# Moving towards a Single Labour Contract: Transition vs. Steady State*

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**Abstract**

This paper analyzes the optimal design of a single open-ended contract (SOEC) and studies the political economy of moving towards such a SOEC in a dual labour market. We compare two economic environments: one with flexible entry-level jobs and high employment protection at long tenure, and another with a SOEC featuring employment protection levels that increase smoothly with tenure. For illustrative purposes, we specialize the discussion of such choices to Spain, a country often considered as an epitome of a dual labor market. A SOEC has the potential of bringing big time efficiency and welfare gains in a steady-state sense. We also identify winners and losers among younger and older workers in the transitional path of such a reform and analyze its political support.

**Keywords:** Single contract; Employment Protection; Dualism; Labour Market Reform

**JEL codes:** H29, J33, J65

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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, 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 employees in identical jobs are not entitled to the same compensation in case of dismissal. In effect, a stylized feature of these labour markets is that workers hired under open-ended/permanent contracts (PC hereafter) are entitled to stringent EPL, while those under fixed-term contracts (FTC henceforth) 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 types of workers makes employers reluctant to transform FTC into PC. As a result, FTC become "dead ends" rather than "stepping stones" toward job stability, 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., 2012) 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), as well as in 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 which advocate the suppression of the firing-cost gap 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 (SOEC hereafter) for new hires.[3] The key feature of 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). In this fashion, a SOEC would provide a sufficiently long entry phase and a smooth rise in protection as job tenure increases, in stark contrast with the 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

[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., Andres et al. 2009) most FTC are abolished – the exception being replacement contracts for maternity or sickness/disability leaves.

been rather vague on their specific recommendations.[4] 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 redundancy 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, not much is known about the magnitude of the allocational and welfare improvements 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 where to investigate the effects of introducing a SOEC in a dual labour market. For tractability, we abstract from modeling FTC and PC separately, as well as ignore the corresponding conversion decision at the termination date of the former.[5] Instead we focus on a labour market with just one type of contract which is characterized by a discontinuous shift in redundancy pay after a few years of job tenure. In this fashion, the first period of this contract plays a similar role to FTC, except that it has not got a prespecified termination dates, while the later periods become akin to those under a PC. In exchange for this analytical shortcut, a distinctive feature of our model is that workers are risk averse and therefore demand insurance. This is the feature that enables us to compute the optimal tenure profile according to some pre-specified aggregate welfare criterion.

More specifically, our model has a life-cycle structure where *young* and *older* workers coexistin the labour market, and the former become older at a given rate.[6] Both receive severance pay but differ as regards the use they can make of this compensation. So, while young workers are modeled as living from hand to mouth, and therefore consume dismissal compensation upon reception (say, because of binding credit constraints associated to lower job stability; see Crossley and Low, 2014), older workers 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 labor market at an age close to retirement. In this way, job security provided by EPL can play an important role in bridging the gap until full retirement. In addition, since our focus is on the political economy of the reform introducing SOEC, steady-state comparisons as well as transitional dynamics are considered.

Optimality is defined in terms of the welfare of a *newborn* in a steady state but we also consider average welfare across the *current* population when taking into account the transition from a dual EPL system to SOEC. While the former criterion accounts for the introduction of a SOEC in a retroactive manner, that is, without looking at the transition from the extant regulation to the SOEC, the latter implies a non-retroactive regulatory change that also takes the transition into account.

[4]See Chapter 4 of the OECD 2014, Employment Outlook devoted to this topic.

[5]Both are issues which have been extensively dealt with in the literature; see, *inter alia*, Blanchard and Landier (2002), Cahuc and Postel-Vinay (2002) and Bentolila et al, (2012).

[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.

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. Specifically, once the parameters are calibrated to reproduce a set of targets prior to the crisis, we compute the optimal tenure profile of redundancy pay according to the above-mentioned criteria. Another important elements in our setup are that unemployment benefits are financed by a payroll tax and that severance pay has in part a layoff tax nature due the existence of red-tape cost associated to litigation procedures. In this fashion, our analysis is related to Blanchard and Tirole (2008)'s discussion of whether the contribution rate –the ratio between layoff taxes and unemployment (UI) benefits – should be greater than, equal or lower than one, depending on the nature of the deviation from their benchmark model where risk-averse workers can be insured by risk-neutral firms.

Indeed, Blanchard and Tirole (2008) is one the main forerunners of this paper. However, while their focus is essentially normative and does not provide actual figures that would inform specific labour market policies, ours is positive being interested in modeling key features of a notoriously 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 of precautionary savings with costly search effort 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 job separations. Yet, at the expense of not modelling savings for computational simplicity, we differ from them in allowing for: (i) wages to be determined through bilateral bargaining, (ii) tenure to be a state variable of the job, (iii) severance payments to depend on job tenure, and (iv) analysis of transitional dynamics rather than exclusive focus on steady-state comparisons. There is also García Pérez and Osuna (2014) who also look at the effects of moving towards a SOEC in the context of the Spanish labour market. The main differences between our approach and theirs is that: (i) they impose a given tenure profile in a SOEC rather than deriving it, and (ii) workers are risk neutral in their setup whereas they are risk averse and value consumption smoothing in ours. Finally, there is a recent paper by Boeri et al. (2013) which proposes a rationale for mandatory severance pay increasing with tenure on the basis that financing initial investment in training trough wage deferrals is not sustainable if employers cannot commit to keep workers who have invested in training. As before, their model is again one where agents are risk neutral and they do not derive specific tenure profiles.

Our main findings are as follows. First, having calibrated the model for Spain, we find that a SOEC with two years of eligibility period and a slope of 9 d.w.y.s maximizes the welfare of the the newborn. 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 equilibrium measure of open vacancies increases significantly which leads to short unemployment spells among young workers. The payroll tax can be lowered by half a percentage point as a result of the decline in the unemployment rate. The early retirement rate rises slightly, but the overall employment effect remains positive. Our findings further suggest significant welfare gains associated with the introduction of the

SOEC. These can be attributed to a smoother wage profile at short tenures as well as higher entry wages. Further welfare gains result from a tighter labor market and the reduction in the payroll tax. Several robustness exercises with respect to key parameters of the model (degree of risk aversion, UI generosity, proportion of quits, etc.) show that the changes experienced by the optimal SOEC are not large. Further, along the transition from a dual EPL system to SOEC we identify winners and losers from the reform as well as the fraction of the population supporting it. Our analysis suggest that roughly 80 percent of the population would be in favor, 10 percent would be against, and the remaining 10 percent would be indifferent to such a reform.

The rest of the paper is structured as follows. Section 2 lays out the main ingredients of the model. Section 3 proceeds to calibrate the model to the Spanish labour market prior to the Great Recession. Section 4 presents the main numerical results of the paper, including the optimal design of the SOEC, a comparison across steady states, results for the transitional phase towards the SOEC, and a discussion of the sensitivity of our results to alternative parameter values. Finally, Section 5 concludes. An Appendix presents our numerical methodology for computing steady states and transition paths.

# 2 The model

This section introduces our proposed search and matching model which is a variant of Mortensen and Pissarides (1994) accommodated to: (i) provide a role for insurance, (ii) allow workers to have different job tenure, and (iii) achieve tractability outside the steady-state to analyze 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 subscript $t$.

### Workers

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

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

where the coefficient of relative risk-aversion, $\eta$, is strictly positive, ensuring that $u'(c_t) > 0$ and $u''(c_t) < 0$. When $\eta = 1$, the utility function is logarithmic.

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 provide and enhance an insurance role for employment protection. While this has 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. Each 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 maximize the sum of profit streams discounted by an interest rate $r$, which is exogenous and fixed.

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 $v_t$ and $u_t$ are the number of vacancies and job-seekers, 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 $\theta_t \equiv v_t/u_t$. Likewise, the job-finding probability for workers, $\theta_t q(\theta_t)$, is increasing in $\theta_t$.

A worker-firm match is characterized by its idiosyncratic productivity $z$. 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 $\prod = \left(\pi_{z,z'}\right)$. Fluctuations in productivity may induce the worker-firm pair to destroy the job.[7]

Finally, anticipating on the design of employment protection schemes, we denote by $\tau$ 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 $\tau$ is: $\tau' = \min\{\tau + 1, T\}$. As a result, notice that there are two state variables for every worker-firm pair: tenure ($\tau$) and productivity ($z$).

### Young vs. older workers

The working life span is uncertain and in each period a fraction of newborns enters the labour market to maintain the size of the workforce at a constant unit level. We distinguish young ($y$) workers from older ($o$) workers. As in Castaneda et al. (2003), it is assumed for tractability of the model that ageing and retirement occur stochastically: at the end of each period, young workers become older with probability $\gamma$ while older workers, when dismissed, enter early retirement and later die with probability $\chi$.

As anticipated earlier, there are two key 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 complete markets contingent on the death shock, and are allowed to buy an annuity from firms upon separation from the job. In so doing, they can increase their consumption until leaving the workforce and passing away.

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

[7] 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.

for jobs once unemployed, the distribution of this type of workers across tenure levels in the previous job has no direct effect on firms' vacancy posting decisions. Conversely, young unemployed workers are homogeneous in that 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 steady-state.

### Government-mandated programs

The government runs two labour market programs: unemployment insurance and employment protection schemes. The provision of unemployment insurance is financed by the proceeds of a payroll tax $\kappa_t$. Importantly, we assume that the budget for this program is balanced in every period (Ricardian equivalence). The employment protection program, in turn, is self-financed (details follow).

The unemployment insurance program provides a constant-level benefit $b$ to the nonemployed. There is no monitoring technology, and therefore older workers can collect $b$ after a job loss, despite stopping search for jobs.

In line with a long-established literature (e.g. Bertola and Rogerson, 1997), it is assumed that redundancy costs have two components: (i) a transfer from the firm to the worker paid at the time of job separation (i.e., government mandated severance pay), and (ii) a firing tax representing red-tape costs involved in the dismissal procedure.[8] The severance pay component, denoted as $\phi(\tau)$, is a function of tenure $\tau$. Workers receive a fraction $\upsilon$ of the severance package while $(1-\upsilon)$ is the fraction of red-tape costs.

### Disposable income

Having described the environment, we are now 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 $w_t^i(z,\tau)$, where $i \in \{y,o\}$ is the age of the worker, after bargaining over the surplus of the match (details follow). Notice that the wage can be contracted upon $z$ and $\tau$, the age of the worker $i$, and that it may depend on calendar time $t$.

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

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

where older workers' unemployment benefits are denoted by $b^o$. The latter term in (3) represents the payoff of an actuarially fair annuity associated with the severance payment $\upsilon\phi(\tau)$, where $1/\chi$ is the expected number of periods until dying.

[8]In 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.

## 2.2 Bellman equations

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

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

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

where $W_{t+1}^y(z_0, 0)$ denotes a young worker's asset value of being employed at the entry productivity level and no tenure. An old unemployed worker with tenure $\tau$ in the previous job has flow income $\widetilde{b}(\tau)$ and remains in the labour market with probability $1-\chi$, such that the corresponding asset value becomes $U_t^o(\tau)$:

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

Notice that this differs from the behaviour of young workers. These workers consume their wage $w_t^y(z, \tau)$ while employed at a job with productivity $z$ and tenure $\tau$, ; yet, in the event of job destruction, their asset value becomes $\tilde{U}_t^y(\tau) = U_t^y + u(b + \phi(\tau)) - u(b)$, 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:

$$\begin{aligned} W_t^y(z, \tau) =& u\left(w_t^y(z, \tau)\right) + \frac{1}{1+r}\left((1-\gamma)\sum_{z'} \pi_{z,z'} \max\left\{W_{t+1}^y(z', \tau'), \tilde{U}_{t+1}^y(\tau')\right\}\right. \\ & \left. + \gamma \sum_{z'} \pi_{z,z'} \max\left\{W_{t+1}^o(z', \tau'), U_{t+1}^o(\tau')\right\}\right) \end{aligned} \tag{6}$$

Finally, the value of employment for older workers, is given by:

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

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

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

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

## 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:

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

$$w_t^o(z,\tau) = \arg\max_w \left(W_t^o(z,\tau;w) - U_t^o(\tau)\right)^\beta \left(J_t^o(z,\tau;w) + \Phi(\tau)\right)^{1-\beta} \quad (11)$$

for all $(z,\tau)$. For future reference, it is useful to write the first-order condition associated with the above maximization problems, namely,

$$(1-\beta)\frac{1+\kappa_t}{J_t^y(z,\tau)+\phi(\tau)} = \beta\frac{u'\left(w_t^y(z,\tau)\right)}{W_t^y(z,\tau) - \tilde{U}_t^y(\tau)}. \quad (12)$$

$$(1-\beta)\frac{1+\kappa_t}{J_t^o(z,\tau)+\Phi(\tau)} = \beta\frac{u'\left(w_t^o(z,\tau)\right)}{W_t^o(z,\tau) - U_t^o(\tau)}. \quad (13)$$

On the one hand, the numerator in the left-hand side of equations (12) and (13) is the effect for the firm of a marginal reduction in the wage, which increases profit streams by $1+\kappa_t$. On the other hand, 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 (right-hand side of the equations). 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]

[9]Another implication is that Lazear (1990)'s "bonding critique" is not applicable to our setup. That is, workers and firms cannot fully neutralize severance payments because they differ as to their valuation of a reallocation of payments over time; see Lalé (2014) 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 upon.

## 2.4 Separation decisions

Associated with the maximization of the asset value functions of employment, there are productivity thresholds determining separation decisions. Let $\bar{z}_t^y(\tau)$ (resp. $\bar{z}_t^o(\tau)$) denote the productivity cutoff for a match with a young (resp. old) worker with tenure $\tau$. The threshold $\bar{z}_t^i(\tau)$, with $i \in \{y, o\}$, 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,

$$W_t^y(\bar{z}_t^y(\tau), \tau) = \tilde{U}_t^y(\tau), \quad J_t^y(\bar{z}_t^y(\tau), \tau) = -\phi(\tau). \tag{14}$$

and

$$W_t^o(\bar{z}_t^o(\tau), \tau) = U_t^o(\tau), \quad J_t^o(\bar{z}_t^o(\tau), \tau) = -\phi(\tau). \tag{15}$$

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 $\tau$ would accept in a job with productivity $\tau$. These reservation wages solve:

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

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

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

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

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

A separation occurs when: $\overline{w}_t^i(z, \tau) < \underline{w}_t^i(z, \tau)$. Thus, one can determine whether the productivity threshold $\bar{z}_t^i(\tau)$ is larger than current productivity $z$ by comparing $\overline{w}_t^i(z, \tau)$ and $\underline{w}_t^i(z, \tau)$. Notice that, in equations (16)–(19), reservation wages depend on calendar time $t$ both through the outside option of agents and the payroll tax $\kappa_t$.

## 2.5 Flow equations

Using labour market tightness $\theta_t$ and separation decisions $\overline{z}_t^y(\tau)$ and $\overline{z}_t^o(\tau)$, we are now in a position to write the flow equations that govern the evolution of the population distributions in the labour market. 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 $\tau$ at time $t$. Likewise, let $\mu_t^y$ (resp. $\mu_t^o(\tau)$) denote the population of young (resp. older) unemployed workers. Note that for older unemployed workers we need to keep track of the tenure variable.

In employment, new hires are given by:

$$\lambda_{t+1}^y(z_0,0) = \theta_t q(\theta_t)(1-\gamma)\mu_t^y, \tag{20}$$

while employment in on-going jobs ($\tau' > 0$, where $\tau'$ denotes tenure in the future) evolves according to:

$$\lambda_{t+1}^y(z',\tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}(1-\gamma)\lambda_t^y(z,\tau), \tag{21}$$

$$\lambda_{t+1}^o(z',\tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_{t+1}^y(z,\tau) + (1-\chi)\lambda_{t+1}^o(z,\tau)\right). \tag{22}$$

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

$$\mu_{t+1}^y = \overline{\mu}^y + (1-\theta_t q(\theta_t))(1-\gamma)\mu_u^y + (1-\gamma)\sum_\tau\sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}\lambda_t^y(z,\tau), \tag{23}$$

where $\overline{\mu}^y = \chi\frac{\gamma}{\chi+\gamma}$ is the mass of new entrants in every period.[10] Among the old non-employed with tenure level $\tau$ at the time of being dismissed from the previous job, the law of motion is:

$$\begin{aligned}\lambda_{t+1}^o(\tau) = \gamma\mu_t^y\mathbb{1}\{\tau=0\} &+ (1-\chi)\mu_t^o(\tau)\\ &+\sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_t^y(z,\tau) + (1-\chi)\lambda_t^o(z,\tau)\right)\end{aligned} \tag{24}$$

The term with $\gamma\mu_t^y\mathbb{1}\{\tau=0\}$ accounts for the fact that a young unemployed worker becoming 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,

$$\sum_\tau\sum_z\left(\lambda_t^y(z,\tau) + \lambda_t^o(z,\tau)\right) + \sum_\tau \mu_t^o(\tau) + \mu_t^y = 1. \tag{25}$$

## 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 $\theta_t$ and the tax rate $\kappa_t$.

[10] That is, with our stochastic life-cycle, there are $\frac{\gamma}{\chi+\gamma}$ older workers in the workforce. A fraction $\chi$ of them leaves every period, and the same number of individuals enters the labour market to keep the size of the workforce at a constant level.

**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

$$\frac{k}{q(\theta_t)} = \frac{1}{1+r} J^y_{t+1}(z_0, 0). \tag{26}$$

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 agents in period $t$ are fully determined once value functions in period $t+1$ are known.

**Balanced budget**

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

$$\kappa_t \sum_\tau \sum_z \left( w^y_t(z,\tau)\, \lambda^y_t(z,\tau) + w^o_t(z,\tau)\, \lambda^o_t(z,\tau) \right) = b \left( \sum_\tau \mu^o_t(\tau) + \mu^y_t \right) \tag{27}$$

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

## 2.7 Transition and steady-state

Once the economic environment and equilibrium conditions have been described, 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 steaty-state equilibria which are 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 $\big(U^y_t,\ U^o_t(\tau), W^y_t(z,\tau), W^o_t(z,\tau), J^y_t(z,\tau), J^o_t(z,\tau)\big)_{t=t_0,\ldots,t_1}$, a sequence of wage functions $\big(w^y_t(z,\tau),\ w^o_t(z,\tau)\big)_{t=t_0,\ldots,t_1}$, a sequence of rules for separation decisions $\big(\bar{z}^y_t(\tau),\ \bar{z}^o_t(\tau)\big)_{t=t_0,\ldots,t_1}$, a time-path for labour market tightness $(\theta_t)_{t=t_0,\ldots,t_1}$ and for the payroll tax $(\kappa_t)_{t=t_0,\ldots,t_1}$, and a sequence of distribution of workers across employment status, productivity levels, tenure and age groups $\big(\mu^y_t,\ \mu^o_t(\tau),\ \lambda^y_t(z,\tau), \lambda^o_t(z,\tau)\big)_{t=t_0,\ldots,t_1}$ 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 $\big(w^y_t(z,\tau), w^o_t(z,\tau)\big)_{t=t_0,\ldots,t_1}$, the value functions $U^y_t$, $U^o_t(\tau)$, $W^y_t(z,\tau)$, $W^o_t(z,\tau)$, $J^y_t(z,\tau)$, $J^o_t(z,\tau)$ satisfy equations (4) – (9), respectively, in every period $t$.

2. Separation: Given the sequence of value functions $\big(U^y_t,\ U^o_t(\tau), W^y_t(z,\tau), W^o_t(z,\tau), J^y_t(z,\tau), J^o_t(z,\tau)\big)_{t=t_0,\ldots,t_1}$, the separation decisions $\bar{z}^y_t(\tau)$, $\bar{z}^o_t(\tau)$ satisfy equations (14) and (15), respectively, 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 equations (12) and (13), respectively, in every period $t$ in matches where $z \geq \bar{z}_t^i(\tau)$ and $i \in \{y,o\}$.

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 (26)

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 (27)

6. Law of motion: Given $(\theta_t)_{t=t_0,\ldots,t_1}$ and the sequence of rules for separation decisions $\big(\bar{z}_t^y(\tau),$ $\bar{z}_t^o(\tau)\big)_{t=t_0,\ldots,t_1}$, the distribution $\mu_t^y$, $\mu_t^o(\tau)$, $\lambda_t^y(z,\tau)$, $\lambda_t^o(z,\tau)$ evolves between from $t$ to $t+1$ according to the law of motion described in equations (20) – (25).

When all exogenous features of the economic environment (policy parameters, preferences, etc.) remain invariant, and absent aggregate shocks, 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 $\theta_{\bar{t}}$ and the rules for separation decisions $\big(\bar{z}_{\bar{t}}^y(\tau),\ \bar{z}_{\bar{t}}^o(\tau)\big)$, the distribution $\mu_{\bar{t}}^y$, $\mu_{\bar{t}}^o(\tau)$, $\lambda_{\bar{t}}^y(z,\tau)$, $\lambda_{\bar{t}}^o(z,\tau)$ is invariant for the law of motion described in equations (20) – (25).

Before turning to numerical applications, we stress a difference between the two aggregate quantities of this economy, namely labour-market tightness $\theta_t$ and the tax rate $\kappa_t$. On the one hand, notice that $\theta_t$ is a forward-looking variable as per equation (26). 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 $\kappa_t$ 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 $\theta_t$ and $\kappa_t$. Appendix A provides the details of our numerical methodology for computing transition paths and steady-state equilibria.

# 3 Calibration and steady-state outcomes

This section describes our calibration and characterizes 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 in the Euro area.

## 3.1 Calibration procedure

We need a number of preliminary specifications in order to list the parameters of the model. Firstly, we parameterize the Markov process for match-specific idiosyncratic productivity as follows. We assume that $z$ takes on values in the interval $[0,1]$ and remains unchanged from one period to the next with probability $\pi_{\bar{z}}$. With complementary probability $1-\pi_{\bar{z}}$, $z$ 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. Next, as indicated in subsection 2.1, jobs are also subject to an exogenous separation shock; we posit that this shock is realized with per-period probability $\delta$.

Under these specifications and assuming no red-tape costs ($\upsilon = 1$) in the benchmark case, the model has 15 parameters, namely $\{r,\ \eta,\ \gamma,\ \chi,\ T,\ \psi,\ \beta,\ A,\ k,\ b^y,\ b^o,\ \delta,\ z_0,\ \pi_{\bar{z}}, \sigma_{\bar{z}}\}$. [11]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 sequel, 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 standard 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.[12] We set the cap on tenure, $T$, equal to 120 model periods, i.e., 30 years.[13] Finally, following standard practice 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 remaining eight rows in Table 1 show the parameters set within the model. We aim at matching the following eight moment conditions, most of which are obtained from the Spanish Labour Force Survey for 2005-2007: (1) the average unemployment spell for young workers is 2.5 quarters, i.e., 7.5 months; (2) the quarterly job destruction rate for temporary jobs is 7.5 percent (García Pérez and Osuna, 2014); (3) the quarterly job destruction rate for permanent jobs is 2.1 percent (García Pérez and Osuna, 2014); (4)-(5) 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 set at 58 percent;[14] (5) the replacement rate of unemployment benefits for older workers, $b^o/\widetilde{w}^o$, is set at 44 percent;[15] (6) the

[11]Later on in Section ?, we allow for the existence of red-tape costs when conducting robustness exercises.

[12]Notice that this is also consistent with the observation that workers aged 55–64 account for about 25 percent of the working-age population in Spain.

[13]That is, with a deterministic lifecycle, no worker (including the young) would ever reach the maximum tenure level.

[14]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 will perform a sensitivity analysis later.

[15]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

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

| Description | Parameter | Value | Moment | Target |
|---|---|---|---|---|
| *Calibrated externally* | | | | |
| Interest rate | $r$ | 0.01 | | |
| Risk aversion | $\eta$ | 2 | | |
| Ageing probability | $\gamma$ | 1/120 | | |
| Retirement probability | $\chi$ | 1/40 | | |
| Cap on tenure | $T$ | 120 | | |
| Matching function | $\psi$ | 0.5 | | |
| Bargaining power | $\beta$ | 0.5 | | |
| *Calibrated internally* | | | | |
| Matching function | $A$ | 0.4000 | Job-finding prob. (%) | 40.0 |
| Vacancy cost | $k$ | 0.1567 | Tightness (norm.) | 1.00 |
| Unemployment income | $b^y$ | 0.2573 | Replacement rate (%) | 58.0 |
| Unemployment income | $b^o$ | 0.2135 | Replacement rate (%) | 45.4 |
| Exogenous separation | $\delta$ | 0.0060 | Fraction of quits (%) | 20.0 |
| Initial productivity | $z_0$ | 0.1429 | Job destr. ($\leq$2 years, %) | 2.09 |
| Persistence of productivity | $\pi_{\bar{z}}$ | 0.2210 | Job destr. ($>$2 years, %) | 7.45 |
| S.d. of productivity draws | $\sigma_{\bar{z}}$ | 0.2000 | Non-empl. (old, %) | 40.0 |

non-employment rate among (male) workers aged 55-64 is 40 percent; (7) quits account for about 20 percent of all separations (Rebollo-Sanz, 2012).[16] To be precise about (6), we consider the non-employment rate of male workers instead of the overall non-employment rate because the latter is driven down by the low participation rates of women aged 55 to 64 reasons, which cannot be explained by the model. As for quits (7), we use this observation to calibrate $\delta$. That is, $\delta$ puts an upper bound on the number of job separations that could be deterred by enforcing tougher employment protection.[17] This upper bound cannot be directly observed in the data, which is why we use a proxy for it. These observations yield a total of six calibration targets. Finally, we follow standard practices and normalize labour market tightness $\theta$ to unity while the free-entry condition is used to pin down the vacancy-posting cost $k$.

### Benchmark severance payments

The crux of our analysis relates to the severance pay function. We follow Bentolila et al. (2012) 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.[18] As the latter authors do, we specify it as a function

duration of 10 years, this yields a weighted average of $2 \cdot 0.67 + 8 \cdot 0.4 = 0.454$.

[16]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.

[17]Following an exogenous separation, we assume that the firms pays the worker the severance package to which she/he is entitled. That is, we do not interpret the $\delta$ shock as a quit decision (it is not a decision). Rather, we use $\delta$ to discipline the elasticity of the separation rate to changes in the employment protection scheme. In sensitivity checks, we will assess to what extent our results change if we assume that severance payments are waived in the event of an exogenous separation.

[18]Later on, 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 García Pérez and Osuna (2014) for details). We use the pre-reform EPL scheme since our calibration targets are based on pre-2012 data.

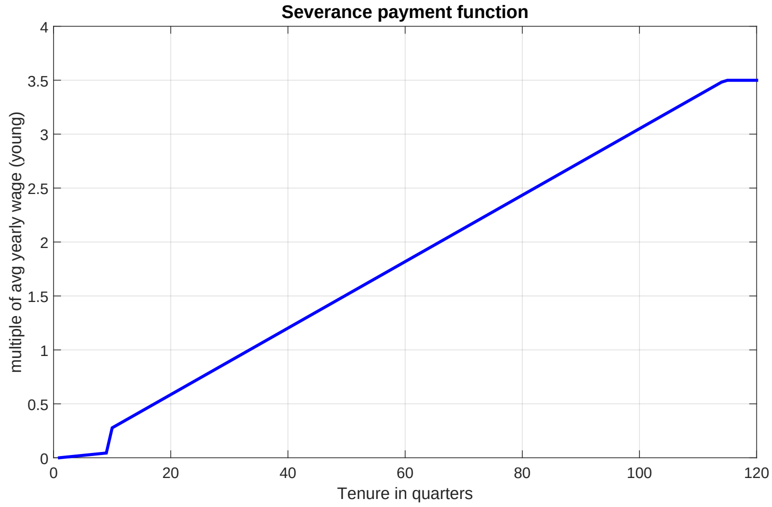


**Figure 1.** Severance payments in the benchmark economy

of the average annual wage in the labour market, rather than as a function of individual tenure and/or productivity. This simplifying assumption facilitates the solution of the model considerably, because no knowledge on the wage profile is required when specifying $\phi(\tau)$.[19]

In particular, we use the following pieces of information to compute $\phi(\tau)$. We identify the first two years of employment with those 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. 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 average yearly wage.

Using these pieces of information, the severance cost function used in the benchmark economy for workers with tenure $\tau$ (in quarter) at the current firm is computed as follows:

$$\phi(\tau) = \begin{cases} (8/365) \times \widetilde{w} \times \tau, & 1 \leq \tau \leq 8 \\ (45/365) \times \widetilde{w} \times \tau, & 9 \leq \tau \leq 113 \\ (45/365) \times \widetilde{w} \times 113, & \tau > 113 \end{cases} \tag{28}$$

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

[19] It is important to note that the average wage is an equilibrium outcome of the model, not a pre-specified parameter. Thus, upon computing a steady-state equilibrium, we add an outside loop to iterate over the average wage used to specify the severance payment function.

**Table 2.** Benchmark model economy: Comparison with the data

| Description | Model | Data | Comment |
|---|---|---|---|
| Unemployment rate, young (%) | 8.9 | 8.6 | |
| Non-employment rate, old (%) | 40.4 | 40.0 | part of calibration |
| Non-employment rate, all (%) | 15.9 | 17.2 | |
| Replacement rate $b^y/\widetilde{w}^y$ (%) | 58.0 | 58.0 | part of calibration |
| Replacement rate $b^o/\widetilde{w}^o$ (%) | 45.4 | 45.4 | part of calibration |
| Average wage, young | 0.44 | – | |
| Average wage, old | 0.47 | – | |
| Relative wage (young/old) | 0.93 | 0.87[a] | |
| Average productivity, young | 0.55 | – | |
| Average productivity, old | 0.70 | – | |
| Job destruction rate, $\leq$2 years of tenure (%) | 7.5 | 7.5 | part of calibration |
| Job destruction rate, $>$2 years of tenure (%) | 2.1 | 2.1 | part of calibration |
| Share of quits among separation (%) | 18.5 | 20.0 | part of calibration |
| Job finding rate (in %) | 40.0 | 40.0 | part of calibration |
| Payroll tax (in %) | 11.66 | 14.95[b] | |

NOTE: [a] Own calculations, based on data from the Spanish Wage Structure Survey (EES): The average wage for young (resp. older) workers is €1,522 (resp. €1,741). [b] Own calculations based on estimates of the overall payroll tax in Spain, which finances unemployment benefits and active labor market policies. The overall payroll tax paid in Spain by employers and workers is about 38% of the wage.

## 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 in the table, the model fits the moments targeted in our calibration strategy almost exactly. Moreover, most non-targeted moments are reasonably close to the corresponding data values. The simulated unemployment rate among young workers in the benchmark economy is 8.9 percent, while the corresponding value in the data is slightly lower at 8.6 percent. Likewise, the aggregate non-employment rate among all workers in our benchmark economy is 16.8 percent against 15.9 percent in the data. Regarding wage differentials, the model generates a gap of 6.9 percent ($0.4707/0.4379-1$) between the average wage of older workers and young workers. This value compares reasonably well with the wage gap observed in the Wage Structure Survey (EES), namely 14.5 percent (€1,522 for younger vs. €1,741 for older workers). Finally, the budget-balancing payroll tax is 11.7 percent in the model. This is a slightly lower number than the actual value of 14.9 percent (the latter is computed as the sum of employers' and workers' social security contributions that are related to unemployment benefits).

We now provide more insight on the equilibrium behavior of worker-firm matches in the model. First, note that the calibrated productivity process implies that new jobs start at a relatively low productivity level ($z_0 = 0.14$). Conditional on not being separated exogenously, worker-firm matches then experience a new productivity draw on average every $1/\pi_{\bar{z}} = 4.5$ quarters. Recall that the new productivity value $z'$ is drawn from a Normal distribution, centered around the current productivity $z$. This entails an additional element of persistence while maintaining the possibility to "climb up" or "fall down" the productivity ladder.

Figure 2 depicts the job destruction region for young and older workers in our benchmark economy (this is a graphical representation of the productivity cutoffs $\bar{z}^y(\tau)$ and $\bar{z}^o(\tau)$). First, note that newly-formed matches start at a productivity level that is very close to the corresponding separation threshold. As a result, most matches that face an adverse productivity draw over the first quarters of tenure will be 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 be converted into permanent jobs and they are characterized by a substantially lower job destruction rate at longer tenures.

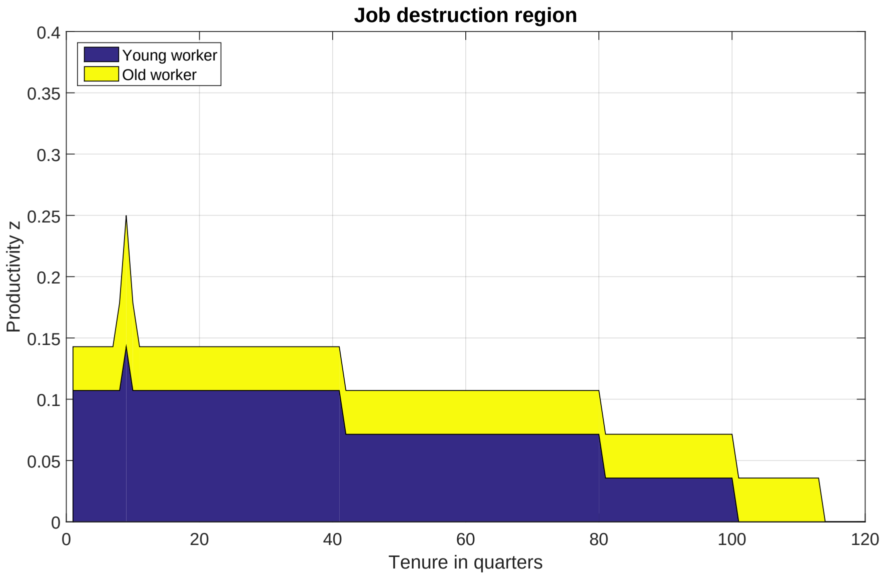


**Figure 2.** Separation thresholds in the benchmark economy

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 if a temporary contract is converted into a permanent contract (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 as the temporary contract comes to an end.

As can be seen in Figure 2, productivity cutoffs are generally higher for older workers because they have access to buying an annuity. This opportunity increases their outside option value in the wage bargaining process. As a result, for given tenure, firms are more demanding with low-productivity older workers than with low-productivity young workers. Finally, the job destruction region is decreasing in tenure as firms find it more costly to fire a worker and pay the severance package.

The wage-tenure profiles for young (upper chart) and older workers (lower chart) are depicted in Figure 3. In both charts, the solid line represents the Nash-bargained wage profile for the initial productivity level $z_0 = 0.14$ by tenure. The dotted and the dashed lines represent wage profiles for matches operating at selected higher productivity levels. There are several important observations. 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 the shape of the severance pay function and the fact that wages are renegotiated every



**Figure 3.** Wage function in the benchmark economy: young (upper) and old workers (lower chart) The plot shows the wage function in the benchmark economy, in low-productivity (solid line), middle-productivity (dotted line) and high-productivity (dashed line) matches. Wage functions are plotted as a function of tenure ($\tau$).

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, their outside option of unemployment increases only very gradually with tenure because a larger severance payment buys them only a one-time increase in the level of consumption (at diminishing marginal utility). By contrast, the wage schedule is much steeper for older workers. As their tenure increases, a more generous entitlement to severance transfers 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. Finally, it is worth emphasizing that the model generates an upward-sloping average wage-tenure profile (Figure 4, bottom panel). This outcome is driven by a combination of factors. At shorter tenures, the average wage increases due to a selection effect, because many jobs experience favorable productivity draws and unproductive jobs get quickly destroyed. At longer 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. All factors contribute to generating an increasing wage-tenure profile, which is consistent with empirical evidence.

# 4 Moving towards a SOEC

This section contains the main numerical results of the paper. We use our model economy as a laboratory to discuss the effects of moving from a dual labour market, as the one in Spain, towards a SOEC. In the first subsection below, we present our preferred choice for the optimal SOEC in our model economy. To this end, we define SOEC by restricting the tenure profile of severance pay to a simple class of functions, and then pick the welfare-maximizing SOEC. In the second subsection, we characterize allocations along the transition path towards the optimal SOEC. Finally, we analyze the welfare implications of the SOEC and discuss feasibility of the policy change.

## 4.1 Designing a SOEC

To define a SOEC, we explore a relatively simple class of severance payment functions, namely a subset of piecewise linear functions of tenure. Specifically, we consider functions of two parameters: (i) the minimum service tenure for eligibility, and (ii) days of wages per year of service (d.w.y.s.), conditional on eligibility. To be precise, we specify severance payments as

$$\phi(\tau) = \begin{cases} 0 & \text{if } \tau \leq \tau_0 \\ g \times (\tau - \tau_0) & \text{otherwise,} \end{cases}$$

where $\tau_0$ is the minimum tenure requirement for eligibility, and $g$ measures the rate of return to each year of tenure, conditional on eligibility. This class of severance payment function is easily interpretable. Notice that smoothness requires that there is no jump at the time of gaining eligibility. Smoothness of the severance pay function is consistent with workers' preference for smoothing consumption.

### Welfare criterion

In order to justify the choice for the optimal SOEC in our model, we proceed in two steps. First, we define optimality according to a specific welfare criterion, and we lay out how to measure the size of welfare effects for different subgroups of the population. Second, we compute the optimal SOEC in our benchmark model. To this end, we implement a variety of SOEC with different combinations of $\tau_0$ and $g$, and we pick the combination that maximizes welfare according to our optimality criterion.

We define the optimal SOEC as the tenure profile of severance payments that maximizes the expected utility of a newborn worker in a steady state:

$$\{\phi^*(\tau)\}_{\tau=1}^{\infty} = \arg\max\{U^y\}. \tag{29}$$

It should be noted that this criterion allows for well-defined comparisons across different steady states, because it does not depend on the distribution of workers. Moreover, we are able to study the welfare implications along different transitional paths by comparing the distribution of welfare gains/losses across workers. As is standard in the literature, we measure welfare effects in terms of consumption equivalent units (CEU). Formally, let $V_0$ denote lifetime utility of a worker under scenario 0, and let $V_1$ be the lifetime utility of the same worker under an alternative scenario 1. The comparison of $V_0$ and $V_1$ measures the welfare effect of moving from scenario 0 to scenario 1. We express this effect in terms of CEU which can be computed as follows:[20]

$$1+\vartheta = \left(\frac{1+r+r(1-\eta)V_1}{1+r+r(1-\eta)V_0}\right)^{\frac{1}{1-\eta}}.$$

At this point, a short comment on the role of employers in the computation of welfare is in order. We abstract from them for the following reason. In our model, like in the standard DMP model, firms are owned by workers who hold identical portfolios of shares of all firms in the economy. We can abstract from including dividends in the budget constraint of each worker, because free entry and the existence of a continuum of potential employers implies that firms run on average zero profits. This implies that our welfare computation based only on workers' utility is valid.

### The optimal SOEC

We evaluate the welfare change associated with various SOEC by computing steady-state equilibria for different combinations of $\tau_0$ and $g$. Table 3 reports our results: on a given row, we fix the minimum service tenure for eligibility and we increase the slope gradually along the columns. We restrict the minimum tenure required for eligibility to be between 0 and 24 months and leave the slope unre-

[20] $1+\vartheta = \exp\left(\frac{r}{1+r}(V_1 - V_0)\right)$ if $\eta = 1$, i.e., when the utility function is logarithmic

**Table 3.** Steady-state comparisons of various SOEC

| | | Slope (in d.w.y.s.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 3 | 6 | 9 | 12 | 15 | 30 | 45 | 60 |
| Initial eligibility | | | | | | | | | | |
| (in months) | 0 | 2.48 | **2.64** | 2.62 | 2.51 | 2.35 | 2.14 | 0.71 | -1.17 | -3.30 |
| | 3 | 2.48 | 2.67 | 2.67 | 2.60 | 2.48 | 2.32 | 1.14 | -0.08 | -1.93 |
| | 6 | 2.48 | 2.68 | **2.70** | 2.65 | 2.56 | 2.42 | 1.41 | 0.37 | -1.29 |
| | 9 | 2.48 | 2.68 | **2.72** | 2.69 | 2.61 | 2.49 | 1.60 | 0.69 | -0.83 |
| | 12 | 2.48 | 2.68 | **2.73** | 2.71 | 2.64 | 2.55 | 1.75 | 0.95 | -0.61 |
| | 18 | 2.48 | 2.68 | 2.74 | **2.74** | 2.70 | 2.63 | 1.98 | 1.36 | -0.05 |
| | 24 | 2.48 | 2.68 | 2.75 | **2.76** | 2.74 | 2.69 | 2.16 | 1.67 | 0.45 |

NOTE: An entry in the table is the percentage change in lifetime consumption experienced by a newborn worker.

stricted.[21] 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 2 years of minimum service and a slope of 9 d.w.y.s. maximizes steady-state lifetime utility of a newborn worker. In the sequel, we refer to this combination of parameters as the *optimal SOEC*. A graphical comparison between the current EPL scheme and the optimal SOEC is provided in Figure 4 (upper panel). As can be be seen, the optimal SOEC is associated with lower severance payments than the benchmark scheme. Interestingly, we find that its slope of 9 d.w.y.s. lies between the respective figures of TC (8 d.w.y.s.) and PC (45 d.w.y.s.) under the old 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.

In the following two subsections, we will evaluate the implications of moving towards the optimal SOEC in our model economy. We will first provide a steady-state comparison between the benchmark economy and the economy with the optimal SOEC to shed more light on the allocative effects of EPL and the source of welfare gains in our model. Subsection 4.3 then proceeds with an investigation of the transitional dynamics associated with the policy reform of introducing the optimal SOEC, and a welfare analysis of the winners and losers.

## 4.2 Steady-state results

Table 4 reports a set of aggregate statistics for the steady-state equilibrium in the economy with the optimal SOEC in comparison with the benchmark economy. As can be observed in the last two columns, our analysis suggests that the introduction of the SOEC has a significant positive effect on the tightness of the labor market. As a result, unemployed workers are matched to firms at a higher rate which decreases the length of unemployment spells. The optimal SOEC, moreover, reduces the job destruction rate for short-tenured jobs below 2 years from 7.5% per quarter to 6.9% per quarter, while the job destruction rate for worker-firm matches with more than 2 years increases slightly from 2.2% to 2.3%. Overall, these effects translate into a reduction in the unemployment rate from 8.9% to 8.2%. While the non-employment rate for older workers rises slightly from 40.2% to 41.2%, the net effect on employment across the whole population remains positive (16.4% vs. 16.8%). Relative to

[21] Relaxing the maximum restriction on $\tau_0$ can potentially yield further welfare gains; however, in this paper we choose to focus on SOEC with at most 2 years of initial eligibility.

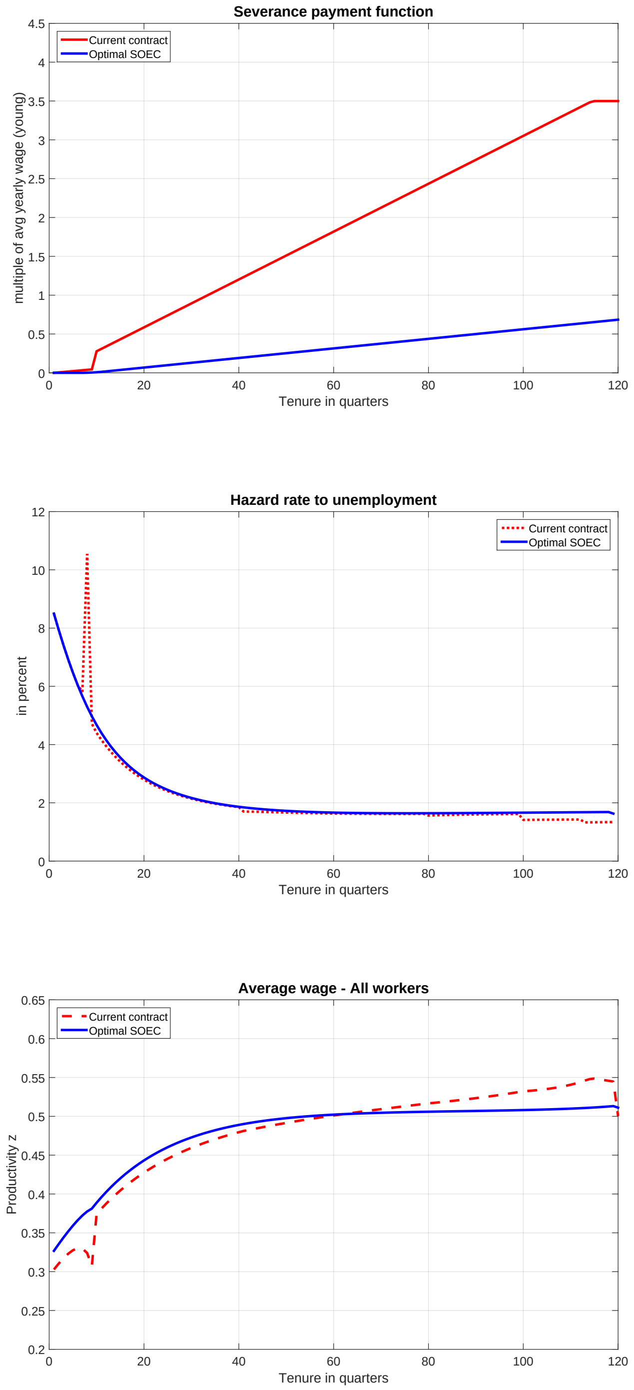


**Figure 4.** Current vs. optimal SOEC: Steady-state comparison

The upper chart compares the current severance payment scheme (reproduced from Figure 1) and the optimal SOEC. The middle chart shows the probability of job separation conditional on job tenure in the benchmark economy and in the economy with the optimal SOEC. The lower chart reports the average wage conditional on job tenure in the benchmark economy and in the economy with the optimal SOEC.

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

| Description | Data | Baseline | Optimal SOEC |
|---|---|---|---|
| Unemployment rate, young (%) | 8.6 | 8.9 | 8.2 |
| Non-employment rate, old (%) | 40.0 | 40.4 | 41.2 |
| Non-employment rate, all (%) | 15.9 | 16.8 | 16.4 |
| Average wage, young | – | 0.43 | 0.47 |
| Average wage, old | – | 0.47 | 0.39 |
| Average productivity, young | – | 0.55 | 0.57 |
| Average productivity, old | – | 0.70 | 0.71 |
| Job destruction rate, less than 2 years of tenure (%) | 7.5 | 7.5 | 6.9 |
| Job destruction rate, more than 2 years of tenure (%) | 2.1 | 2.2 | 2.3 |
| Job finding rate (in %) | 40.0 | 40.0 | 44.4 |
| Labor market tightness, i.e. $v/u$ | – | 1.00 | 1.23 |
| Payroll tax (in %) | 14.95 | 11.67 | 11.18 |
| Total output (relative to baseline) | – | – | +1.07% |
| Welfare of a newborn worker (relative to baseline) | – | – | +2.76% |

the benchmark economy, our analysis further suggests that the optimal SOEC gives rise to an increase in total output and a reduction in the budget-balancing payroll tax rate.

Figure 5 sheds more light on these results. More specifically, the middle panel draws attention to the fact that the optimal SOEC removes "revolving doors" in labor market trajectories implied by dual EPL. The characteristic spike in the hazard rate to unemployment after 2 years under the dual system disappears and is replaced by a smooth, monotonically decreasing function. The lower panel, in turn, depicts the average wage-tenure profile across productivities of surviving matches and contrasts it with the benchmark scheme. There are several key differences, pointing to potential welfare gains for consumption-smoothing seeking workers. First, the optimal SOEC implies a smoother, monotonically increasing wage profile at short tenures. As explained above, this outcome is driven by the continuous shape of the severance payment schedule. Second, the wage-tenure profile is flattened out: as the option value of future severance payments increases at a smaller rate, the degree to which they are internalized at short and medium tenures diminishes. This translates into significantly higher entry wages.

We provide further insight into the positive welfare effect of the optimal SOEC by means of a simple decomposition analysis. Starting from the benchmark economy, we run a sequence of counterfactual experiments that aim at disentangling the overall effect into four sub-components. First, we adjust the benchmark firing cost 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 it 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, raises entry wages for newly-matched workers. Thirdly, we impose the labor market tightness computed from the economy with the optimal SOEC, keeping the tax constant. Finally, we adjust the payroll tax as well. We interpret the first two steps as governing partial equilibrium effects, while the latter two steps account for general equilibrium adjustments in prices.

| | Total effect | Decomposition (in percent) Remove wall | Adjust slope | Tightness $\theta$ | Payroll tax $\kappa$ |
|---|---|---|---|---|---|
| Optimal SOEC : | $+2.76\%$ | 32.2 | 27.4 | 28.0 | 12.4 |

The table above presents our results. The total welfare gain of 2.76% is again reported in the first column. The remaining columns then provide the relative contribution of each counterfactual (the figures sum up to 100). As can be seen, partial equilibrium effects jointly account for roughly 60 percent of the overall welfare gain, while general equilibrium effects account for the remaining 40 percent. The largest contribution stems from the elimination of the discontinuity in the severance payment schedule after 2 years (32.2 percent). Decreasing the gradient yields significant further welfare gains, accounting for 27.4 percent. Finally, regarding price adjustments, our results suggests that a tighter labor market with larger job creation rates leads to greater welfare gains (28.0 percent) than the reduction in the payroll tax (12.4 percent).

## 4.3 Transitional dynamics and welfare analysis

The optimal SOEC is based on a comparison between different steady states and, thus, provides an important benchmark for the efficiency and desirability of EPL reforms. At the same time, studying the transitional period from the current to a new EPL scheme is at least equally important. There are two main reasons for this. First, changes to EPL can typically only be applied in a non-retroactive manner, i.e. workers that are employed under the old contract when the policy reform occurs cannot be exempted retroactively from their entitlements. This implies that upon introduction of any policy reform workers under the old scheme and the new SOEC will coexist. Second, studying the transition to the optimal SOEC will allow us to assess the political economy dimension of such a reform. Specifically, we are able to identify winners and losers and, on a more general level, we can assess whether there is enough political support, e.g. manifested in a simple majority of winners.

In the following, we are going to study two types of reforms. In both scenarios, the economy is in steady state under the current EPL scheme when at time $t_0$ an unanticipated reform is implemented.

- For reform 1 ("R1"), 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 $t > t_0$ will be subject to the new severance payment schedule. Workers who are still employed under the old contract have the option to remain under the old contract. If they want to change to the new SOEC, they have to dissolve their current employment relationship first and then search for a new job. Once they are matched to a firm, they are subject to the new SOEC.

- Reform 2 ("R2") implements the SOEC instantaneously not only for new matches, but also for existing ones. Specifically, we assume that, from $t_0$ onwards, all existing worker-firm matches accumulate entitlements to severance payments at a rate of 9 d.w.y.s. as prescribed by the optimal SOEC (we abstract from the initial eligibility requirement here). Any previous entitlements to severance payments accumulated during the tenure prior to the reform are retained. This assumption accounts for the fact that previously established rights cannot be affected retroactively. At the same time, workers may have different preferences about the desired tenure profile of severance pay, depending on their age, tenure and productivity.

**Reform 1 (R1)**

Figure 5 shows the time path of several labour market variables during the transition. As can be observed, most of the adjustment takes place during the first two years of the reform. 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 initial spike in employment-unemployment flows leads to a temporarily higher unemployment rate in the first 6 quarters after the reform. At the same time, since labor market tightness is a jump variable, the job-finding rate soars instantaneously as firms create more vacancies associated with the SOEC. Put together, these newly created vacancies partly offset the initial increase in the unemployment pool of young workers, leading to a permanently smaller unemployment rate from the second year onwards level. Likewise, the rise in the payroll tax required to finance unemployment benefits is short-lived. After an initial increase by roughly one percentage point, the tax rate quickly approaches values that lie below the pre-reform figure.

We now provide an analysis of the welfare gains of a non-retroactive reform during the transition (for illustrative purposes, we also compare them with those stemming from a retroactive reform where the SOEC is applied to the entire population of workers in $t_0$ and not just to the newborns). Specifically, when taking the transition into account, the average welfare gain adds lifetime utilities of young and older workers under existing matches and non-employment to the utility of the newborns, namely,

$$\sum_{\tau}\sum_{z}\left(\lambda_{t_0}^{y}(z,\tau)\,W_{t_0}^{y}(z,\tau)+\lambda_{t_0}^{o}(z,\tau)\,W_{t_0}^{o}(z,\tau)\right)+\sum_{\tau}\mu_{t_0}^{o}(\tau)\,U_{t_0}^{o}(\tau)+\mu_{t_0}^{y}U_{t_0}^{y},$$

where the distribution is from the benchmark economy, i.e., the time-invariant distribution just before the government implements the reform.

Table 5 reports the welfare effects of moving towards a SOEC for the current generation of workers. The upper and lower panels gather the results regarding a non-retroactive and retroactive reforms, respectively. In order to gain some insights about these results, columns 2-4 report the welfare changes associated with three partial-equilibrium experiments: first introducing a SOEC, then adjusting labour-market tightness, and finally letting the payroll tax change. As can be inspected, young workers benefit from the non-retroactive reform through all the three aforementioned adjustment margins. Among them, the most relevant one is the direct effect of SOEC (removing the EPL discontinuity and adjusting the slope) which accounts for 52% of their overall welfare gain averaged over the transition. By contrast, older workers only benefit from the reduction in payroll taxes, therefore making their welfare gain much smaller than that achieved by younger workers.

The main welfare changes from implementing a retroactive reform are that young workers' wel-

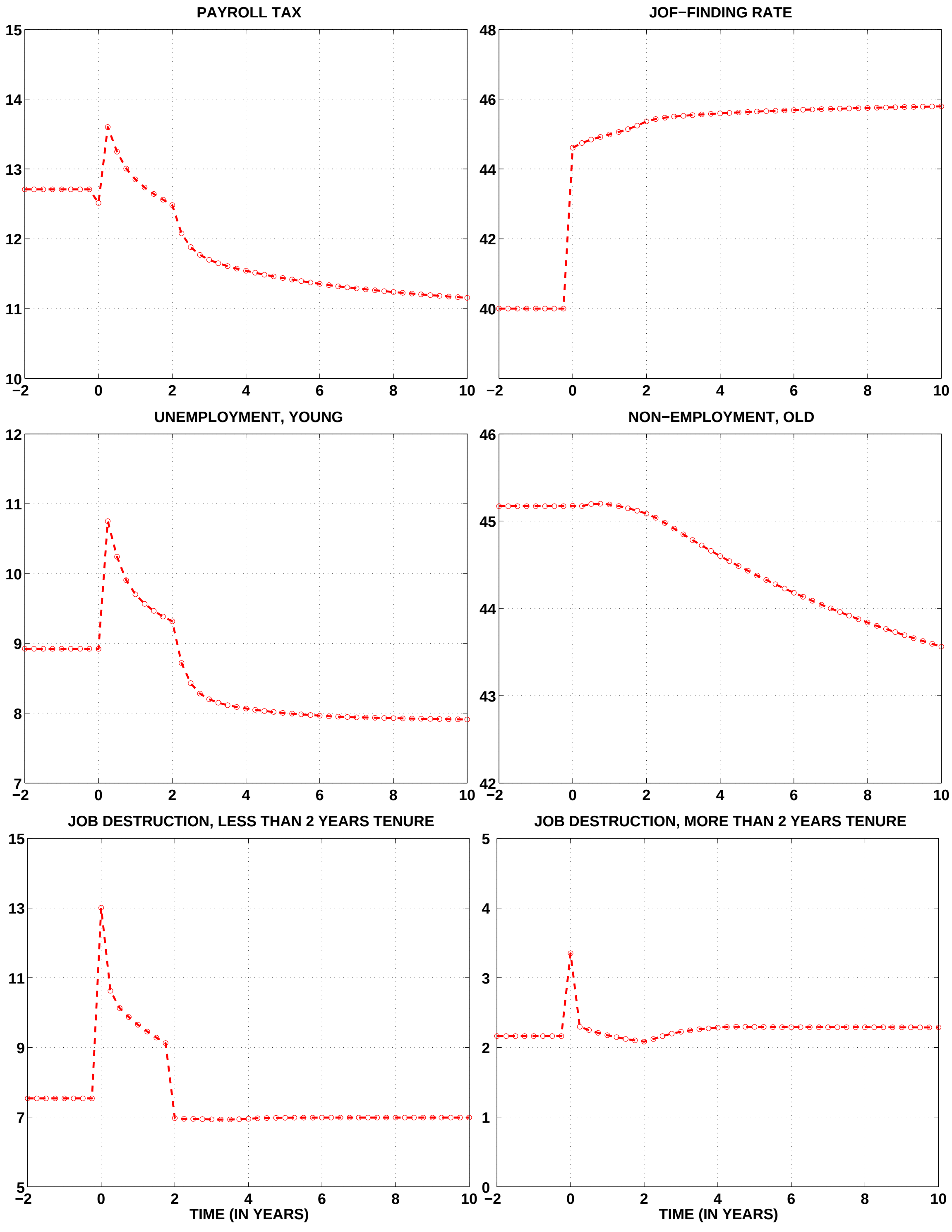


**Figure 5.** Transition dynamics: A non-retroactive introduction of a SOEC
The charts display the time path of several labour market variables during the transition towards a SOEC introduced in a non-retroactive manner. On the x-axis, time is measured in years relative to the introduction of the SOEC, which occurs in period 0.

**Table 5.** Current vs. optimal SOEC: Welfare and role of transition dynamics

| | Average welfare gain (1) | Effect of SOEC (2) | Effect of $\theta$ (3) | Effect of $\kappa$ (4) |
|---|---|---|---|---|
| **A. Non-retroactive reform** | | | | |
| Overall | 3.054 | 1.573 | 0.624 | 0.857 |
| Young workers | 3.595 | 1.861 | 0.737 | 0.997 |
| | [0.044, 4.234] | | | |
| Older workers | 0.098 | 0.0 | 0.0 | 0.098 |
| | [-0.337, 0.180] | | | |
| **B. Retroactive reform** | | | | |
| Overall | 1.257 | -0.231 | 0.629 | 0.859 |
| Young workers | 2.373 | 0.633 | 0.744 | 0.996 |
| | [-1.098, 9.091] | | | |
| Older workers | -4.846 | -4.960 | 0.0 | 0.114 |
| | [-8.101, 3.204] | | | |

NOTE: An entry in the table is the percentage change in lifetime consumption associated with the policy reform (column 1), which we further decompose into three consecutive adjustments: effects of introducing a SOEC (column 2), the resulting change in $\theta$ (column 3) and the resulting change in $\kappa$ (column 4). The numbers in brackets in column 1 are the minimum and maximum welfare change experienced by workers.

fare gains are smaller (2.37% vs. 3.59%) and that, on average older, workers would lose from this type of reform. Yet, the overall welfare gains are still positive meaning that, despite counting with less support than a non-retroactive reform, it is bound to be approved.

**Reform 2 (R2)**

[ *Transitional analysis still incomplete* ]

Table 6 reports the population shares that would gain or lose from implementing R2. As can be observed in the last row, overall, there is a large majority in favor of such a reform: almost 80 percent of the population would gain, 10 percent would lose, and the remaining 10 percent would be indifferent (those are the early retired who are, by construction, not affected). However, there is a substantial discrepancy across the two age groups: while there is universal support across young workers, (employed and unemployed), the majority of employed older workers would actually be against the reform. [...]

## 4.4 Sensitivity analysis

In this section we conduct a few sensitivity exercises to check how the shape of the optimal SOEC varies if some key parameters in the baseline setup are changed (cf. Table 7). In particular, we consider the following alternative scenarios: (i) the coefficient of risk aversion is set at $\eta = 1$ and $\eta = 3$ respectively; (ii) the UI replacement rates for young workers is set at 50 percent and 65 percent

**Table 6.** Political support for transition to SOEC (reform R2)

| | | Pro | Con | Indiff |
|---|---|---|---|---|
| Young workers | employed | 100 | 0 | 0 |
| | not employed | 100 | 0 | 0 |
| Older workers | employed | 31.7 | 68.3 | 0 |
| | not employed | 0 | 0 | 100 |
| Overall | | 79.7 | 10.2 | 10.1 |

NOTE: All numerical entries refer to population measures in percent.

respectively; (iii) there are red-tape costs such that 50% of the total severance package is lost; and (iv) exogenous separations (quits) do not entitle the worker to a severance payment.

Table 7 provides an overview of our results. The SOEC design is fairly robust to the degree of risk aversion and the generosity of public unemployment insurance. Larger values for risk aversion imply a stronger motive to smooth consumption. On the one hand, this increases the insurance value of severance payments upon dismissal as an additional source of income. On the other hand, a more rigid EPL is associated with less job creation which prolongs the expected unemployment spell. Intuitively, the optimal SOEC balances these two forces by means of a severance payment function that increases mildly with tenure. A similar argument can be made for different levels of UI generosity. Finally, the SOEC slope is flatter 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 redundancy pay as an insurance device for workers is more limited.

**Table 7.** Sensitivity analysis

| | Optimal SOEC | |
|---|---|---|
| | Initial eligibility | Slope |
| Baseline | 24 months | 9 d.w.y.s. |
| Risk aversion: $\eta = 1$ | 24 months | 9 d.w.y.s. |
| Risk aversion: $\eta = 3$ | 24 months | 11 d.w.y.s. |
| UI replacement rate: 50% | 24 months | 8 d.w.y.s. |
| UI replacement rate: 65% | 24 months | 8 d.w.y.s. |
| Red-tape costs: 50% | 24 months | 7 d.w.y.s. |
| Quits vs. layoffs | 24 months | 4 d.w.y.s. |

# 5 Conclusion

[TBC]

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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 drop the time subscript throughout this section. A steady-state is nontrivial to compute because the continuation values in certain labour market states are unknown. Specifically, we need to solve for $U^y$, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$ and $J^o(z,T)$, as well as for $w^y(z,T)$ and $w^o(z,T)$. The algorithm is as follows:

1. Solve for $W^o(z,T)$, $J^o(z,T)$ and $w^o(z,T)$ 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 (17) and (18).

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

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

   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 nonlinear equation, which we solve 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 $\widehat{W}^o(z,T)$ and $\widehat{J}^o(z,T)$ 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. Solve for $W^o(z,\tau)$, $J^o(z,\tau)$ and $w^o(z,\tau)$ recursively from $\tau = T-1$. That is:

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

   (b) If $\underline{w}^o(z,\tau) \le \overline{w}^o(z,\tau)$, then solve for the Nash-bargained wage using the first-order condition (13). 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 $U^y$, $W^y(z,\tau)$, $J^y(z,\tau)$ and $w^y(z,\tau)$ using the following steps:

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

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

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

   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) Solve for $W^y(z,\tau)$, $J^y(z,\tau)$ and $w^y(z,\tau)$ recursively from $\tau = T-1$ 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 the initial and the updated guess 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 features an equilibrium tuple $(\theta,\kappa)$. Thus, the algorithm is nested into outer loops to iterate on $(\theta,\kappa)$: we fix the payroll tax $\kappa$, solve for labour market tightness $\theta$, and then update $\kappa$ until convergence. In the benchmark economy, our calibration procedure allows to skip the loop for $\theta$ (recall that it is normalized to pin down the vacancy creation cost). Finally, the specification of the $\phi(\tau)$ implies an outer loop to iterate on the average wage $\widetilde{w}$.

## 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, the payroll tax, and the distribution of workers across employment status, productivity levels, tenure and age groups. These sequences satisfy a set of conditions presented in Subsection 2.7.

During the transition towards a new steady-state equilibrium, computations at time $t$ are simplified in that all continuation values depend on time $t+1$. That is, the transition path eliminates the infinite horizon problem that arises in steady-state. As noted in the text, another simplification comes from the fact that the sequence $(\theta_t)_{t=t_0,\dots,t_1}$ can be constructed backwards as value functions are compute along the path. Meanwhile, there is a problem specific to the transition, namely that it requires knowledge of the time-path of $(\kappa_t)_{t=t_0,\dots,t_1}$. Moreover, there is an additional state variable for employed workers and for the old unemployed, $\varepsilon \in \{t_0,t_1\}$, indicating whether their current labour market status pertains to the contract that existed before $t_0$ ($\varepsilon = t_0$) or to the contract that prevails in $t_1$ ($\varepsilon = t_1$).

The structure of our model implies that, instead of storing the sequence for all the objects of the transition path, we need "only" the distribution of agents at $t_0$ and the sequences $(\theta_t)_{t=t_0,\ldots,t_1}$, $\left(w_t^y(z,\tau,\varepsilon),\ w_t^o(z,\tau,\varepsilon)\right)_{t=t_0,\ldots,t_1}$ and $\left(\overline{z}_t^y(\tau,\varepsilon),\ \overline{z}_t^o(\tau,\varepsilon)\right)_{t=t_0,\ldots,t_1}$ to check that a time-path $(\kappa_t)_{t=t_0,\ldots,t_1}$ 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. Plug the initial severance payment function (that of $\varepsilon = t_0$) into the outside option of agents at time $t_1$. Compute the wage and value functions of being in a match at time $t_1$ with the outside option set by the $\varepsilon = t_0$ contract.
3. Guess a path for the payroll tax $(\widehat{\kappa}_t)_{t=t_0,\ldots,t_1}$.
4. Solve for value functions, wages, separation decisions and labour market tightness recursively from $t_1 - 1$ until $t_0$ as follows:

   (a) Compute labour market tightness consistent with free-entry at time $t$ and store it.

   (b) 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 $\varepsilon = t_1$ contract applying to this job.

   (c) 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.

5. Set the initial distribution of agents to the time-invariant distribution that obtains in the steady-state before $t_0$.
6. Using $(\theta_t)_{t=t_0,\ldots,t_1}$, $\left(w_t^y(z,\tau,\varepsilon),\ w_t^o(z,\tau,\varepsilon)\right)_{t=t_0,\ldots,t_1}$ and $\left(\overline{z}_t^y(\tau,\varepsilon),\ \overline{z}_t^o(\tau,\varepsilon)\right)_{t=t_0,\ldots,t_1}$ and the stock-flow equations described in Subsection 2.5, compute the evolution of the distribution during the time path. Each period, compute the realized payroll tax $\kappa_t$ implied by the balanced budget condition in order to obtain $(\kappa_t)_{t=t_0,\ldots,t_1}$.
7. If $(\widehat{\kappa}_t)_{t=t_0,\ldots,t_1}$ and $(\kappa_t)_{t=t_0,\ldots,t_1}$ are close enough, then we are done. Otherwise, go back to step (3) 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 in the $t_0$ contract is less than 0.02 percent.