w_c, F_c, a') = (1-\lambda\Delta) W^e(y, w_c, F_c, a') + \lambda\Delta \int W^e(y', w_c, F_c, a') \, dG$. Expanding $W^e(., a')$ in a around $W^e(., a)$, replacing in (5)and eliminating terms of order $o(\Delta)$ gives

$$W^t(y, w_c, F_c, a) = \max_{c_t} u(c^t)\Delta + \beta_w W^e(y, w_c, F_c, a) + W^e_a \Delta a + \tag{27}$$

$$\lambda\Delta \int_{y_l}^{1} [W^e(y', w_c, F_c, a) - W^e(y, w_c, F_c, a)] dG. \tag{28}$$

Noticing that if in a SSP equilibrium trade takes place at w_c in state (y, w_c, F_c, a) it is $W^e(y, w_c, F_c, a) = W^t(y, w_c, F_c, a)$, replacing for Δa using (6) and taking the limit for $\Delta \to 0$ yields (11). $\square$

Proof of Lemma 1. The programme (16) maximises $W^e(1, \sigma, \alpha)$ subject to $J^e(1, \sigma) \geq \bar{J}$. The firm's (signed) marginal rate of substitution between w_c and F_c is given by

$$-\frac{\partial J(1, \sigma)/\partial w_c}{\partial J(1, \sigma)/\partial F_c} = -\frac{1}{\lambda G(\bar{y})}. \tag{29}$$

Since $\bar{y}$ is increasing in w_c, the firm's indifference curves are convex to the origin and their lower contour set is convex. Hence, the programme (16) is non-concave in σ. Yet, because workers are more risk-averse than firms their indifference curves are more convex to the origin than the firm's at any σ. Therefore a point of tangency is a local maximum and is unique. $\square$

Lemma 2. *It is* $W^e(1, \sigma^*, a) = W^t(\sigma^*, a)$.

Proof. For the firm's participation constraint to be satisfied it has to be $J^e(1, \sigma^*) \geq 0 > F_c$, which implies that if at t_0 the match survives trade takes place at w_c. That the match survives at t_0 follows the assumptions of efficient bargaining and the existence of mutual gains from matching. □

Proof of Proposition 4. Lemma 2 implies $W^e(1, \sigma^*, a) = W^t(\sigma^*, a)$. Totally differentiating equations (20) and (11) with respect to wealth a and using the envelope conditions $W^i_a = u'(c^i),\ i = t, u$, we can write

$$-W^u_{aa} s^u = p(\theta) \left[u'[c^c(1, \sigma^*, \alpha)] + \frac{\partial W^c}{\partial \sigma^*} \frac{d\sigma^*}{da} - u'(c^u) \right] \tag{30}$$

and

$$\begin{aligned} & -W^t_{aa}(y, \sigma, a) s^t(\sigma, a) = \\ & \lambda \left[\int_{y_d}^{1} u'[c^t(w', F_c, a] dG + \int_{y_l}^{y_d} u'[c^u(a - J(y', \sigma)] dG - u'[c^t(\sigma, a)] \right], \end{aligned} \tag{31}$$

where $w'(y, \sigma) = \min\{w_c, \bar{w}(y', F_c)\}$ and $s^t(\sigma, a) = ra + w_c - c^t(\sigma, a)$.

We guess and verify: 1) the value function; 2) that $d\sigma^*/da = 0$. Suppose $W^u(a) = -e^{-\alpha(ra+b-s^u)}/r$ and $W^t(y, \sigma, a) = -e^{-\alpha[ra+b-s^t(\sigma)]}/r$ with s^u and $s^t(\sigma)$ unknown functions independent of wealth. Replacing for W^i_{aa}, for $u'(c^i) = \alpha e^{-\alpha c^i}$ and for c^i using the dynamic constraint (2), it is easily verified that equations (30) and (31) form a system of functional equations in the two functions s^u and s^t. It is evident that the solution is independent of a, for given σ^*. It remains to verify that σ^* in equation (30) is also independent of a. The worker's surplus in the Nash maximand (16) is $W^t(\sigma, a) - W^u(a) = -e^{-\alpha(ra)}(e^{-\alpha(w_c - s^t(\sigma,a))} - e^{-\alpha(b-s^u)})/r$. Since s^i is independent of wealth, the latter does not enter the first order condition for σ. □

Proof of Proposition 5. Lemma 2 implies $W^e(1, \sigma^*, a) = W^t(\sigma^*, a)$. Using Remark 1 and the envelope condition $u'(c^t) = W^t_a$, the worker's marginal rate of substitution between w_c and F_c can be written as

$$-\frac{\partial W^e(1,\sigma,a)/\partial w_c}{\partial W^e(1,\sigma,a)/\partial F_c} = -\frac{\partial W^t(\sigma,a)/\partial w_c}{\partial W^t(\sigma,a)/\partial F_c} = \tag{32}$$
$$-\frac{u'(c^t) + \frac{\partial W_a^t}{\partial w_c}s^t - \lambda\int_{\bar{y}}^{\max\{y_d,\bar{y}\}} u'[c^u(a-J(y,\sigma)]\frac{\partial J(y,\sigma)}{\partial w_c}dG}{\frac{\partial W_a^t}{\partial F_c}s^t + \lambda\left[\int_{\min\{y_d,\bar{y}\}}^{\bar{y}} \frac{dW^t(y,.)}{dF_c}dG - \int_0^{y_d} u'[c^u(a-J(y,\sigma)]\frac{\partial J(y,\sigma)}{\partial F_c}dG\right]}.$$

For a given $w_c \in (b, \bar{w}(1,0))$, select F_c such that $y_d = \bar{y}$. It follows from point 1 in Proposition 4 that $c^t(y_d,\sigma,a) = c^u(a+F_c)$ and, from Remark 1, that $w(y',F_c) = w_c$, $\forall y' > y_d$, $J(y',\sigma) = -F_c$, $\forall y' < \bar{y}$ and $c^t(y,\sigma,a) = c^u(a+F_c)$ $\forall y$. It follows from equation (31) that $s^t(y,\sigma) = 0$, $\forall y > y_d$. Since the last integral in the square bracket on the denominator of (32) equals $G(\bar{y})u'[c^u(a+F_c)]$, it follows that the worker's marginal rate of substitution in equation (32) coincides with the firm's one in (29). □

Proof of Corollary 1. If $\gamma \to 0$ it is $W^e(1,\sigma,a) = W^u(a)$. The contract $w_c = b$ and $F_c = 0$ is trivially optimal. If $\gamma > 0$, the Nash bargaining solution requires $W^e(1,\sigma,a) > W^u(a)$ and $w_c > b$. It remains to prove that $F_c > (w_c - b)/(p(\theta)+r)$. Proposition 5 implies $w_c = b + rF_c - s^u$. Hence, it needs to be proved that $s^u > -p(\theta)(w_c - b)/(p(\theta)+r)$. From Proposition 4, equation (30) can be rewritten as

$$s^u = \frac{p(\theta)}{r\alpha}\left[e^{-\alpha(w_c - b + s^u)} - 1\right]. \tag{33}$$

The left and right hand side of (33) are respectively increasing and decreasing in s^u. It is easily checked that $w_c > b$ implies that the left hand side is smaller than the right hand side at $s^u = -p(\theta)(w_c - b)/(p(\theta)+r)$. □

Proof of Proposition 6. The left hand side of (18) is strictly increasing in both F_c and w_c. It follows from Proposition 5 that, at the private optimum, it is $s^t = 0$ and the right hand side of (18) can be shown to equal the numerator on the right hand side of (32) and to be strictly decreasing in F_c and w_c. Hence, if F_c increases w_c has to fall to satisfy (18). Equation (13) implies $\bar{y}$ falls as a result and, since positive discounting and uncertainty imply F_c increases $c^u(a+F_c)$ more than $c^t(1,\sigma,a)$, it follows from Proposition 4 that $W^t(1,\sigma,a) < W^u(a+F_c)$ and y_d increases. □

Proof of Proposition 7. It needs to be proved that if $c^u(a+F_c) < c^t(1,\sigma,a)$ the worker's marginal rate of substitution between w_c and F_c in equation (32), exceeds the firm's one in equation (29). Replacing for $\partial J(y,\sigma)/\partial w_c = -[r+\lambda G(\bar{y})]^{-1}$, $\partial J(y,\sigma)/\partial F_c = -\lambda G(\bar{y})[r+\lambda G(\bar{y})]^{-1}$ and $J(y,\sigma) = -F_c$, $\forall y < \bar{y}$, on the right hand side of (32) the condition to be verified can be written as

$$\lambda G(\bar{y})[u'(c^t) - u'(c^u(a+F))] \leq \lambda \int_{\min\{y_d,\bar{y}\}}^{y_d} \frac{dW^t(y,.)}{dF_c} dG + s^t \left[\frac{\partial W_a^t}{\partial F_c} - \lambda G(\bar{y}) \frac{\partial W_a^t}{\partial w_c}\right]. \quad (34)$$

Differentiating the envelope condition $W_a^t = u'(c^t)$ and replacing for $\partial W_a^t/\partial w_c$ and $\partial W_a^t/\partial F_c$ one obtains

$$\lambda G(\bar{y})[u'(c^e) - u'(c^u(a+F))] \leq \lambda \int_{\min\{y_d,\bar{y}\}}^{y_d} \frac{dW^e(y,.)}{dF_c} dG + u''(c^e) s^e \left[\frac{\partial c^e}{\partial F_c} - \lambda G(\bar{y}) \frac{\partial c^e}{\partial w_c}\right]. \quad (35)$$

The left hand side of the inequality is negative by assumption. Since the first addendum on the right hand side of (35) is non-negative it is sufficient to show that so is the second addendum. It is $s^t \geq 0$, as $c^t(1,\sigma,a) > c^u(a+F_c)$ implies that the marginal utility of consumption is expected to increase. It remains to prove that

$$-\lambda G(\bar{y}) \leq -(\partial c^t/\partial F_c)/(\partial c^t/\partial w_c). \quad (36)$$

The left hand side of (36) is the actuarially fair rate of exchange dw_c/dF_c. Trading a higher F_c for lower w_c at such rate leaves permanent income unchanged, but, given $c^t(1,\sigma,a) > c^u(a+F_c)$, reduces future consumption variability. Since $u''' > 0$, c^t increases. Hence, the rate of change dw_c/dF_c that leaves c^t unchanged, the right hand side of (36), is smaller in absolute value. □

A.2 Data and variables used in Section 5.1

This section contains the data used to construct Figure 3 in section 5.1. The data for the monthly exit rate from unemployment $p(\theta)$ are from the OECD unemployment duration database. The benefit replacement rates ρ are from Nickell (1997) with the exception of the Italian replacement rate which has been updated on the basis of information in Office of Policy (2002). The average completed job tenure ACJT is from the dataset in Nickell et al. (2002). It is an average over each country's sample period.

The notice periods and severance payments in columns 5 to 8 are obtained by applying the appropriate formulas for legislated notice and severance pay to a tenure equal to the average completed job tenure in column 4. The relevant formulas for the European countries come from Grubb and Wells (1993), with the exception of those for Austria, Finland, Norway, Sweden which are derived from IRS (Industrial Relations Service) (1989). The size of the legislated severance pay for Italy is the sum of the damages workers are entitled to if their dismissal is deemed unfair (5 months) plus the amount they are entitled to if they give up their right to reinstatement (15 months). Our value is consistent with the

Table 5: Legislated severance pay for blue and white collar workers.

Country	$p(\theta)$ (monthly)	ρ (%)	ACJT (yrs)	f_c	Notice BC (months)	Sev. pay BC (months)	Notice WC (months)	Sev. pay WC (months)
Australia	0.15	36	7.6	4.2	1	2	1	2
Belgium	0.04	60	24.4	9.2	1.9	-	21[a]	-
Canada	0.29	59	3.5	1.4	0.5	0.25	0.5	0.25
Denmark	0.12	90	11.9	0.8	3	-	6	1
Finland	0.15	63	10.4	2.4	4	-	4	-
France	0.05	57	21.1	8	2	1.7	2	1.7
Germany	0.13	63	26.5	4.4	2[b]	-	6[b]	-
Ireland	0.03	37	11.4	19	1.5	1.4	1.5	1.4
Italy	0.03	40 (3)	41.2	18 (29)	0.5	20	4	20
Netherlands	0.05	70	15.3	5.6	3.3	-	3.3	-
Norway	0.25	65	11.6	1.4	3	-	3	-
New Zealand	0.17	30	6.8	4	1	-	1	-
Portugal	0.06	65	14.9	5.7	2	15	2	15
Spain	0.02	70	26.8	12.9	3	12	3	12
Sweden	0.25	80	10.6	0.8	4[b]	-	4[b]	-
UK	0.1	38	4.5	6	1.2	1.2	1.2	1.2
USA	0.33	50	3.1	1.5	2[c]	-	2[c]	-

[a] 0.86 times length of service in years. This is an approximation of the Claeys formula in Grubb and Wells (1993).
[b] For Germany and Sweden the formulas are a function of both age and length of services. We assumed employment started at age 20.
[c] It applies only to large scale redundancies covered by the Worker Advanced Retraining Notification Act.

estimates in Ichino (1996). The formula in Grubb and Wells (1993) wrongly treats as severance pay the *Trattamento di fine rapporto,* a form of forced saving workers are entitled to whatever the reason for termination[1], including voluntary quit and summary dismissal. The data for Portugal and New Zealand come respectively from European Foundation (2002) and CCH New Zealand Ltd (2002). The data for legislation in Australia, Canada and the United States are from Bertola, Boeri and Cazes (1999).

[1] On this see Brandolini and Torrini (2002).