From Dual to Unified Employment Protection: Transition and Steady State*

Juan J. Dolado†
European University Institute

Etienne Lalé‡
University of Bristol

Nawid Siassi§
University of Konstanz

Abstract

This paper studies the equilibrium and welfare implications of replacing a highly dual employment protection legislation (EPL) system with a unified EPL scheme. We develop a computationally tractable model and specialise the discussion to Spain – a country often considered as an epitome of a labour market with dual EPL. We use the model to design an optimal, unified EPL scheme defined as the employment protection scheme maximising the steady-state lifetime utility of new labour-market entrants. Our approach allows to tabulate the key parameters of this scheme, i.e. the eligibility rule and the increase in the level of employment protection with job tenure. We also consider the transition path of a reform implementing the unified EPL scheme: we find a positive welfare impact of the reform on average, alongside substantial welfare losses concentrated on a few workers.

Keywords: Employment Protection; Dualism; Labour Market Reform; Welfare

JEL codes: E24, H29, J33, J65

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†Address: Department of Economics, Villa San Paolo, Via della Piazzuola 43, 50133 Florence, Italy – Phone: [+39] 055 4685 956/954 – Email: juan.dolado@eui.eu

‡Address: Department of Economics, University of Bristol, Priory Road Complex, Priory Road, Bristol BS8 1TU, United Kingdom – Phone: +44(0)117 331 7912 – E-mail: etienne.lale@bristol.ac.uk

§Address: Department of Economics, University of Konstanz, Universitätsstraße 10, 78457 Konstanz, Germany – Phone: +49-7531-88-2197 – Email: nawid.siassi@uni-konstanz.de

1 Background and Introduction

There is an ongoing debate on how to reform employment protection legislation (EPL) in the so-called dual labour markets in Europe – typically in Mediterranean countries and France (Saint-Paul (1996), Dolado (2016)). A recurrent theme is that of the EPL *gap*, alluding to the abrupt increase in the stringency of EPL that occurs after a few periods of employment. In this setting, workers who have been employed long enough benefit from high employment protection (including the right to appeal for unfair dismissals to labour courts), whereas those just hired enjoy virtually none. As pointed out by Blanchard and Landier (2002), lacking enough wage flexibility, a large EPL gap creates a "revolving door" through which workers rotate between short-term jobs and unemployment. There is plentiful evidence of the negative equilibrium and welfare consequences of this excess job turnover,[1] which in turn has led to several proposals to remove once and for all the large discontinuity in employment protection.[2] Regrettably but not surprisingly, this call has been reiterated in the wake of the Great Recession and the ensuing poor performance of the labour markets in southern Europe (Bentolila et al. (2012a)).

The motivating point of this paper is that these proposals of structural EPL reforms remain rather vague on their specific recommendations. That is, they mainly advocate replacing dual EPL with a unified EPL scheme consisting of a sufficiently long entry phase and a *smooth* tenure profile of statutory severance payments.[3] As far as we are aware, however, there has been almost no attempt to define quantitatively the entry phase and the tenure profile of a unified EPL scheme. This leads to several limitations. First, without a precise definition of a unified EPL scheme, little is known about the improvements in equilibrium allocations and welfare that it would bring about. Second, in the specific context of dual labour markets, there is a presumption that a non-negligible number of insiders would lose from the policy change and, thus, would oppose a reform leading to a unified EPL scheme. Yet, lacking a precise definition of such a scheme, there is also little known about the relevance of this argument.

Our paper takes a step towards addressing these limitations. We develop a general equilibrium search-matching model of the labour market, geared to assess the effects of replacing a dual EPL system by a unified scheme. In the benchmark equilibrium of the model, there is an abrupt shift in severance pay entitlements after a short period on the job, which alters wages as well as decisions to dissolve the employment relationship between workers and firms. We emphasise risk aversion and imperfect capital markets as key reasons for workers to value a smooth EPL scheme (see, e.g., Pissarides (2001)). The welfare implications of a unified EPL scheme that improves job stability at short tenure and reduces income volatility are not trivial in this context. Our model allows to assess these implications not only in a steady-state sense, but also taking account of the

[1] For instance, Bentolila and Dolado (1994) emphasise the high wage pressure that results from dual EPL; Saint-Paul (2002) shows that it incentivises the adoption of mature rather than innovative technologies; Bentolila et al. (2012c) present evidence of negative effects on unemployment, human capital and innovation; Cabrales et al. (2014) document that dual EPL leads to low investment in employer-sponsored training schemes.

[2] Inspired by Blanchard and Tirole (2003), these proposals include Cahuc and Kramarz (2004) and Cahuc (2012) for France, Boeri and Garibaldi (2008) and Ichino et al. (2009) for Italy, and Andrés et al. (2009) for Spain.

[3] The rationales for the gradual increase in severance pay range from insurance motives to the large losses of specific human capital and psychological costs suffered by long-tenured workers in case of dismissal, leading to a negative externality that firms should internalise (see Blanchard and Tirole (2003)).

transition path from the dual EPL system to the unified one; that is, the model is computationally tractable outside the steady state. This is an important feature of our analysis as it enables us to evaluate the welfare consequences of introducing unified EPL for the *current* population in the labour market, and to study the political support of the reform.

For illustrative purposes, the model is calibrated to the Spanish labour market before the Great Recession, when the unemployment rate in this country was similar to the European average, i.e. around 8.5 percent. We choose Spain because it is often considered as the epitome of a labour market with a very large EPL gap (see Dolado et al. (2002) and OECD (2014)). Within this framework, we compute the optimal profile of unified EPL, defined as the profile maximising the steady-state lifetime utility of new labour-market entrants.[4] We then study the transition path, with a view of evaluating how the change in EPL affects workers who are already employed when the reform is introduced. Our calibrated model is well suited for this purpose because it generates a job tenure distribution that closely resembles its empirical counterpart. More importantly, we account for a key feature of EPL reforms, that employed individuals cannot be exempted retroactively from their accrued-to-date rights. Namely, workers already employed retain any previous entitlements to severance payments accumulated under the dual EPL system, and they accumulate additional entitlements at a rate prescribed by the unified EPL scheme from the date of the reform onwards.[5]

The main results of the paper are as follows. First, we find that a unified scheme with 5 months of eligibility period and severance pay worth 20 days of wages per year of services (d.w.y.s.) is optimal according to the criterion described previously. This is much less generous than the EPL scheme that prevailed in Spain before the Great Recession, but it is similar to the current regulation of redundancy pay for dismissals due to fair (e.g., economic) reasons.[6] This unified EPL scheme avoids inefficient turnover at short tenure, and hence it improves welfare through an increase in initial job stability. At the same time, it promotes job creation by reducing the costs of dismissing long-tenured workers. The insight for not diminishing further severance payments at long job tenure (compared to the benchmark scheme with a large EPL gap) is that these workers face deteriorated opportunities in the labour market – a feature that is also captured by our model. Foremost, we find that the high welfare gains from unified EPL can be attributed to a reduction in the volatility of income, absent the "revolving door" effect.

Second, taking the transition path into account, we find that the unified EPL scheme increases welfare by 0.85 percent (in consumption equivalents) on average among individuals in the labour market when the reform is introduced. This figure masks important discrepancies between workers: though the vast majority of them benefits from the reform, we think the main finding pertains to the heterogeneity of the welfare effects. In our setting that distinguishes between young and older workers, the former experience a welfare gain by 1.2 percent whereas older workers suffer a 0.78 percent loss, on average. Among the latter, two thirds experience a negative welfare effect, and the average loss suffered by the bottom quintile is 2.1 percent. These

[4]In line with existing regulations, we determine severance payments in terms of days of wages per years of service. The profile of a unified EPL scheme refers to the way these payments increase with job tenure.

[5]See, e.g., García Pérez and Osuna (2014): this matches the way the 2012 reform of the EPL system of the Spanish labour market was implemented. In Subsection 6.1, we use our model to analyse this reform.

[6]See OECD (2014), García Pérez and Osuna (2014), and the figures in Table 1 of Boeri et al. (2017).

figures reflect the implementation of the EPL reform, which reduces the entitlements brought about by an additional year of tenure for workers in employment relations that started before the reform. We emphasise these findings because they may well underscore the actual difficulty of implementing a unified EPL scheme in a highly dual labour market.

Before discussing the related literature, it is worth highlighting two features of the analysis. First, our model precludes access to savings, but it includes an annuity scheme that enables workers to use their severance package so as to increase consumption during unemployment. This allows us to provide an insurance role for severance pay without jeopardising the tractability of the model. Of course, the absence of savings implies that we may overstate the welfare effects of the policies considered. We note, meanwhile, that the model is calibrated to match the generous unemployment insurance (UI) benefits of the Spanish economy, which should substantially mitigate the precautionary savings motive.[7] Second, the optimality concept used throughout the paper is a "constrained" one in that we take UI benefits as given. In other words, we abstain from considering policies which simultaneously change statutory severance payments and unemployment compensation, such as the "experience-rating" type of policies which has been advocated, *inter alia*, by Blanchard and Tirole (2008) (see below). This issue would deserve a study in its own right.[8] We instead analyse, and do report, how the constrained optimal EPL scheme changes with exogenous changes in the generosity of UI benefits.

Related Literature

This paper contributes to the rich policy debate presented in the opening paragraphs of the paper. Following Blanchard and Tirole (2008), we focus on the design of EPL when its main role is to provide insurance to risk-averse workers.[9] Our approach is quantitative and intended to provide figures that would inform actual policy schemes in the context of a dysfunctional labour market as the Spanish one. The model that we develop for this purpose involves rich dynamics and considers the transition from dual EPL to a unified EPL scheme. Thus, our analysis is related to three strands of literature that we describe in the next paragraphs.

The first strand of literature studies the effects of statutory severance payments in heterogeneous agents, incomplete market models. Alvarez and Veracierto (2001) consider a model with precautionary savings, costly search efforts for the unemployed, and wage rigidities that result in an inefficiently high number of layoffs. Cozzi and Fella (2016) analyse a similar model that features, in addition, human capital losses after job displacement. The paper by Lalé (2016) is closer to ours: he develops a model with search-matching frictions in the labour market, wherein workers and firms bargain over wages and separation decisions. The key differences between

[7] Lalé (2016) studies the effects of government-mandated severance payments in an economy with a frictional labour market, risk-averse workers and imperfect insurance against shocks. He finds that the welfare figures are not too different with and without access to savings (although his model is calibrated on U.S. data and policies, which implies UI benefits that are much less generous than in Spain). Due to the complexity of the model with savings, he does not study the impact of the transition path.

[8] In particular, to properly assess the effects of changing UI policies, one should consider the moral hazard problems that arise with the search behaviour of benefit recipients; this is beyond the scope of our analysis.

[9] As already mentioned, Blanchard and Tirole (2008) study of the joint design of UI and EPL. They use a static model and a mechanism design approach. Their focus is theoretical and aims to establish the optimal relationship between these labour market programs.

these and the present paper is that they introduce simple EPL schemes (typically: a uniform lump-sum severance package) in a *laissez-faire* economy, they abstract from optimality issues and they conduct "only" steady-state comparisons. While we rule out precautionary savings, we carry job tenure as a state variable so as to allow EPL to depend on tenure, and we are able to study the transition dynamics. We think the latter is especially important because we consider the effects of moving *away* from a highly dual EPL system.

The second strand of relevant literature deals with the relationship between job tenure and severance payments. A closely related analysis in this respect is that of García Pérez and Osuna (2014), who study the effects of introducing a so-called single open-ended contract in the Spanish labour market. The main differences with our approach are as follows: (i) workers are risk neutral in their setup whereas they are risk averse and value consumption smoothing in ours, (ii) they impose a given tenure profile for the single open-ended contract rather than deriving it from a welfare criterion, and (iii) they do not seek to finance the provision of unemployment insurance benefits, which makes the transition dynamics trivial in their setup (i.e. labour market variables are "jump" variables). The other related paper is Boeri et al. (2017). The authors propose a rationale for having mandatory severance pay increase with tenure on the job using a stylised model with risk-neutral agents. The insight is that financing initial investment in training trough wage deferrals is not sustainable if employers cannot commit to keep workers who have invested in training. We view our work as complementary to theirs, in that they provide a different rationale for a positive slope in the tenure profile of EPL.

Last, there is a strand of literature that studies the employment effects of the co-existence of fixed-term and open-ended contracts. Some prominent examples of this line of research include Blanchard and Landier (2002), Cahuc and Postel-Vinay (2002), Bentolila et al. (2012b), and Cahuc et al. (2016) among others. These papers are related to ours in that they study labour markets that are dual as per the different types of employment contracts used by workers and firms. To a large extent, the EPL gap in the benchmark equilibrium of our model has the flavour of the divide between fixed-term and open-ended contracts. Indeed, the first periods of employment play a role similar to temporary contracts, except that it does not have a pre-specified termination date, while the latter periods become akin to those under open-ended employment contracts. In Spain, only 8 percent of new hires are under open-ended contracts (Bentolila et al. (2012c)). Temporary contracts are sometimes subject to a termination cost that is typically much lower than redundancy pay for workers under open-ended contracts with similar tenure (Cahuc et al. (2016)). Thus, it is accurate to describe employment in the Spanish labour market as contractual relationships starting with low EPL, where no worker is directly hired with a contract entailing high EPL. Our paper therefore complements this line of research. By not modelling different employment contracts separately, we simplify the analysis in ways that enable us to tackle more computationally involved issues, such as, e.g., the transition dynamics from dual to unified EPL in a labour market with risk-averse workers.

The rest of the paper is structured as follows. Section 2 presents the environment of our model, the Bellman equations and bargaining relationships between agents. In Section 3, we define the equilibrium conditions and establish results which enable us to study the transition dynamics. Section 4 proceeds with the calibration of the model to Spanish labour market data and policies.

We use this model to conduct two series of experiments in Section 5 considering, respectively, the optimal design of a unified EPL scheme and the welfare effects of transitioning towards this scheme. Section 6 provides further analyses and robustness checks. Section 7 concludes.

Two appendices are included in the paper: Appendix A is a technical appendix for the model and Appendix B contains additional tables and figures.

2 The Model

This section introduces our search-matching model of the labour market. There are three key elements in our setup: (i) a demand for insurance, and a vehicle to partially meet this demand, (ii) bilateral bargaining over wages and decisions to terminate the employment relationship between workers and firms, and (iii) job tenure as a state variable of these employment relations.

2.1 Economic Environment

Time is discrete and runs forever. Since our analysis is partly focused on the transition to a steady-state equilibrium, we keep track of calendar time indexed by the subscript t.

Workers

The economy is populated by a continuum of workers, who live through a stochastic life cycle: each period, young workers (y) become older with probability γ, while older workers (o) retire and exit our economy with probability χ. A measure of newborns enters the economy at the beginning of each period, so that the size of the workforce is kept at a constant unit level. We use index i to denote the age of the workers, i.e. $i \in \{y, o\}$.

Workers are risk averse: they value consumption $c_t > 0$ according to a CRRA utility function:

$$u(c_t) = \frac{c_t^{1-\eta} - 1}{1-\eta}, \tag{1}$$

where $\eta > 0$ is the coefficient of relative risk aversion. Workers discount the future using the real interest rate denoted by r.

An important assumption is that workers face incomplete asset markets and that there is no full storage technology. As mentioned in the introduction, we preclude access to savings in order to reduce the dimension of state variables in the model and, foremost, to provide and enhance an insurance role for EPL. Nevertheless, we include public insurance from UI benefits and also allow for some form of private insurance in the model, as will be explained in detail below.

Production

Production is carried out by a continuum of firms. Each firm is a small production unit with only one job, either filled or vacant. Labour is the only input and production is linear in labour. Productivity, denoted by z_t, is idiosyncratic to the worker-firm pair. All worker-firm pairs start at the same initial productivity level z_0. In subsequent periods, productivity evolves according to a finite Markov-chain process, where $\pi_{z,\bullet}$ denotes the transition function for z, i.e. $\pi_{z,z'} = \Pr\{z_{t+1} = z'|z_t = z\}$. Fluctuations in productivity may induce the worker-firm pair to destroy the job. Later on in the analysis, we also allow for exogenous separation shocks (i.e., quits) in order to improve the fit of the model. To economise on notation, we defer this element to the calibration section of the paper (cf. Section 4).

Anticipating on the design of government-mandated employment protection schemes, we denote by τ the tenure of a worker-firm match. Thus, every worker-firm pair in each period t is characterised by at least two state variables: productivity z and tenure τ.

Search-matching Frictions

Workers and firms meet each other via random search. Firms incur a per-period cost $k > 0$ of posting a vacancy to attract workers. The number of meetings between workers and firms is determined by a standard Cobb-Douglas matching function with constant returns to scale:

$$m(u_t, v_t) = Au_t^{\psi} v_t^{1-\psi}, \tag{2}$$

where u_t and v_t are the number of *job seekers* and vacancies, respectively. The parameter $\psi \in (0, 1)$ measures the elasticity of the number of meetings to the number of job seekers and A characterises matching efficiency. Accordingly, the vacancy-filling probability faced by firms, $q(\theta_t) = A\theta_t^{-\psi}$, is decreasing in labour market tightness $\theta_t \equiv v_t/u_t$, while the job-finding probability for job seekers, $\theta_t q(\theta_t)$, is increasing in θ_t.

To circumscribe the population of job seekers, we make the following two assumptions. First, we rule out on-the-job search: workers can only search while being unemployed. Second, and more importantly, we assume that young workers keep searching for new jobs following job losses, whereas older workers abandon job search until they retire. This assumption, which is not essential for the workings of our model, enables us to capture a relevant phenomenon in most countries, namely, that re-entering the labour market at an age close to retirement is often difficult. In this respect, it provides a role for EPL to foster job security and help older workers bridge the gap to retirement.

Government-mandated Programs

The government runs two labour market programs. The first one is an unemployment insurance (UI) program which provides a constant-level benefit, denoted as b^i with $i \in \{y, o\}$, to non-employed workers, where benefits are allowed to depend on the age group of the worker. There is no monitoring technology; therefore, older workers can collect b^o after a job loss even though they stop searching for jobs. The provision of unemployment insurance is financed by the proceeds of a payroll tax denoted as κ_t.

The other labour market program is employment protection. This program consists of government-mandated severance pay, which is paid at the time of job separation. Consistent with actual policies, the severance pay component, denoted as $\phi(\tau)$, is a function of job tenure.

In our benchmark model, we ignore pure red-tape costs involved in the dismissal procedure. Later on in our robustness checks, we will also introduce a firing tax component, in line with a long-established literature (e.g. Bertola and Rogerson (1997)). Thus, unless otherwise indicated, the severance package is a pure transfer from the firm to the worker.[10] Finally, in the event of a separation between a firm and an older worker triggered by the ageing shock χ, we assume that severance payments are waived.

Annuities

As mentioned earlier, while workers cannot save, they nevertheless have access to a partial insurance vehicle. Specifically, they are allowed to buy an annuity upon separation from the job with the proceeds of the severance pay that they receive. We assume that, in contrast with the UI program, the annuity system monitors perfectly the job-search behaviour of workers.[11] Thus, the insurance is partial in that workers can use the annuity scheme only to increase consumption until their next job arrives (young workers) or until they leave the economy (older workers). In our view, this provides a reasonable middle course between precluding any form of private insurance and allowing for savings in the model.

The annuity system works as follows: upon job loss, a worker uses her severance package, $\phi(\tau)$, to purchase an actuarially-fair annuity which she holds for the duration of her spell of joblessness. Since unemployed older workers do not search for a new job any more, their per-period payment is given by:

$$a^{o}(\tau) = \frac{1}{1-(1+r)^{-1/\chi}}\frac{r}{1+r}\phi(\tau), \quad \tau = 1, \ldots \tag{3}$$

where $1/\chi$ is the expected number of periods until the worker retires. For a young worker, on the other hand, the payment depends on the expected duration of joblessness at the time when she loses her job and buys the annuity. We denote this expected duration by Δ. It is important to note that a young unemployed workers carries Δ as a *fixed* state variable for the duration of her spell of joblessness. As a result, the annuity payment received by a young worker is:

$$a^{y}(\Delta, \tau) = \frac{1}{1-(1+r)^{-\Delta}}\frac{r}{1+r}\phi(\tau), \quad \tau = 1, \ldots. \tag{4}$$

For future reference, we also define $a^{y}(\Delta, 0)$ as follows: $a^{y}(\Delta, 0) = 0$ for all Δ. Notice that when a worker unemployed at time t holds an annuity $a^{y}(\Delta, \tau)$, the variable Δ can in general be different from the expected duration of a jobless spell at time t, denoted by Δ_t.

[10] As a result, the EPL program is self-financed. In our robustness checks with a firing tax, we assume that the proceeds are wasted instead of being used to lower the payroll tax κ_t. Thus, we do not study whether the EPL scheme could help financing the provision of UI benefits.

[11] This assumption has the following two implications. First, for unemployed workers, the value of reemployment upon meeting a new employer dominates the value of continued search (since the latter would entail losing the annuity). Thus, it is always optimal to begin the employment relationship conditional on meeting. Second, for firms with a vacancy, the assumption implies that the job seekers whom they meet are homogeneous with respect to their outside option (continued search with no annuity). As a result, firms need not keep track of the distribution of annuities among unemployed workers to compute the returns to filling a vacancy.

2.2 Bellman Equations

We formulate workers' and firms' decision problems in recursive form. Let us denote by U_t^i (resp. W_t^i) the value of being non-employed (resp. being employed), with $i \in \{y, o\}$.

While unemployed, a young worker receives a flow income b^y and, potentially, an annuity payment $a^y(\Delta, \tau)$. A young worker becomes old with probability γ and the asset value becomes $\widetilde{U}_{t+1}^o(\Delta, \tau)$, which we define momentarily. Otherwise, she remains in the current age category and either finds a firm with a vacancy with probability $\theta_t q(\theta_t)$, or remains unemployed. If the worker finds a vacancy, her asset value is $W_t^y(z_0, 0)$, the value of being employed at the entry productivity level and with no tenure. This is her preferred option since, under perfect monitoring, rejecting the job yields the asset value $U_t^y(\Delta, 0)$. Hence:

$$U_t^y(\Delta, \tau) = u(a^y(\Delta, \tau) + b^y) + \frac{1}{1+r}\Big[(1-\gamma)\big(\theta_t q(\theta_t) W_{t+1}^y(z_0, 0) + (1-\theta_t q(\theta_t)) U_{t+1}^y(\Delta, \tau)\big) + \gamma \widetilde{U}_{t+1}^o(\Delta, \tau)\Big]. \quad (5)$$

In turn, an older non-employed worker with τ periods of tenure in her previous job receives a flow income b^o and an annuity payment $a^o(\tau)$, and she remains in the labour market with probability $1-\chi$. Thus, the corresponding asset value $U_t^o(\tau)$ is:

$$U_t^o(\tau) = u(a^o(\tau) + b^o) + \frac{1-\chi}{1+r} U_{t+1}^o(\tau). \quad (6)$$

Likewise, the asset value $\widetilde{U}_t^o(\Delta, \tau)$ satisfies:

$$\widetilde{U}_t^o(\Delta, \tau) = u(a^y(\Delta, \tau) + b^o) + \frac{1-\chi}{1+r} \widetilde{U}_{t+1}^o(\Delta, \tau). \quad (7)$$

Next, consider employed workers. These workers consume their wage, denoted by $w_t^i(z, \tau)$, while employed at a job with productivity z and tenure τ. Productivity evolves stochastically over time, and tenure increases deterministically according to: $\tau' = \tau + 1$. Every period, the value of continuing the employment relationship is compared to the value of job destruction. In the latter event, older workers receive the asset value $U_t^o(\tau)$ whereas the value of younger workers becomes $U_t^y(\Delta_t, \tau)$. Therefore, $W_t^y(z, \tau)$ satisfies:

$$W_t^y(z, \tau) = u(w_t^y(z, \tau)) + \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'} \pi_{z,z'} \max\Big\{W_{t+1}^y(z', \tau'), U_{t+1}^y(\Delta_{t+1}, \tau')\Big\} + \gamma \sum_{z'} \pi_{z,z'} \max\Big\{W_{t+1}^o(z', \tau'), U_{t+1}^o(\tau')\Big\}\Bigg). \quad (8)$$

The value of employment for older workers, $W_t^o(z, \tau)$, is given by:

$$W_t^o(z, \tau) = u(w_t^o(z, \tau)) + \frac{1-\chi}{1+r} \sum_{z'} \pi_{z,z'} \max\Big\{W_{t+1}^o(z', \tau'), U_{t+1}^o(\tau')\Big\}. \quad (9)$$

With regard to firms, let J_t^i denote the value of having a filled job, where $i \in \{y, o\}$ is the age of the worker who is currently employed. Just like the worker, the firm forms expectations over future values of productivity and age. In the event of job destruction, the value of a firm is that of having a vacant position minus the severance package $\phi(\tau)$. To close the model, in Section 3 we impose a free-entry condition, so that in the sequel the asset value of having a vacant position is zero in every period t. Hence:

$$\begin{aligned} J_t^y(z,\tau) =& z-(1+\kappa_t)w_t^y(z,\tau)+\frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^y(z',\tau'),-\phi(\tau')\right\} \\ &+\gamma\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'),-\phi(\tau')\right\}\Bigg), \end{aligned} \tag{10}$$

$$J_t^o(z,\tau)=z-(1+\kappa_t)w_t^o(z,\tau)+\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'),-\phi(\tau')\right\}. \tag{11}$$

2.3 Wage Setting

In line with most of the literature, we assume that wages are set by Nash bargaining each period. Let $\beta\in(0,1)$ denote the bargaining power of the worker. The wage schedules are then determined as follows:

$$w_t^y(z,\tau)=\arg\max_w\left\{\Big(W_t^y(z,\tau;w)-U_t^y(\Delta_t,\tau)\Big)^\beta\Big(J_t^y(z,\tau;w)+\phi(\tau)\Big)^{1-\beta}\right\} \tag{12}$$

$$w_t^o(z,\tau)=\arg\max_w\left\{\Big(W_t^o(z,\tau;w)-U_t^o(\tau)\Big)^\beta\Big(J_t^o(z,\tau;w)+\phi(\tau)\Big)^{1-\beta}\right\} \tag{13}$$

for all (z,τ). It is useful to study the first-order condition associated with these maximisation problems. For instance, for equation (12), we have:

$$(1-\beta)\frac{1+\kappa_t}{J_t^y(z,\tau)+\phi(\tau)}=\beta\frac{u'\left(w_t^y(z,\tau)\right)}{W_t^y(z,\tau)-U_t^y(\Delta_t,\tau)}. \tag{14}$$

The numerator on the left-hand side of equation (14) is the effect for the firm of a marginal reduction in the wage, which increases profit streams by $1+\kappa_t$. On the right-hand side of the equation, the effect of a marginal increase in the wage on the utility of the worker depends on the value of the wage, due to diminishing marginal utility of consumption. Notice that this feature prevents us from solving for the joint surplus of the match in order to obtain the wage functions and separation decisions. This is unlike the canonical search-matching model, which assumes that utility can be transferred between the worker and the firm.[12]

[12]Another implication is that Lazear (1990)'s "bonding critique" is not entirely applicable here. Lazear's result refers to the fact that severance payments can be undone by efficient worker-firm bargains. In our setup, workers and firms differ as to their valuation of payments and there is a non-negativity constraint on workers' consumption, which prevents neutralizing severance payments fully. Lalé (2016) discusses this issue in a similar context (i.e., risk-averse workers who bargain with risk-neutral employers).

2.4 Separation Decisions

Associated with the max operator in the value functions of employment, there are productivity thresholds that determine separation decisions. Let $\overline{z}_t^i(\tau)$ denote the productivity cutoff, i.e. the value of z that makes both parties indifferent between keeping the job alive and dissolving the match. Furthermore, let $\underline{w}_t^i(z,\tau)$ denote the lowest possible wage that a worker of age i and current tenure τ would accept in a job with productivity z, and let $\overline{w}_t^i(z,\tau)$ denote the highest possible wage that the firm would accept to pay to this worker. By definition, we have:

$$\underline{w}_t^i\left(\overline{z}_t^i(\tau),\tau\right)=\overline{w}_t^i\left(\overline{z}_t^i(\tau),\tau\right). \tag{15}$$

For workers, reservation wages $\underline{w}_t^i(z,\tau)$ satisfy:

$$\begin{aligned} u\left(\underline{w}_t^y(z,\tau)\right)=U_t^y(\Delta_t,\tau)-\frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^y(z',\tau'),U_{t+1}^y(\Delta_{t+1},\tau')\right\}\\ +\gamma\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'),U_{t+1}^o(\tau')\right\}\Bigg), \end{aligned} \tag{16}$$

$$u\left(\underline{w}_t^o(z,\tau)\right)=U_t^o(\tau)-\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'),U_{t+1}^o(\tau')\right\}. \tag{17}$$

The highest possible wages paid by firms, $\overline{w}_t^i(z,\tau)$, solve:

$$\begin{aligned} \overline{w}_t^y(z,\tau)=\frac{1}{1+\kappa_t}\Bigg[z+\phi(\tau)+\frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^y(z',\tau'),-\phi(\tau')\right\}\\ +\gamma\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'),-\phi(\tau')\right\}\Bigg)\Bigg], \end{aligned} \tag{18}$$

$$\overline{w}_t^o(z,\tau)=\frac{1}{1+\kappa_t}\left(z+\phi(\tau)+\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'),-\phi(\tau')\right\}\right). \tag{19}$$

Notice that, in equations (16)–(19), reservation wages depend on the current calendar time t through the outside option of workers and the payroll tax κ_t. These are the variables that make the bilateral bargains between workers and firms depend on the aggregate state of the economy.

3 Steady State and Transition

Having described the environment and the employment relationships, we next formulate the equilibrium conditions of the model. These conditions are satisfied in any period t irrespective of whether the economy is at a steady state or not. We provide two key results below which enable us to study the transition path consistent with the equilibrium conditions.

3.1 Equilibrium Conditions

There are two aggregate quantities which are pinned down by equilibrium conditions: labour market tightness θ_t and the tax rate κ_t. The latter depends on the cross-sectional distribution of workers. We denote by $\lambda_t^y(z,\tau)$ (resp. $\lambda_t^o(z,\tau)$) the population measure of young (resp. older) workers employed at a job with current productivity z and with tenure τ, and by $\mu_t^y(\tau)$ (resp. $\mu_t^o(\tau)$) the measure of young (resp. older) unemployed workers at time t.[13] These measures satisfy a set of stock-flow equations which we defer to Appendix A.1 to save on space.

Free Entry

As already mentioned, we let a free-entry condition pin down the equilibrium value of θ_t. In every period t, firms exhaust the present discounted value of job creation net of the vacancy-posting cost. Since workers and firms always form a match conditional on meeting, and workers are homogeneous with respect to their outside option at that point, the free-entry condition yields:

$$\frac{k}{q(\theta_t)} = \frac{1}{1+r} J_{t+1}^y(z_0, 0) \tag{20}$$

for all t. Notice that the right-hand side of the equation, i.e. the present discounted value of filling a vacant position, depends on calendar time $t+1$ only.

Balanced Budget

To pin down the payroll tax, it is assumed that the government balances the budget of the unemployment insurance system period by period. Thus, κ_t satisfies:

$$\kappa_t \sum_\tau \sum_z \left(w_t^y(z,\tau)\,\lambda_t^y(z,\tau) + w_t^o(z,\tau)\,\lambda_t^o(z,\tau) \right) = \sum_\tau \left(b^o \mu_t^o(\tau) + b^y \mu_t^y(\tau) \right) \tag{21}$$

for all t. Workers and firms need to know the tax rate κ_t to set wages, and the latter in turn affect the revenues raised by the tax.

3.2 Two Definitions

When all exogenous features of the economic environment (policy parameters, preferences, etc.) remain constant, and because there is no aggregate shock, the economy reaches a steady-state equilibrium after a possibly long transition path. We define the latter in detail below, and use a less formal definition for the steady state in what follows:

Definition 1. A steady-state equilibrium is: (i) a list of value functions and separation decision rules that satisfy optimization (equations (5) – (11) and equation (15)) (ii) a list of wage functions

[13] The variable Δ is not included in $\mu_t^y(\tau)$ because we do not need to keep track of the population $\mu_t^y(\Delta,\tau)$ during the transition phase. For the analysis of the transition dynamics in Section 5, the only expected duration Δ that is relevant is the value in the steady state prior to the policy reform, which is a fixed number. Thus, we do need the distribution of young unemployed workers across previous tenure (τ) to conduct the analysis of the transition dynamics.

consistent with Nash bargaining (equations (12) and (13)), (iii) a value for labour market tightness pinned down by free entry of firms (equation (20)), (iv) a payroll tax that balances the budget of the unemployment insurance system (equation (21)) and (v) a time-invariant distribution for the law of motion described in Appendix A.1.

Appendix A.2 provides an algorithm to compute a steady-state equilibrium allocation. In the sequel, we are typically interested in the transition between two equilibrium allocations indexed by calendar dates, say t_0 and $t_1 > t_0$. We use the following definition:

Definition 2. A transition path between t_0 and t_1 is a sequence of value functions $(U_t^y(\Delta, \tau), U_t^o(\tau), \widetilde{U}_t^o(\Delta, \tau), W_t^y(z, \tau), W_t^o(z, \tau), J_t^y(z, \tau), J_t^o(z, \tau))_{t=t_0,\dots,t_1}$, a sequence of wage functions $(w_t^y(z, \tau), w_t^o(z, \tau))_{t=t_0,\dots,t_1}$, a sequence of separation decision rules $(\overline{z}_t^y(\tau), \overline{z}_t^o(\tau))_{t=t_0,\dots,t_1}$, a time-path for labour market tightness $(\theta_t)_{t=t_0,\dots,t_1}$ and for the payroll tax $(\kappa_t)_{t=t_0,\dots,t_1}$, and a sequence of distribution of workers across employment status, productivity levels, tenure and age groups $(\mu_t^y(\tau), \mu_t^o(\tau), \lambda_t^y(z, \tau), \lambda_t^o(z, \tau))_{t=t_0,\dots,t_1}$ such that:

1. Agents optimise: Given $(\theta_t)_{t=t_0,\dots,t_1}$, $(\kappa_t)_{t=t_0,\dots,t_1}$ and the sequence of wage functions $(w_t^y(z, \tau), w_t^o(z, \tau))_{t=t_0,\dots,t_1}$, the value functions $U_t^y(\Delta, \tau)$, $U_t^o(\tau)$, $\widetilde{U}_t^o(\Delta, \tau)$, $W_t^y(z, \tau)$, $W_t^o(z, \tau)$, $J_t^y(z, \tau)$, $J_t^o(z, \tau)$ satisfy equations (5) – (11), respectively, and the separation decisions $\overline{z}_t^y(\tau)$, $\overline{z}_t^o(\tau)$ satisfy equation (15) in every period t.

2. Nash bargaining: Given $(\theta_t)_{t=t_0,\dots,t_1}$, $(\kappa_t)_{t=t_0,\dots,t_1}$ and the sequence of value functions $(U_t^y$, $U_t^o(\tau), W_t^y(z, \tau), W_t^o(z, \tau), J_t^y(z, \tau), J_t^o(z, \tau))_{t=t_0,\dots,t_1}$, the wage functions $w_t^y(z, \tau)$, $w_t^o(z, \tau)$ solve equations (12) and (13) in matches where $z \geq \overline{z}_t^i(\tau)$ and $i \in \{y, o\}$ in every period t.

3. Free entry: Given $\left(J_{t+1}^y(z_0, 0)\right)_{t=t_0,\dots,t_1}$, labour market tightness $(\theta_t)_{t=t_0,\dots,t_1}$ is the solution to equation (20) in every period t.

4. Balanced budget: Given the sequence of wage functions $(w_t^y(z, \tau), w_t^o(z, \tau))_{t=t_0,\dots,t_1}$ and the sequence of distribution of workers across states of nature $(\mu_t^y(\tau), \mu_t^o(\tau), \lambda_t^y(z, \tau), \lambda_t^o(z, \tau))_{t=t_0,\dots,t_1}$, $(\kappa_t)_{t=t_0,\dots,t_1}$ is the solution to equation (21) in every period t.

5. Law of motion: Given $(\theta_t)_{t=t_0,\dots,t_1}$ and the sequence decision rules $(\overline{z}_t^y(\tau), \overline{z}_t^o(\tau))_{t=t_0,\dots,t_1}$ for separation, the distribution $\mu_t^y(\tau)$, $\mu_t^o(\tau)$, $\lambda_t^y(z, \tau)$, $\lambda_t^o(z, \tau)$ evolves according to the law of motion described in Appendix A.1 from period t to $t+1$.

Whether a transition path can actually be computed is not clear from the above definition. We discuss this issue in the next subsection before turning to numerical applications.[14]

[14] Another issue is whether the steady-state equilibrium and the transition path are unique. Firstly we note that, in principle, there may exist multiple equilibria due to the fixed-point nature of a steady-state equilibrium with respect to tightness and the payroll tax. We are not interested *per se* in the high-tax/high-unemployment equilibria that can be triggered by the payroll tax. Therefore, in the computations, we always start by picking a low tax rate and we iterate until convergence of the balanced-budget equation. As for the transition path, we never encountered multiple solutions for any guess of the time path $(\kappa_t)_{t=t_0,\dots,t_1}$ used in the computations. This, of course, does not rule out the existence of multiple transition paths.

3.3 The Transition Dynamics

The transition dynamics depend crucially on the time path of the aggregate quantities of the economy, namely $(\theta_t)_{t=t_0,\dots,t_1}$ and $(\kappa_t)_{t=t_0,\dots,t_1}$. On the one hand, θ_t is a forward-looking variable as per equation (20). Thus, we can proceed backwards from period t_1 in order to construct the sequence $(\theta_t)_{t=t_0,\dots,t_1}$. On the other hand, the tax rate κ_t is partly a backward-looking variable through the cross-sectional distribution of the economy, and partly a forward-looking variable through wages negotiated in period t. Computing a transition path therefore requires knowledge of the entire sequence $(\kappa_t)_{t=t_0,\dots,t_1}$.

In practice, we construct the sequence $(\kappa_t)_{t=t_0,\dots,t_1}$ iteratively. The two propositions below proceed under the assumption that we have such a sequence $(\kappa_t)_{t=t_0,\dots,t_1}$ at hand:

Proposition 1. *(Feasibility of a transition path) Suppose that the economy reaches a steady-state equilibrium at a finite date t_1. Then computing a transition path starting from the allocation in period t_0 is feasible.*

Proof. See Appendix A.3. The insight is that for any expected duration of a spell of joblessness, Δ, we have a closed-form solution to calculate $U^y_{t_1}(\Delta,\tau)$. This enables us to construct $U^y_t(\Delta,\tau)$ for all $t \leq t_1$ and all Δ. Finally, computing the value of young employed workers, $W^y_t(z,\tau)$, requires knowledge of Δ_t, the expected duration of a jobless spell if they were to become unemployed in period t, and Δ_{t+1}. We use $(\theta_t)_{t=t_0,\dots,t_1}$ to construct the sequence $(\Delta_t)_{t=t_0,\dots,t_1}$. □

We now discuss the type of transition path that is of interest for our study. We focus on the path of an EPL reform that resembles real-life EPL reforms, such as the latest EPL reform in the Spanish labour market that took place in February 2012 (see Subsection 6.1). A key feature of such reforms is that they are *partially non-retroactive*: workers employed before the reform cannot be exempted retroactively from their accrued-to-date rights. In practice, existing worker-firm matches accumulate entitlements to severance payments at a rate prescribed by the new policy scheme from the date of the reform onwards, and any previous entitlements accumulated during the tenure prior to the reform are retained.

Formally, we are interested in a reform that introduces a new severance package function, $\phi_1(\tau)$, in period t_0. Until date t_0, the economy is at a steady state and the severance payment under the EPL program that prevails is denoted as $\phi_0(\tau)$. The specificity of the transition path of an EPL reform is twofold: it involves the co-existence of worker-firm matches that started either during the $\phi_0(\tau)$ or the $\phi_1(\tau)$ regime, and $\phi_0(\tau)$ differs from the *actual* severance payment in existing worker-firm matches under a partially non-retroactive reform.

Proposition 2. *(Feasibility of an EPL reform) A transition path towards the equilibrium obtained under $\phi_1(\tau)$ is computationally feasible. If the reform is partially non-retroactive, then in any period $t \geq t_0$ worker-firm matches that have existed at t_0 are subjected to:*

$$\phi_t(\tau) = \phi_0(\tau - (t - t_0)) + \phi_1(\tau) - \phi_1(\tau - (t - t_0)). \tag{22}$$

Proof. The co-existence of two types of employment relationships adds a binary state variable to the model, so as to distinguish between existing and newly-formed matches. Next, under a partially non-retroactive reform, we draw on the observation that τ and t are sufficient statistics for pre- and post-reform tenure. That is, a worker whose tenure at time t is τ had $\tau - (t - t_0)$ periods of tenure when the reform was implemented, and $(t - t_0)$ of post-reform tenure. Then, $\phi_0 (\tau - (t - t_0))$ is the severance pay retained from the pre-reform period. The post-reform scheme entitles the worker to receive $\phi_1 (\tau)$ minus payments that have not been accumulated under that scheme, which amount to $\phi_1 (\tau - (t - t_0))$. □

In the sequel, the partially non-retroactive reform is our baseline scenario. In addition, we will also study the path of an alternative EPL reform, denoted as a *statu-quo* reform in Subsection 6.2, where only new workers are subject to the unified EPL rules.[15] In all our applications, we will impose a cap T on tenure τ (see "Preliminaries" in Section 4). This implies that the pre-reform tenure for workers who have reached T cannot be recovered. However, this does not jeopardise the result of Proposition 2 since the severance pay $\phi_0 (\tau)$ is also capped in our application, and the cap is maintained after the reform.

4 Equilibrium in the Benchmark Economy

In this section, we present the calibration of our benchmark economy and we describe the steady-state equilibrium. We select parameter values to reproduce a set of informative data moments for Spain in the years before the Great Recession. The Spanish Labour Force Survey and the European Labour Force Survey serve as our main data sources to calibrate the model and evaluate its fit for untargeted moments.

Preliminaries

We need a number of preliminary specifications in order to list the parameters of the model. Firstly, we parametrise the Markov process for match-specific idiosyncratic productivity as follows. We assume that z can take on values in the interval $[0, 1]$. Each period, z switches to a new value z' which is drawn from a Normal distribution with mean z and standard deviation $\sigma_{\overline{z}}$, truncated and normalised to integrate to one over the support of productivity.[16] Next, as indicated in Subsection 2.1, we assume that matches are also subject to an exogenous separation shock. We denote by δ the per-period probability that this shock is realised. Finally, we impose a cap on job tenure denoted by T.

Under these specifications, the model has 14 parameters, namely $\{r, \eta, \gamma, \chi, T, \psi, \beta, A, k, b^y, b^o, \delta, z_0, \sigma_{\overline{z}}\}$. The first seven parameters are set outside the model while the remaining seven are calibrated internally to match a set of data moments. Throughout the analysis, we interpret the model period as one quarter.

[15] Another type of EPL reform that could be studied using our model is a "pure" retroactive reform, where the new severance package function, $\phi_1 (\tau)$ replaces the previous scheme in existing jobs $\phi_0 (\tau)$ irrespective of any accrued-to-date rights. However, such a scenario appears unrealistic, and is actually prevented by the Spanish constitution.

[16] Though this suggests that the resulting productivity process is a random walk, it must be noted that the truncation makes the innovation term different from a Normal white-noise process. We experimented with many stochastic processes for z, including less persistent ones. Since other specifications did not substantially alter the model's workings, we have chosen to revert to a process parametrised only by $\sigma_{\overline{z}}$.

Table 1. Parameter values (one model period is one quarter)

Description	Parameter	Value	Moment	Target	Model
Calibrated externally					
Interest rate	r	0.01			
Risk aversion	η	2			
Ageing probability	γ	1/120			
Retirement probability	χ	1/40			
Cap on tenure	T	120			
Matching function	ψ	0.5			
Bargaining power	β	0.5			
Calibrated internally					
Matching function	A	0.4000	Job-finding prob. (%)	40.0	40.0
Vacancy cost	k	0.2201	Tightness (norm.)	1.00	1.00
Unemployment income	b^y	0.2203	Replacement rate (%)	58.0	58.0
Unemployment income	b^o	0.1617	Replacement rate (%)	45.0	45.4
Exogenous separation	δ	0.0050	Fraction of quits (%)	17.0	17.1
Initial productivity	z_0	0.2800	Job destr. ($\leq$2 years, %)	7.5	7.6
S.d. of productivity draws	$\sigma_{\overline{z}}$	0.0440	Job destr. (>2 years, %)	2.1	2.3

Parameters Set Externally

The first seven rows of Table 1 report parameter values set outside the model. The interest rate is set at $r = 0.01$ to yield an annual interest rate of 4 percent. The coefficient of relative risk aversion is $\eta = 2$, which is a common value in the literature. The demographic probabilities are set at $\gamma = 1/120$ and $\chi = 1/40$ to match the expected durations of the first ("young") and second ("old") phase of a worker's life cycle. This choice is motivated by our interpretation of young workers as those aged 25–54, and older workers as those aged 55–64. Moreover, it is consistent with the observation that workers aged 55–64 account for about 25 percent of the working-age population in Spain. We set the cap on job tenure T equal to 120 model periods, i.e., 30 years. Finally, as is conventional in the literature (see Petrongolo and Pissarides (2001)), we set the elasticity of the vacancy-filling probability with respect to tightness ψ and the bargaining power of workers β equal to 0.5.

Calibrated Parameters

The last seven rows in Table 1 show the parameters set within the model. We follow standard practices and use the free-entry condition to pin down the vacancy-posting cost k after normalizing labour market tightness θ to unity. For the remaining six parameters, we aim at matching the following six moment conditions: (1) the quarterly job-finding rate is 40 percent (García Pérez and Osuna (2014)); (2) the quarterly job destruction rate for short-term tenured (temporary) jobs is 7.5 percent (García Pérez and Osuna (2014)); (3) the quarterly job destruction rate for open-ended (permanent) jobs is 2.1 percent (García Pérez and Osuna (2014)); (4) the replacement rate of unemployment benefits for young workers, defined as the ratio between the benefit payment b^y and the average wage $\widetilde{w}^y$, is 58 percent;[17] (5) the replacement rate of unemployment benefits for older workers $b^o/\widetilde{w}^o$ is 45 percent;[18] (6) the quit rate among all separations is 17 percent (Rebollo-Sanz (2012)). Our motivation for using information on quits is as follows. In the data, we cannot observe the number of job separations that could be deterred by enforcing tougher employment protection. We interpret quits as putting an upper bound to this number. In the model, the parameter that embodies this role is δ, the probability of an exogenous separation. Thus, we use condition (6) to pin down a value for δ.[19]

The Severance Pay Function

The crux of our analysis relates to the severance pay function. We follow Bentolila et al. (2012c) and García Pérez and Osuna (2012) in specifying a function of job tenure that stands similar to the discontinuous EPL scheme ruling in Spain prior to the onset of the Great Recession.[20] As the latter authors do, we parametrise severance pay as a function of tenure and the average annual wage in the labour market, rather than as a function of wage-tenure and/or productivity-tenure profiles. Notice that the average wage is an equilibrium outcome of the model, not a pre-specified parameter. To compute a steady-state equilibrium, we add an outside loop to iterate over the average wage used to specify the severance pay function (cf. Appendix A.2).

We use the following pieces of information to compute $\phi(\tau)$. We identify the first two years of employment with fixed-term contracts prevailing in the Spanish labour market. During the chosen calibration period, these contracts featured termination costs of 8 d.w.y.s., representing 2.2 percent ($= 8/365$) of the average yearly wage. If the worker is not dismissed before the end of this two-year period, we identify the subsequent periods of employment as those regulated by open-ended contracts. Workers on these more permanent contracts were entitled to 45 d.w.y.s., with a cap of 3.5 annual wages, under an unfair dismissal which represent most of the dismissals during the calibration period.[21] For instance, a worker who has been employed at the same firm for more than two years and loses her/his job at the end of the third year would be entitled to 37 percent ($= 3 \times 45/365$) of the yearly wage.

[17]Estimates for the average net replacement rate across different family types and earnings levels range from an initial value of 67 percent after layoff to 49 percent over 60 months of unemployment (OECD (2004)). We pick an intermediate value of 58 percent and perform a sensitivity analysis in Section 6.3.

[18]We make the assumption that older workers can draw on regular unemployment benefits for 2 years (at a 67-percent replacement rate), and then fall back on less generous social assistance (at a 40-percent replacement rate). At an expected duration of 10 years, this yields a weighted average of $2 \cdot 0.67 + 8 \cdot 0.40 = 0.454$.

[19]Following an exogenous separation, we assume that the firm pays the severance package to which the worker is entitled. That is, we do not interpret the δ shock as a quit decision – it is not a decision. We use δ to discipline the elasticity of the job destruction rate to changes in the employment protection scheme. In sensitivity checks (Subsection 6.3), we re-run our experiments under the assumption that severance payments are waived in the event of an exogenous separation.

[20]There was a reform in February 2012 when severance pay for unfair dismissals of permanent workers went down from 45 to 33 d.w.y.s. while termination costs to temporary workers went up from 8 to 12 d.w.y.s. (see Subsection 6.1). We use the pre-reform EPL scheme since our calibration targets are based on pre-2012 data.

[21]We assume that firms pay unfair dismissal costs of 45 d.w.y.s., even though severance for fair (economic) reasons was lower, i.e., 20 d.w.y.s. (with a maximum of 24 months). We do so because, even during the Great Recession, two thirds of all dismissals have been unfair since firms avoided appeals to court by workers by paying the maximum rate, under the so-called "express dismissal" rule (see Bentolila et al. (2012c)).

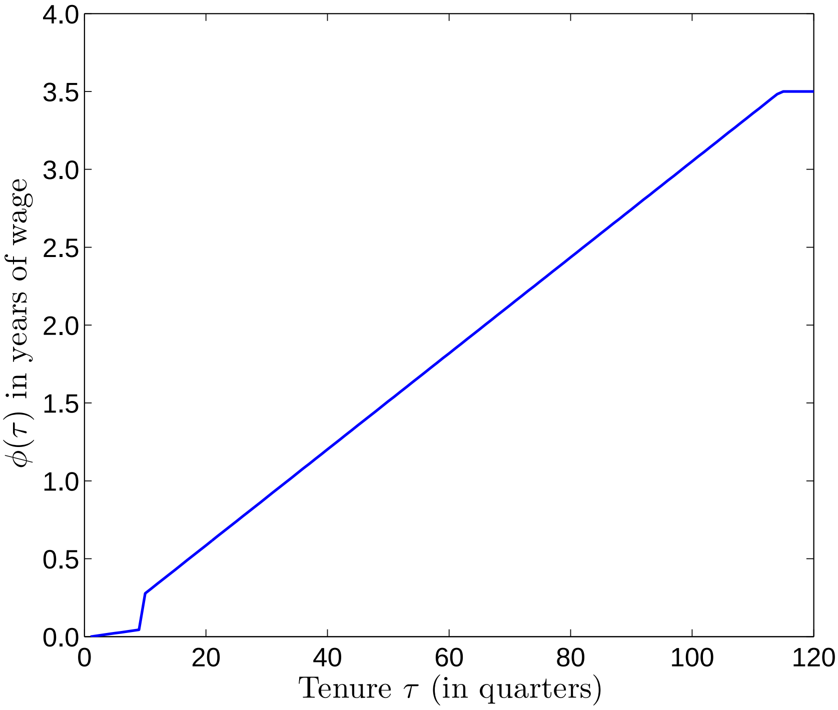

Figure 1. Severance payments in the benchmark economy

Thus, severance payments for a worker with tenure τ are specified as follows:

$$\phi(\tau) = \begin{cases} (8/365) \times \widetilde{w} \times \tau, & 1 \leq \tau \leq 8 \\ (45/365) \times \widetilde{w} \times \tau, & 9 \leq \tau \leq 113 \\ (45/365) \times \widetilde{w} \times 113, & \tau > 113. \end{cases} \tag{23}$$

Figure 1 depicts this function with job tenure (in quarters) on the horizontal axis and a multiple of the average annual wage on the vertical axis.

Model Fit

Table 1 summarises the set of parameter values in our benchmark economy. As can be observed in the last two columns, the model is able to match the list of calibration targets almost exactly. We also assess the fit of the model using a set of statistics which have not been used as targets. Table 2 presents a comparison between moments generated by our benchmark model and their data counterparts. Our focus is on the distribution of workers across employment and non-employment, as well as across tenures. It is important to note that our calibration targets for short- and long-term job destruction rates do not uniquely pin down the share of non-employed workers and the distribution of employed workers across different tenures.

As shown in Table 2, the model does well in fitting the data. The unemployment rate among young workers in our benchmark economy is 9.7 percent, while the corresponding value in the data is 9.0 percent. Across the population of older workers, the model generates a non-employment rate of 36.3 percent. This value is lower than the empirical fraction of non-employed male workers between 55 and 64 years, which is 43.1 percent. However, since our model abstracts from disabilities, health shocks and other reasons for non-employment, we interpret this gap as plausible. The aggregate non-employment rate among all workers in our benchmark economy is 16.3 percent against 16.5 percent in the data. In terms of the tenure distribution, the fit is satisfactory as well. The model slightly overpredicts the share of workers with more than 10 years of tenure, and the share of workers with less than 1 year of tenure is marginally lower than in the data. On the other hand, 45.6 percent of employed workers in the model have between 1 and 10 years of tenure, which happens to match the data value exactly.

Table 2. Model fit

Description	Data	Model
Unemployment rate, young	9.0	9.7
Nonemployment rate, old	43.1	36.3
Nonemployment rate, all	16.5	16.5
Distribution of tenure (τ)		
$\tau \leq 2$ quarters	8.7	6.8
2 quarters $< \tau \leq 4$ quarters	8.8	5.7
1 year $< \tau \leq 3$ years	15.9	15.9
3 years $< \tau \leq 5$ years	13.2	10.9
5 years $< \tau \leq 10$ years	16.5	18.8
$\tau > 10$ years	36.9	41.9

Separation Decisions

To give additional insights into the mechanics of the benchmark economy, let us describe the interaction between the productivity process and decision rules for job separation, and the aggregation across young and older workers. As just explained, this gives rise to a good fit between the model and the tenure profile of the job destruction rate observed in Spanish data.

Figure 2 displays the productivity cutoffs to dismiss young and older workers, resp. $\overline{z}^y(\tau)$ and $\overline{z}^o(\tau)$, as a function of job tenure. Several features are worth highlighting. First, newly-formed matches for young workers in our calibration start at the productivity level $z_0 = 0.28$, which is not far from the separation threshold $\overline{z}^y(1) = 0.22$. As a result, a large fraction of matches facing an adverse productivity draw over the first quarters of tenure are dissolved endogenously. This feature of the model makes new jobs relatively fragile and rationalises high job destruction rates at short tenures. On the other hand, matches that experience a positive productivity draw move towards the upper region of the productivity domain and thus become less susceptible to being destroyed. These "career jobs" are bound to become stable employment relationships and they are characterised by a substantially lower job destruction rate at longer tenures.

Second, there are noticeable spikes in the job destruction region at $\tau = 8$. These reflect the discontinuous jump in the severance pay function after two years of tenure (cf. Figure 1). Since workers and firms differ with respect to preferences, future severance payments are only partially internalised through lower wages (see Footnote 12). This implies that relatively unproductive matches get dissolved before the worker becomes entitled to more generous severance pay. Third, we note that productivity cutoffs are generally lower for older workers because they face a shorter

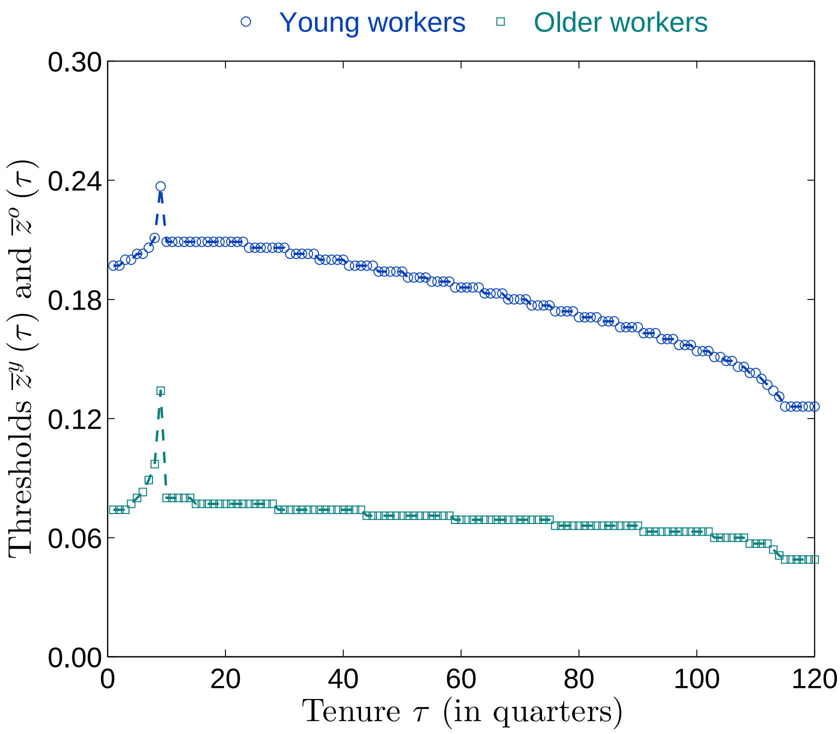

Figure 2. Job destruction thresholds conditional on job tenure τ

time horizon and they do not have the option value of searching for a new job. Only worker-firm units operating at very low productivity levels find it beneficial to terminate the match and let the older worker separate to nonemployment. Finally, the productivity thresholds are also slowly decreasing with tenure as firms find it more costly to fire a worker and pay the severance package.

5 The Experiments

This section contains the results of the main numerical experiments of the paper. We use our calibrated model as a laboratory to design an optimal, unified EPL scheme for the Spanish labour market. We then discuss the general equilibrium consequences of this EPL scheme on allocations and welfare.

5.1 Designing an Optimal, Unified EPL Scheme

We consider a relatively simple class of severance payment functions to define a unified EPL scheme, namely a subset of piecewise-linear functions. We specify severance payments as:

$$\phi(\tau) = \max\left\{\alpha_s + \rho_s \times \tau \; ; \; 0\right\}, \tag{24}$$

where $\alpha_s \in \mathbb{R}$ is a parameter, and $\rho_s \geq 0$ measures the rate of return to each year of tenure (in d.w.y.s.), conditional on eligibility. We explicitly allow the intercept α_s to be negative. In that case, $\tau_s \equiv -\alpha_s/\rho_s$ is the point where severance payments are activated; that is, the minimum service tenure required for eligibility. If α_s is non-negative, then $\tau_s = 0$, and newly-matched workers become entitled to severance payments immediately. Note that specification (24) also encompasses the possibility of a *laissez-faire* scheme ($\alpha_s = \rho_s = 0$) without government-mandated employment protection.

There are three main principles guiding the design of a simple EPL scheme as in equation (24). First and foremost, in spite of its parsimonious parametrisation, it can be readily compared to actual policy schemes.[22] Second, while our model rationalises implementing a smooth EPL scheme, it does not provide arguments for having a function with many kinks and different slopes across tenure levels. Third, with only two parameters, we reduce the likelihood of having local maxima for the optimality criterion presented in the next paragraph. As reported below, our objective function is concave in α_s and ρ_s, which facilitates our search of a global maximum. Finally, it is worth noting that we have experimented with various non-linear specifications. In Appendix B.5, we show that more flexible non-linear schemes lie close to the unified EPL scheme delivered by our optimality criterion. We have also experimented with a cap on severance payments and never found it to be desirable.

The Optimality Criterion

Within the class of unified EPL schemes considered, we focus on a so-called *optimal* unified EPL scheme. Our optimality criterion draws on steady-state comparisons: we define the optimal EPL scheme as the parameter combination $\{\alpha_s, \rho_s\}$ that maximises the steady-state lifetime utility of new labour-market entrants, U^y.[23] In practice, we implement a unified EPL scheme for different combinations of α_s and ρ_s, we compute the corresponding new steady-state equilibrium, and we store the equilibrium value for U^y. We show in Figure B1 in the appendix that the optimality criterion U^y is concave in α_s and ρ_s (this property also holds in all our robustness checks; the corresponding charts are displayed in the online appendix). As a result, the optimal EPL scheme is unique within the class of severance pay functions considered. Moreover, we find that a positive intercept α_s deteriorates welfare. For this reason, in the sequel we focus on the effects of the minimum service tenure τ_s (negative α_s), combined with the effects of ρ_s.

Using our optimality criterion, we find that the welfare-maximising, unified EPL is characterised by an eligibility period of 5 months and a slope of 20 d.w.y.s. from that tenure onwards. Figure B2 in the appendix displays this scheme in comparison to the benchmark EPL scheme. Interestingly, the slope of the optimal EPL scheme lies in between the two slopes under the discontinuous EPL rules in Spain and corresponds to the current slope for economic dismissals. The combination of a short entry phase and a slope that is much lower than the benchmark EPL scheme suggests the existence of a trade-off between promoting job creation and enhancing job stability. Intuitively, the optimal EPL scheme provides some minimum level of insurance by fostering job stability even at short tenure, and then the generosity of severance pay is bounded

[22] See, for instance, Section 1 in Boeri et al. (2017). Figure 1 in the appendix of that paper shows that a piecewise-linear function of tenure is an accurate description of the government-mandated severance payments implemented in most countries.

[23] It is possible to define an optimality criterion that would include the transition dynamics studied in Subsection 5.2, but such a criterion would have numerous drawbacks. First, by construction, it would depend on the distribution of workers at the time when the reform is implemented. Second, as shown in Section 6, the transition path is difficult to predict and, as a result, it is likely that this optimality criterion is not well-behaved in α_s and ρ_s. Third, the computational burden makes it impractical to run a grid search on α_s and ρ_s to maximise a criterion that includes the transition path.

from above to avoid deterring job creation. We confirm this intuition in the next paragraphs.

Results and Discussion

To understand the allocational and welfare consequences of introducing the unified EPL scheme, we start out by gauging its long-run effects. Table 3 presents a steady-state comparison for certain labour market outcomes and welfare between the benchmark and the economy with the optimal EPL scheme. A result to highlight is that, as shown in the last row of Table 3, a newborn worker in that economy would enjoy a welfare gain of 1.52 percent, measured in consumption equivalent units. As will be argued below, this welfare gain is due to a combination of partial and general equilibrium effects that give rise to a substantial reduction in the volatility of income.

Table 3. Benchmark vs. optimal EPL scheme: Steady-state comparison

Description	Baseline	Optimal EPL
Unemployment rate, young (%)	9.70	8.96
Non-employment rate, old (%)	36.3	35.2
Non-employment rate, all (%)	16.3	15.5
Average wage, young	0.38	0.39
Average wage, old	0.36	0.31
Average productivity, young	0.47	0.47
Average productivity, old	0.53	0.52
Job destruction rate, less than 2 years of tenure (%)	7.64	6.49
Job destruction rate, more than 2 years of tenure (%)	2.30	2.44
Job finding rate (%)	40.0	41.8
Labour market tightness θ	1.00	1.09
Payroll tax κ (%)	9.76	9.09
Welfare of a newborn worker (%, relative to baseline)	–	1.52

Table 3 shows that the unified EPL scheme promotes job creation, as indicated by the increase in labour market tightness. As a consequence, young workers face a lower expected duration of unemployment. The optimal EPL scheme, moreover, reduces the job destruction rate for short-tenured jobs below 2 years from 7.6 to 6.5 percent per quarter, while the job destruction rate for matches with longer tenure increases slightly from 2.2 to 2.4 percent. In particular, as shown in Figure 3, the visible spike in the job destruction rate at 8 quarters of job tenure disappears under unified EPL, leading to a much smoother profile. Overall, these effects translate into a reduction in the unemployment rate from 9.7 to 9.0 percent. As the non-employment rate for older workers also decreases by roughly one percentage point from 36.3 to 35.2 percent, the net effect on employment across the whole population is positive (16.3 vs. 15.5 percent). In our view, this effect is plausibly small.

To provide further insights into the welfare effects of the optimal EPL, we run a sequence of experiments that aim at disentangling the role of four components. First, we adjust the benchmark severance pay function so as to remove the "wall" effect: keeping tightness and tax constant, we shift the schedule downwards in the second segment to eliminate the discontinuity after two years (cf. Figure 1). Second, we adjust the slope by rotating the function on both

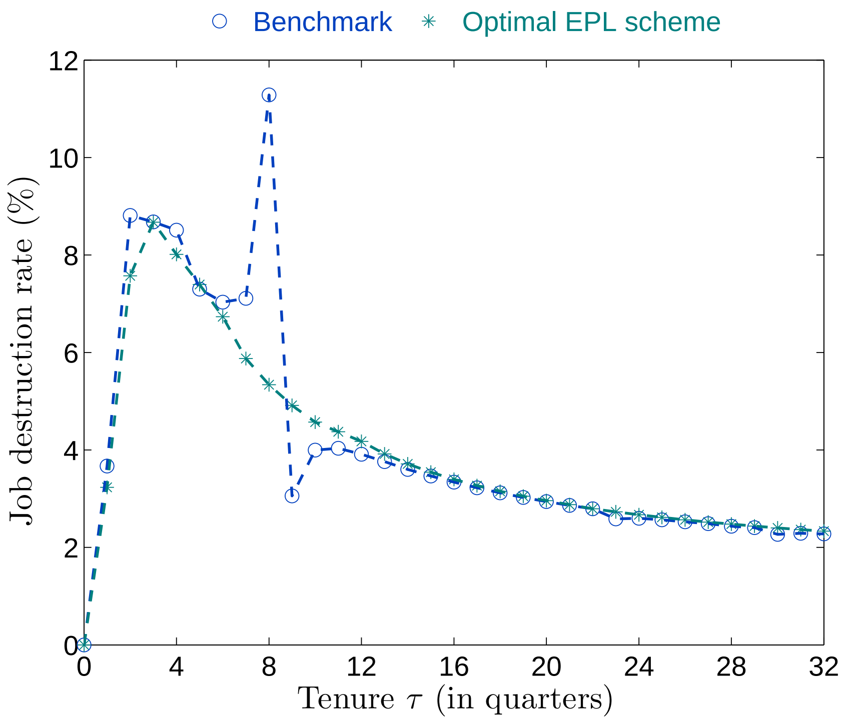

Figure 3. Job destruction rate conditional on job tenure τ

segments to yield the actual optimal EPL scheme (again, keeping tightness and tax constant). These adjustments imply a smoother wage-tenure profile with higher entry wages as the dip in wages implied by future severance pay becomes smaller. As a third step, we raise labour market tightness to its equilibrium level under the optimal EPL scheme, keeping the tax constant. Finally, we let the payroll tax adjust as well. We interpret the first two adjustments as governing partial equilibrium effects, while the latter two account for general equilibrium adjustments in prices.[24]

Total effect	Remove wall	Adjust slope	Tightness θ	Payroll tax κ
1.522	0.366	0.316	0.404	0.436
	(24.1)	(20.7)	(26.6)	(28.6)

The figures above presents our results. The total welfare gain of 1.52 percent is again reported in the first column. The remaining columns provide the welfare change associated with each counterfactual (the bracketed figures give the relative contribution of each counterfactual). As can be seen, general equilibrium effects jointly account for more than half (55.2 percent) of the overall welfare gain. The largest contribution stems from the reduction in the payroll tax (28.6 percent), followed by higher job-finding rates due to a tighter labour market (26.6 percent). The elimination of the discontinuity in the severance pay schedule after 2 years yields considerable further welfare gains (24.1 percent), while decreasing the gradient accounts for the remaining 20.7 percent.

[24]The equilibrium and welfare effects obtained in this numerical exercise are not independent of the order in which these adjustments are implemented. In practice, we find that the results are quantitatively similar when we change the order of these four adjustments.

5.2 From Dual to Unified Employment Protection

In this section we present our second set of findings, building and expanding on the previous results. Our model provides a framework for analysing a policy reform that introduces a unified EPL scheme in a dual labour market. As pointed out in Subsection 3.3, our main focus is on a partially non-retroactive EPL reform. In the sequel, we analyse the dynamics of the labour market during the transition to a new steady state, as well as the welfare implications for workers who are in the labour market when the reform is implemented.

Transition Path

Figure 5 shows the time path of several labour market variables during the transition from the baseline EPL scheme to the unified EPL scheme. As the figure reveals, most of the transitional dynamics take place during the first year of the reform. This outcome is shaped by the fact that a partially non-retroactive reform affects not only new jobs, but also existing worker-firm matches. The upper panels show the time path of the general equilibrium variables, tightness θ_t and the payroll tax κ_t. Labour market tightness acts like a jump variable: it overshoots slightly on impact and then converges quickly to its new steady-state level. The gradual decrease in taxes, on the other hand, is explained by a more sluggish decline in non-employment after the reform. Unemployment among young workers mirrors the behaviour of tightness: the job-finding rate soars as firms create more vacancies associated with the unified EPL scheme, which lowers unemployment. The decline in non-employment among older workers is more gradual since it is only driven by inflows from employment and outflows into retirement.

To summarise, implementing a unified EPL scheme through a partially non-retroactive reform leads to very fast transitional dynamics where most labour market variables converge to their new steady-state values within just a few quarters.

Welfare Implications

We now turn to the implications of the unified EPL scheme for workers who are in the labour market when the reform is introduced. Table 4 summarises the distribution of welfare effects (Panel A) and income changes (Panel B) across the population of these workers.[25] As indicated in the last row of Panel A, the average welfare gain amounts to 0.85 percent (again, in consumption equivalents), which is about one half of the 1.52-percent welfare gain obtained by new labour-market entrants in the steady-state comparison. This discrepancy is not surprising because most workers would value the unified EPL scheme less than a new labour-market entrant does. In effect, we find a stark contrast in the welfare changes experienced by young and older workers: while there is an average welfare gain of 1.2 percent among young workers, older workers suffer a welfare loss of -0.78 percent. The distributional analysis further shows that young workers unambiguously gain from the reform, whereas only a minority of older workers would be in favour of the reform. Two thirds of the latter actually experience a negative welfare effect and

[25] We exclude one group of workers to perform these calculations, namely older workers who are in nonemployment at date t_0. Since they never return to employment before leaving the economy, older non-employed workers are not impacted by the policy changes under study.

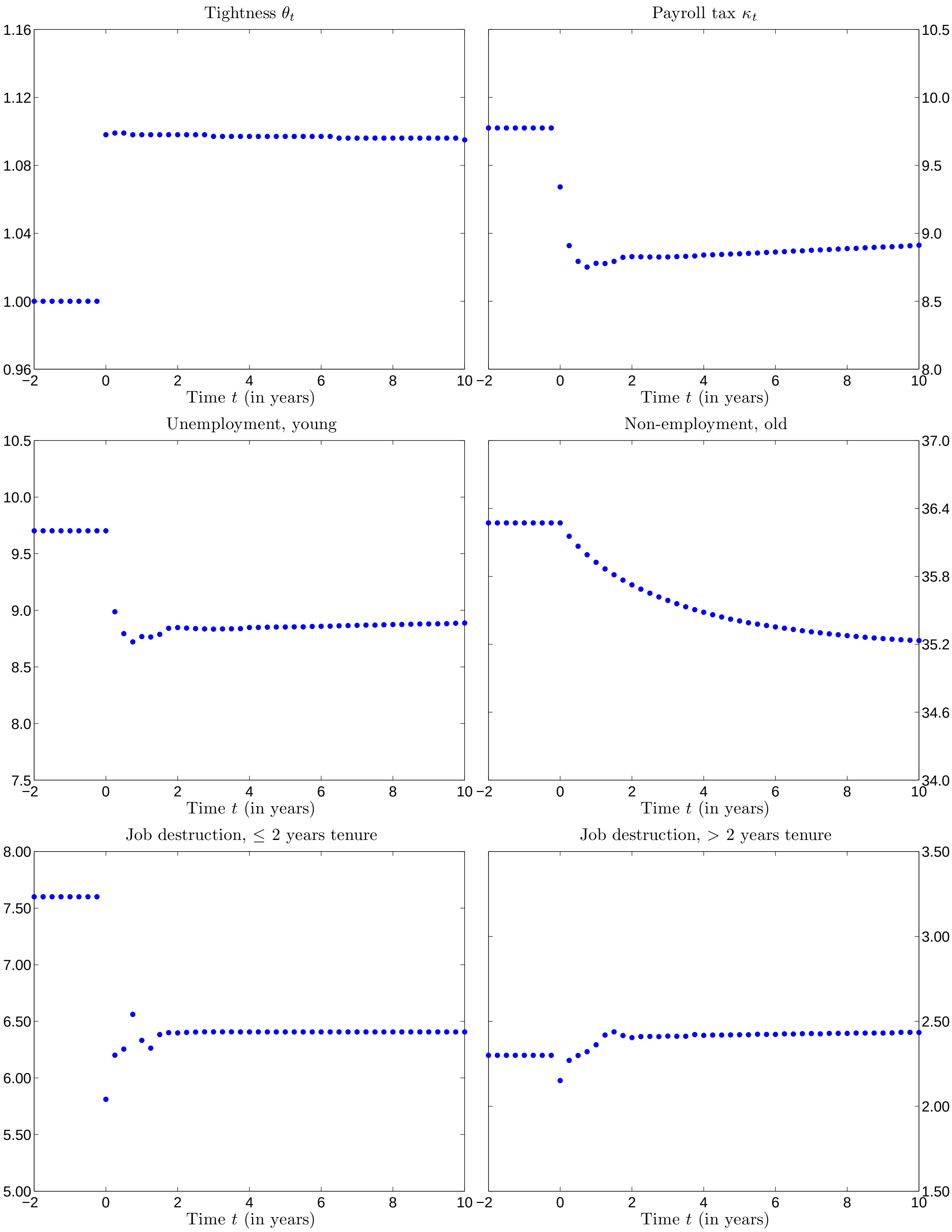

Figure 4. Transition dynamics towards the unified EPL scheme

NOTE: The charts display the time path of several labour market variables during the transition towards the unified EPL scheme under a partially non-retroactive reform. Except for labour market tightness θ, the figures on the vertical axis are expressed in percent. On the horizontal axis, time is measured in years relative to the introduction of the unified EPL scheme, which occurs in period 0.

Table 4. Income and welfare effects of the unified EPL scheme

	Average	Average in each quintile				
		1st	2nd	3rd	4th	5th
A. Welfare						
Young workers	1.195	0.619	1.010	1.126	1.347	1.676
Older workers	-0.782	-2.096	-1.392	-0.834	0.003	0.407
All	0.849	-0.673	0.769	1.126	1.347	1.676
B. Income		Young workers				
Mean	-0.541	-13.70	-2.690	0.494	2.522	10.66
Std. deviation	-2.209	-43.43	-22.12	-7.629	3.073	59.36
		Older worker				
Mean	0.913	-7.256	-0.456	0.027	1.379	10.87
Std. deviation	18.00	-49.84	-13.05	-1.574	15.25	139.2

NOTE: Panel A reports the percentage change in lifetime utility (measured in consumption equivalent units) of workers following the EPL reform. Panel B reports the percentage change of the lifetime value of income, and of the transitory component of income following the EPL reform. The first column reports the average change across the distribution, while the other columns report the average change within each quintile of the distribution of the variable under study.

the average loss suffered by the bottom quintile is -2.1 percent. Overall, our results indicate strong, but not universal, political support for the reform.

To gain a better understanding of the sources of these welfare effects, we use our framework to analyse the impact of the reform on individuals' trajectories. In particular, we are interested in the change in the level and volatility of their income (hence consumption). To this end, we create a large artificial panel of workers who are in the labour market at the time of the reform. For each worker, we simulate her individual income trajectory after the reform, given a randomly-drawn sequence of idiosyncratic shocks, until she leaves the economy. We also trace out her individual income history had the reform not been put in place.[26] Based on these simulated sequences, we compute two statistics for each individual: (i) the net present value of lifetime income; and (ii) the standard deviation of the income path as a measure of volatility.

Panel B in Table 4 presents our results. Strikingly, we find that young workers actually experience a decrease in the net present value of lifetime income of 0.5 percent on average, and that they benefit from a reduction by 2.2 percent in the standard deviation of income over their lifetime. The lower value of income on average stems mostly from the weaker outside option of workers under the unified EPL scheme. The lower volatility of the income paths, on the other hand, comes from eliminating the "revolving door" effect (cf. Figure 3): this makes young workers transit less frequently through unemployment, and it also removes a dip in the wage function caused by the EPL "wall" at 8 quarters of job tenure. These effects outweigh the slight

[26]We use the same sequence of random numbers to simulate the two income trajectories of a given individual. So, any difference between the two trajectories is driven only by changes in wages and transition rates (which come from changes in the EPL scheme), and not by different random draws. Of course, we use different sequences of randomly-drawn numbers for different individuals.

reduction in the net present value of lifetime income.

For older workers, the main effect of the EPL reform is to increase the variability of their income (on average by 18 percent), which makes many of them worse off. A closer look at the distribution of changes in the volatility of income reveals that it is right-skewed, implying that the 18 percent average reported in Table 4 is driven by a fraction of workers who experience a very large increase in the volatility of their income. Intuitively, in the benchmark economy, there are older workers who experience virtually no income volatility because their earnings remain constant once they become nonemployed. With the new unified EPL scheme, some of these workers remain employed for a longer period of time, and therefore the volatility of their income increases dramatically in relative terms.

In sum, young workers are able to compensate the short-run wage changes and higher job destruction risk after 2 years of tenure by the advantageous effects of unified EPL – shorter unemployment spells, lower taxes and a smoother wage-tenure profile – in the medium and long run. Older workers who face a much shorter time horizon until leaving the labour market are less likely to reap the benefits of the EPL reform. Thus, the positive role of unified EPL is strongly associated with a reduction in income volatility, and the extent to which workers are able to take advantage of this effect critically determines their welfare outcomes.

6 Further Analyses

We provide further results about the equilibrium and welfare effects of a unified EPL scheme in this section. We do so by studying two different EPL reforms, namely (i) the EPL reform that was implemented in Spain in 2012 and (ii) an alternative implementation of the unified EPL scheme which we dub the *statu-quo* reform. Finally, we also report the results from several robustness checks.

6.1 Comparison: The 2012 EPL Reform

In February 2012, Spain underwent an EPL reform (Decree Law 3/2012), whereby severance pay during the first two years of tenure was raised from 8 to 12 d.w.y.s. while severance pay for longer-tenured workers was lowered from 45 to 33 d.w.y.s. (with a cap of 24 months, lower than the previous cap of 42 months). Figure B3 in the appendix depicts the pre-2012 and post-2012 profiles of severance pay.

Using our benchmark economy as the starting point, we analyse the effects of replacing the pre-2012 EPL scheme with the post-2012 scheme. The results of the steady-state comparisons and transition dynamics are summarised in Tables B1 and B2 in the appendix. We find that the steady-state welfare gain under the 2012 reform is 1.02 percent, and that the welfare gain for workers who are in the labour market when the reform is implemented is 0.59 percent on average. Though substantial, these are about one-third lower than the welfare gains brought about by the optimal unified EPL scheme. Qualitatively, the 2012 reform does change labour market variables in ways similar to the unified EPL scheme: it lowers the separation rate at short tenure, increases it at longer tenures, and raises labour market tightness. From a quantitative standpoint, however, these changes are limited relative to those propelled by the unified EPL reform. In sum, the main reason for the lower welfare gains is that the 2012 reform reduced but did not fully eliminate the discontinuity in severance pay after two years.

6.2 Comparison: A *statu-quo* EPL Reform

We compare the transition dynamics of our main numerical experiment with those of an alternative reform, the *statu-quo* reform. In this alternative scenario, we assume that workers who are already employed at the time of reform remain employed under the terms of the old EPL scheme. To change to the unified EPL scheme, they therefore have to dissolve their current employment relationship first and search for a new job (thus, only young workers have the option of eventually being employed under the terms of unified EPL). Finally, unemployed workers who become matched to a firm at any date $t \geq t_0$ are subject to the new EPL scheme, as in the benchmark reform studied in Section 5.

Figure 5 contrasts the transition dynamics of a *statu-quo* reform (marked with green stars) with the benchmark partially non-retroactive reform (marked with blue circles reproduced from Figure 4). As can be observed, the transition is substantially slower after a *statu-quo* reform and there are some detrimental effects in the short run. Labour market tightness surges instantaneously but by less than under the benchmark reform. The payroll tax rate falls more slowly because of the initial increase in the unemployment rate of young workers. Indeed, many short-tenured employment relations are destroyed immediately to take advantage of the unified EPL scheme. This is also the case, albeit to a lesser extent, for low-productivity jobs held by workers with longer tenure. These effects explain the more sluggish decline in non-employment rates among both young and older workers.

Turning to the welfare impact of the reform, Table B3 in the appendix reports an average gain among workers who are in the labour market when the reform is implemented of 1.10 percent. This is higher than the 0.85 percent gain from the benchmark EPL reform, mainly because the latter is overtly adverse to older workers. Under a *statu-quo* reform, these workers do not experience any change in their severance package and they benefit from the decrease in the payroll tax. For younger workers, on the other hand, the average welfare effect is not too different from that under the partially non-retroactive reform (respectively at 1.29 and 1.20 percent). The main difference relates to the variance of the welfare changes across workers: there is very little dispersion since the *statu-quo* reform avoids the welfare losses at long tenure entailed by a partially non-retroactive reform. In our view, these results indicate that an appropriately designed transition can go a long way towards limiting the losses entailed by an EPL reform.

6.3 Robustness Checks

In this section, we report sensitivity exercises to analyse how the numerical results change with some key parameters of the model. In particular, we consider the following alternative scenarios: (i) the UI replacement rates for young workers is set at 50 percent and 65 percent respectively; (ii) there are red-tape costs such that 50% of the total severance package is lost; and (iii) exogenous

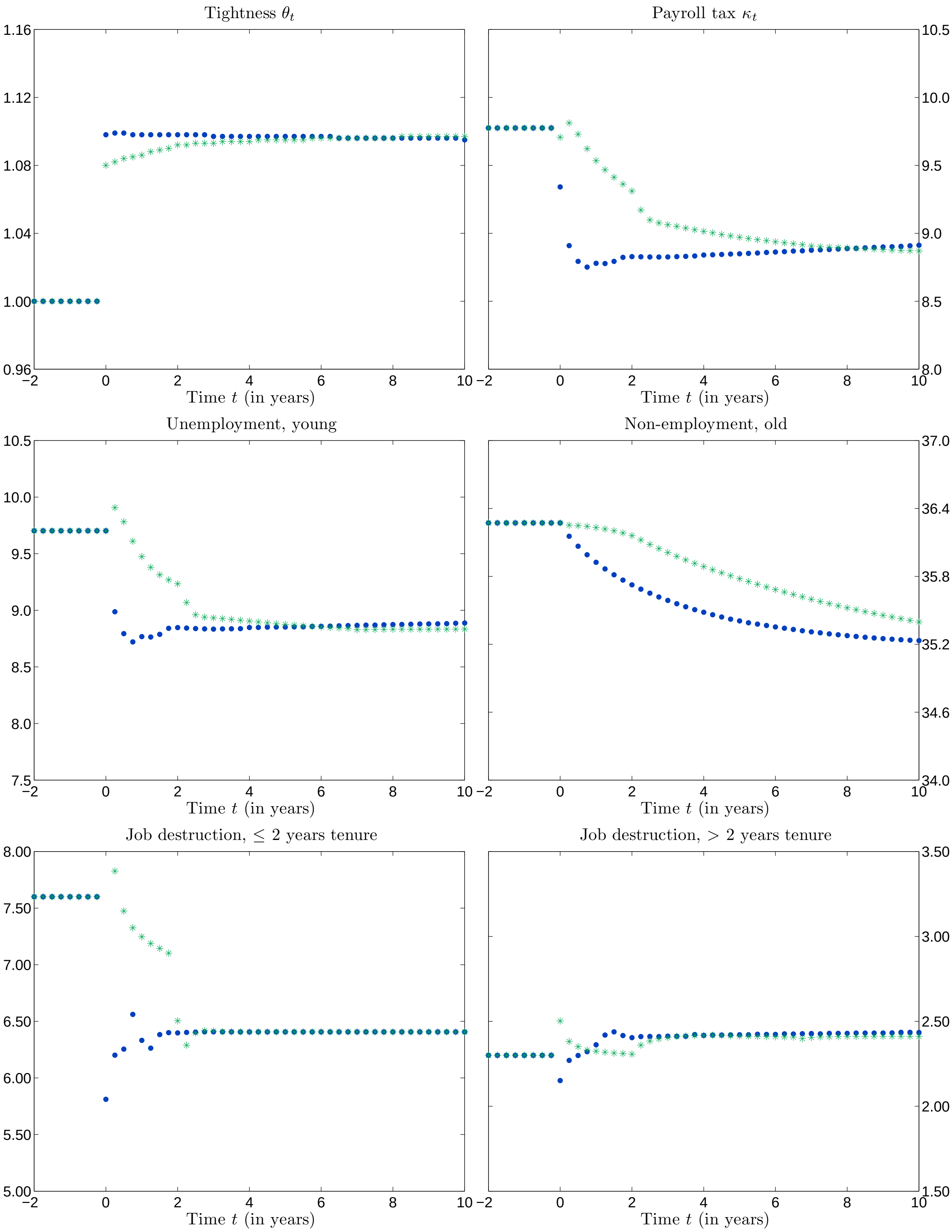

Figure 5. Transition dynamics: non-retroactive vs *statu-quo* reforms

NOTE: The charts display the time path of several labour market variables during the transition towards a unified EPL scheme. The green stars correspond to the *statu-quo* reform. The blue circles correspond to the partially non-retroactive reform. Except for labour market tightness θ, on the vertical axis the figures are expressed in percent. On the horizontal axis, time is measured in years relative to the introduction of the unified EPL scheme, which occurs in period 0.

separations (quits) do not entitle the worker to severance payments. In each scenario, the model is recalibrated to match the list of targets presented in Section 4 (see Appendix B.4 for details).

Table 5. Optimal EPL scheme and welfare effects under alternative calibrations

	Severance pay function		Welfare effect	
	τ_s (in months)	ρ_s (in d.w.y.s.)	Steady state	Transition path
	(1)	(2)	(3)	(4)
Benchmark	5	20	1.522	0.849
Lower UI benefits	2	17	1.825	1.007
Higher UI benefits	8	24	1.232	0.673
Red-tape costs	6	16	1.564	0.886
Quits vs. layoffs	12	28	0.637	0.276

NOTE: Each row displays the parameters of the optimal EPL (Columns 1 and 2), the welfare effect as measured by the steady-state lifetime utility of new labour-market entrants (Column 3) and the welfare effects on average across workers in the period when the reform is introduced (Column 4).

Table 5 provides an overview of our results (the details are available in the online appendix). The optimal EPL scheme is fairly robust to changes in the calibration. For example, in a calibrated model with lower UI benefits, the optimal EPL scheme has a shorter initial eligibility period (2 months instead of 5 months) and a flatter slope (17 d.w.y.s. rather than 20 d.w.y.s.). If UI benefits are calibrated to a higher level, newly-matched workers become eligible to severance pay only after 8 months, and the slope is slightly steeper (24 d.w.y.s.). Since the optimal EPL scheme strikes a balance between job creation and job destruction effects, these findings suggest that this balance is only mildly affected by the generosity of unemployment benefits.

In the presence of red-tape costs, the eligibility period increases to 6 months and the slope is reduced to 16 d.w.y.s. If we assume that exogenous separations (quits) do not entitle the workers to severance pay, the initial eligibility increases to 12 months, with a slope of 28 d.w.y.s. The intuition in both instances is that the effectiveness of severance pay as an insurance device for workers is more limited; for red-tape cost, this translates into a flatter slope, and for quits into a much longer eligibility period. Overall, we conclude that the precise shape of the optimal EPL scheme is relatively robust to changes in the calibration. As can be seen in the last two columns of Table 5, this also applies to the welfare effects, in steady state and during the transition.

7 Conclusions

This paper provides a computationally tractable approach for the design and implementation of a unified EPL scheme replacing the highly dual EPL systems that characterise segmented labour markets. We advance a model with risk-averse workers, who can convert their severance packages into annuities to increase consumption during their jobless spells, and whose bargaining relationship with firms is crucially affected by the increase in severance pay with job tenure. In this context, a unified EPL scheme allows workers to enjoy a smoother consumption path relative to a two-tier EPL system. An important feature of our analysis is that we can take account of the transition path between the two employment protection systems. This enables us to evaluate the consequences of a unified EPL scheme for workers who populate the initial, dual labour market when the reform is introduced. Our framework is thus well suited to draw quantitative inference and to provide figures that would inform real-life labour market policies. We use it to contribute to the debate on structural EPL reforms in southern Europe and France, which often lacks specific recommendations on the actual design of a unified EPL scheme, its welfare implications and political support.

We focus on the Spanish labour market to illustrate our approach. We firstly use our model to tabulate the parameters of a welfare-maximising, unified EPL scheme: we find that it is characterised by a minimum service for eligibility of 5 months and severance pay worth 20 days of wages per year of services. Then, we examine through various experiments the improvements propelled by a unified EPL scheme. An important theme in this respect is eliminating the so-called "revolving door" through which workers rotate between short periods of employment and unemployment. Finally, we analyse the transition from an equilibrium with dual EPL to another equilibrium with the unified EPL scheme. A realistic reform that adjusts entitlements accumulated after the reform while maintaining accrued-to-date rights for existing jobs yields a substantial welfare increase in the aggregate. The gains, meanwhile, are unequally distributed across workers: the reform improves welfare among young workers by more than 1 percent (in consumption equivalents), but deteriorates welfare among older workers by around three quarters of a percent on average, and by more than 2 percent for some of them. This heterogeneity might explain resistance to this kind of EPL reform.

The model presented in this paper can be extended to address a number of related issues. One potentially interesting question is how to limit the uncertainty associated with workers' appeal to labour courts in order to obtain higher redundancy pay for unfair dismissals. For example, exploring the possibility of having a fast-track compensation, as in the recent Jobs Act in Italy, and its implications could be a fruitful line of future analysis (see Sestito and Viviano (2015)). Another question worth pursuing is whether the current EPL scheme can be rationalised as maximising some particular social welfare function. As in the recent optimal tax literature (e.g., Weinzierl (2014), Saez and Stantcheva (2016)), one may ask whether there is an appropriate set of welfare weights that a social planner would assign to different groups of workers such that the EPL scheme we observe is optimal. Finally, our model can be used to delve into further political economy issues of reforming EPL in dual labour markets. Modelling political influence and lobbying by certain groups (e.g. labour unions) could help explain the observed inertia to reform the extant regulations, and shed new light on the interplay between insiders' and outsiders' preferences and actions.

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A Model Appendix

This appendix contains four subsections. The first one is an appendix to Section 3 presenting the equilibrium stock-flow equations of the model. In Appendix A.2, we provide an algorithm to compute a steady-state equilibrium of the economy. Appendix A.3 contains the proof of Proposition 1. Finally, in Appendix A.4, we provide an algorithm to compute a transition path of the economy.

A.1 Stock-flow Equations

Using labour market tightness θ_t and separation decisions $\overline{z}_t^i(\tau)$, we can write the set of stock-flow equations that governs the evolution of population distributions from one period to the next.

Firstly, new hires are given by:

$$\lambda_{t+1}^y(z_0, 0) = \theta_t q(\theta_t)(1-\gamma)\sum_\tau \mu_t^y(\tau) \tag{25}$$

while employment in on-going jobs ($\tau' > 0$) evolves according to:

$$\lambda_{t+1}^y(z', \tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}(1-\gamma)\lambda_t^y(z,\tau) \tag{26}$$

$$\lambda_{t+1}^o(z', \tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_{t+1}^y(z,\tau) + (1-\chi)\lambda_{t+1}^o(z,\tau)\right). \tag{27}$$

For the evolution of the non-employment pool, recall that new workers enter the economy in every period. With our stochastic life cycle, there are $\frac{\gamma}{\chi+\gamma}$ older workers in the workforce; a fraction χ of them retires every period, and the same number of individuals enters to keep the size of the workforce at a constant level. Thus, we have:

$$\mu_{t+1}^y(0) = \chi\frac{\gamma}{\chi+\gamma} + (1-\theta_t q(\theta_t))(1-\gamma)\mu_t^y(0) \tag{28}$$

and, for all $\tau' > 0$,

$$\mu_{t+1}^y(\tau') = (1-\theta_t q(\theta_t))(1-\gamma)\mu_t^y(\tau') + (1-\gamma)\sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}\lambda_t^y(z,\tau). \tag{29}$$

Among the old non-employed with tenure level τ' at the time of dismissal from the previous job, the law of motion is:

$$\begin{aligned}\mu_{t+1}^o(\tau') &= \gamma\mu_t^y(\tau') + (1-\chi)\mu_t^o(\tau') \\ &\quad + \sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_t^y(z,\tau) + (1-\chi)\lambda_t^o(z,\tau)\right).\end{aligned} \tag{30}$$

Finally, given that the size of the workforce is equal to one in every period t, it follows that:

$$\sum_{\tau}\sum_{z}\left(\lambda_t^y(z,\tau)+\lambda_t^o(z,\tau)\right)+\sum_{\tau}\left(\mu_t^o(\tau)+\mu_t^y(\tau)\right)=1 \tag{31}$$

A.2 Computing Steady States

We omit the time subscript in this subsection to indicate that the economy is in steady state. Computing a steady state is not trivial because the continuation values in certain labour market states are unknown. Specifically, $U^y(\Delta,\tau)$, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$, $J^o(z,T)$, as well as $w^y(z,T)$, $w^o(z,T)$ are the solution to fixed-point problems. Our algorithm is as follows:

1. Solve for $W^o(z,T)$, $J^o(z,T)$, $w^o(z,T)$ using the following steps:

   (a) Set initial guesses $\widehat{W}^o(z,T)$, $\widehat{J}^o(z,T)$, $\widehat{w}^o(z,T)$, where we use $\widehat{\cdot}$ to indicate a guess.

   (b) Compute the reservation wage of the worker $\underline{w}^o(z,T)$ and that of the firm $\overline{w}^o(z,T)$ associated with $\widehat{W}^o(z,T)$ and $\widehat{J}^o(z,T)$ using equations (17) and (18).

   (c) If $\underline{w}^o(z,T)\leq\overline{w}^o(z,T)$, then solve for the wage w using the first-order condition of the generalised Nash product:

$$\begin{aligned}\frac{\beta}{1+\kappa_t}&\left(z-(1+\kappa)w+\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{\widehat{J}^o(z',T),-\Phi(T)\right\}+\Phi(T)\right)\\&=\frac{1-\beta}{u'(w)}\left(u(w)+\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{\widehat{W}^o(z,T),U^o(T)\right\}-U^o(T)\right)\end{aligned}$$

   and update $\widehat{w}^o(z,T)$ using this value (observe that $U^o(T)$ is completely determined, as per equation (6)). This is a non-linear equation that can be solved using the bisection method. If, on the other hand, $\overline{w}^o(z,T)<\underline{w}^o(z,T)$, set $\widehat{w}^o(z,T)=\frac{1}{2}\left(\overline{w}^o(z,T)+\underline{w}^o(z,T)\right)$.

   (d) Update $\widehat{W}^o(z,T)$, $\widehat{J}^o(z,T)$ using equations (9) and (11).

   (e) If initial and updated guesses for value functions and wages are close enough, then we are done. Otherwise, go back to step (1a).

2. Compute $W^o(z,\tau)$, $J^o(z,\tau)$, $w^o(z,\tau)$ recursively from $\tau=T$. That is:

   (a) Compute the reservation wage of the worker $\underline{w}^o(z,\tau)$ and that of the firm $\overline{w}^o(z,\tau)$ using equations (17) and (18). Notice that the continuation values only involve $\tau+1$, which allows to compute $\underline{w}^o(z,\tau)$ and $\overline{w}^o(z,\tau)$.

   (b) If $\underline{w}^o(z,\tau)\leq\overline{w}^o(z,\tau)$, then solve for the Nash-bargained wage using the first-order condition (14). The continuation values in this equation depend on $\tau+1$ only, and the outside option of the worker $U^o(\tau)$ is pre-determined.

   (c) Compute the value functions $W^o(z,\tau)$ and $J^o(z,\tau)$ from equations (9) and (11).

3. Solve for $U^y(\Delta,\tau)$, $W^y(z,\tau)$, $J^y(z,\tau)$, $w^y(z,\tau)$ using the following steps:

(a) Set an initial guess for $\widehat{U}^y(\Delta,\tau)$.

(b) Solve for $W^y(z,T)$, $J^y(z,T)$, $w^y(z,T)$ using a methodology similar to step (1), i.e.:

i. Set initial guesses $\widehat{W}^y(z,T)$, $\widehat{J}^y(z,T)$, $\widehat{w}^y(z,T)$.

ii. Use the analogue of step (1b) to obtain the reservation wage of the worker and the reservation wage of the firm.

iii. Use the analogue of step (1c) to update the wage. Observe that $\widehat{U}^y(\Delta,T)$ is used as the outside option of the worker in the Nash bargain.

iv. Update $\widehat{W}^y(z,T)$ and $\widehat{J}^y(z,T)$ using equations (8) and (10).

v. Iterate until convergence.

(c) Compute $W^y(z,\tau)$, $J^y(z,\tau)$, $w^y(z,\tau)$ recursively from $\tau=T$ using a methodology similar to step (2). Again, observe that knowledge of $\widehat{U}^y(\Delta,\tau)$ is required to compute the Nash-bargained wage.

(d) Use the Bellman equation of a young unemployed worker to update $\widehat{U}^y(\Delta,\tau)$. If initial and updated guesses are close enough, then we are done. Otherwise, go back to step (3a) using the updated $\widehat{U}^y(\Delta,\tau)$.

The algorithm above builds on the observation that, in a steady state, the value functions $U^y(\Delta,\tau)$, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$ and $J^o(z,T)$ are the solution to an infinite-horizon problem, whereas the other value functions associated with employment solve a standard finite-period (T) problem, and $U^o(\tau)$ is completely determined.

A steady state also involves finding the equilibrium tuple (θ,κ) and the expected duration of a jobless spell Δ. Therefore, the algorithm above is nested into two outer loops to iterate on the tuple (θ,κ). First, we fix the payroll tax κ and iterate to solve for labour market tightness θ. At a given θ, the expected duration Δ is fixed and known since the economy is at a steady state (see equation (34) below). Second, we solve for the time-invariant distribution, calculate the budget-clearing payroll tax and update κ accordingly.

Finally, notice that the severance pay function $\phi(\tau)$ is specified as a function of the average wage $\widetilde{w}$. Since this is an equilibrium object, we must add an outer loop to iterate on $\widetilde{w}$.

A.3 Proof of Proposition 1

At date t_1, the economy is assumed to be at a steady-state equilibrium. For *any* Δ, we can solve for $U^y_{t_1}(\tau,\Delta)$ in the steady-state counterpart of equation (5). This yields:

$$\begin{aligned} U^y_{t_1}(\tau,\Delta) = & \frac{1}{r+\gamma\left(1-\theta_{t_1}q\left(\theta_{t_1}\right)\right)+\theta_{t_1}q\left(\theta_{t_1}\right)}\Big[(1+r)\,u(a^y(\Delta,\tau)+b^y) \\ & + (1-\gamma)\,W^y_{t_1}(z_0,0)+\gamma\widetilde{U}^o_{t_1}(\tau,\Delta)\Big]. \end{aligned} \tag{32}$$

$\widetilde{U}^o_{t_1}(\tau,\Delta)$ is trivial to compute and $W^y_{t_1}(z_0,0)$ can be computed using the approach described in Appendix A.2. Next, using the sequence $(W^y_t(z_0,0))_{t=t_0,\ldots,t_1}$ and combining equations (5) and (32) enables us to construct $(U^y_t(\Delta,\tau))_{t=t_0,\ldots,t_1}$ backwards for any Δ. Notice that, on the other hand, $\widetilde{U}^o_t(\tau,\Delta)$ does not change over time, i.e. $\widetilde{U}^o_t(\tau,\Delta)=\widetilde{U}^o_{t_1}(\tau,\Delta)$ for all t.

Finally, to compute the outside option and the continuation values of employed workers, we need Δ_t and Δ_{t+1} (see, for instance, equation (16)). The expected duration of a jobless spell during the transition path satisfies the following dynamic equation:

$$\Delta_t = (1-\gamma)\left[\theta_t q(\theta_t) + (1-\theta_t q(\theta_t))(1+\Delta_{t+1})\right] + \frac{\gamma}{\chi}. \tag{33}$$

Thus, we can use the sequence $(\theta_t)_{t=t_0,\ldots,t_1}$ to obtain $(\Delta_t)_{t=t_0,\ldots,t_1}$: just like θ_t, Δ_t is a forward-looking variable. Notice that equation (33) yields the following relationship between Δ and θ when the economy is at a steady state:

$$\Delta = \frac{1-\gamma+\frac{\gamma}{\chi}}{\gamma(1-\theta q(\theta)) + \theta q(\theta)}. \tag{34}$$

A.4 Computing Transition Paths

The transition path eliminates the infinite horizon problem analysed in Appendix A.2 since all the continuation values depend on $t+1$. Another key observation is that, instead of keeping track of all the sequences of the transition path (cf. Definition 2), we require "only" the following objects: the cross-sectional distribution of agents at t_0, the sequences $(W_t^y(z_0,0))_{t=t_0,\ldots,t_1}$, $(w_t^y(z,\tau,\epsilon),\ \ w_t^o(z,\tau,\epsilon))_{t=t_0,\ldots,t_1}$, $(\overline{z}_t^y(\tau,\epsilon),\ \ \overline{z}_t^o(\tau,\epsilon))_{t=t_0,\ldots,t_1}$ and $(\theta_t)_{t=t_0,\ldots,t_1}$, as well as the time-path $(\kappa_t)_{t=t_0,\ldots,t_1}$. In these notations, in line with Proposition 2, there is an additional state variable $\epsilon \in \{0,1\}$ indicating whether the worker-firm match already exists when the reform is introduced ($\epsilon=0$) or not ($\epsilon=1$, which results in the ϕ_1 function in equation (22)).

Our methodology to construct the transition path is as follows:

1. Compute the steady state of the economy in period t_1.
2. Guess a path for the payroll tax $(\widehat{\kappa}_t)_{t=t_0,\ldots,t_1}$.
3. Solve for value functions, wages, separation decisions and labour market tightness backwards from t_1 until t_0 as follows:
   (a) Compute the severance pay function for workers in $\epsilon=0$ using Proposition 2.
   (b) Compute labour market tightness consistent with free entry at time t, and store it.
   (c) Use Proposition 1 to compute $U_t^y(\Delta_t,\tau)$ and $U_{t+1}^y(\Delta_{t+1},\tau)$. Notice that these require the sequences of Δ_t and $W_{t+1}^y(z_0,0)$ from t onwards, which we have at hand.
   (d) Solve for the wage functions of older and younger workers at time t, store them, and compute the associated value functions. Finally, compute the separation decisions at time t and store them.
4. Set the initial distribution of agents to the cross-sectional distribution of agents at t_0.
5. Using $(\theta_t)_{t=t_0,\ldots,t_1}$, $(w_t^y(z,\tau,\epsilon),\ \ w_t^o(z,\tau,\epsilon))_{t=t_0,\ldots,t_1}$ and $(\overline{z}_t^y(\tau,\epsilon),\ \ \overline{z}_t^o(\tau,\epsilon))_{t=t_0,\ldots,t_1}$ and the stock-flow equations described in Appendix A.1 (augmented to include the state variable ϵ), compute the evolution of the cross-sectional distribution from t_0 until t_1 . Each period, compute the budget-clearing value of the payroll tax κ_t to obtain $(\kappa_t)_{t=t_0,\ldots,t_1}$.

6. If $(\widehat{\kappa}_t)_{t=t_0,\dots,t_1}$ and $(\kappa_t)_{t=t_0,\dots,t_1}$ are close enough, then we are done. Otherwise, go back to step (2) with a new guess.

To ensure that the payroll tax obtained at the end of the transition path coincides with the t_1 steady-state payroll tax, we allow for a very large number of periods between t_0 and t_1. In our application, we set the number of period to 1,000 (250 years). After 500 periods, the measure of workers who remain in state $\epsilon = 0$ is 0.0001.

B Additional Tables and Figures

B.1 Optimality Criterion

An analytical formula for the optimality criterion is beyond reach. Meanwhile, in our numerical experiments we find that the steady-state lifetime utility of new labour-market entrants is concave in ρ_s and α_s. Figure B1 illustrates this property using our benchmark calibration.

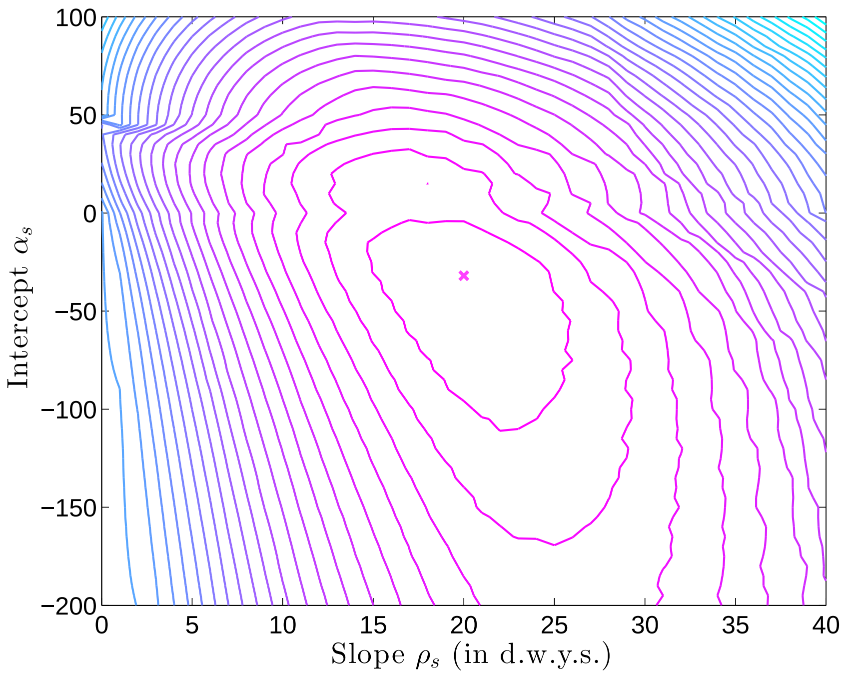

Figure B1. Optimality criterion in the benchmark economy

NOTE: This figure is a contour plot of the steady-state lifetime utility of new labour-market entrants as a function of the rate of return to each year of tenure, ρ_s, and the intercept α_s.

The solid line in Figure B2 displays the optimal unified EPL scheme. For comparative purposes, the dashed line reproduces the benchmark EPL scheme shown in Figure 1.

B.2 The 2012 EPL Reform

The solid line in Figure B3 shows the EPL scheme implemented in Spain in 2012. Table B1 reports the effects of the 2012 EPL scheme on equilibrium allocations and steady-state welfare.

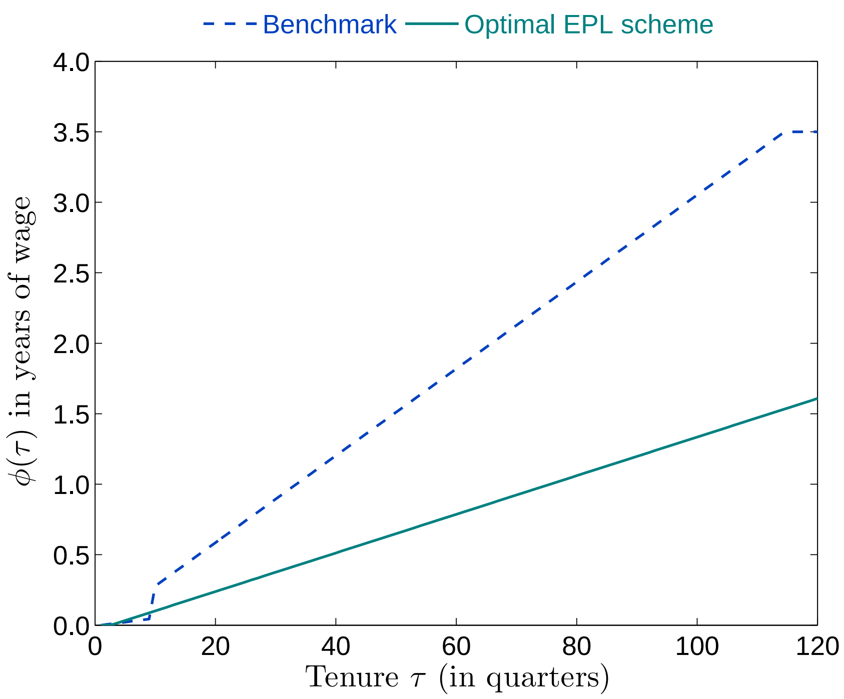

Figure B2. Severance payments: benchmark vs. optimal unified EPL scheme

Table B2 reports the income and welfare effects accounting for the transition dynamics. The results of these numerical experiments are discussed in Subsection 6.1.

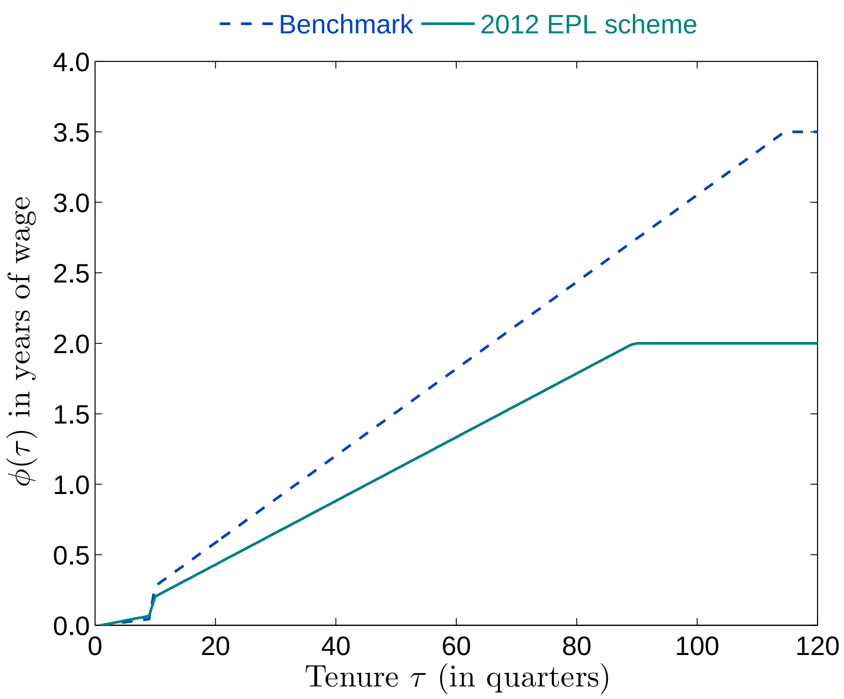

Figure B3. Severance payments: benchmark vs. 2012 EPL scheme

Table B1. Benchmark vs. 2012 EPL scheme: Steady-state comparison

Description	Baseline	2012 EPL scheme
Unemployment rate, young (%)	9.70	9.34
Non-employment rate, old (%)	36.3	35.8
Non-employment rate, all (%)	16.3	15.9
Average wage, young	0.38	0.39
Average wage, old	0.36	0.33
Average productivity, young	0.47	0.47
Average productivity, old	0.53	0.52
Job destruction rate, less than 2 years of tenure (%)	7.64	6.88
Job destruction rate, more than 2 years of tenure (%)	2.30	2.35
Job finding rate (%)	40.0	40.4
Labour market tightness θ	1.00	1.02
Payroll tax κ (%)	9.76	9.44
Welfare of a newborn worker (%, relative to baseline)	–	1.02

Table B2. Income and welfare effects of the reform implementing the 2012 EPL scheme

	Average	Average in each quintile				
		1st	2nd	3rd	4th	5th
A. Welfare						
Young workers	0.832	0.457	0.711	0.805	1.000	1.176
Older workers	-0.551	-1.275	-0.864	-0.668	-0.167	0.233
All	0.590	-0.508	0.599	0.760	0.958	1.178
B. Income		Young workers				
Mean	-0.902	-11.99	-1.852	0.191	1.225	7.908
Std. deviation	-1.782	-35.99	-15.12	-4.607	0.751	46.01
		Older worker				
Mean	0.420	-5.089	-0.374	-0.071	0.461	7.194
Std. deviation	13.33	-46.78	-9.073	-2.085	10.56	113.9

NOTE: Panel A reports the percentage change in lifetime utility (measured in consumption equivalent units) of workers following the EPL reform. Panel B reports the percentage change of the lifetime value of income, and of the transitory component of income following the EPL reform. The first column reports the average change across the distribution, while the other columns report the average change within each quintile of the distribution of the variable under study.

B.3 A *statu-quo* EPL Reform

Table B3 reports the income and welfare effects of a *statu-quo* reform implementing the unified EPL scheme. The results of these numerical experiments are discussed in Subsection 6.2.

Table B3. Income and welfare effects of the unified EPL scheme under a *statu-quo* reform

	Average	Average in each quintile				
		1st	2nd	3rd	4th	5th
A. Welfare						
Young workers	1.294	1.158	1.206	1.268	1.352	1.481
Older workers	0.210	0.153	0.194	0.223	0.237	0.243
All	1.104	0.328	1.170	1.234	1.320	1.471
B. Income		Young workers				
Mean	-0.243	-12.41	-1.604	0.853	2.330	9.621
Std. deviation	-3.400	-40.60	-17.73	-2.530	2.869	40.99
		Older worker				
Mean	0.376	-2.289	0.003	0.019	0.163	3.984
Std. deviation	5.165	-13.25	-0.119	0.091	0.620	38.47

NOTE: Panel A reports the percentage change in lifetime utility (measured in consumption equivalent units) of workers following the EPL reform. Panel B reports the percentage change of the lifetime value of income, and of the transitory component of income following the EPL reform. The first column reports the average change across the distribution, while the other columns report the average change within each quintile of the distribution of the variable under study.

B.4 Alternative Calibrations

In Subsection 6.3, we describe the results based on various alternative calibrations of the model. These are presented in Table B4. The alternatives considered are numbered as follows: (1) the UI replacement rate for young workers is 50 percent, (2) the UI replacement rate for young workers is 65 percent; (3) red-tape costs waste 50% of the total severance package and (4) exogenous separations do not entitle the worker to a severance payment.

Table B4. Parameter values (one model period is one quarter)

Description	Parameter	Benchmark	Sensitivity check			
			(1)	(2)	(3)	(4)
Vacancy cost	k	0.2201	0.2185	0.2234	0.2246	0.2623
Unemployment income	b^y	0.2203	0.1635	0.2803	0.2370	0.2432
Unemployment income	b^o	0.1617	0.1482	0.1753	0.1862	0.1443
Exogenous separation	δ	0.0050	0.0050	0.0050	0.0050	0.0050
Initial productivity	z_0	0.2800	0.2200	0.3400	0.3100	0.2900
S.d. of productivity draws	$\sigma_{\overline{z}}$	0.0440	0.0440	0.0440	0.0440	0.0550

B.5 Non-linear EPL Schemes

In this appendix we provide results for the optimal EPL scheme in a broader, non-linear class of functions. We consider the following two parametric functional forms:

$$\phi_{\mathrm{I}}(\tau) = \max\left\{\iota_1 + \iota_2 \times \tau^{\iota_3}\ ;\ 0\right\} \tag{35}$$

where $\iota_1 \in \mathbb{R}$, and $\iota_2, \iota_3 \in \mathbb{R}^+$ are parameters. This specification has been used in Benabou (2002) and Heathcote et al. (2016) to approximate income tax functions. The parameter ι_3 determines how close the schedule is to being linear, and whether it is convex or concave. The constant ι_1 in equation (35) allows us to potentially capture an initial eligibility period. The second parametric functional form is:

$$\phi_{\text{II}}(\tau) = \max\left\{\nu_1 + \nu_2 \times \exp\left(\frac{\tau^{\nu_3}}{\nu_4}\right) \; ; \; 0\right\} \tag{36}$$

where $\nu_1 \in \mathbb{R}$, $\nu_2, \nu_3 \in \mathbb{R}^+$ and $\nu_4 \in \mathbb{R}^*$ are parameters. This functional form has been used in Koehne and Kuhn (2015) to parametrise an asset-dependent UI system. The class of functions described by (36) contains convex functions, approximately linear ones, and also functions that are concave at low tenure levels and convex at longer tenures.

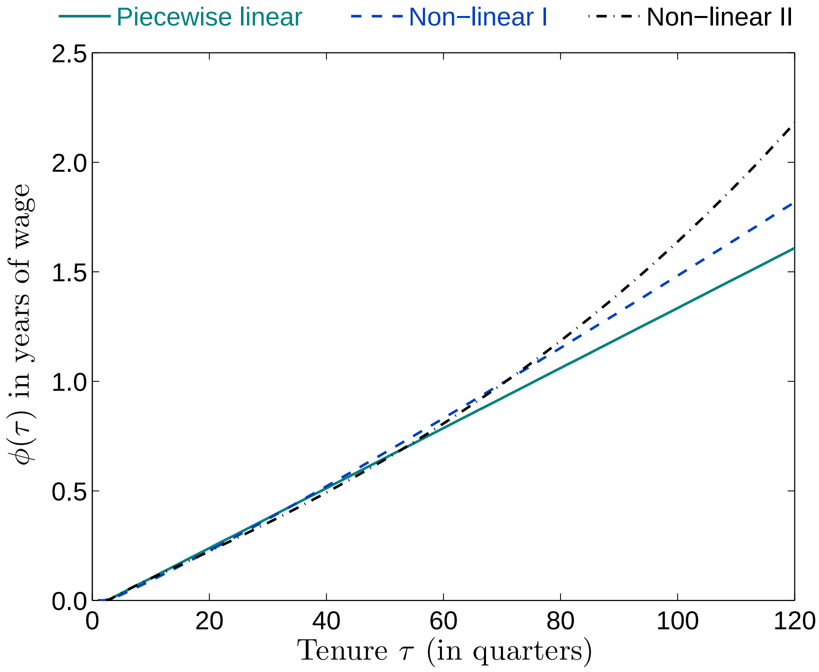

Figure B4. Optimal piecewise linear and non-linear EPL schemes

We compute the optimal EPL scheme for the functional forms described by equations (35) and (36) starting from very large domains on the parameter space to search for the global maximum. These are the solutions we obtain: $\{\iota_1, \iota_2, \iota_3\}^* = \{-0.0260, -0.0145, 1.1000\}$ and $\{\nu_1, \nu_2, \nu_3, \nu_4\}^* = \{-0.6070, 0.5460, 0.6940, 14.00\}$. Both functions are plotted in Figure B4, in conjunction with the optimal piecewise-linear scheme. The figure indicates that both non-linear schedules are remarkably close to the optimal linear scheme, with a slight convex shape towards very long tenures. Moreover, the steady-state welfare gain associated with both solutions is identical to the gain obtained under the piecewise-linear specification up to the fourth decimal place. These results indicate that parametrising the EPL scheme to this shape is not only consistent with the arguments provided at the outset of Section 5.1; it also does not entail a significant restriction compared to a broader class of functions.