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MOVING TOWARDS A SINGLE LABOUR CONTRACT: TRANSITION VS. STEADY-STATE[†]

Abstract

This paper analyses the optimal design of a single open-ended contract (SOEC) and studies the political economy of moving towards such a SOEC in a labour market with dual employment protection. We develop a computationally tractable approach to compare two economic environments: one with flexible entry-level jobs and high employment protection at longer tenures, and another one with a SOEC featuring employment protection levels that increase smoothly with tenure. For illustrative purposes, we specialise the discussion of such choices to Spain, a country often considered as an epitome of a dual labour market. We show that a SOEC has the potential of bringing substantial improvements in equilibrium allocations and welfare. We provide estimates for the eligibility rule and tenure profile of the optimal SOEC, defined as the contract maximising the steady-state lifetime utility of new labour-market entrants. Finally, we use the model to identify winners and losers among younger and older workers in the transitional path of such a reform, and evaluate its political support.

JEL Classification: H29, J33 and J65
Keywords: dualism, employment protection, labour market reform and single contract

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1 Introduction

Employment protection legislation (EPL) has been rationalized on several grounds. These range from strengthening workers' bargaining power in wage negotiations to avoiding moral hazard by employers or increasing employer-sponsored training.[1] In addition, a very important rationale is that, absent perfect capital markets, EPL could insure risk-averse workers against job losses by increasing job stability (Pissarides, 2001). This role of EPL is especially relevant in countries with dual labour markets since workers in otherwise identical jobs are not entitled to the same compensation in case of dismissal. Indeed, a stylized feature of these labour markets is that workers hired under open-ended/permanent contracts (henceforth PC) are entitled to stringent EPL, while those under fixed-term contracts (henceforth FTC) enjoy little or even none. In particular, PC bear mandated severance payments that increase with tenure, typically subject to a cap. Compensation is usually determined in terms of days of wages per years of service (d.w.y.s.), being lower for dismissals due to fair (e.g., economic) reasons than those deemed unfair. By contrast, despite FTC being hardly ever destroyed before their end dates due to their short-term duration, they are sometimes subject to a fixed termination cost (again in terms of d.w.y.s.) which is typically much lower than redundancy pay for workers under PC with similar tenure (see Cahuc et al., 2012).

As noted by Blanchard and Landier (2002), lacking enough wage flexibility, a large gap in dismissal costs between these contracts makes employers reluctant to transform FTC into PC. As a result, FTC become "dead ends" rather than "stepping stones" toward more stable jobs, while dual EPL creates a "revolving door" through which workers rotate between temporary jobs and unemployment. This has negative consequences for unemployment, human capital and innovation (see, e.g., Bentolila et al., 2012b) embodied in inefficient turnover (Blanchard and Landier, 2002), excessive wage pressure (Bentolila and Dolado, 1994), low investment in employer-sponsored training schemes (Cabrales et al., 2014), and the adoption of mature rather than innovative technologies (Saint-Paul, 2002).

This has triggered a heated debate on how to redesign dual employment protection, leading to policy initiatives in southern Europe and France which advocate removing the gap in firing costs once and for all.[2] To achieve this goal, a key policy advice in most of these proposals is to replace dual EPL by a single/unified open-ended contract (henceforth SOEC) for new hires.[3] The key feature of a SOEC is that it has no *ex ante* time limit (unlike FTC) and that mandatory severance pay increases smoothly with seniority (unlike current EPL where the increase is abrupt). Thus, a SOEC would provide a sufficiently long entry phase and a smooth rise in protection as job tenure increases, in stark contrast with the extant EPL discontinuity. The rationale for the gradually increasing redundancy pay could be that the longer a worker stays in a given firm, the larger is her/his loss of specific human capital and the psychological costs suffered in case of dismissal – a negative externality that firms should also internalize (see Blanchard and Tirole, 2003). However, despite being high on the European political agenda, so far most SOEC proposals have been rather vague on their specific

[1] See Booth and Chatterji (1989, 1998).

[2] Inspired by Blanchard and Tirole (2003), among these proposals one could find 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] While in some of these proposals FTC and PC remain available as separate contracts (see e.g., Cahuc, 2012), in others (see e.g., Andrés et al., 2009) most FTC are abolished – the exception being replacement contracts for maternity or sickness/disability leaves.

recommendations; see, e.g., Chapter 4 of the 2014 OECD Employment Outlook devoted to this topic. As a result, several design and implementation issues need to be worked out before new employment protection regulations can become operational.

In this paper, we take a first step towards addressing the following pending issues. First, in contrast to the abrupt discontinuity that mandatory severance pay exhibits under current dual EPL regulations, it is broadly agreed that a SOEC should exhibit a smooth tenure profile; yet, little is known on the precise definition of such a profile. Secondly, despite general agreement that a SOEC would benefit the functioning of labour markets, little is known about the improvements in equilibrium allocations and welfare that would result from its implementation. Lastly, in the specific context of dual labour markets, it is believed that a non-negligible number of insiders would lose from the policy change and, thus, would oppose a reform leading to a SOEC; yet, little is known about the relevance of this argument, i.e., the political strength of insiders, the size of their welfare losses, and whether an appropriately designed transition towards the new steady-state could limit these losses.

To tackle these issues, we develop an equilibrium search and matching model in order to investigate the effects of introducing a SOEC in a labour market subject to a large EPL gap between short and long-tenure jobs. For tractability, we abstract from modelling FTC and PC separately and we ignore the corresponding conversion decision at the termination date of the former.[4] Instead we focus on a labour market with just one type of contract which is characterised by a discontinuous shift in severance pay after a few years of job tenure. In this regard, the first period of this contract plays a similar role to FTC, except that it does not have pre-specified termination date, while the later periods become akin to those under a PC.[5] In exchange for this analytical shortcut, our model has a number of distinctive features that are essential for our purposes. First, workers are risk averse and therefore demand insurance. This enables us to design a SOEC which is optimal according to a welfare criterion reflecting its insurance role. Second, despite having a distribution of workers across tenure levels and a period-by-period budget constraint for a tax-financed unemployment insurance scheme, our model is computationally tractable outside the steady-state. Thus, we can study the transition from the extant regulation to the SOEC. Third, during the transition, we are able to recover the pre-reform tenure of workers who are already employed when the SOEC reform is introduced. In this fashion, we account for the fact that those workers cannot be exempted retroactively from their accrued-to-date rights.

More specifically, the insurance role of EPL is linked to a distinction between *young* and *older* workers who coexist in the labour market of our model.[6] Both receive severance pay but differ with respect to the use they can make of this compensation. While young workers are modelled as living from hand to mouth, and therefore consume the severance package immediately after a job loss (e.g., because of binding credit constraints associated to lower job stability; see Crossley and Low, 2014),

[4]Both are issues which have been extensively dealt with in the literature; see, *inter alia*, Blanchard and Landier (2002); Cahuc and Postel-Vinay (2002); Bentolila et al. (2012a). Our implicit assumption is that all contracts start with low EPL, like with TC, and therefore that no worker is ever directly hired under a contract entailing high EPL. This seems to line up well with Spain (our case study) where only 8% of new hires are under PC (see Bentolila et al., 2012b).

[5]As argued by Bentolila et al. (2012b), what really defines a dual labour market is not the co-existence of TC and PC (a common feature in all countries) but the distortion implied by a large gap in EPL. It is this gap, in combination with wage rigidity, which converts TC into dead ends rather than stepping stones (see Cabrales et al., 2014).

[6]In our model, young workers should be interpreted as prime-age workers (workers aged 25 to 54). Correspondingly, older workers are those aged 55 to 64 years old. We use this terminology for simplicity, and in keeping with standard OLG models where young agents are those who work and old agents are those who consume savings and get a pension.

older workers cannot search for jobs and are allowed to buy annuities in order to smooth out their consumption until retirement. The latter feature captures the fact that older workers often have a hard time re-entering the labour market at an age close to retirement. In this respect, job security provided by EPL can play an important role in bridging the gap until full retirement.

For illustrative purposes, the model is calibrated to the Spanish labour market before the Great Recession, at a time when the unemployment rate in this country was similar to the EU average rate, namely about 8.5%. We choose Spain because it has been often considered as the epitome of a dual labour market (see e.g., Dolado et al., 2002). Nonetheless, the methodology proposed here could be extended to other segmented labour markets, like France or Italy.[7] Using the calibrated model, we compute the optimal profile of a SOEC, defined as the profile maximising the steady-state lifetime utility of new labour-market entrants. We then study the transitional path, in order to evaluate the welfare implications for the *current* population in the labour market and assess the political support of the reform. We now provide an overview of our results.

First, we find that a SOEC with one year of eligibility period and a slope of 14 d.w.y.s. is optimal according to the criterion just described. The SOEC avoids the excess worker turnover rate implied by dual EPL and generates a reduction in job destruction rates at short and medium tenure. At the same time, the number of jobs created in equilibrium increases significantly, which leads to shorter unemployment spells among young workers. The unemployment insurance payroll tax can be lowered by 0.8 percentage points as a result of the decline in unemployment. The early retirement rate decreases by a percentage point. Our findings further suggest significant welfare gains associated with the introduction of the SOEC: a new labour-market entrant experiences a 1.7% increase in steady-state lifetime consumption. This can be attributed to a smoother wage profile at short tenures and higher entry wages, as well as a tighter labour market and the reduction in the payroll tax.

Second, for the current generation of workers, we find that the welfare gain in terms of lifetime consumption is 0.9% on average. We identify winners and losers from the reform along the transition from a dual EPL system to the SOEC. Our analysis suggests that roughly 87% of workers would benefit from the policy change. This figure masks important discrepancies across age groups. Implementing a SOEC improves welfare on average by 1.3% among young/prime-age workers whereas older workers experience a loss of similar magnitude. These welfare losses are caused by the actual implementation of the reform: while previous entitlements to severance payments accumulated during the period prior to the reform are retained, the optimal SOEC reduces entitlements brought about by an additional year of tenure from the date of the reform onwards. Several sensitivity exercises with respect to key parameters of the model (UI generosity, the costs of dismissal procedures, etc.) show the robustness of the optimal profile of the SOEC and its welfare implications.

Our analysis contributes to the very rich policy debate presented in the opening paragraphs of the paper. One of the main forerunners of our analysis is Blanchard and Tirole (2008)'s study of the joint design of unemployment insurance and employment protection. Their focus is theoretical and aims to establish the optimal relationship between these labour market programs. By contrast, our approach

[7] Likewise, our model could also be used to study other severance payments schemes compared to the simple SOEC we propose. For instance, since we model individual job tenure explicitly, it is possible to introduce severance payments that vary non-linearly with tenure. We illustrate this point in Subsection 5.4. This is not the route we pursue in the rest of the paper: our main motivation for modelling tenure is that we seek to capture the abrupt shift and the cap in severance pay observed in a dual labour market.

is quantitative and intended to provide figures that would inform actual policy schemes in the context of a dysfunctional labour market, as is the case of Spain. Further, while their analysis is static, ours involves rich dynamics and considers the transition from dual EPL to a SOEC.

Another closely related paper is Alvarez and Veracierto (2001), who consider a model with precautionary savings and costly search efforts for the unemployed. Their goal is to study the consequences of introducing mandatory (lump-sum) severance payments in an environment where wage rigidity results in an inefficiently high number of layoffs. Recently, Lalé (2015) has analysed a model that also features savings, but wherein wages are allowed to be flexible, which entails non-trivial welfare implications. We differ from these two papers essentially by: (i) precluding savings, (ii) explicitly modelling tenure as a state variable and (iii) allowing severance payments to depend on tenure. While (i) is a limitation to our analysis, it is unavoidable given the complexity of the computational task we address: it enables us to study the transition dynamics while these two papers are restricted to steady-state comparisons. Interestingly, Lalé (2015) obtains similar steady-state welfare gains when studying a combination of severance compensations and unemployment insurance benefits. Thus, with hand-to-mouth young workers and older workers who have access to annuities, our model seems to approximate well the welfare figures that arise in a complete life-cycle model with savings. This is due partly to the fact that most job destruction occur for jobs of shorter duration, which involve young workers whose savings are bound to be very limited.

The relationship between tenure and severance payments is also carefully analysed in two recent papers. The first one is García Pérez and Osuna (2014), who study the effects of introducing a SOEC in the context of the Spanish labour market. The main differences between our approach and theirs is that: (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 a SOEC 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. The other paper is Boeri et al. (2013): they propose a rationale for having mandatory severance pay increase with tenure on the job. 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. They establish this argument within a stylized model with risk neutral agents and where labour market variables are jump variables. Thus, we view their work as complementary to ours.

The rest of the paper is structured as follows. Section 2 presents our model. Section 3 calibrates the model to Spanish labour market data and policies and analyses the steady-state. Section 4 presents the optimal design of the SOEC and a comparison across steady states. Section 5 discusses the results for the transitional phase towards the SOEC. Section 6 reports a number of robustness checks. Finally, Section 7 concludes. Two appendices are included in the paper: Appendix A presents our numerical methodology in detail and Appendix B contains additional tables and figures.

2 The model

This section presents our model. It is a variant of Mortensen and Pissarides (1994), which we accommodate to: (i) provide a role for insurance, (ii) allow workers to have different tenure at their job and (iii) obtain tractability outside the steady-state to analyse transition dynamics.

2.1 Economic environment

Time is discrete and runs forever. The economy may not be in steady-state and thus we need to keep track of calendar time. This is indexed by the subscript t.

Workers

The economy is populated by a continuum of risk-averse workers who work and then retire from the labour market. Workers derive utility from consumption $c_t > 0$ according to a constant relative risk aversion (CRRA) utility function:

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

The coefficient of relative risk-aversion, η, is strictly positive and ensures that $u'(c_t) > 0$ and $u''(c_t) < 0$. A coefficient of one makes this utility function logarithmic. Workers use the interest rate, denoted as r, to discount the future. r is exogenous and fixed.

An important assumption is that workers face incomplete asset markets and that there is no storage technology. 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 employment protection. While this has the potential of exacerbating welfare effects, we will also model public insurance stemming from unemployment benefits and allow for some form of private insurance (details follow).

Production

Production is carried out by a continuum of firms. A firm is a small production unit with only one job, either filled or vacant. There is a per-period cost $k > 0$ of having a vacant job. Firms enter and leave the market freely and maximise the expected discounted sum of profit streams.

Workers and firms meet each other via search. They are brought together by a Cobb-Douglas matching function with constant returns to scale:

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

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

Labour is the only input and production is linear in labour. Productivity, denoted as z, is idiosyncratic to the worker-firm pair. Every worker-firm pair starts at the same productivity level, which is denoted as z_0. In subsequent periods, productivity evolves according to a finite Markov process with transition matrix $\prod = (\pi_{z,z'})$. Fluctuations in productivity may induce the worker-firm pair to destroy the job. Later on in the analysis, we also introduce an exogenous separation shock in order to improve the fit of the model; we defer this element to the calibration section of the paper.

Finally, anticipating on the design of employment protection schemes, we denote by τ the tenure of a given worker-firm match. In our applications, we impose a cap on tenure at a value T. Thus, the law of motion for τ is: $\tau' = \min\{\tau+1, T\}$. As a result, every worker-firm pair is characterised by at least two state variables: productivity z and tenure τ.

Young vs. older workers

The working life span is uncertain and, for tractability of the model, it is assumed that ageing occurs stochastically; see e.g. Castañeda et al. (2003). We distinguish young (y) workers from older (o) workers and use index i in $\{y, o\}$ to denote the age of the workers. In each period, young workers become older with probability γ while older workers leave the labour force with probability χ. A measure of newborns enters the economy at the beginning of each period to maintain the size of the workforce at a constant unit level.

There are two essential differences between young workers and older workers. First, following job loss, young workers keep searching for new jobs whereas older workers abandon job search until they leave the labour market. Secondly, older workers have access to an insurance vehicle in that they are allowed to buy an annuity upon separation from the job. In this way, they can smooth their consumption until leaving the workforce.

It is appropriate here to comment on these two assumptions. Under the considered annuity system, we must keep track of older workers' tenure levels at the time of job loss, since this capitalizes into the annuity scheme. However, due to our simplifying assumption that older unemployed do not search for jobs once unemployed, the distribution of these workers across tenure levels in their previous job is irrelevant for firms' vacancy posting decisions. Conversely, young unemployed workers are homogeneous as they are prevented from capitalizing their employment history into annuities. Thus, although admittedly somewhat extreme, these two assumptions allow us to provide a role for insurance while maintaining feasibility for computations outside the steady-state.

Government-mandated programs

The government runs two labour market programs: unemployment insurance and employment protection schemes.

The unemployment insurance program provides a constant-level benefit, denoted as b^i, to non-employed workers; that is, we allow the benefit level to depend on the age group of the worker. There is no monitoring technology, and therefore older workers can collect b^o after a job loss, although they stop searching for jobs. The provision of unemployment insurance is financed by the proceeds of a payroll tax κ_t. Importantly, we assume that the budget for this program is balanced in every period.

The other labour market program, employment protection, consists of mandating a transfer from the firm to the worker which is paid at the time of job separation (i.e., government mandated severance pay). Consistent with actual policies, the severance pay component, denoted as $\phi(\tau)$, is a function of tenure τ of the worker. While in the benchmark model we ignore red-tape costs involved in the dismissal procedure, later on in the analysis we introduce a firing tax representing such redundancy costs, 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.[8] Finally, in

[8] As a result, this labour market program is self-financed. In the 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

the event of a separation between a firm and an older worker triggered by the exogenous retirement shock, we assume that severance payments are waived.

Disposable income

Having described the economic environment, we are in a position to describe the income workers receive (and consume) in the different states of the labour market. While employed, workers obtain a wage $w_t^i(z,\tau)$ after bargaining over the surplus of the match (see Subsection 2.3). Notice that the wage can be contracted on productivity z, tenure τ, the age of the worker i, and that it also depends on calendar time t.

In non-employment, young workers collect unemployment benefits b^y. As mentioned earlier, lacking access to annuity schemes, they consume the severance package $\phi(\tau)$ entirely upon separation. Older workers, on the other hand, can buy an annuity upon receiving the severance package and collect the proceeds until they leave the workforce. As a result, the total disposable income of older non-employed workers becomes:

$$\tilde{b}(\tau) = b^o + \frac{1}{1-(1+r)^{-1/\chi}} \frac{r}{1+r} \phi(\tau). \tag{3}$$

b^o denotes older workers' unemployment benefits. The last term in equation (3) represents the payoff of an actuarially fair annuity associated with the severance payment $\phi(\tau)$, where $1/\chi$ is the expected number of periods until an old workers leaves the workforce.

2.2 Bellman equations

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

While unemployed, a young worker receives a flow income b^y, remains in the current age category with probability $(1-\gamma)$ and either finds a job with probability $\theta_t q(\theta_t)$, or stays unemployed. Otherwise, such a worker becomes old with probability γ and the asset value is $U_{t+1}^o(0)$. Hence:

$$U_t^y = u(b^y) + \frac{1}{1+r}\left[(1-\gamma)\left(\theta_t q(\theta_t) W_{t+1}^y(z_0,0) + (1-\theta_t q(\theta_t)) U_{t+1}^y\right) + \gamma U_{t+1}^o(0)\right] \tag{4}$$

where $W_t^y(z_0,0)$ denotes a young worker's asset value of being employed at the entry productivity level and with no tenure. An old non-employed worker with τ periods of tenure in her previous job has flow income $\widetilde{b}(\tau)$ and remains in the labour market with probability $(1-\chi)$, such that the corresponding asset value $U_t^o(\tau)$ is:

$$U_t^o(\tau) = u\left(\widetilde{b}(\tau)\right) + \frac{1-\chi}{1+r} U_{t+1}^o(\tau). \tag{5}$$

Next, consider employed workers. These workers consume their wage $w_t^i(z,\tau)$ while employed at

could help financing the provision of unemployment insurance benefits.

a job with productivity z and tenure τ. In the event of job destruction, older workers receive the asset value $U_t^o(\tau)$ whereas the value of younger workers becomes: $U_t^y(\tau) \equiv U_t^y + u(b^y + \phi(\tau)) - u(b^y)$. That is, being hand-to-mouth, they consume the severance payment (as a function of previous tenure) in the period immediately after dismissal. Therefore, $W_t^y(z,\tau)$ satisfies:

$$W_t^y(z,\tau) = u\left(w_t^y(z,\tau)\right) + \frac{1}{1+r}\left((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^y(z',\tau'), U_{t+1}^y(\tau')\right\} + \gamma\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'), U_{t+1}^o(\tau')\right\}\right). \quad (6)$$

The value of employment for older workers, on the other hand, is given by:

$$W_t^o(z,\tau) = u\left(w_t^o(z,\tau)\right) + \frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'), U_{t+1}^o(\tau')\right\}. \quad (7)$$

As for 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 $\phi(\tau)$. Finally, it is assumed that the value of holding a vacant job is zero in every period t (free-entry condition). Hence:

$$J_t^y(z,\tau) = z - (1+\kappa_t)w_t^y(z,\tau) + \frac{1}{1+r}\left((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^y(z',\tau'), -\phi(\tau')\right\} + \gamma\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'), -\phi(\tau')\right\}\right) \quad (8)$$

$$J_t^o(z,\tau) = z - (1+\kappa_t)w_t^o(z,\tau) + \frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'), -\phi(\tau')\right\}. \quad (9)$$

2.3 Wage setting

In line with most of the literature, it is assumed that wages are set by Nash bargaining. Let $\beta \in (0,1)$ denote the bargaining power of the worker. Wages are therefore given by:

$$w_t^i(z,\tau) = \arg\max_w \left\{\left(W_t^i(z,\tau;w) - U_t^i(\tau)\right)^{\beta}\left(J_t^i(z,\tau;w) + \phi(\tau)\right)^{1-\beta}\right\} \quad (10)$$

for all (z,τ) and $i \in \{y,o\}$. For future reference, it is useful to write the first-order condition associated with the above maximisation problems. That is,

$$(1-\beta)\frac{1+\kappa_t}{J_t^i(z,\tau)+\phi(\tau)} = \beta\frac{u'\left(w_t^i(z,\tau)\right)}{W_t^i(z,\tau) - U_t^i(\tau)}. \quad (11)$$

The numerator on the left-hand side of equation (11) 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. Thus, unlike the canonical search and matching model, our model features non-transferable utilities between agents. This implies that we cannot solve for the joint surplus of the match in order to obtain the wage functions.[9]

2.4 Separation decisions

Associated with the max operator in the value functions of employment, there are productivity thresholds that determine separation decisions. Let $\bar{z}_t^i(\tau)$ denote the productivity cutoff for a match with a worker of age $i \in \{y, o\}$ and tenure τ: this is the value of z that makes both parties indifferent between keeping the job alive and dissolving the match. Since private bargains are efficient, $\bar{z}_t^i(\tau)$ can be recovered by using either the value functions of the worker or that of the firm. That is,

$$W_t^i(\bar{z}_t^i(\tau), \tau) = U_t^i(\tau), \quad J_t^i(\bar{z}_t^i(\tau), \tau) = -\phi(\tau). \tag{12}$$

Due to the non-standard problem in the determination of wages, it is also convenient to define separation decisions in relation to the reservation wages of the worker and the firm. 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 τ. These reservation wages solve:

$$u\left(\underline{w}_t^y(z,\tau)\right) = U_t^y(\tau) - \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^y(z',\tau'), U_{t+1}^y(\tau')\right\} + \gamma\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'), U_{t+1}^o(\tau')\right\}\Bigg) \tag{13}$$

$$u\left(\underline{w}_t^o(z,\tau)\right) = U_t^o(\tau) - \frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^o(z',\tau'), U_{t+1}^o(\tau')\right\}. \tag{14}$$

Similarly, the highest possible wage that the firm would pay to this worker, $\overline{w}_t^i(z, \tau)$, is given by:

$$\overline{w}_t^y(z,\tau) = \frac{1}{1+\kappa_t}\Bigg[z + \phi(\tau) + \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^y(z',\tau'), -\phi(\tau')\right\} + \gamma\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o(z',\tau'), -\phi(\tau')\right\}\Bigg)\Bigg] \tag{15}$$

[9] Another implication is that Lazear (1990)'s "bonding critique" is not entirely applicable to 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; see Lalé (2015) for a discussion in a similar context. Moreover, in the calibrated version of the model, there is an exogenous separation shock, which hence cannot be contracted on.

$$\overline{w}_t^o(z,\tau) = \frac{1}{1+\kappa_t}\left(z+\phi(\tau)+\frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^o\left(z',\tau'\right),-\phi\left(\tau'\right)\right\}\right). \tag{16}$$

A separation occurs when: $\overline{w}_t^i(z,\tau) < \underline{w}_t^i(z,\tau)$. This condition pins down the productivity thresholds $\overline{z}_t^i(\tau)$. Notice that, in equations (13)–(16), reservation wages depend on calendar time t through the outside option of workers and through the payroll tax κ_t.

2.5 Stock-flow equations

Using labour market tightness θ_t and separation decisions $\overline{z}_t^i(\tau)$, we can write the stock-flow equations that govern the evolution of population distributions from one period to the next. Let $\lambda_t^y(z,\tau)$ (resp. $\lambda_t^o(z,\tau)$) denote the population of young (resp. older) workers employed at a job with current productivity z and with tenure τ at time t. Likewise, let μ_t^y (resp. $\mu_t^o(\tau)$) denote the population of young (resp. older) unemployed workers. Notice that for older non-employed workers we need to keep track of the tenure variable.

In employment, new hires are given by:

$$\lambda_{t+1}^y(z_0,0) = \theta_t q(\theta_t)(1-\gamma)\mu_t^y \tag{17}$$

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

$$\lambda_{t+1}^y\left(z',\tau'\right) = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^y\left(\tau'\right)\right\}\pi_{z,z'}(1-\gamma)\lambda_t^y(z,\tau) \tag{18}$$

$$\lambda_{t+1}^o\left(z',\tau'\right) = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^o\left(\tau'\right)\right\}\pi_{z,z'}\left(\gamma\lambda_{t+1}^y(z,\tau)+(1-\chi)\lambda_{t+1}^o(z,\tau)\right). \tag{19}$$

As for the evolution of the non-employment pool, we have:

$$\mu_{t+1}^y = \overline{\mu}^y + (1-\theta_t q(\theta_t))(1-\gamma)\mu_u^y + (1-\gamma)\sum_\tau\sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^y\left(\tau'\right)\right\}\pi_{z,z'}\lambda_t^y(z,\tau) \tag{20}$$

where $\overline{\mu}^y = \chi\frac{\gamma}{\chi+\gamma}$ is the mass of new entrants in every period. That is, with our stochastic life-cycle there are $\frac{\gamma}{\chi+\gamma}$ older workers in the workforce; a fraction χ of them leaves every period, and the same number of individuals enters to keep the size of the workforce at a constant level.

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

$$\begin{aligned}\lambda_{t+1}^o(\tau) = {} & \gamma\mu_t^y\mathbb{1}\{\tau=0\} + (1-\chi)\mu_t^o(\tau) \\ & + \sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^o\left(\tau'\right)\right\}\pi_{z,z'}\left(\gamma\lambda_t^y(z,\tau)+(1-\chi)\lambda_t^o(z,\tau)\right).\end{aligned} \tag{21}$$

The term $\gamma\mu_t^y\mathbb{1}\{\tau=0\}$ accounts for the fact that a young unemployed worker who becomes old enters the pool of older workers with no tenure accumulated in the previous job.

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

$$\sum_{\tau}\sum_{z}\left(\lambda_t^y(z,\tau)+\lambda_t^o(z,\tau)\right)+\sum_{\tau}\mu_t^o(\tau)+\mu_t^y=1 \tag{22}$$

2.6 Equilibrium conditions

There are two aggregate quantities which are pinned down by equilibrium conditions, both in steady-state and during the transition phase: labour-market tightness θ_t and the tax rate κ_t.

Free-entry

As is conventional, in every period of the model a free-entry condition dictates that firms exhaust the present discounted value of job creation net of the vacancy-posting cost. This implies that labour market tightness in period t is given by

$$\frac{k}{q(\theta_t)}=\frac{1}{1+r}J_{t+1}^y(z_0,0). \tag{23}$$

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. Using this insight, it follows that the outside options of both agent types in period t are fully determined once value functions in period $t+1$ are known.

Balanced budget

Since the government balances the budget of the unemployment insurance system period by period, the payroll tax satisfies

$$\kappa_t\sum_{\tau}\sum_{z}\left(w_t^y(z,\tau)\lambda_t^y(z,\tau)+w_t^o(z,\tau)\lambda_t^o(z,\tau)\right)=\sum_{\tau}b^o\mu_t^o(\tau)+b^y\mu_t^y \tag{24}$$

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

2.7 Transition and steady-state

Having described the economic environment and equilibrium conditions, we are in a position to define transition paths and steady-state equilibria. In the sequel, we are typically interested in the transition between two allocations indexed by calendar time, say t_0 and $t_1>t_0$. Hence:

Definition. A transition path between t_0 and t_1 is a sequence of value functions $\left(U_t^y,\ U_t^o(\tau), W_t^y(z,\tau), W_t^o(z,\tau), J_t^y(z,\tau),\ J_t^o(z,\tau)\right)_{t=t_0,\dots,t_1}$, a sequence of wage functions $\left(w_t^y(z,\tau),\ w_t^o(z,\tau)\right)_{t=t_0,\dots,t_1}$, a sequence of separation decision rules $\left(\bar{z}_t^y(\tau),\ \bar{z}_t^o(\tau)\right)_{t=t_0,\dots,t_1}$, 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 $\left(\mu_t^y,\ \mu_t^o(\tau), \lambda_t^y(z,\tau), \lambda_t^o(z,\tau)\right)_{t=t_0,\dots,t_1}$ such that:

1. Agents optimize: Given $(\theta_t)_{t=t_0,\ldots,t_1}$, $(\kappa_t)_{t=t_0,\ldots,t_1}$ and the sequence of wage functions $\big(w_t^y(z,\tau)$, $w_t^o(z,\tau)\big)_{t=t_0,\ldots,t_1}$, the value functions U_t^y, $U_t^o(\tau)$, $W_t^y(z,\tau)$, $W_t^o(z,\tau)$, $J_t^y(z,\tau)$, $J_t^o(z,\tau)$ satisfy equations (4) – (9), respectively, in every period t.

2. Separation: Given the sequence of value functions $\big(U_t^y$, $U_t^o(\tau)$, $W_t^y(z,\tau)$, $W_t^o(z,\tau)$, $J_t^y(z,\tau)$, $J_t^o(z,\tau)\big)_{t=t_0,\ldots,t_1}$, the separation decisions $\bar{z}_t^y(\tau)$, $\bar{z}_t^o(\tau)$ satisfy equation (12) in every period t.

3. Nash-bargaining: Given $(\theta_t)_{t=t_0,\ldots,t_1}$, $(\kappa_t)_{t=t_0,\ldots,t_1}$ and the sequence of value functions $\big(U_t^y$, $U_t^o(\tau)$, $W_t^y(z,\tau)$, $W_t^o(z,\tau)$, $J_t^y(z,\tau)$, $J_t^o(z,\tau)\big)_{t=t_0,\ldots,t_1}$, the wage functions $w_t^y(z,\tau)$, $w_t^o(z,\tau)$ solve equation (11) in matches where $z \geq \bar{z}_t^i(\tau)$ and $i \in \{y,o\}$ in every period t.

4. Free-entry: Given $\big(J_{t+1}^y(z_0,0)\big)_{t=t_0,\ldots,t_1}$, labour market tightness $(\theta_t)_{t=t_0,\ldots,t_1}$ is the solution to equation (23) in every period t.

5. Balanced budget condition: Given the sequence of wage functions $\big(w_t^y(z,\tau),\ w_t^o(z,\tau)\big)_{t=t_0,\ldots,t_1}$ and the sequence of distribution of workers across states of nature $\big(\mu_t^y$, $\mu_t^o(\tau)$, $\lambda_t^y(z,\tau)$, $\lambda_t^o(z,\tau)\big)_{t=t_0,\ldots,t_1}$, $(\kappa_t)_{t=t_0,\ldots,t_1}$ is the solution to equation (24) in every period t.

6. Law of motion: Given $(\theta_t)_{t=t_0,\ldots,t_1}$ and the sequence of separation decision rules $\big(\bar{z}_t^y(\tau)$, $\bar{z}_t^o(\tau)\big)_{t=t_0,\ldots,t_1}$, the distribution μ_t^y, $\mu_t^o(\tau)$, $\lambda_t^y(z,\tau)$, $\lambda_t^o(z,\tau)$ evolves according to the law of motion described in equations (17) – (22) from period t to $t+1$.

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 use the following definition:

Definition. A steady-state equilibrium is the limit of the sequences of a transition path. In a steady-state, conditions (1) – (5) of the transition path are satisfied. A time-invariant condition replaces condition (6): given θ and the separation decision rules $(\bar{z}^y(\tau),\ \bar{z}^o(\tau))$, the distribution μ^y, $\mu^o(\tau)$, $\lambda^y(z,\tau)$, $\lambda^o(z,\tau)$ is time-invariant for the law of motion described in equations (17) – (22).

Before turning to numerical applications, we stress a difference between the two aggregate quantities of this economy, namely labour-market tightness θ_t and the tax rate κ_t. On the one hand, θ_t is a forward-looking variable as per equation (23). Thus, we can proceed backwards from steady-state t_1 in order to construct the time-path $(\theta_t)_{t=t_0,\ldots,t_1}$. On the other hand, due to the stock-flow equations, the tax rate κ_t is a backward-looking variable which depends on wages negotiated in period t and the distribution of workers across employment status, productivity levels, tenure and age groups. Hence, computing a transition path requires knowledge of the entire sequence $(\kappa_t)_{t=t_0,\ldots,t_1}$. Yet, a key feature of our environment is that decisions along the transition path depend on the aggregate state of the economy only through θ_t and κ_t. Appendix A provides the details of our numerical methodology to compute steady-state equilibria and transition paths.

3 Computation of benchmark equilibrium

This section describes our calibration and characterises the steady state of the benchmark economy. We select parameters to reproduce a set of informative data moments for Spain over the period 2005-2007, i.e. just before the outbreak of the Great Recession, when the Spanish unemployment rate was similar to the average unemployment rate (about 8.5%) in the Euro area. We choose that period because, in our view, an 8.5% unemployment rate is a plausible steady-state value, instead of the subsequent 25% reached during the slump (see Bentolila et al., 2012b).

3.1 Calibration procedure

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 $\sigma_{\bar{z}}$, truncated and normalized to integrate to one over the support of productivity. The resulting productivity process resembles a random walk, although 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, but these did not change the model's workings substantially, which is why we reverted to a process parametrised only by $\sigma_{\bar{z}}$. Next, as indicated in Subsection 2.1, we assume that jobs are also subject to an exogenous separation shock. We denote as δ the per-period probability that this shock is realised.

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

Parameters set externally

The first seven rows of Table 1 report parameter values set outside the model. The chosen interest rate is set at $r = 0.01$ to yield an annual interest rate of about 4 percent. The coefficient of relative risk aversion in (1) 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 tenure, T, equal to 120 model periods, i.e., 30 years.[10] Finally, as is conventional in the literature (see Petrongolo and Pissarides, 2001), the unemployment-elasticity of the number of matches and workers' bargaining power are set to $\psi = \beta = 0.5$.

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 moment conditions, most of which are obtained from the Spanish Labour Force Survey for 2005-2007: (1) the average duration of unemployment for young workers is 2.5 quarters, i.e., 7.5 months; (2) the quarterly job destruction rate for temporary jobs is 7.44 percent (García Pérez and Osuna,

[10]That is, with a deterministic life-cycle, workers (including the young) would never reach the maximum tenure level.

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

Description	Parameter	Value	Moment	Target
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
Vacancy cost	k	0.2805	Tightness (norm.)	1.00
Unemployment income	b^y	0.2637	Replacement rate (%)	58.0
Unemployment income	b^o	0.1953	Replacement rate (%)	45.4
Exogenous separation	δ	0.0060	Fraction of quits (%)	20.0
Initial productivity	z_0	0.3233	Job destr. ($\leq$2 years, %)	7.44
S.d. of productivity draws	$\sigma_{\bar{z}}$	0.0590	Job destr. (>2 years, %)	2.09

2014); (3) the quarterly job destruction rate for permanent jobs is 2.09 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;[11] (5) the replacement rate of unemployment benefits for older workers, $b^o/\widetilde{w}^o$, is 45 percent;[12] (6) quits account for about 20 percent of all separations (Rebollo-Sanz, 2012).[13] 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 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.[14]

The severance pay function

The crux of our analysis relates to the severance pay function. We follow Bentolila et al. (2012b) and García Pérez and Osuna (2012) in computing a function of job tenure that stands similar to EPL in Spain prior to the onset of the Great Recession.[15] As the latter authors do, we specify it as a function

[11]Estimates for the average net replacement rate across different family types and earnings levels range from an initial value of 67% after layoff to 49% over 60 months of unemployment (OECD, 2004). We pick an intermediate value of 58% and perform a sensitivity analysis in Section 6.

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

[13]To be precise, Rebollo-Sanz (2012) reports that quits account for 22 percent of all separations over the years 2000–2007. This was a period of economic expansion in Spain, and job-to-job transitions are notoriously pro-cyclical. For these reasons, we use a more conservative figure of 20 percent.

[14]Following an exogenous separation, we assume that the firms 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 separation rate to changes in the employment protection scheme. In sensitivity checks (Section 6), we re-run the experiments under the assumption that severance payments are waived in the event of an exogenous separation.

[15]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 5.4).

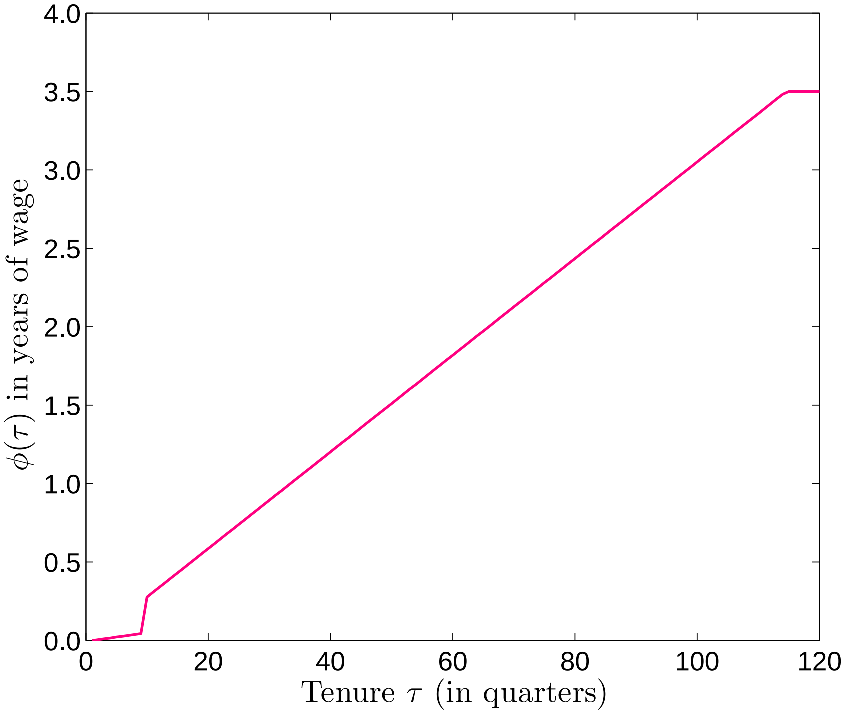

Figure 1. Severance payments in the benchmark economy

of the average annual wage in the labour market, rather than as a function of individual tenure and/or productivity. This simplifying assumption allows us to keep the solution of the model on a tractable level, because no knowledge on the wage profile is required when specifying $\phi(\tau)$.[16]

In particular, we use the following pieces of information to compute $\phi(\tau)$. We identify the first two years of employment with FTC prevailing in the Spanish labour market. During the chosen calibration period, these contracts feature 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 period, we identify the subsequent periods of employment as those regulated by PC. Workers on PC are entitled to 45 d.w.y.s. since joining the firm, with a maximum of 3.5 annual wages, under an unfair dismissal which represent most of the dismissals until 2012.[17] For instance, a worker who is employed at the same firm for more than two years and loses her/his job in the third year is entitled to 37 percent ($= 3 \times 45/365$) of the average yearly wage.

Using these pieces of information, severance payments for a worker whose tenure at the current firm is τ are computed as follows:

$$\phi(\tau) = \begin{cases} (8/365) \times \widetilde{w} \times \tau, & 1 \leq \tau \leq 8 \\ (45/365) \times \widetilde{w} \times \tau, & 9 \leq \tau \leq 113\,. \\ (45/365) \times \widetilde{w} \times 113, & \tau > 113. \end{cases} \tag{25}$$

We use the pre-reform EPL scheme since our calibration targets are based on pre-2012 data.

[16]Notice that the average wage is an equilibrium outcome of the model, not a pre-specified parameter. To compute an equilibrium, we add an outside loop to iterate over the average wage used to specify the severance pay function.

[17]We assume that all firms pay unfair dismissal costs of 45 d.w.y.s., even when 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 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., 2012b).

Table 2. Benchmark economy: Comparison with the data

Description	Model	Data	Comment
Unemployment rate, young (%)	9.0	8.6	
Non-employment rate, old (%)	36.2	43.0	
Non-employment rate, all (%)	15.8	16.5	
Replacement rate $b^y/\widetilde{w}^y$ (%) [(a)]	58.0	58.0	part of calibration
Replacement rate $b^o/\widetilde{w}^o$ (%) [(a)]	45.4	45.4	part of calibration
Average wage, young	0.46	–	
Average wage, old	0.43	–	
Average productivity, young	0.57	–	
Average productivity, old	0.62	–	
Job destruction rate, $\leq$2 years of tenure (%)	7.46	7.44	part of calibration
Job destruction rate, $>$2 years of tenure (%)	2.08	2.09	part of calibration
Share of quits among separation (%) [(b)]	20.4	20.0	part of calibration
Job finding rate (%)	40.0	40.0	part of calibration
Payroll tax (%)[(c)]	9.25	7.60	

NOTE: Unless otherwise indicated by a footnote, data moments are obtained from the Spanish Labour Force survey for the years 2005-2007. [(a)] Based on estimates from OECD (2004). [(b)] Based on estimates from Rebollo-Sanz (2012). [(c)] Own calculations based on Social Security contributions geared towards unemployment insurance.

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

3.2 Benchmark economy

Table 2 reports a selection of aggregate statistics in our benchmark economy. These value are, whenever possible, compared to their empirical counterparts. As can be observed, the model fits the moments targeted in our calibration strategy very precisely. Moreover, most non-targeted moments are reasonably close to the corresponding data values. The unemployment rate among young workers in the benchmark economy is 9.0 percent, while the corresponding value in the data is slightly lower at 8.6 percent. Across the population of older workers, the model generates a non-employment rate of 36.2 percent. The empirical share of non-employed male workers between 55 and 64 years of age is slightly larger at 43 percent. Since our model abstracts from disabilities, health shocks and other reasons for non-employment, we interpret the gap between the observed share and the model value as a plausible outcome. The aggregate non-employment rate among all workers in our benchmark economy is 15.8 percent against 16.5 percent in the data. Finally, the budget-balancing payroll tax is 9.25 percent in the model. This is slightly larger than the actual value of 7.60 percent, which is the sum of employers' and workers' social security contributions to unemployment insurance in Spain.

Separation decisions

Figure 2 depicts the productivity cutoffs to dismiss young and older workers, resp. $\bar{z}^y(\tau)$ and $\bar{z}^o(\tau)$ (the vertical axis covers only the interval $[0.0, 0.3]$ to improve legibility). First, note that newly-formed matches start at a productivity level that is fairly close to the corresponding separation threshold (0.32 vs. 0.22). As a result, a large fraction of matches facing an adverse productivity draw over the first

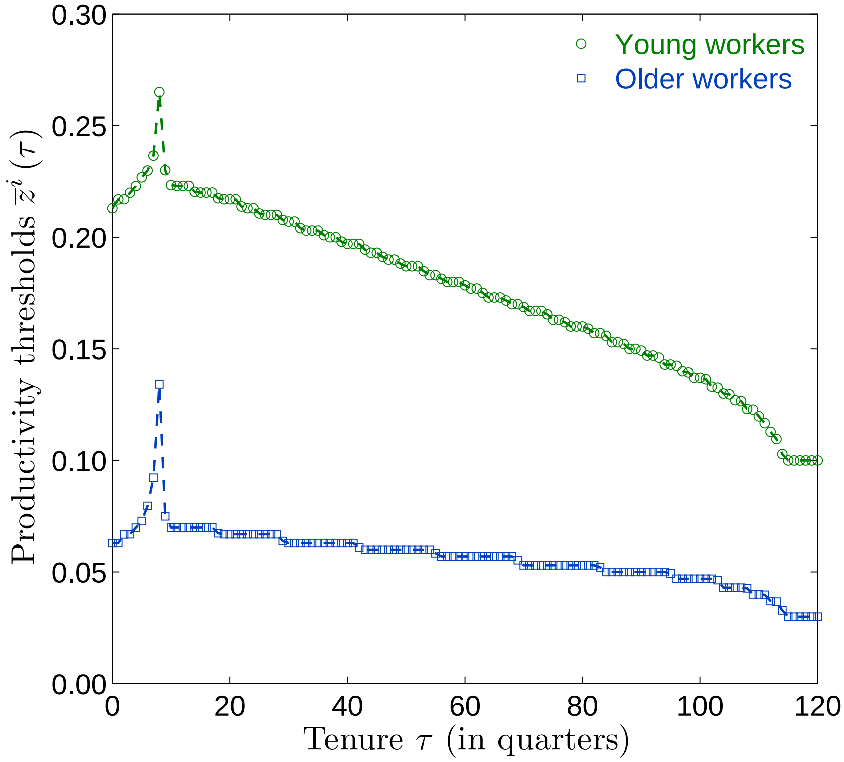

Figure 2. Separation thresholds in the benchmark economy
The plot shows the separation thresholds for young (green circles) and older workers (blue squares). Separation thresholds are plotted as a function of tenure τ.

quarters of tenure are dissolved endogenously. This feature of the model makes new jobs relatively fragile and rationalizes high job destruction rate 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 of being destroyed. These "career" jobs are bound to become stable jobs and they are characterised by a substantially lower job destruction rate at longer tenures.

Next, as evidenced in Figure 2, there are characteristic spikes in the job destruction region at $\tau = 8$. These reflect the discontinuous jump ("wall") in the firing cost schedule (Figure 1). Since workers are risk averse, future severance payments are only partially internalized through lower wages. This puts a lower bound on workers' reservation wages and implies that relatively unproductive matches are destroyed before the increase in severance pay takes place. Overall, this results in a "camel shaped" distribution of tenure, with a large fraction of jobs with less than 2 years and a large fraction with more than 10 years of tenure.

As can be seen in Figure 2, productivity cutoffs are generally lower for older workers because in our model they do not have the option value of searching for a new job. Only worker-firm matches operating at very low productivity levels find it optimal to discontinue the match and let the worker retire early. Finally, the productivity thresholds are decreasing with tenure as firms find it more costly to fire a worker and pay the severance package. We also find that workers who entered the labour market less than 10 years ago are five times more likely to be dismissed than workers with job tenures above 30 years. Since the former are likely to be rather young and not able to save much, this may justify our assumption than young workers are hand to mouth.

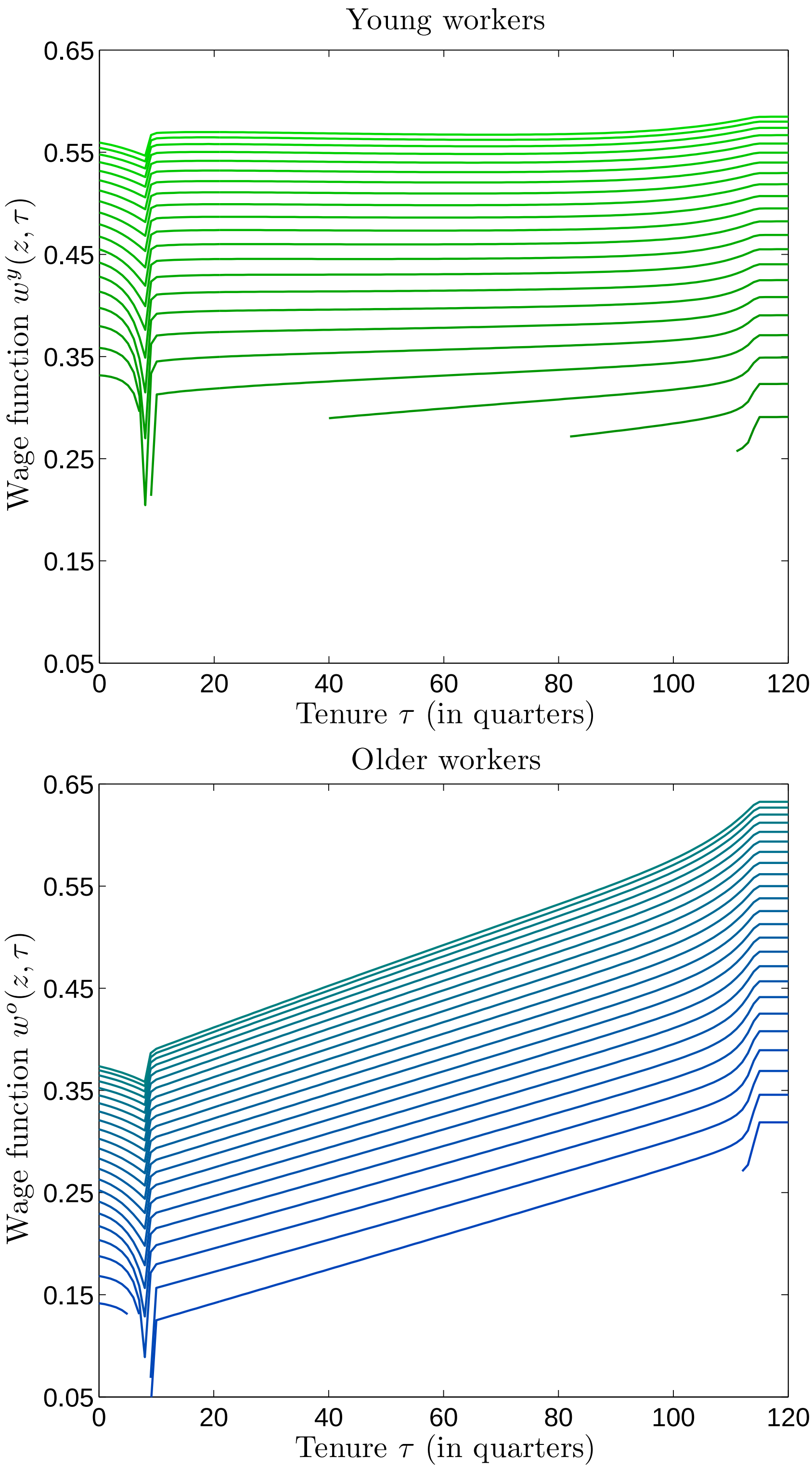

Figure 3. Wage function in the benchmark economy for young and older workers

The plot shows the wage functions in the benchmark economy (young workers in the upper chart, older workers in the lower chart). In each chart, the top line indicates high-productivity and the bottom line indicates low-productivity levels. Wage functions are plotted as a function of tenure τ. To improve legibility, we report wages at 25 evenly-spaced points of the support for productivity. The lines are not shown or they are interrupted if $z < \bar{z}^i(\tau)$.

Wages and tenure

The wage functions for young and older workers are depicted in Figure 3. There are several features to highlight. Firstly, there is a dip in the wage schedule at the end of the first two years of tenure. The key for this result is again the shape of the severance pay function and the fact that wages are renegotiated every period: as the worker-firm match approaches the period in which the increase in severance pay hits, workers are willing to accept lower wages temporarily in exchange for higher future entitlements to severance payments if their job is not destroyed. Secondly, the wage curve is rather flat for young workers and steeper for old workers. This reflects the degree to which firm-worker matches are willing to internalize future severance payments through lower initial wages. Young workers consume their severance package instantaneously in the period after a layoff. Thus, a larger severance payment buys them only a one-time increase in the level of consumption (at diminishing marginal utility), which makes their outside option increase only very gradually with tenure. By contrast, for older workers, a more generous entitlement to severance transfers as their tenure increases allows them to buy more valuable annuities. In other words, their wage profile resembles more the shape that one would obtain in a Lazear (1990)-type setting where severance payments are fully neutralized.

4 Designing a SOEC

This section contains the first part of our main quantitative results. We use our model calibrated to Spanish data and policies as a laboratory to design a SOEC. We lay out an optimality criterion, and describe the implications of the optimal SOEC on steady-state equilibrium allocations and welfare.

4.1 Implementation

We use a relatively simple class of severance payment functions to define a SOEC, namely a subset of piecewise linear functions of tenure. We specify severance payments as:

$$\phi(\tau) = \begin{cases} 0 & \text{if } \tau < \tau_s \\ \rho_s \times (\tau - \tau_s) & \text{otherwise} \end{cases}. \tag{26}$$

τ_s is the minimum service tenure for eligibility, and ρ_s measures the rate of return to each year of tenure (in days of wages per year of service, d.w.y.s.), conditional on eligibility.

There are three main principles guiding the design of a simple SOEC as in equation (26). First, the parameters τ_s and ρ_s are readily interpretable. For instance, they can be compared to actual policy schemes.[18] Second, while our model rationalizes implementing a SOEC, it does not provide arguments for having a function with many kinks and different slopes across tenure levels. Third, with more parameters in the severance pay function, it becomes more likely to have local optima only in the objective function presented in the next Section. In addition, with only two parameters, we find that our optimality criterion has a global maximum.

[18] See, for instance, Section 1 in Boeri et al. (2013). Figure 1 in that paper shows that a piecewise linear function of tenure is an accurate description of EPL schemes implemented in most countries.

4.2 The optimality criterion

The optimality criterion draws on steady-state comparisons: we define an optimal SOEC as the contract maximising the steady-state lifetime utility of new labour-market entrants.[19] In practice, we implement a SOEC for different combinations of τ_s and ρ_s, compute the steady-state equilibrium and store the value U^y that results. Thus, the optimal SOEC is the bundle (τ_s, ρ_s) defined as:

$$(\tau_s, \rho_s) = \arg\max \{U^y\}. \tag{27}$$

In the sequel, instead of reporting the lifetime value U^y achieved in equation (27), we measure welfare effects in terms of consumption equivalent units. Formally, let U_b^y denote the lifetime utility of a newborn worker in the benchmark economy, and let U_s^y be her lifetime utility under the optimal SOEC. The percentage change in lifetime consumption arising from the optimal SOEC is given by ϑ, which solves:

$$1+\vartheta = \left(\frac{(r+\chi)U_s^y + \frac{1+r}{1-\eta} \times \frac{r+\gamma+\chi}{r+\gamma}}{(r+\chi)U_b^y + \frac{1+r}{1-\eta} \times \frac{r+\gamma+\chi}{r+\gamma}} \right)^{\frac{1}{1-\eta}}. \tag{28}$$

We show in Figure B1 in the Appendix that the optimality criterion is concave in τ_s and ρ_s (this property also holds in all our robustness checks, whose corresponding charts are displayed in the online appendix). As a result, within the class of severance payment functions considered, the optimal SOEC is unique.

4.3 Steady-state results

Table 3 reports the welfare change associated with different combinations of τ_s and ρ_s. On a given row, we fix the minimum service tenure for eligibility and we increase the slope gradually along the columns.

Table 3. Steady-state comparisons of various SOEC

		Slope ρ_s (in d.w.y.s.)								
		0	4	8	12	14	16	20	45	60
Initial eligibility										
τ_s (in months)	0	0.956	1.439	1.573	1.589	1.571	1.508	1.365	-0.437	-2.014
	6	0.956	1.431	1.599	1.665	1.666	1.643	1.572	0.265	-0.980
	12	0.956	1.408	1.585	1.668	**1.681**	1.680	1.630	0.584	-0.443
	18	0.956	1.385	1.565	1.652	1.671	1.680	1.651	0.801	-0.086
	24	0.956	1.365	1.540	1.636	1.655	1.669	1.658	0.950	0.176
	30	0.956	1.343	1.516	1.612	1.638	1.654	1.654	1.062	0.379
	36	0.956	1.324	1.496	1.588	1.617	1.636	1.644	1.148	0.544

NOTE: An entry in the table is the percentage change in lifetime consumption of new labour-market entrants.

[19] It is possible to define an optimality criterion that would include the transition dynamics, but such a criterion would have several 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 5, the transition path is difficult to predict and, as a result, it is likely that the optimality criterion is not well-behaved in τ_s and ρ_s. Third, the computational burden makes it impractical to run a grid search on τ_s and ρ_s to maximise a criterion that includes the transition path.

As illustrated in the table, a SOEC has the potential to generate significant welfare gains when compared to the current EPL scheme. In particular, a SOEC with 1 year of minimum service and a slope of 14 d.w.y.s. maximises steady-state lifetime utility of a newborn worker. Henceforth, we refer to this combination as the optimal SOEC. A graphical comparison between the current EPL scheme and the optimal SOEC is provided in Figure 4 (upper panel). The latter is associated with lower severance payments than the benchmark scheme, and the slope of 14 d.w.y.s. lies between the respective figures of TC (8 d.w.y.s.) and PC (45 d.w.y.s.) that prevail under current EPL. Furthermore, our analysis suggests that there is a welfare-improving role for severance pay as the optimal SOEC is strictly preferred to a laissez-faire scheme (first column, $\rho_s = 0$).

Equilibrium allocations and welfare

Table 4 reports a set of aggregate statistics for the steady-state equilibrium under the optimal SOEC in comparison with the benchmark economy. Our analysis suggests that introducing this SOEC has a significant positive effect on labour market tightness. As a result, jobless workers are matched to firms at a higher rate, which decreases the duration of unemployment. The optimal SOEC, moreover, reduces the job destruction rate for short-tenured jobs below 2 years from 7.5% to 6.3% per quarter, while the corresponding rate for worker-firm matches with longer tenure increases slightly from 2.08% to 2.25%. Overall, these effects translate into a reduction in the unemployment rate from 9.0% to 8.1%. As the non-employment rate for older workers also decreases by roughly one percentage point from 36.2% to 35.1%, the net effect on employment across the whole population is positive (14.9% vs. 15.8%). Relative to the benchmark economy, the optimal SOEC results in an increase in welfare of 1.68% and a reduction in the budget-balancing payroll tax rate of 0.8 percentage points.

The bottom panel of Figure 4 sheds more light on these results. It depicts the wage-tenure profile (the wage averaged across match productivities for each tenure) in the benchmark case and under the optimal SOEC. As can be observed, the wage-tenure profile is smoother under the optimal SOEC: it is higher than the benchmark profile during the first 18 years and lower afterwards.[20] The insights are that, under the continuous shape of the severance payment schedule associated with the SOEC, (i) young workers do not need to accept large wage cuts in order to make up for the expected future severance pay, which implies higher earnings at the entry level; and (ii) older workers have lower reservation values since the slope of the severance pay function is lower under the SOEC than in the benchmark case. This smoother wage profile is behind the potential welfare gains from consumption-smoothing that benefit workers under the SOEC.

Foremost, the optimal SOEC removes "revolving doors" in labour market trajectories implied by dual EPL. Under the benchmark scheme, the tenure distribution is characterised by a large fraction of jobs with less than 2 years of tenure, as those matches that have not experienced favourable productivity changes get quickly destroyed (in a dual labour market, temporary contracts are hardly converted into permanent contracts). The optimal SOEC, in turn, by exhibiting a smoother year-by-year profile, shifts the distribution towards longer tenures; the tenure distribution under the optimal SOEC has

[20]The upward-sloping wage-tenure profile is due to a combination of factors. At short tenures, the average wage increases due to a selection effect, as many jobs experience favourable productivity draws while unproductive jobs get destroyed. At long tenures, the average wage rises further, due to an increasing share of jobs occupied by older workers. Furthermore, workers can bargain for higher wages as their outside option increases with larger severance packages.

Table 4. Current vs. optimal SOEC: Steady-state comparison

Description	Baseline	Optimal SOEC
Unemployment rate, young (%)	9.0	8.1
Non-employment rate, old (%)	36.2	35.1
Non-employment rate, all (%)	15.8	14.9
Average wage, young	0.46	0.48
Average wage, old	0.43	0.36
Average productivity, young	0.57	0.57
Average productivity, old	0.62	0.62
Job destruction rate, less than 2 years of tenure (%)	7.46	6.26
Job destruction rate, more than 2 years of tenure (%)	2.08	2.25
Job finding rate (%)	40.0	43.0
Labour market tightness θ	1.00	1.15
Payroll tax κ (%)	9.25	8.46
Welfare of a newborn worker (%, relative to baseline)	–	1.68

more jobs between 2 and 10 years of tenure.

A decomposition exercise

To provide further insight into the welfare effects of the optimal SOEC, we run a sequence of counterfactual 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 2 years. This implies a smoother wage profile over the first two years of tenure, and shifts the wage-tenure profile upwards as the degree of internalization of future severance payments diminishes. Secondly, we adjust the slope by rotating the function on both segments to yield the actual SOEC (again, keeping tightness and tax constant). Rotating the firing cost function flattens out the wage profile and, thus, increases entry wages for newly-matched workers. Thirdly, we raise labour market tightness to the equilibrium level computed under the optimal SOEC, keeping the tax constant. Finally, we adjust the payroll tax as well. We interpret the first two adjustments as governing partial equilibrium effects, while the latter two account for general equilibrium adjustments in prices.

Total effect	Remove wall	Adjust slope	Tightness θ	Payroll tax κ
1.681	0.429	0.091	0.693	0.470
	(25.5)	(5.4)	(41.2)	(27.9)

The figures above presents our results (the second row gives the relative contribution of each counterfactual). The total welfare gain of 1.68% is again reported in the first column. The remaining columns provide the welfare change associated with each counterfactual. As can be seen, general equilibrium effects jointly account for roughly 70 percent of the overall welfare gain, while partial equilibrium effects account for the remaining 30 percent. The largest contribution stems from higher job finding rates due to a tighter labour market (41.2 percent), followed by the reduction in the payroll tax (27.9 percent). The elimination of the discontinuity in the severance payment schedule after 2 years yields considerable further welfare gains (25.5 percent), while decreasing the gradient accounts for

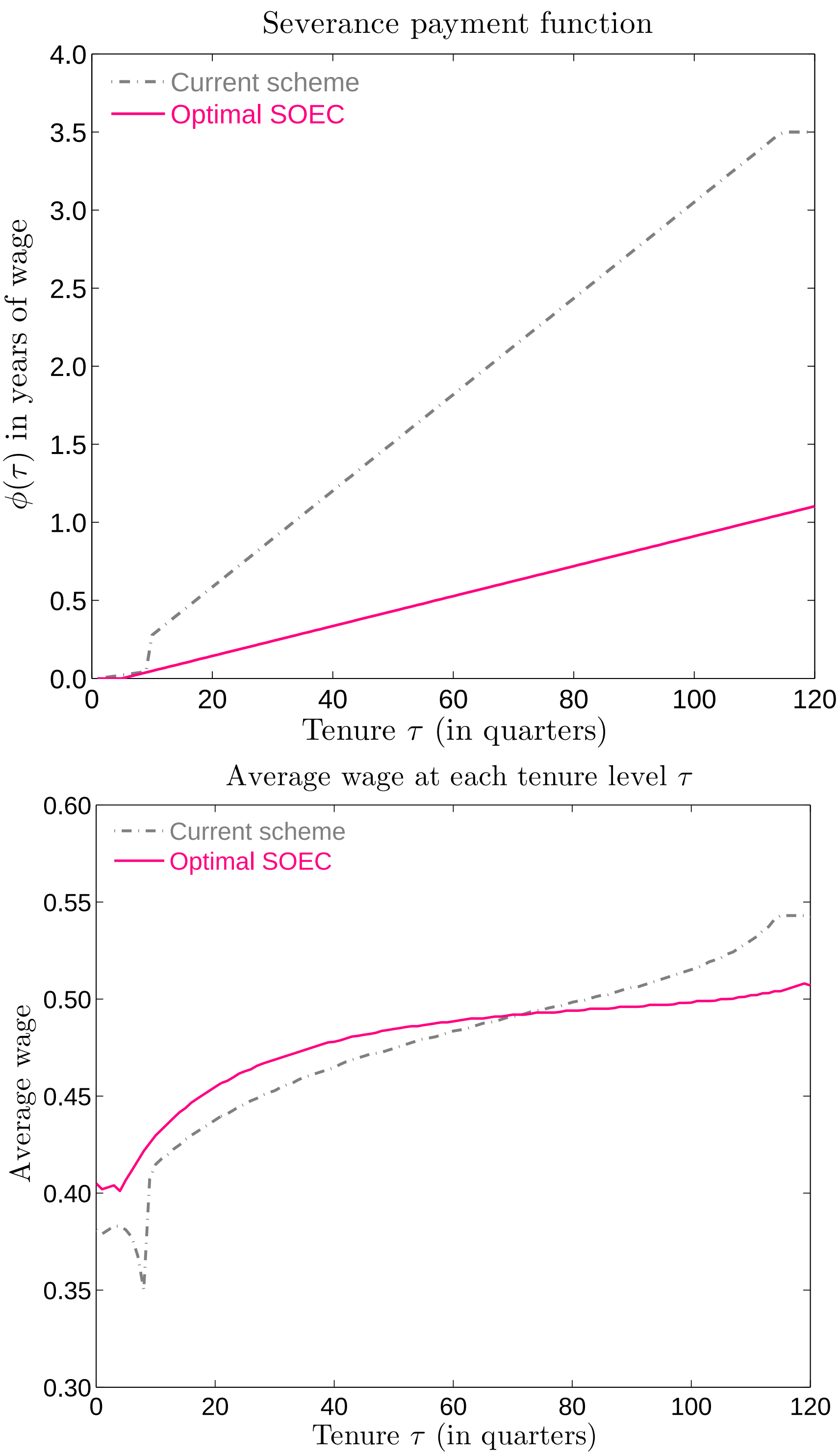

Figure 4. Current scheme vs. optimal SOEC: Steady-state comparison of selected outcomes
The upper chart shows severance payments as a function of tenure τ. The lower chart shows the wage on average across match across match productivities for each tenure. In each chart, the dashed line corresponds to the current scheme (benchmark economy) and the solid line corresponds to the optimal SOEC.

the remaining 5.4 percent. In the next section, we show that general equilibrium effects play a more important role when the transition path is taken into account.

5 Moving towards a SOEC

In this section, we present our second set of findings, building and expanding on the results of Section 4. Our model provides a framework for discussing further issues, such as the actual introduction of a SOEC and the transition dynamics that result, as well as the implications for workers who are already in the labour market when the reform is implemented.

5.1 Implementation

A key feature of our model is that we can mimic real-life EPL reforms upon introducing a SOEC. Indeed, in actual EPL reforms, workers employed before the reform cannot be exempted retroactively from their accrued-to-date rights. In line with the February 2012 reform of the Spanish labour market, we therefore assume that all 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 that any previous entitlements accumulated during the tenure prior to the reform are retained.[21] Formally, we assume that the reform introduces the optimal SOEC, denoted as $\phi_1(.)$, in the calendar period t_0, and we let $\phi_0(.)$ denote the severance pay function that prevails before t_0. The severance pay function for an existing worker-firm match in some period $t \geq t_0$ is then:

$$\phi_t(\tau) = \phi_0(\tau - (t - t_0)) + \phi_1(\tau_s + (t - t_0))\,\mathbb{1}\{\tau - (t - t_0) \geq \tau_s\}. \tag{29}$$

That is, a worker whose tenure at time t is τ had $\tau - (t - t_0)$ periods of tenure when the reform was announced, and $(t - t_0)$ of post-reform tenure. $\phi_0(\tau - (t - t_0))$ is the severance pay retained from the pre-reform period and $\phi_1(\tau_s + (t - t_0))$ is the payment in any post-reform period, conditional on eligibility (i.e., if $\tau - (t - t_0) \geq \tau_s$).[22] Notice that, during the transition towards a new steady-state, workers under the $\phi_t(\tau)$ and the $\phi_1(\tau)$ scheme coexist in the labour market.

5.2 Transition path

Figure 5 shows the time path of several labour market variables during the transition from dual EPL to the optimal SOEC. Most of the adjustment takes place during the first year of the reform, which dovetails with the fact that the reform affects not only new jobs but also existing worker-firm matches.

[21]To emphasize differences with a *statu-quo* reform where any worker employed at the time of the reform can remain under the previous EPL scheme (a scenario we study in Subsection 5.5), we call this a partially non-retroactive reform. Using our model, we can also study a "pure" retroactive reform where the SOEC replaces the previous scheme in existing jobs irrespective of any accrued-to-date rights. However, such a scenario appears unrealistic, and is actually prevented by the Spanish constitution.

[22]Put differently, τ and t are sufficient statistics for pre-reform tenure, which is key for our application. There is one exception, namely workers who have reached T, the cap for tenure. But since the slope of the optimal SOEC is lower than in the benchmark (and we maintain the initial cap on severance payments), this case can be ignored: a worker employed in period t_0 and with T periods of tenure in any period $t \geq t_0$ is entitled to $\phi_0(T)$, and therefore we do not need to recover her pre-reform tenure.

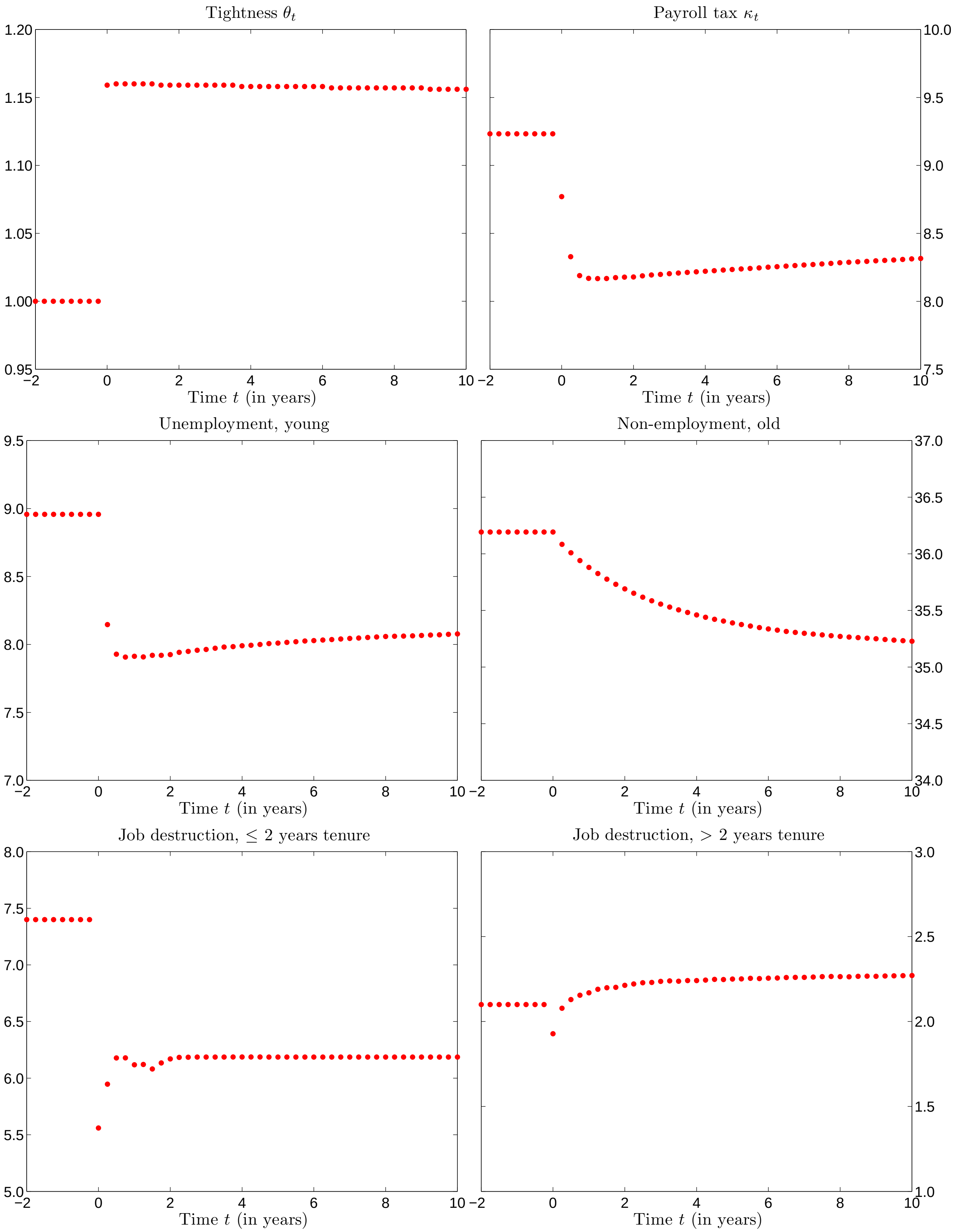

Figure 5. Transition dynamics towards the optimal SOEC

The charts display the time path of several labour market variables during the transition towards the optimal SOEC 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 SOEC, which occurs in period 0.

The upper charts 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 decreases to its future steady-state level. The gradual decrease in taxes, on the other hand, is explained by the decline in non-employment after the reform (details follow). Unemployment among younger workers mirrors the behaviour of tightness: the job-finding rate soars instantaneously as firms create more vacancies associated with the SOEC, which lowers unemployment. The decline in non-employment among older workers is more gradual since it is only driven by the flows from employment. Finally, short-tenured jobs (less than 2 years) are extended in the short run: the job destruction goes down from 7.5% to 5.5% on impact. It then rises slightly to its future steady state value of 6.3%, reflecting that the less stringent SOEC scheme facilitates dismissals. For jobs with more than 2 years of tenure, there is a short-lived decline followed by convergence to the higher long-run level.[23]

5.3 Welfare and political support

The upper panel of Table 5 reports the welfare effects of moving towards a SOEC for the *current* generation of young and older workers.[24] The lower panel shows the political support for this reform. In both panels, we exclude older workers who have already retired early at time t_0 since they cannot be affected by the policy change. In order to gain some insights about these results, Columns 2-4 display the welfare changes associated with three partial-equilibrium, consecutive experiments: first introducing a SOEC (aggregating changes in intercept and slope), then adjusting labour-market tightness, and finally letting the payroll tax change.

As can be inspected, a large majority of young workers benefits from the reform through the three adjustment margins. The reason is that the surge of the job finding rate following the introduction of the SOEC compensates them for the lower redundancy pay in case of dismissal. In contrast, most older workers are harmed by the SOEC, because severance pay is lower after the reform, although they benefit from the reduction in the payroll tax due to lower unemployment. Yet, the overall effect is negative for these workers. Among the three adjustments in Columns 2-4, the most relevant (and beneficial) one for younger workers is the fall in the tax rate while the most relevant for older workers is the reduction in severance pay (detrimental). In sum, despite the fact that young workers gain 1.32% and old workers lose 1.34%, the main welfare change from implementing a reform is positive and amounts to an increase of 0.88% in overall welfare because the former group represent a larger

[23]In fact, the job destruction rate at more than 2 years of tenure remains more elevated than the value reached in the future steady-state for roughly 30 years. This is explained by severance pay that combine accrued-to-date rights with the new EPL scheme (i.e. equation (29)). Workers who would have stayed in employment otherwise become more likely to separate from their jobs since the returns to tenure (in terms of severance pay) are lower. Charts for the long-run dynamics of the transition are available from the authors upon request.

[24]For young workers, the formula for computing welfare effects in consumption equivalent units is similar to equation (28). The formula for older workers is:

$$1+\vartheta = \left(\frac{(r+\chi)V_s + \frac{1+r}{1-\eta}}{(r+\chi)V_b + \frac{1+r}{1-\eta}} \right)^{\frac{1}{1-\eta}} \tag{30}$$

where V_b is the lifetime utility of an old worker in a given labour market state of the benchmark economy, and V_s is her lifetime utility at the time when the reform is implemented.

Table 5. Welfare effects of a SOEC and political support

	Overall effect (1)	Effect of SOEC (2)	Effect of θ_t (3)	Effect of κ_t (4)
A. Welfare effect				
All workers	0.887	-0.093	0.438	0.543
Young workers	1.323	0.241	0.514	0.594
	[-0.748, 2.924]	(18.2)	(38.9)	(44.9)
Older workers	-1.341	-1.666	0.000	0.325
	[-6.837, 8.023]	(124.2)	(0.0)	(-24.2)
B. Political support				
All workers	87.06	64.14	21.01	1.91
Young workers	99.98	73.41	25.48	1.09
Older workers	26.25	20.54	0.00	5.71

NOTE: Column 1 present the overall effect of the policy reform. Columns 2, 3, 4 decompose the reform into three consecutive adjustments: effects of introducing a SOEC (Column 2), the resulting change in θ (Column 3) and the resulting change in κ (Column 4). An entry in Panel A of the table is the percentage change in lifetime consumption. The numbers in squared brackets in Panel A are the minimum and maximum welfare change experienced by workers. The numbers in parenthesis in Panel A, Columns 2, 3, 4 are the relative contribution of each consecutive adjustments. An entry in Panel B of the table is the fraction of workers who benefit from the policy reform. In Panel B, Columns 2, 3, 4, an entry is the increment in the fraction of winners brought by each consecutive adjustments.

fraction of the population compared to the second group.

The previous results predict very well political support of this reform. As can be observed in lower panel of Table 5, there is a large majority in favour of such a reform: almost 87 percent of the population would gain from the policy change. However, there is a substantial discrepancy across the two age groups: while there is almost universal support across young workers, three quarters of older workers would actually be against the reform and suffer non-negligible losses.[25] This result is noteworthy because in Southern EU countries unions are often dominated by older workers, which could explain the resistance to EPL reforms in those countries.

5.4 Comparison: The 2012 reform

As already mentioned, Spain underwent an EPL reform in February 2012 (Decree Law 3/2012), whereby compensation costs for TC went up from 8 to 12 d.w.y.s. while severance pay for PC decreased from 45 to 33 d.w.y.s. (with a cap of 24 months, lower than the previous cap of 42 months). Figure B2 in Appendix B depicts the pre-2012 and post-2012 profiles of severance payments, while Tables B2 and B3 perform the steady-state comparison and welfare analysis that were provided for the optimal SOEC in Tables 4 and 5, respectively. We observe in Table B2 that the steady-state welfare effect of the 2012 reform (0.86%) is about one-half of the corresponding gain under the optimal SOEC

[25]While the welfare losses for older workers seem very large, one should bear in mind that the figures measure a change in permanent consumption over an horizon of ten years (in expectation) for this age group.

(1.68%). The gain from the 2012 reform is even lower than under the SOEC when considering welfare for the current generation of workers: 0.38% vs. 0.89%. The insight for these results is that the 2012 reform decreased but did not eliminate the discontinuity in severance pay which leads to "revolving doors". Despite increasing the separation rate for short tenures and increasing it at longer tenure, the 2012 scheme leaves labour market tightness almost unchanged, in contrast with the implementation of the optimal SOEC which raises tightness from the baseline value of 1.00 to 1.15.

5.5 Comparison: A *statu-quo* reform

For completeness, we compare the transition dynamics of our benchmark reform with those of an alternative reform, which we denote as the *statu-quo*. In this alternative scenario, we assume that the optimal SOEC is introduced in the following way: unemployed and newborn workers who are matched to a firm at any date $t \geq t_0$ are subject to the new severance payment schedule while workers who are still employed under the previous EPL scheme have the option to remain under the terms of this scheme. If they want to change to the SOEC introduced at t_0, they have to dissolve their current employment relationship first and then search for a new job (thus, only young workers already employed at t_0 have the option of being eventually employed under the terms of the SOEC).

As can be observed in Figure 6, where we compare the two reforms (red circles correspond to the benchmark case whilst the blue dots correspond to the *statu-quo* reform), the transition is slower under the *statu-quo* reform and there are some detrimental effects in the short run. Labour market tightness surges immediately but by less than under the benchmark reform, whereas the tax rate falls more slowly because of the initial increase in the unemployment rate of young workers. Short-tenured jobs (less than 2 years) are destroyed immediately to take advantage of the much less stringent SOEC scheme; this is also the case, albeit to a much lesser extent, for low-productivity jobs held by workers with longer tenure. The effects explain the more sluggish decline in non-employment rates among both young and older workers.

It is important to note that, in spite of the sluggish reaction of the tax rate and non-employment rates, a *statu-quo* reform maximises political support and leads to higher welfare gains compared to our benchmark, the partially non-retroactive reform.[26] Among the current generation of workers, the welfare effects are as follows:

All workers	Young workers	Older workers
1.261	1.457	0.236
(25.5)	[1.351, 1.643]	[0.037, 0.751]

(as in Table 5, the numbers in squared brackets are the minimum and maximum of welfare change). A *statu-quo* reform provides agents with the option value of choosing the EPL scheme they prefer, which accounts for the findings. Overall, the difference in welfare effects between the benchmark and

[26] In the short-run, it is likely that an actual *statu-quo* reform deteriorates welfare compared to our benchmark reform, due to the greater number of transitions through unemployment and the sluggish adjustment of the tax rate (cf. Figure 6). Our model cannot capture these effects well because of the stochastic structure of the life-cycle. Indeed, any worker aged 25 to 54 in the model expects to stay in this age category for 30 years. This mitigates the detrimental short run effects just discussed. In this regard, our benchmark reform which changes the generosity of EPL schemes in existing worker-firm matches performs better in capturing negative effects in the short run.

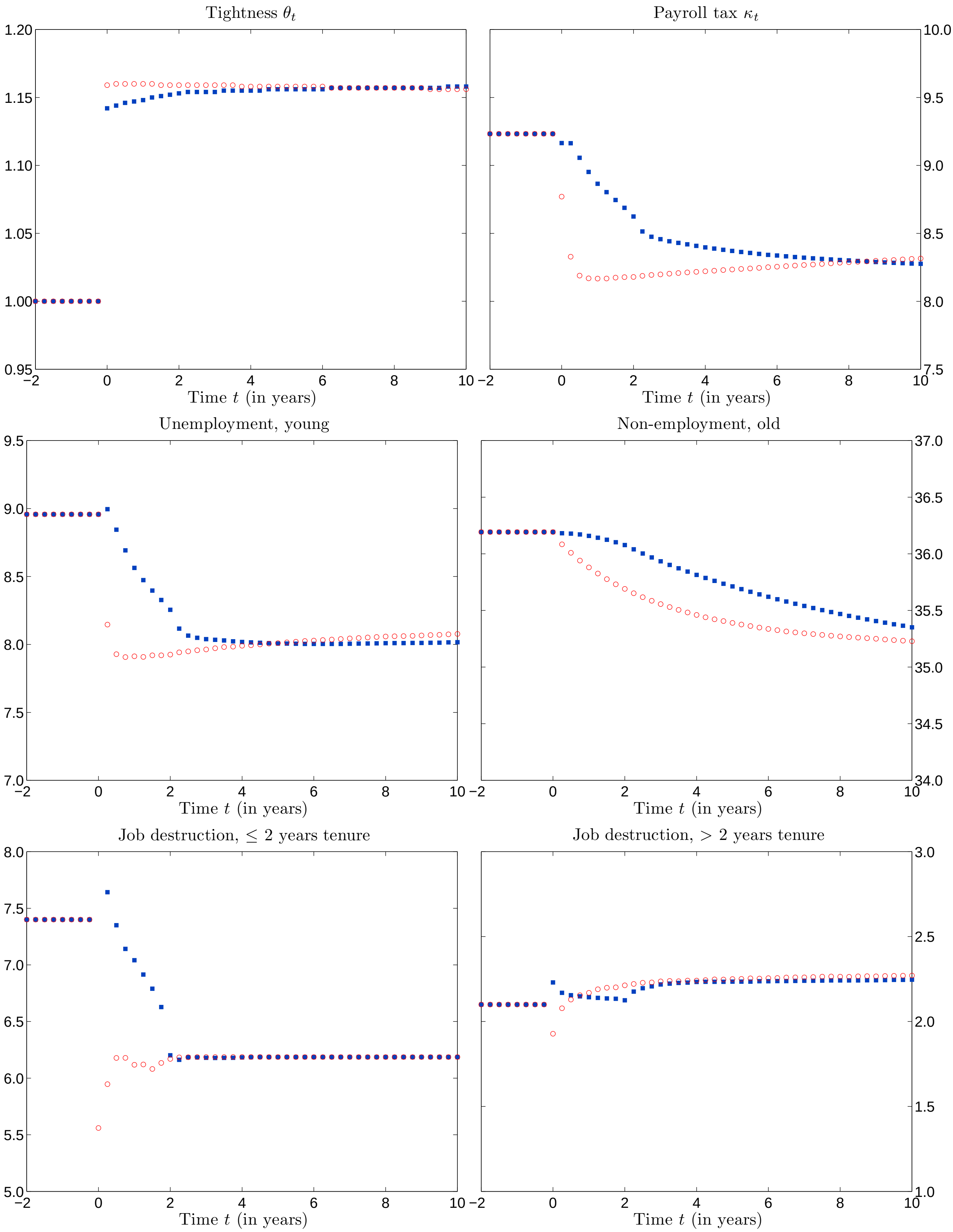

Figure 6. Transition dynamics: non-retroactive vs *statu-quo* reforms
The charts display the time path of several labour market variables during the transition towards a SOEC. The blue squares correspond to the *statu-quo* reform. The red circles correspond to the partially non-retroactive reform. Except 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 SOEC, which occurs in period 0.

the *statu-quo* reform seems plausible. In particular, we observe that the welfare losses suffered by some older workers in Table 5 (up to -6.8% in terms of consumption units) are caused by the partially retroactive component of the reform.

6 Sensitivity analysis

In this section we conduct a few 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 separations (quits) do not entitle the worker to a severance payment. In each scenario, the model is recalibrated to match the targets presented in Section 3 (see Appendix B.2 for details). In this regard, this is not simple comparative statics exercise.

Table 6. Optimal SOEC 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	12	14	1.681	0.887
Lower UI benefits	6	10	2.068	1.134
Higher UI benefits	18	20	1.329	0.725
Red-tape costs	18	17	1.266	0.527
Quits vs. layoffs	18	15	1.500	0.851

NOTE: Each row displays the parameters of the optimal SOEC (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 6 provides an overview of our results (the details are available in the online appendix). The SOEC design is fairly robust to changes in the calibration. For example, lower UI benefits implies a lower eligibility period (6 months instead of 12 months) and a flatter slope (10 d.w.y.s rather than 14 d. w.y.s) while higher UI benefits implies longer eligibility period (18 months rather than 12 months) and steeper slope (20 d.w.y.s rather than 14 d,w.y.s.). The insight for these results is that when UI generosity is low, unemployed workers wish to find a job soon and therefore choose lower severance pay because this increases job creation by more that it increases job destruction. The opposite argument hold when UI is generous and therefore workers find it less costly to remain unemployed in exchange for higher redundancy pay in the future. Furthermore, the SOEC eligibility period increases to 18 months with small changes in the slope, in the presence of red-tape costs and if we assume that exogenous separations (quits) do not entitle the worker to severance compensations. The intuition in both instances is that the effectiveness of severance pay as an insurance device for workers is more limited. In all four specifications, the overall shape of the optimal SOEC is similar to that obtained under the benchmark calibration.

As can be inspected in the last two columns of Table 6, introducing optimal SOECs involves substantial welfare gains in a steady-state sense as well as for the current generation of workers. Compared to the benchmark, the welfare effects are more (resp. less) pronounced with lower (resp. higher) UI benefits. This dovetails with the idea that severance payments and UI benefits are substitutes in providing workers with a means to smooth consumption. The welfare effects are lower in the presence of red-tape costs because those represent a deadweight loss for the worker-firm pair. They are also lower in the fourth scenario because fewer workers receive a severance package following a job separation. In all instances, the welfare figures (both in steady-state and accounting for the transition) are in the same ballpark as the figures based on the benchmark calibration.

Finally, we conjecture that had we allowed for savings among the young workers, the slope would be lower (for given UI), since there is less scope for the insurance mechanism provided by EPL. Likewise, had we allowed for job search among older unemployed workers, it is likely that the slope would be lower as well since now workers have another source of income, besides the redundancy package. Analysing both issues in depth remain high in our future research agenda.

7 Conclusion

This paper provides a computationally tractable approach for the design and implementation of an optimal single open-ended labour contract (SOEC). Such a contract could replace large discontinuities in EPL in segmented labour markets. As discussed in the opening paragraphs, there have been several proposals in southern Europe and France regarding the implementation of a SOEC, but none of them provides figures as to the actual profile of an optimal SOEC, its welfare implications and political support. In our model, individuals are risk averse, and therefore prefer consumption smoothing, young/prime-age workers face liquidity constraints and older workers cannot regain employment after a job loss, which we interpret as early retirement. Under these conditions, a SOEC provide a much better insurance mechanism against job losses than dual employment protection.

We calibrate the model and find that a SOEC with 1 year of entry phase and a slope of 14 d.w.y.s maximises the lifetime utility of workers who enter the labour market in steady-state equilibrium. This SOEC delivers substantial improvements in allocations and welfare by removing the "revolving doors" implied by dual EPL, hence eliminating inefficient job turnover at short tenures. We also analyse the transition from an equilibrium with dual EPL to the equilibrium of the SOEC, and find that such a reform entails significant welfare gains for the current population, especially for young workers. For example, a realistic reform that imposes a SOEC for new jobs and maintains accrued-to-date rights for existing jobs while adjusting entitlements accumulated after the reform improves welfare for about 87% of workers, with three quarters of the older workers losing from the reform.

These results are based on a calibration for Spain before the Great Recession. Yet, our approach could also be used to design and analyse a SOEC for other countries with dual employment protection.

In our future research agenda, we would also like to deal with the design of optimal SOEC in combination with the design of optimal UI which, due to the computational complexity of modelling the transition to a new steady state, has been taken as given. Another pending issue is how to limit the uncertainty associated to workers´appeal to labour courts to obtain higher redundancy pay for unfair dismissals. The possibility of having a fast-track compensation together with a SOEC as in the recent Jobs Act in Italy could be a fruitful avenue of research (see Sestito and Viviano, 2015).

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A Numerical appendix

This appendix details our numerical methodology to compute steady-state equilibria and transition paths of the model economy presented in Section 2.

A.1 Computing steady-states

To indicate that the economy is in steady-state, we omit the time subscript throughout this subsection. A steady-state is non-trivial to compute because the continuation values in certain labour market states are unknown. Specifically, U^y, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$, $J^o(z,T)$, as well as $w^y(z,T)$, $w^o(z,T)$ are the solution to fixed-point problems. The computational 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 $\widehat{\ }$ 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 (14) and (15).

   (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 generalized Nash product:

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

   and update $\widehat{w}^o(z,T)$ using this value (observe that $U^o(T)$ is completely determined, as per equation (5)). 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 (7) and (9).

   (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 (14) and (15). 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 (11). 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 (7) and (9).

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

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

(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 analogon of step (1b) to obtain the reservation wage of the worker and the reservation wage of the firm.

iii. Use the analogon of step (1c) to update the wage. Observe that $\widehat{U}^y$ 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 (6) and (8).

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 $\widehat{U}^y$ is required to compute the Nash-bargained wage.

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

The algorithm above builds on the observation that, in a steady-state, the value functions U^y, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$ 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). Thus, the algorithm is nested into outer loops to iterate on (θ,κ): we fix the payroll tax κ, solve for labour market tightness θ, and then update κ until convergence. In the benchmark economy, our calibration procedure allows to skip the loop for θ (recall that θ is fixed to pin down the vacancy creation cost). Finally, since $\phi(\tau)$ is specified as a function of the average wage $\widetilde{w}$, there is an outer loop to iterate on $\widetilde{w}$.

A.2 Computing transition paths

A transition path between t_0 and t_1 involves a sequence of value functions, wage functions, rules for separation decisions, labour market tightness, payroll tax, and distribution of workers across employment status, productivity levels, tenure and age groups. These sequences satisfy a set of conditions presented in Subsection 2.7.

The transition path avoids some computational issues that arise for the steady-state and brings subtleties of its own to the computational task. On the one hand, the transition path eliminates the infinite horizon problem since all continuation values depend on time $t+1$. Moreover, the sequence $(\theta_t)_{t=t_0,\dots,t_1}$ can be constructed backwards as we compute value functions along the transition path. On the other hand, the transition path requires knowledge of the sequence $(\kappa_t)_{t=t_0,\dots,t_1}$ and there is an additional state variable for employed workers and for the old unemployed, $\varepsilon \in \{0,1\}$, indicating whether the worker-firm match already exists when the reform is announced ($\varepsilon = 0$) or not ($\varepsilon = 1$, which results in the ϕ_1 function in equation (29)).

The structure of the model implies that, instead of storing the sequence for all the objects of the transition path, we "only" need the distribution of agents at t_0 and the sequences $(\theta_t)_{t=t_0,\dots,t_1}$, $\left(w_t^y(z,\tau,\varepsilon),\ w_t^o(z,\tau,\varepsilon)\right)_{t=t_0,\dots,t_1}$ and $\left(\bar{z}_t^y(\tau,\varepsilon),\ \bar{z}_t^o(\tau,\varepsilon)\right)_{t=t_0,\dots,t_1}$ to check that a time-path $(\kappa_t)_{t=t_0,\dots,t_1}$ is consistent with the equilibrium budget condition.

Our methodology to compute these sequences is as follows:

1. Compute the steady-state of the economy in period t_1.
2. Guess a path for the payroll tax $(\widehat{\kappa}_t)_{t=t_0,\dots,t_1}$.
3. Solve for value functions, wages, separation decisions and labour market tightness recursively from t_1 until t_0 as follows:
   (a) Compute the severance pay function for workers in $\varepsilon = 0$ using equation (29).
   (b) Compute labour market tightness consistent with free-entry at time t and store it.
   (c) Compute the value of searching for a new job at time t, U_t^y. Note that, in every period of the transition path, a young unemployed worker can only find a job with the t_1 severance pay function applying to this job.
   (d) Solve for the wage functions of older and younger workers at time t and store them. Then 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 time-invariant distribution that obtains in the steady-state before t_0.
5. Using $(\theta_t)_{t=t_0,\dots,t_1}$, $\left(w_t^y(z,\tau,\varepsilon),\ w_t^o(z,\tau,\varepsilon)\right)_{t=t_0,\dots,t_1}$ and $\left(\bar{z}_t^y(\tau,\varepsilon),\ \bar{z}_t^o(\tau,\varepsilon)\right)_{t=t_0,\dots,t_1}$ and the stock-flow equations described in Subsection 2.5 (augmented to include the state variable ε), compute the evolution of the distribution during the time path. Each period, compute the realised payroll tax κ_t implied by the balanced budget condition in order to obtain $(\kappa_t)_{t=t_0,\dots,t_1}$.
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 coincide with the steady-state t_1 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 number of workers who are still employed under the $\varepsilon = 0$ rule is 0.0001.

B Additional tables and figures

B.1 Concavity of the optimality criterion

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

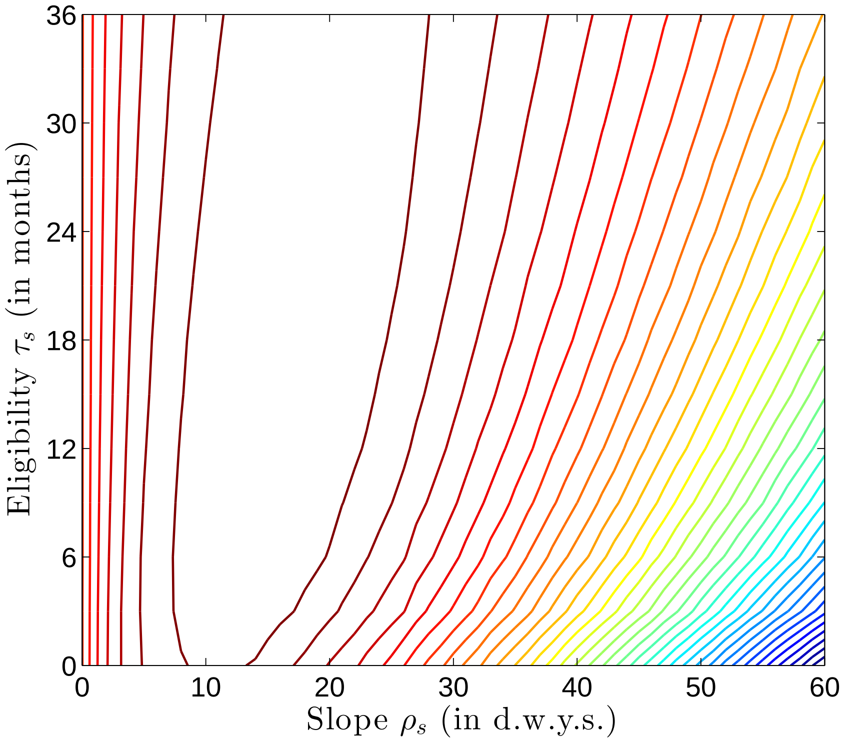

Figure B1. Optimality criterion in the benchmark economy
This figure is a contour plot of the steady-state lifetime utility of new labour-market entrants as a function of the rate of return to each year of tenure ρ_s and minimum service tenure for eligibility τ_s.

B.2 Alternative calibrations

The alternative calibrations presented in Table B1 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 B1. Parameter values (one model period is one quarter)

Description	Parameter	Benchmark	Sensitivity check			
			(1)	(2)	(3)	(4)
Vacancy cost	k	0.2805	0.2828	0.2828	0.3202	0.2869
Unemployment income	b^y	0.2637	0.2049	0.3219	0.2539	0.2881
Unemployment income	b^o	0.1953	0.1845	0.2043	0.1569	0.2258
Exogenous separation	δ	0.0060	0.0060	0.0060	0.0060	0.0060
Initial productivity	z_0	0.3233	0.2600	0.3850	0.2970	0.3650
S.d. of productivity draws	σ_z	0.0590	0.0590	0.0610	0.0700	0.0630

B.3 The 2012 reform

Figure B2 shows the EPL scheme implemented in Spain in 2012; Table B2 reports the effects on equilibrium allocations and steady-state welfare; Figure B3 shows the transition path for this reform; Table B3 reports the welfare effects accounting for the transition dynamics.

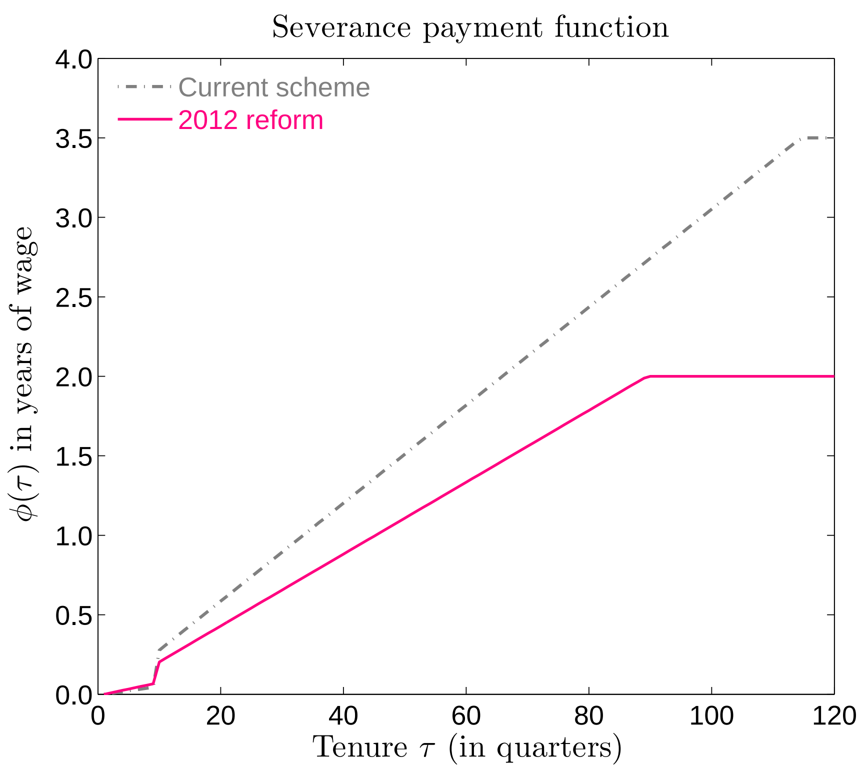

Figure B2. Current scheme vs. 2012 scheme: Comparison of the severance pay functions

Table B2. Current scheme vs. 2012 scheme: Steady-state comparison

Description	Baseline	2012 scheme
Unemployment rate, young (%)	9.0	8.8
Non-employment rate, old (%)	36.2	35.8
Non-employment rate, all (%)	15.8	15.5
Average wage, young	0.46	0.47
Average wage, old	0.43	0.40
Average productivity, young	0.57	0.57
Average productivity, old	0.62	0.62
Job destruction rate, less than 2 years of tenure (%)	7.46	6.86
Job destruction rate, more than 2 years of tenure (%)	2.08	2.19
Job finding rate (%)	40.0	40.3
Labour market tightness θ	1.00	1.01
Payroll tax κ (%)	9.25	9.03
Welfare of a newborn worker (%, relative to baseline)	–	0.86

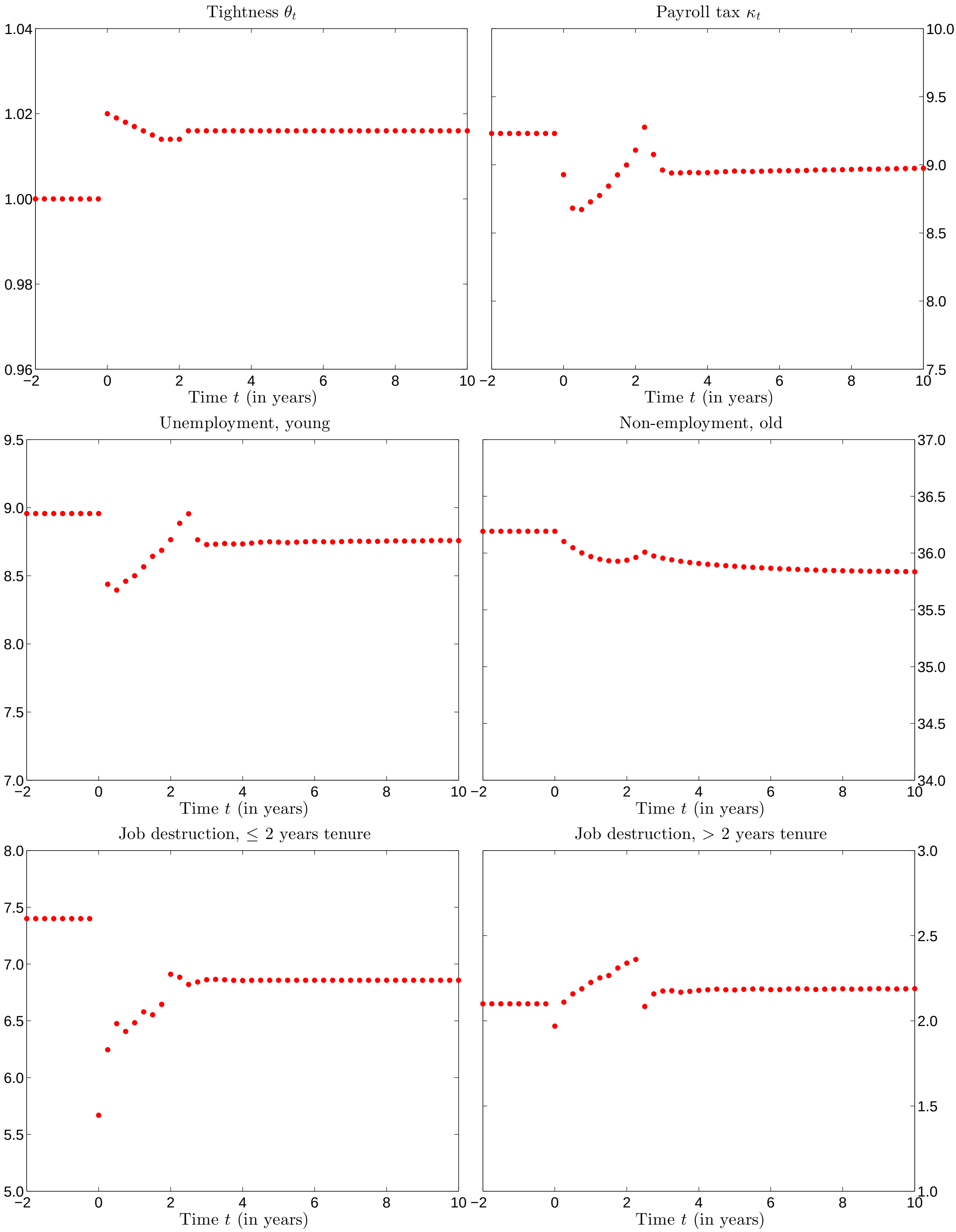

Figure B3. Transition dynamics towards the 2012 scheme

The charts display the time path of several labour market variables during the transition towards the 2012 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 SOEC, which occurs in period 0.

Table B3. Welfare effects of the 2012 reform

	Overall effect (1)	Effect of 2012 scheme (2)	Effect of θ_t (3)	Effect of κ_t (4)
All workers	0.384	0.177	0.049	0.158
Young workers	0.657	0.451	0.059	0.171
	[-0.270, 2.026]	(68.6)	(9.0)	(26.0)
Older workers	-1.010	-1.113	0.000	0.003
	[-4.980, 7.420]	(110.2)	(0.0)	(-10.2)

NOTE: Column 1 present the overall effect of the policy reform. Columns 2, 3, 4 decompose the reform into three consecutive adjustments: effects of introducing the 2012 scheme (Column 2), the resulting change in θ (Column 3) and the resulting change in κ (Column 4). An entry in Panel A of the table is the percentage change in lifetime consumption. The numbers in squared brackets are the minimum and maximum welfare change experienced by workers. The numbers in parenthesis in Columns 2, 3, 4 are the relative contribution of each consecutive adjustments.