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

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**Abstract**

Three features of real-life reforms of dual employment protection legislation (EPL) systems are particularly hard to study through the lens of standard labour-market search models: (i) the excess job turnover implied by dual EPL, (ii) the non-retroactive nature of EPL reforms, and (iii) the transition dynamics from dual to a unified EPL system. In this paper, we develop a computationally tractable model addressing these issues. Our main finding is that the welfare gains of reforming a dual EPL system are sizeable and achieved mostly through a decrease in turnover at short job tenures. This conclusion continues to hold in more general settings featuring wage rigidities, heterogeneity in productivity upon matching, and human capital accumulation. We also find substantial cross-sectional heterogeneity in welfare effects along the transition to a unified EPL scheme. Given that the model is calibrated to data from Spain, often considered as the epitome of a labour market with dual EPL, our results should provide guidance for a wide range of reforms of dual EPL systems.

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

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# 1 Introduction

Reforms of employment protection legislation (EPL hereafter) remain high on the policy agenda for the so-called dual labour markets in Europe – typically in Mediterranean countries and France (Saint-Paul [1996], Dolado [2017]). A recurrent theme is that of the EPL *gap*, alluding to the abrupt increase in the stringency of EPL that occurs after a few periods of employment. In this setting, workers who have been employed long enough benefit from high employment protection, whereas those just hired enjoy virtually none. As pointed out by Blanchard and Landier [2002], lacking enough wage flexibility, a large EPL gap creates a "revolving door" through which workers rotate between short-term employment and unemployment. There is plentiful evidence of the negative consequences of this excess worker turnover.[1] As a result, proposals have been put forward to remove once and for all the large discontinuity in EPL, and replace it with a unified scheme where employment protection would increase only gradually with job tenure.[2] This call has been reiterated in the wake of the Great Recession and the ensuing poor performance of some southern European labour markets (Bentolila et al. [2012a]).

Against this backdrop, our paper takes a step towards addressing two questions facing reforms of the EPL gap. First, what are the improvements in equilibrium allocations that can be achieved through these reforms? Despite general agreement that it would benefit the functioning of labour markets, very little work has been done to assess the allocational impact of replacing dual EPL with a unified scheme. Second, what are the distributional consequences of such structural EPL reforms? There is a presumption that there are numerous insiders who would lose from the policy change and, thus, who would oppose a reform leading to a new EPL scheme. Yet little is known about the relevance of this argument, i.e. the heterogeneity of the impact among workers who populate the labour market when the EPL reform is implemented. To our knowledge, this paper is the first to propose a quantitative analysis of these two issues.

We investigate the effects of replacing a dual EPL system by a unified scheme through the lens of a general equilibrium search model of the labour market. The model that we advance has a number of distinctive features that are essential for our purposes. Firstly, we explicitly keep track of job tenure in order to model the EPL gap. In the benchmark equilibrium, there is an abrupt shift in severance pay entitlements after a short period on the job, which alters wages as well as decisions to dissolve the employment relationship between workers and firms. Second, we consider key elements that provide a role for an EPL scheme whose generosity increases gradually with job tenure, in line with the policy proposals advocating a unified EPL scheme. There is no saving, agents are risk averse and therefore demand a smooth income stream. They transit stochastically from being young to old, and are prevented from receiving job offers in the

[1] For instance, Bentolila and Dolado [1994] emphasise the high wage pressure that results from dual EPL; Saint-Paul [2002] shows that it incentivises the adoption of mature rather than innovative technologies; Bentolila et al. [2012c] present evidence of negative effects on unemployment, human capital and innovation; Cabrales et al. [2017] document that dual EPL leads to low investment in employer-sponsored training schemes.

[2] Inspired by Blanchard and Tirole [2003], these policy proposals include Cahuc and Kramarz [2004] and Cahuc [2012] for France, Boeri and Garibaldi [2008] and Ichino [2009] for Italy, and Andrés et al. [2009] for Spain. The rationales for making employment protection increase with job tenure range from the large losses of specific human capital to the psychological costs suffered by long-tenured workers in case of dismissal, documented for instance in the abundant literature on displaced workers.

latter state.[3] Facing such deteriorated employment opportunities, workers at longer job tenures (hence more likely to be older workers) value a generous severance package which they can use to buy an annuity allowing them to increase consumption until they leave the economy. Third, we demonstrate that the model is computationally tractable outside the steady state. This is an important feature of our analysis as it enables us to evaluate the consequences of introducing unified EPL for the *current* population in the labour market at the time of the reform.

To conduct our quantitative assessment, we anchor the model to Spanish data and policies. Spain is a natural choice because it is often considered as the epitome of a labour market with a very large EPL gap (see Dolado et al. [2002] and OECD [2014]). We design a simple unified EPL scheme for the Spanish labour market, namely one with an entry phase and a linear relationship between statutory severance payments and job tenure.[4] The parameters of this scheme are set to maximise the steady-state lifetime utility of new labour-market entrants. Not surprisingly (since the ingredients motivating the introduction of EPL in the model are quite minimal), this yields an EPL scheme that is much less generous than in the benchmark equilibrium, which replicates the large Spanish EPL gap before the Great Recession.[5] Therefore, the reform that we consider entails a substantial shift in government-mandated severance pay. Importantly, we account for a key feature of EPL reforms, namely that agents cannot be exempted retroactively from their accrued-to-date rights. That is, workers already employed retain any previous entitlements to severance payments accumulated under the dual EPL system, and they accumulate additional entitlements at a rate prescribed by the unified EPL scheme from the date of the reform onwards. The model remains computationally tractable in this context.

Our main results are as follows. First and foremost, we show that the welfare gains of reforming a dual EPL system are sizeable and achieved mostly through a reduction in turnover at short job tenures. We quantify that a decrease of the separation rate by about 15–20 percent leads – through the adjustments in wages, job creation and taxes – to an improvement in steady-state welfare of 1.5 percent in permanent consumption units (i.e. the equivalent increase in consumption at every stage of the life cycle). Second, among workers who populate the labour market when the reform is implemented, the welfare effects are vastly heterogeneous. The gains from replacing dual EPL by a unified scheme turn out to be concentrated on labour-market outsiders, that is to say workers who are unemployed or employed with a short tenure, while many workers employed at longer tenure suffer welfare losses. On average among young workers, the welfare gain accounting for the transition dynamics of the reform is 1.2 percent. On the other

[3]We use the terminology "young" and "old" for simplicity, and in keeping with life-cycle OLG models where young agents are those who work. Alternatively, one can think of our model as featuring a risk of job displacement, where workers can be hit by a shock to their employability; e.g., jobs in the industry of employment of the worker have been offshored. The stochastic life-cycle (or job displacement) structure captures adequately the uncertainty associated with individuals' employment histories: while some workers lose the ability to find another job long before retirement, others transit only briefly through this phase.

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

[5]We use calibration targets from data and policies before the Great Recession, when the unemployment rate in Spain was similar to the European average, i.e. around 8.5 percent. The Spanish labour market underwent a significant reform of its EPL system in 2012. The parameters of the unified EPL scheme that we compute are closer to (but still less generous than) the post-2012 Spanish regulation of redundancy pay for dismissals due to economic reasons.

hand, the average effect for older workers is equivalent to reducing consumption by 0.8 percent over the time they have left in the labour market. We emphasise these findings because they may well underscore the real-life challenges of reforming a highly dual labour market.

We conduct extensive analyses to understand how these results are shaped by the specifics of the model. To begin with, we devise an approximate version of the model with savings, meaning a model with similar labour-market trajectories but in which workers are allowed to save in a risk-free asset. We find that the baseline model, which precludes access to savings, provides a reasonable approximation of welfare effects among older workers since their labour-market trajectories lead to consumption paths that are easily predictable. For younger workers, on the other hand, our model ignores the fact that they would build up additional wealth by saving a larger share of their income following the EPL reform. Thus, the gain from the EPL reform for this group of workers is slightly overestimated. In addition, we examine three (independent from each other) extensions of the baseline model. In the first one, we introduce some degree of wage rigidity. This leads to slower adjustments along the transition path and welfare gains that are larger than in the baseline model. In other words, the model is consistent with the view that the negative consequences of ill-designed EPL are magnified by wage rigidities. Second, we extend the model to add heterogeneity in productivity upon matching, so as to lift certain restrictions on the search behaviour of unemployed workers. Lastly, we consider the effects of endogenous human capital accumulation. In the last two model extensions, unified EPL has larger effects on equilibrium allocations compared to the baseline model, but the welfare effects remain in the same ballpark. In sum, our main results survive the scrutiny of several extensions of the model.

Our paper contributes to the rich policy debate presented in the opening paragraphs. It is mainly related to three strands of literature on employment protection.

First, there is a rich literature dealing with the relationship between EPL and the provision of insurance against income fluctuations. The theoretical underpinnings of this relationship are discussed in Pissarides [2001] and Blanchard and Tirole [2008]. Alvarez and Veracierto [2001] propose a first quantitative assessment using a model with precautionary savings, costly search efforts, and wage rigidities that result in privately inefficient layoffs. Cozzi and Fella [2016] analyse a similar model that features, in addition, human capital losses after job displacement. The papers closer to ours are Rogerson and Schindler [2002] and Lalé [2019]. Rogerson and Schindler [2002] use a partial equilibrium model with a job displacement shock, which is similar to the shock in our model that prevents (older) workers from regaining employment before leaving the economy. Lalé [2019] develops a model with precautionary savings, search-matching frictions, and where workers and firms bargain over wages and separation decisions. Among many differences, these papers consider simple EPL schemes (a uniform lump-sum severance package) in a *laissez-faire* economy, and they focus exclusively on steady-state analyses. By contrast, while we rule out precautionary savings, we carry job tenure as a state variable so as to allow EPL to depend on tenure, and we are able to study the transition dynamics. The latter is especially important because we consider the effects of moving *away* from a dual EPL system.

The second strand of relevant literature focuses on the interactions between the stringency of EPL and workers' job tenure. A closely related paper in this respect is that of García Pérez and Osuna [2014], who study the effects of introducing a so-called single open-ended contract in Spain. There is no rationale for having a smooth EPL scheme in their setup since they consider risk-neutral agents, and they do not have the type of shock (deteriorated employment opportunities) that motivates a positive relationship between EPL and job tenure in our model. Besides these differences, the authors abstract from the government budget constraint financing the provision of unemployment insurance (UI) benefits, which is key to making the transition dynamics non-trivial. Another related paper in this literature is Boeri et al. [2017]. The authors study a stylised model with risk-neutral agents, where financing initial investment in training trough wage deferrals is not sustainable if employers cannot commit to keep workers who have invested in training. We view our work as complementary to theirs, in that they provide a different rationale for an increasing tenure profile of EPL based on a moral hazard argument. The two papers are also much different in scope and approach, since ours aims at assessing quantitatively the effects of a reform of the EPL gap.

Finally, our paper is also related to a strand of literature that studies the co-existence of fixed-term and open-ended employment contracts, and the duality of labour markets that results from it. Some prominent examples include Blanchard and Landier [2002], Cahuc and Postel-Vinay [2002], Bentolila et al. [2012b], and Cahuc et al. [2016] among others. To a large extent, the EPL gap in the benchmark equilibrium of our model has the flavour of the divide between fixed-term and open-ended contracts. The first periods of employment play a similar role to temporary contracts, except that there is no pre-specified termination date, while the latter periods become akin to those under open-ended employment contracts. In fact, it seems accurate to describe contractual employment relationships in the Spanish labour market as bound to start with low EPL, since very few workers in Spain are directly hired with an employment contract entailing high EPL.[6] Our paper therefore complements this line of research. By not modelling different employment contracts explicitly, we simplify the analysis in ways that enable us to tackle more computationally involved issues, such as, e.g., the transition dynamics from dual to unified EPL in a labour market with risk-averse workers.

**Outline.** The paper is organised as follows. Section 2 presents the environment of our model, the Bellman equations and bargaining protocol between workers and firms. In Section 3, we define the equilibrium conditions and establish results which enable us to study the transition dynamics. We select parameter values for the benchmark equilibrium with dual EPL in Section 4 and proceed with the numerical analysis of introducing a unified EPL scheme in Section 5. In Section 6, we extend this analysis by studying three generalisations of the model. Section 7 concludes the paper.

# 2 The Model

This section presents our general equilibrium search model of the labour market. There are a number of assumptions that are conventional in this class of models. In addition, there are a few

[6] In Spain, between 6 and 10 percent of new hires are under open-ended contracts (Bentolila et al. [2012c]). Temporary contracts are sometimes subject to a termination cost that is typically much lower than redundancy pay for workers under open-ended contracts with similar job tenure (Cahuc et al. [2016]).

assumptions that are specific to our model, and which are tailored to tackle our main research questions. We highlight these assumptions in the first subsection below.

## 2.1 Economic Environment

Time is discrete and runs forever. The economy may be out of its steady-state equilibrium, and thus we keep track of calendar time indexed by the subscript $t$.

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

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

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

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

In addition to risk-averse preferences, an important assumption is that workers face incomplete asset markets and do not have access to a full storage technology. As will be explained in detail below, they have access to an annuity scheme that enables them to use their severance package so as to increase consumption during unemployment. Given that workers value a smooth consumption stream and their means to achieve this goal are limited, the main motivation for having EPL is that it can partially remedy this issue.

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

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

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

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

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

To circumscribe the population of job seekers, we make the following two assumptions. First, we rule out on-the-job search: workers can only search while being unemployed. The second and more important assumption concerns older workers who, unlike young workers, stop receiving job offers. As a consequence, following job losses, they remain out of work until they leave the economy. This assumption enables us to capture a relevant phenomenon in most countries, namely, that re-gaining employment at an age close to retirement is difficult. Via the correlation between age and job tenure, this creates a simple rationale for EPL to increase with tenure. At higher $\tau$, more stringent EPL can help prevent workers from being laid-off (job security motive), and/or provide them with a generous severance package to sustain consumption after job loss (insurance motive).

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

The second program, which is the focus of our analysis, is employment protection. This program consists of government-mandated severance pay, which is paid at the time of job separation. Consistent with real-life policies, the severance pay component, denoted as $\phi(\tau)$, is a function of job tenure. In our benchmark model, we ignore pure red-tape costs involved in the dismissal procedure. In additional robustness checks, we consider the effects of a firing tax component, in line with a long-established literature (e.g. Bertola and Rogerson [1997]). Thus, unless otherwise indicated, the severance package is a pure transfer from the firm to the worker.

**Annuities.** As mentioned earlier, while workers cannot save, they nevertheless have access to a partial insurance vehicle. Specifically, they are allowed to buy an annuity upon separation from the job with the proceeds of the severance pay that they receive. We assume that, in contrast with the UI program, the annuity system monitors perfectly the job-search behaviour of workers.[7] Thus, the insurance is partial in that workers can use the annuity scheme only to

[7]The implications of this assumption are twofold. First, for unemployed workers, the value of re-employment upon meeting a new employer dominates the value of continued search (since the latter would entail losing the annuity). Thus, it is always optimal to begin the employment relationship conditional on meeting. Second,

increase consumption until their next job arrives (young workers) or until they leave the economy (older workers). Later on in Section 4, we will test whether the consumption path implied by the annuity scheme resembles that in a model where workers have access to savings.

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

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

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

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

For future reference, we also define $a^y(\Delta, 0)$ as follows: $a^y(\Delta, 0) = 0$ for all $\Delta$. Notice that when a worker already unemployed at time $t$ holds an annuity $a^y(\Delta, \tau)$, his/her own $\Delta$ can in general be different from the expected duration of a jobless spell for those who become unemployed at time $t$, denoted by $\Delta_t$.

## 2.2 Bellman Equations

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

While unemployed, a young worker receives a flow income $b^y$ and, potentially, an annuity payment $a^y(\Delta, \tau)$. A young worker becomes older with probability $\gamma$ and the asset value becomes $\widetilde{U}_{t+1}^o(\Delta, \tau)$, which we define momentarily. Otherwise, she remains in the current age category and either finds a firm holding a vacancy with probability $\theta_t q(\theta_t)$, or remains unemployed. If the worker finds a vacancy, her asset value is $W_{t+1}^y(z_0, 0)$, the value of being employed at the entry productivity level and with zero job tenure. This is her preferred option since, under perfect monitoring, rejecting the job yields the asset value $U_{t+1}^y(\Delta, 0)$. Hence:

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

for firms with a vacancy, the assumption implies that the job seekers whom they meet are homogeneous with respect to their outside option (continued search with no annuity). As a result, firms need not keep track of the distribution of annuities among unemployed workers to compute the returns to filling a vacancy. We examine the consequences of relaxing these assumptions in Section 6, where we extend the model to allow for heterogeneity in productivity upon matching.

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

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

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

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

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

$$\begin{aligned} W_t^y(z,\tau) =& u\left(w_t^y(z,\tau)\right) + \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'} \pi_{z,z'} \max\left\{W_{t+1}^y(z',\tau'), U_{t+1}^y(\Delta_{t+1},\tau')\right\} \\ &+ \gamma \sum_{z'} \pi_{z,z'} \max\left\{W_{t+1}^o(z',\tau'), U_{t+1}^o(\tau')\right\}\Bigg). \end{aligned} \tag{8}$$

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

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

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

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

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

## 2.3 Wage Setting

As is standard in the literature, we assume that wages are set by Nash bargaining each period. Let $\beta \in (0,1)$ denote the bargaining power of the worker. The wage schedules for all $(z,\tau)$ are then determined as follows:

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

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

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

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

The numerator on the left-hand side of equation (14) is the effect for the firm of a marginal reduction in the wage, which increases profit streams by $1+\kappa_t$. On the right-hand side of the equation, the effect of a marginal increase in the wage on the utility of the worker depends on the wage itself, due to diminishing marginal utility of consumption. Notice that this feature prevents us from solving for the joint surplus of the match in order to obtain the wage functions and separation decisions. This is unlike the canonical labour-market search model, which assumes that utility can be transferred between the worker and the firm.[8,9]

## 2.4 Job Separation Decisions

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

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

[8] Another implication is that Lazear [1990]'s "bonding critique" is not entirely applicable here. Lazear's result refers to the fact that severance payments can be undone by efficient worker-firm bargains. In our setup, workers and firms differ as to their valuation of payments and there is a non-negativity constraint on workers' consumption, which prevents neutralizing severance payments fully. Lalé [2019] discusses this issue in a similar context (i.e., risk-averse workers who bargain with risk-neutral employers).

[9] In Subsection 6.1, we extend the model to allow for some degree of wage rigidity. A key feature of this environment is that the worker must compute her continuation value by taking the separation decision of the firm as given, and vice versa (see online appendix for details).

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

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

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

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

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

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

Notice that, in equations (16)–(19), reservation wages depend on the current calendar time $t$ through the outside option of workers and the payroll tax $\kappa_t$. These are the variables that make the negotiations between workers and firms depend on the aggregate state of the economy (i.e., on whether the economy is at a steady state or not). They become independent of the aggregate state if we assume away the budget constraint that pins down $\kappa_t$.

# 3 Steady State and Transition

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

## 3.1 Equilibrium Conditions

Two aggregate quantities are pinned down by equilibrium conditions: labour market tightness $\theta_t$ and the payroll tax rate $\kappa_t$. The latter depends on the cross-sectional distribution of workers. We denote by $\lambda_t^y(z,\tau)$ (resp. $\lambda_t^o(z,\tau)$) the population measure of young (resp. older) workers employed at a job with current productivity $z$ and job tenure $\tau$, and by $\mu_t^y(\tau)$ (resp. $\mu_t^o(\tau)$) the measure of young (resp. older) unemployed workers at time $t$.[10] These measures satisfy a set of stock-flow equations which we defer to Appendix A to save on space.

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

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

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

**Balanced Budget.** To pin down the payroll tax, it is assumed that the government balances the budget of the unemployment insurance system period by period. Thus, $\kappa_t$ satisfies:

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

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

## 3.2 Two Definitions

When all exogenous features of the economic environment (preferences, EPL design, etc.) are constant, and because there is no aggregate shock, the economy is in a steady-state equilibrium. Otherwise the economy is evolving along a transition path. We define the latter in detail below, and use a less formal definition for the steady state in what follows:

**Definition 1.** A steady-state equilibrium is: (i) a list of value functions and separation decision rules that satisfy optimization (equations (5)–(11) and equation (15)); (ii) a list of wage functions consistent with Nash bargaining (equations (12) and (13)); (iii) a value for labour market tightness determined by free entry of firms (equation (20)); (iv) a payroll tax that balances the budget of the unemployment insurance system (equation (21)); (v) a distribution that is time-invariant with respect to the law of motion described by equations (A1)–(A7).

Appendix C.1 provides an algorithm to compute a steady-state equilibrium allocation. In the sequel, we are typically interested in the transition between two allocations indexed by calendar dates, say $t_0$ and $t_1 > t_0$. We use the following definition:

[10] The variable $\Delta$ is not included in $\mu_t^y(\tau)$ because we do not need to keep track of the *joint* distribution $\mu_t^y(\Delta, \tau)$ during the transition phase (see equation (B3) in Appendix B). As for the analysis of distributional effects, the only expected duration $\Delta$ that is relevant is the value of $\Delta$ in the steady state prior to the policy reform, which is a fixed number. So, regarding young unemployed workers, all the calculations related to the transition dynamics require only the marginal distribution across previous job tenure ($\tau$).

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

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

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

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

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

5. Law of motion: Given $(\theta_t)_{t=t_0,\dots,t_1}$ and the sequence of decision rules $(\overline{z}_t^y(\tau),\ \overline{z}_t^o(\tau))_{t=t_0,\dots,t_1}$ for job separation, the distribution $\mu_t^y(\tau)$, $\mu_t^o(\tau)$, $\lambda_t^y(z,\tau)$, $\lambda_t^o(z,\tau)$ evolves between $t$ and $t+1$ according to the law of motion described by equations (A1)–(A7).

It is not clear from the above definition whether a transition path can actually be computed. We discuss this issue in the next subsection before turning to numerical applications.[11] In addition to giving insights into the workings of the model, this discussion allows us to explain how the details of the implementation of EPL reforms matter for the transition dynamics.

## 3.3 The Transition Dynamics

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

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

through the cross-sectional distribution of the economy, and partly a forward-looking variable through wages negotiated in period $t$. Computing a transition path therefore requires knowledge of the entire sequence $(\kappa_t)_{t=t_0,\dots,t_1}$.

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

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

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

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

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

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

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

*Proof.* The co-existence of two types of employment relationships implies that we keep track of a binary state variable to distinguish between existing and newly-formed matches (Appendix C.2). Then, we draw on the fact that $\tau$ and $t$ are sufficient statistics for pre-reform and post-reform job tenure: a worker whose job tenure at time $t$ is $\tau$ had $\tau - (t - t_0)$ periods of job tenure when the reform was implemented, and $(t - t_0)$ of post-reform job tenure. $\phi_0(\tau - (t - t_0))$ is the severance pay retained from the pre-reform period. The post-reform scheme entitles the worker to receive $\phi_1(\tau)$ minus payments that have not been accumulated under that scheme, which amount to $\phi_1(\tau - (t - t_0))$. □

In the sequel, the partially non-retroactive reform is our baseline scenario. We will also study the path of an alternative EPL reform, denoted as a *statu-quo* reform, where only new workers are subject to the unified EPL rule (Section 5).[12] In all our applications, we will impose a cap $T$ on job tenure $\tau$ (see "Preliminaries" in Subsection 4.1). This implies that the pre-reform job tenure for workers who have reached $T$ cannot be recovered. However, this does not jeopardise the result of Proposition 2 since the severance pay $\phi_0(\tau)$ is also capped in our applications, and the cap is maintained after the reform.[13]

# 4 Computation and Validation of Benchmark Equilibrium

In this section, we select parameter values to compute the benchmark equilibrium of our economy and describe some of its key outcomes. Additionally, and importantly, we compare it to the steady-state equilibrium of a model that lifts the restrictions on workers' savings decisions. This comparison gives us confidence that the benchmark equilibrium is well suited for the experiments conducted in the next two sections of our analysis.

## 4.1 Parameterisation/Calibration

**Preliminaries.** We need a number of preliminary specifications in order to list the parameters of the model. To parameterise the Markov process for idiosyncratic match productivity, we assume that $z$ takes on values in the interval $[0, 1]$, and that $z$ switches each period to a new value $z'$ which is drawn from a Normal distribution with mean $z$ and standard deviation $\sigma$, truncated and normalised to integrate to one over the interval $[0, 1]$.[14] Next, to better control the job separation rate, we add to the model an additional shock that destroys job matches exogenously. We denote by $\delta$ the per-period probability that this shock is realised. Finally, we impose an upper bound on job tenure denoted by $T$.

Under these specifications, the model has 14 parameters, namely $\{r,\ \eta,\ \gamma,\ \chi,\ T,\ \psi,\ \beta,\ A,\ k,\ b^y,\ b^o,\ \delta,\ z_0,\ \sigma\}$. The first seven parameters are set outside the model while the remaining ones are calibrated internally to match a set of data moments for Spain in the years before the Great Recession. Throughout the analysis, the model period is taken to be one quarter.

**Parameters Set Externally.** The top panel of Table 1 reports parameter values set outside the model. The interest rate is $r = 0.01$ to yield an annual interest rate of 4 percent. The coefficient of relative risk aversion is $\eta = 2$, which is a common value in the literature. The

[12]Another type of EPL reform that can be readily described by our model is a "pure" retroactive reform, where the new severance package function, $\phi_1(\tau)$ replaces the previous scheme in existing jobs $\phi_0(\tau)$ irrespective of any accrued-to-date rights. However, such a scenario appears unrealistic.

[13]In the numerical experiments, the severance pay function $\phi_1(\tau)$ is always much less generous at long job tenures than the $\phi_0(\tau)$ function. Therefore we assume that a worker who is already entitled to $\phi_0(T)$ when the reform is implemented does not accumulate additional entitlements prescribed by the $\phi_1(\tau)$ scheme. This is innocuous because we set $T$ to a large number in the experiments.

[14]Though this suggests that the resulting productivity process is a random walk, it must be noted that the truncation makes the innovation term different from a Normal white-noise process. We experimented with several stochastic processes for $z$, including less persistent ones. They did not substantially alter the workings of the model, and so we focus on this more parsimonious process parameterised only by $\sigma$.

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

| **Parameters set externally** | | **Description** | | |
|---|---|---|---|---|
| interest rate $r$ | 0.01 | 4-percent annual interest rate | | |
| risk aversion $\eta$ | 2 | literature | | |
| ageing probability $\gamma$ | 0.0830 | age range 25-54 is 120 quarters | | |
| retirement probability $\chi$ | 0.0250 | age range 55-64 is 40 quarters | | |
| tightness elasticity of job filling proba. $\psi$ | 0.5 | literature | | |
| bargaining power $\beta$ | 0.5 | literature | | |
| cap on job tenure $T$ | 120 | 30 years cap on job tenure | | |
| **Parameters set internally** | | **Moment** | **Data** | **Model** |
| matching efficiency $A$ | 0.4000 | job-finding rate | 40.0 | 40.0 |
| unemp. income, young workers $b^y$ | 0.2203 | replacement rate | 58.0 | 58.0 |
| unemp. income, older workers $b^o$ | 0.1616 | replacement rate | 45.0 | 45.4 |
| vacancy cost $k$ | 0.2204 | tightness (norm.) | 1.00 | 1.00 |
| exogenous separation probability $\delta$ | 0.0050 | quits / total job separation | 17.0 | 17.1 |
| initial match prod. $z_0$ | 0.2800 | job destruction, $\leq$2 years | 7.5 | 7.6 |
| standard dev. of match prod. shock $\sigma$ | 0.0440 | job destruction, >2 years | 2.1 | 2.3 |

**Notes:** The top panel describes parameters whose values are chosen using external information. The bottom panel describes parameters whose values are based on calibrating the model to data moments shown in the rightmost columns. Data and model-generated moments (with the exception of tightness, which is normalised to 1) are expressed in percent.

demographic probabilities are set at $\gamma = 1/120$ and $\chi = 1/40$ to match the expected durations of the first ("young") and second ("older") 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 to 64 account for about 25 percent of the working-age population in Spain. As is conventional in the literature (see Petrongolo and Pissarides [2001]), we set both the elasticity of the vacancy-filling probability with respect to tightness $\psi$ and the bargaining power of workers $\beta$ equal to 0.5. Finally, we set the cap on job tenure $T$ equal to 120 model periods, i.e. 30 years.

**Calibrated Parameters.** We follow standard practices and use the free-entry condition to pin down the vacancy-posting cost $k$ after normalizing labour market tightness $\theta$ to unity. Next, we use the Spanish Labour Force Survey and the European Labour Force Survey to calibrate the remaining parameters (and, later on, to evaluate the fit for untargeted moments). We aim at matching the following data moments: (1) the quarterly job-finding rate is 40 percent (García Pérez and Osuna [2014]); (2) the quarterly job destruction rate for short-term tenured (temporary) jobs is 7.5 percent (García Pérez and Osuna [2014]); (3) the quarterly job destruction rate for open-ended (permanent) jobs is 2.1 percent (García Pérez and Osuna [2014]); (4) the replacement rate of UI benefits for young workers, defined as the ratio between the benefit payment $b^y$ and the average wage $\widetilde{w}^y$, is 58 percent;[15] (5) the replacement rate of UI benefits for older workers $b^o/\widetilde{w}^o$ is 45 percent;[16] (6) the quit rate among all job separations is 17 percent

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

[16] Suppose that older workers can draw on regular unemployment benefits for 2 years (at a 67-percent replacement rate), and then fall back on less generous social assistance (at a 40-percent replacement rate). At an expected duration of 10 years, this yields a weighted average of $0.67 \times {}^2/_{10} + 0.40 \times {}^8/_{10} = 0.454$.

(Rebollo-Sanz [2012]). Our motivation for using information on quits is as follows. In the data, we cannot observe the number of job separations that could be deterred by enforcing tougher employment protection. We interpret quits as putting an upper bound to this number. In the model, the parameter that embodies this role is $\delta$, the probability of an exogenous job separation. Thus, we use condition (6) to pin down a value for $\delta$.[17] The bottom panel of Table 1 summarizes the calibration.

**Dual EPL Scheme.** The crux of our analysis relates to severance pay functions. In the benchmark equilibrium, our goal is to reproduce the discontinuous EPL scheme ruling in Spain prior to the onset of the Great Recession (Bentolila et al. [2012c]), in line with the data used to calibrate the model. As in García Pérez and Osuna [2012], we express severance pay as a function of job tenure and of the average (annual) wage. Notice that the average wage is an equilibrium outcome of the model, not a pre-specified parameter. To compute a steady-state equilibrium, we must add an outside loop to iterate over the average wage used to specify the severance pay function (cf. Appendix C.1).

We use the following pieces of information to specify $\phi(\tau)$ in the benchmark equilibrium. We identify the first two years of employment with fixed-term contracts prevailing in the Spanish labour market. During the pre-recession period, these contracts featured termination costs of 8 days of wages per year of services (d.w.y.s. hereafter), representing 2.2 percent (= 8/365) of the average yearly wage. If the worker is not dismissed before the end of this two-year period, we identify the subsequent periods of employment as those regulated by open-ended contracts. Workers on these more permanent contracts were entitled to 45 d.w.y.s. under an unfair dismissal, with a cap of 3.5 annual wages.[18] For instance, a worker who has been employed at the same firm for more than two years and loses her/his job at the end of the third year would be entitled to 37 percent ($= 3 \times 45/365$) of the yearly wage.

Thus, severance payments for a worker with job tenure $\tau$ are specified as follows:

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

Figure 1a depicts this function with job tenure (in quarters) on the horizontal axis and a multiple of the average annual wage on the vertical axis. To better visualise the discontinuity entailed by this dual EPL scheme, in Figure 1b we "zoom in" on the first five years of an employment relationship. As can be seen, not only is the slope of the severance pay function different across

[17]Following an exogenous separation, we assume that the firm pays the severance package to which the worker is entitled. That is, we do not interpret the $\delta$ shock as a quit decision – it is not the outcome of a choice. We use $\delta$ to discipline the elasticity of the job destruction rate to changes in the employment protection scheme. In sensitivity checks reported in the online appendix, we re-run our experiments under the assumption that severance payments are waived in the event of an exogenous job separation.

[18]We assume that firms pay unfair dismissal costs because, even during the Great Recession, two thirds of all dismissals in Spain have been labelled 'unfair'. Indeed, firms avoided appeals to court by workers by paying the maximum rate, under the so-called "express dismissal rule" (see Bentolila et al. [2012c]).

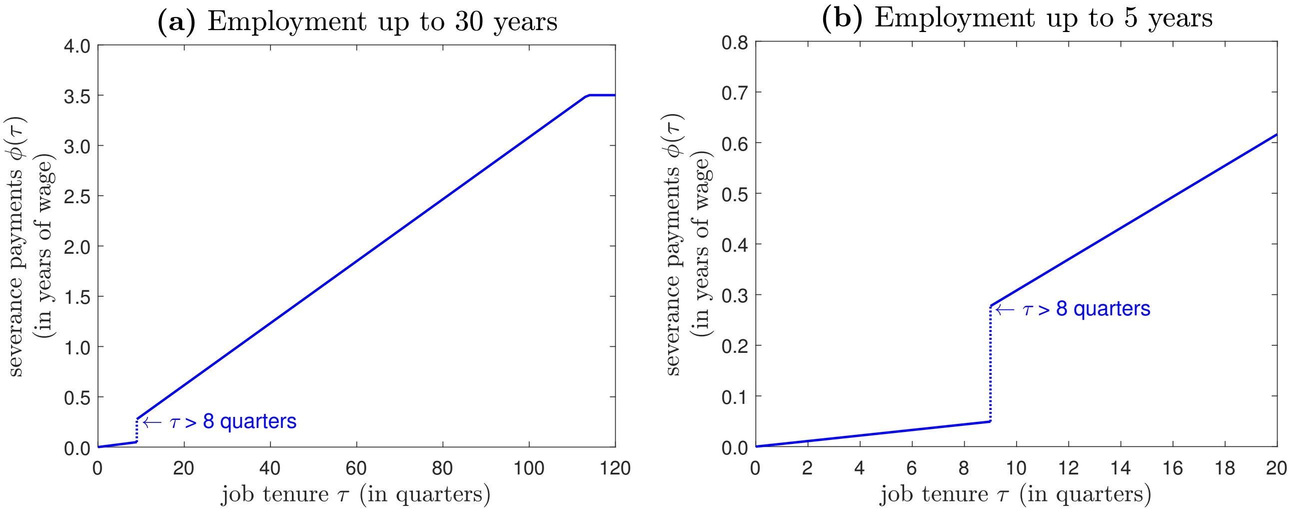


**Figure 1.** Severance payments in the benchmark equilibrium

**Notes:** The figure shows the severance pay function of the benchmark equilibrium. Figure 1a displays the function up to the cap on job tenure at 120 quarters. For legibility purposes, Figure 1b displays only the first 20 quarters of job tenure. Scales differ on each vertical axis.

the 9th quarter of employment, but the generosity of the severance package jumps up abruptly.

## 4.2 Validation of the Model

**Non-employment and Job Tenure.** Table 2 presents moments that characterise the cross-sectional distribution of the economy and compares them with their empirical counterparts. Recall that our calibration targets the job-finding rate and the job-destruction rates below and above two years of job tenure, meaning it does *not* directly targets data moments by age. As shown in the top panel, the model nevertheless does a satisfactory job at predicting these data moments. The unemployment rate among young workers is 9.7 percent vs. 9.0 percent in the data. The model generates a non-employment rate of 36.3 percent for older workers. This value is lower than the share of non-employed male workers between 55 and 64 years observed in the data (43.1 percent), but the gap seems reasonable since our model abstracts from disabilities, health shocks and other reasons for non-employment at older ages. The aggregate non-employment rate among all workers in the benchmark equilibrium is 16.3 percent vs. 16.5 percent in the data. Turning to the distribution of workers by job tenure (bottom panel of Table 2), the model does well in fitting the data. It slightly overpredicts the share of workers with more than 10 years of tenure, and the share of workers with less than 1 year of tenure is marginally lower than in the data. On the other hand, 45.6 percent of employed workers in the model have between 1 and 10 years of job tenure, which happens to match the data value exactly.

To complement the results in Table 2, Figure 2 displays the job separation probability computed as a function of job tenure $\tau$. Figure 2a, which reports the probability at each job tenure $\tau$, shows that the model reproduces the "revolving door" effect of the EPL gap which has been documented in the empirical literature (e.g., García-Pérez and Muñoz-Bullón [2011]). As can be seen, the separation rate jumps up at job tenure $\tau = 8$ quarters, just before EPL increases to much higher levels (see the jump at $\tau > 8$ quarters in Figure 1b). Consequently, the first few

**Table 2.** Comparison between the model and data

| **Non-employment rates** | **Data** | **Model** |
|---|---|---|
| unemployment, young workers | 9.0 | 9.7 |
| non-employment, older workers | 43.1 | 36.3 |
| non-employment, all workers | 16.5 | 16.4 |
| **Distribution of job tenure** | **Data** | **Model** |
| less than 2 quarters | 8.7 | 6.8 |
| 2 to 4 quarters | 8.8 | 5.7 |
| 1 to 3 years | 15.9 | 15.9 |
| 3 to 5 years | 13.2 | 10.9 |
| 5 to 10 years | 16.5 | 18.8 |
| more than 10 years | 36.9 | 41.9 |

**Notes:** The table provides a comparison between model-generated moments and their empirical counterparts computed from the Spanish Labour Force survey for the years 2005–2007. All entries are expressed in percent.

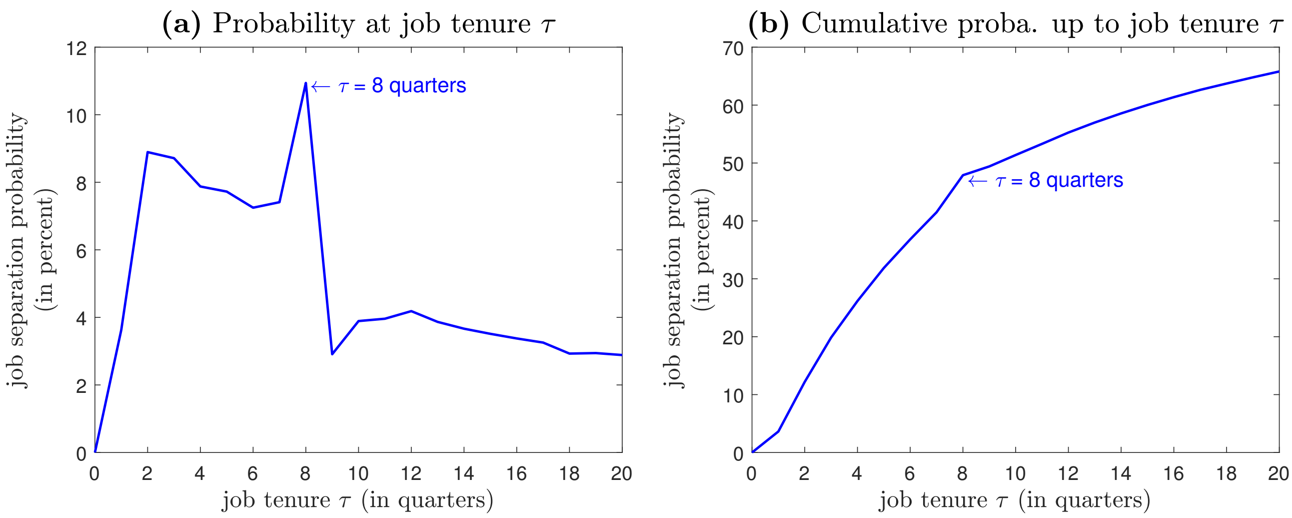


**Figure 2.** Job separation probability by job tenure

**Notes:** The figure shows the probability of a job separation occurring at job tenure $\tau$ (Figure 2a) and the cumulative sum of the probability up to job tenure $\tau$ (Figure 2b). In both plots, job tenure refers to the first 20 quarters of employment. Scales differ on each vertical axis.

periods of employment in this economy entail a very large risk of job loss; Figure 2b shows that the cumulative probability reaches 50 percent after 'only' just 10 quarters of employment. Past this point, there is substantial flattening out of the job separation probability, meaning that the employment relationship becomes similar to that of "career jobs" that are hardly ever destroyed. Jobs wiped out by the "revolving door" are those where match productivity did not improve much from the initial productivity level $z_0$. Finally, although not shown in Figure 2 which focuses on the first five years of an employment relationship, the probability of a job separation occurring before or at job tenure $\tau = 120$ quarters is close to 100 percent. The cap on job tenure $T$ has no bearing on our results for this reason.

**Consumption/Savings Behaviour.** We continue our examination of the outcomes of the benchmark equilibrium by comparing them with a model where workers are allowed to save in a risk-free asset. A complete description of this more general model is provided in the online appendix. To sum up, this is a standard incomplete-markets model with a risk-free asset to smooth consumption intertemporally, where the earnings process (wages and transition probabilities of moving in and out of employment) are those obtained from the benchmark equilibrium. We do not allow individual savings decisions to affect wages and job turnover, meaning that we take the earnings process as exogenous when solving for the savings decisions of agents.[19] Therefore, this model with savings is only an *approximation* of the full-fledged model with both incomplete markets and bargaining on wages and job separation, which remains beyond computational reach.

The first question we ask is whether the unrestricted consumption/savings behaviour of unemployed workers in that model are very different from those in the benchmark equilibrium. To answer this question, in the top panel of Table 3 we study the consumption path of workers from their first period of unemployment onwards, conditional on remaining non-employed. The approximate model with savings does not seem to generate a large deviation from the reference point – no consumption decrease in the baseline model. For young workers in the lower part of the asset distribution though, consumption would drop by 16.2 percent on average after 1 year of non-employment. But young workers face a job-finding probability of 40 percent per quarter, making this outcome unlikely. For older workers who remain non-employed until they leave the economy, consumption declines only slowly (-4.7 percent after 1 year). Thus, the assumption that consumption remains constant during non-employment in the baseline model does not seem too unreasonable.

Next, we examine more broadly the consumption/savings behaviour of workers across the whole cross-sectional distribution. In particular, our assumption of period-by-period Nash bargaining makes income (hence consumption in the baseline model) relatively volatile during employment. Thus, workers face no consumption volatility during unemployment, but this outcome is counterbalanced by higher consumption volatility while they are employed. To what extent are agents able to reduce consumption volatility in the approximate model with savings? The bottom panel of Table 3 answers this question by looking at the dispersion of individual consumption

[19]Notice that the first-order impact of EPL is on wages and job turnover, which are endogenous in our labour market model that generates the earnings process. EPL also affects wages and turnover decisions by changing the precautionary savings behaviour of agents, but this effect (not captured by our model, because otherwise it would become computationally intractable) is likely to be less important.

**Table 3.** Comparison with an approximate model with savings

| Drop in consumption after job loss | Approximate model After 1 quarter | Approximate model After 1 year | Baseline model |
|---|---|---|---|
| young workers, average | -2.1 | -7.5 | 0.0 |
| young workers, asset-poorest | -5.2 | -16.2 | – |
| older workers, average | -1.3 | -4.7 | 0.0 |
| older workers, asset poorest | -3.7 | -6.5 | – |
| **Dispersion of consumption growth rates** | **Approximate** | | **Baseline** |
| all workers | 6.9 | | 13.2 |
| young workers | 6.9 | | 14.7 |
| older workers | 6.6 | | 4.6 |

**Notes:** The table reports the drop in consumption among workers who lose their job (top panel) and the standard deviation of workers' consumption growth rates (bottom panel). Drops in consumption are measured during the first quarter after job loss and after 1 year spent in non-employment, both on average and among workers who are in the bottom two quartile of the asset distribution at the time of a job loss. All entries are expressed in percent. 'Approximate model' and 'Approximate' denote outcomes of the approximate model with savings (see text and online appendix). 'Baseline model' and 'Baseline' denote outcomes of the baseline model presented in Section 2.

growth rates. When they have access to a risk-free bond instead of saving their severance package in the annuity market, workers manage to substantially reduce the volatility of consumption – the measure of volatility we use to quantify this is lowered by half. In other words, workers use their severance package not only to increase consumption while unemployed, but also to smooth consumption when moving in and out of employment and in future periods. The benchmark model therefore clearly overstates the volatility of consumption among workers. However, this does not mean that it cannot measure the changes in the volatility of consumption that would be triggered by an EPL reform. We will report in the next section that it actually can capture these changes.

# 5 Benchmark Experiments

This section reports the quantitative results characterising the effects of replacing dual EPL with a unified scheme. To begin with, we must define a unified EPL scheme.

**Unified EPL.** We consider simple instruments for this purpose, namely an entry phase (i.e. the minimum service tenure required for eligibility) and a linear relationship between severance pay and job tenure. Formally, we define severance payments under unified EPL as follows:

$$\phi(\tau) = \max\left\{\rho_u \times (\tau - \tau_u)\,,\ 0\right\}. \tag{24}$$

$\tau_u \geq 0$ measures the number of periods on the job before severance payments are activated. $\rho_u \geq 0$ is the rate of return to job tenure in terms of severance pay (expressed in d.w.y.s.), conditional on eligibility. To select values for $\tau_u$ and $\rho_u$, we search for the combination that maximises $U^y$, the steady-state lifetime utility of new labour-market entrants.[20] This is a natural criterion in

[20]Our task of choosing a unified EPL scheme turns out to be facilitated by the fact that the steady-state value of $U^y$ appears to be concave with respect to $\{\tau_u, \rho_u\}$. This property also holds in the robustness checks and model

our view because it matches the objective function of a planner looking at our life-cycle model economy. In addition, notice that the ingredients motivating the introduction of EPL are rather minimal in this model. First, severance payments perform an insurance role only through the annuity scheme, and they are introduced on top of UI benefits which are likely more adequate to provide insurance to workers. Second, the rationale for the stringency of EPL to increase with tenure builds on the correlation between age (deteriorated employment opportunities) and job tenure. This role is substantially discounted from the perspective of new labour-market entrants, which we use as our criterion to select $\tau_u$ and $\rho_u$. So, the EPL scheme of the benchmark equilibrium will appear overly generous through the lens of this criterion, and we are bound to obtain a unified scheme that is more stingy and entails a considerable shift in EPL policies. Consistent with this, we find that the unified EPL for our benchmark economy is characterised by an eligibility period of 5 months and a slope of 20 d.w.y.s. from that job tenure onwards. This is substantially less generous than the EPL scheme shown in Figure 1.

## 5.1 Steady State

We start out by presenting our results for the long-run allocational and welfare consequences of introducing the unified EPL scheme. Table 4 provides a comparison between different steady-state statistics before and after the reform. Several results stand out. First, we find that introducing unified EPL raises employment by about 1 percentage point both among young and older workers. The EPL reform triggers higher job creation rates by firms (as reflected by a larger labour market tightness) which, in turn, implies that unemployed young workers transit back to employment at a faster rate. Second, and strikingly, switching from dual to unified EPL reduces the job destruction rate at short tenures (under 2 years), and partially removes the spike at $\tau = 8$ quarters (the so-called "revolving door") displayed in Figure 2. On the other hand, long-tenured workers face a slightly higher risk of losing their job as evidenced by a mild increase in the job destruction rate after 2 years. The third remark is that a similar divide can be observed for the change in average wages. While young workers start out their tenure at slightly higher wages, older workers see their wages decline considerably. The intuition behind this result is that the unified EPL scheme is associated with substantially lower severance pay at longer tenure, which depresses the bargaining position for workers in these jobs. Fourth, on the aggregate, higher employment rates translate into a reduction in the payroll tax as less workers receive unemployment income from the government.

Turning to the normative implications of unified EPL, we find that the reform leads to sizeable welfare gains for labour-market entrants.[21] In a steady-state sense, unified EPL improves welfare in a way that is equivalent to increasing consumption at every stage of the life cycle by 1.52

extensions examined in the next sections.

[21] Let $U_b^y$ denote the lifetime utility of new labour-market entrants in the benchmark equilibrium. Similarly, denote by $U_u^y$ their lifetime utility under the unified EPL scheme. Then

$$\left[\frac{(r+\chi)\,U_u^y + \frac{1+r}{1-\eta}\frac{r+\chi+\gamma}{r+\gamma}}{(r+\chi)\,U_b^y + \frac{1+r}{1-\eta}\frac{r+\chi+\gamma}{r+\gamma}}\right]^{\frac{1}{1-\eta}} - 1$$

gives the equivalent change in permanent consumption faced by the agents.

**Table 4.** Comparison between two steady states

| **Aggregate equilibrium variables** | **Dual EPL** | **Unified EPL** | **Change (%)** |
|---|---|---|---|
| tightness | 1.00 | 1.10 | 9.6 |
| payroll tax | 9.77 | 9.04 | -7.6 |
| **Non-employment and job turnover** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| unemployment, young workers | 9.70 | 8.93 | -8.0 |
| non-employment, older workers | 36.3 | 35.1 | -3.2 |
| job-finding rate | 40.0 | 41.9 | 4.7 |
| job destruction, ≤2 years | 7.64 | 6.41 | -16.2 |
| job destruction, >2 years | 2.26 | 2.42 | 6.5 |
| **Wages and productivity** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| average wage, young workers | 0.38 | 0.39 | 3.9 |
| average wage, older workers | 0.36 | 0.31 | -12.4 |
| average match prod., young workers | 0.47 | 0.47 | -0.3 |
| average match prod., older workers | 0.53 | 0.52 | -0.8 |
| **Welfare in consumption equivalents** | | | (%) |
| new entrants | – | – | 1.52 |

**Notes:** The table provides a comparison between the steady-state equilibrium with unified EPL and the steady-state equilibrium with dual EPL. Payroll taxes in the first panel and all entries in the second panel are expressed in percent. The fourth panel reports the change in the lifetime utility of new entrants between the two steady states, and is expressed in percent of consumption-equivalent units.

percent. As should be clear from the discussion above, new labour-market entrants are bound to benefit from unified EPL, as the post-reform economy exhibits shorter unemployment spells, lower job destruction rates at short tenures, higher entry wages, and lower taxes.[22] Yet in order to paint a more nuanced picture of the distributional implications of the reform, the analysis must be extended to assessing the transitional dynamics. We turn to this issue next.

## 5.2 The Transition Dynamics

Figure 3 shows the time path of several labour market variables during the transition from the benchmark equilibrium to the equilibrium under unified EPL. The vertical line in each plot indicates time $t_0 = 0$ when the reform is implemented. At this date, there is a cross-sectional distribution of workers for whom we measure the welfare effects of the reform.

As shown in Figure 3, most of the adjustments take place during the first year of the reform. This outcome is shaped by the fact that a partially non-retroactive reform affects not only new jobs, but also existing worker-firm matches. The upper panel of Figure 3 shows the time path of the general equilibrium variables, tightness $\theta_t$ and the payroll tax $\kappa_t$. Labour market tightness jumps up on impact to converge quickly to its new steady-state equilibrium value. The gradual adjustment in taxes, on the other hand, is explained by a more sluggish decline in non-employment after the reform. Unemployment among young workers mirrors the behaviour of aggregate equilibrium variables (Figure 3c). The job-finding rate soars as firms create more

[22] We performed the following out-of-equilibrium exercises: removing the discontinuity in EPL by shifting the severance pay function in Figure 1 downwards, then adjusting the slope and finally adjusting tightness and the payroll tax to their new steady-state values (see Dolado et al. [2016]). We find that each of these adjustments contributes to about 25 percent of the welfare effect reported in Table 4. Thus, eliminating the "revolving door" leads to an improvement in steady-state welfare by at least 0.4 percent.

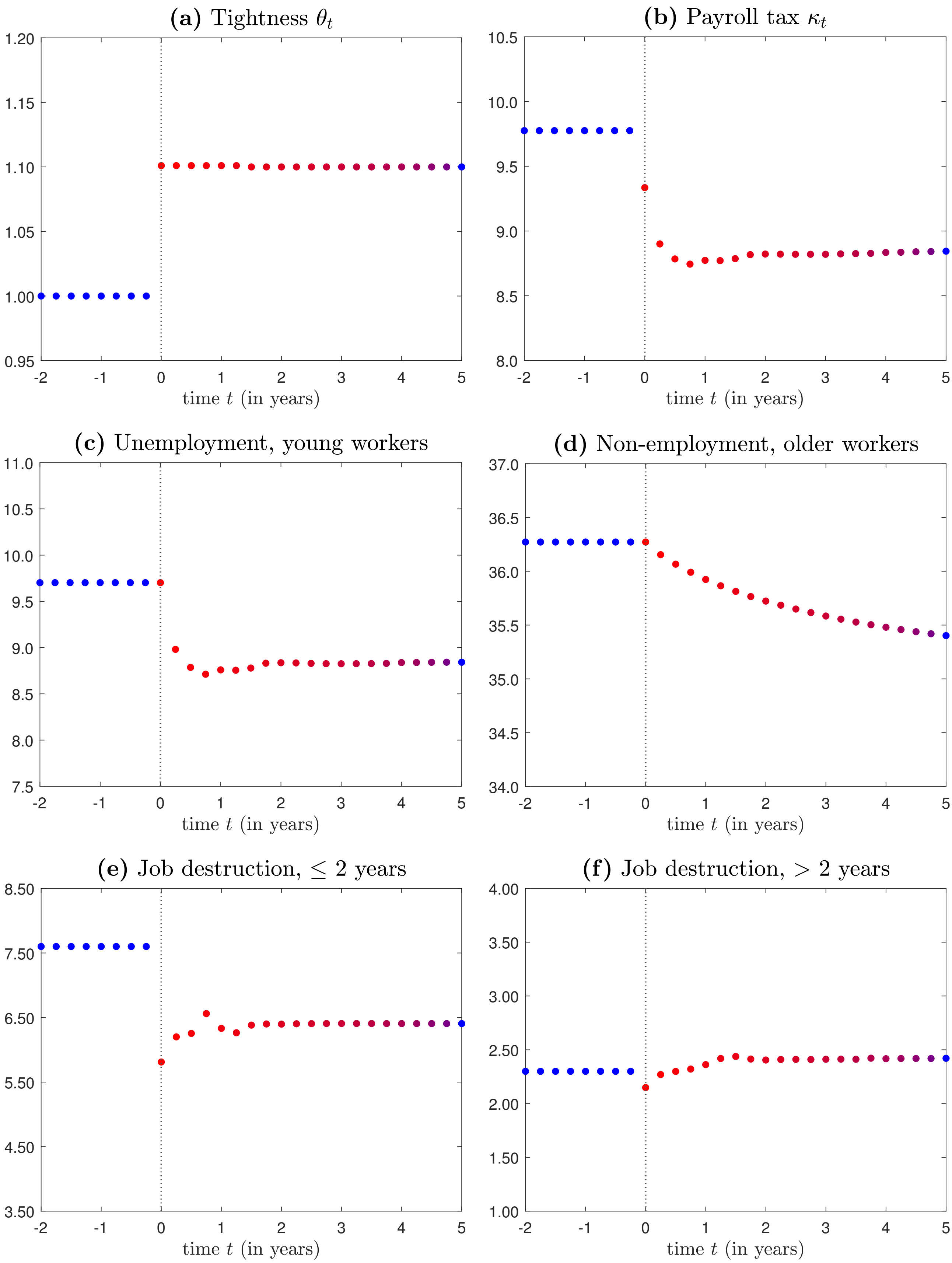


**Figure 3.** Transition dynamics towards unified EPL

**Notes:** The figure displays the time path of several labour market variables during the transition towards unified EPL under a partially non-retroactive reform. Figures on the vertical axis are expressed in percent, except for tightness $\theta$ (Figure 3a) which is reported in levels. On the horizontal axis, time is measured in years relative to the introduction of the unified EPL scheme, which occurs in period 0.

**Table 5.** Welfare effects of the transition dynamics

| | | Average in each quintile | | | | |
|---|---|---|---|---|---|---|
| | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 1.19 | 0.61 | 1.00 | 1.21 | 1.43 | 1.69 |
| older workers | -0.79 | -2.11 | -1.41 | -0.85 | -0.00 | 0.41 |

**Notes:** The table reports the welfare changes (measured in consumption-equivalent units) arising from the transition towards unified EPL. All entries are expressed in percent.

vacancies associated with the unified EPL scheme. The decline in non-employment among older workers displayed in Figure 3d is more gradual since it is only driven by the inflows from employment and the exogenous outflows of workers leaving the economy. To summarise, implementing a unified EPL scheme through a partially non-retroactive reform leads to fast transitional dynamics, where most labour market variables shift towards their new steady-state equilibrium values within just a few model periods. As can be seen in Figure 3e, the decrease in turnover at short job tenures occurs right when the reform is implemented.

Table 5 presents the "true" welfare effects of introducing the unified scheme replacing dual EPL. To this end, we compute the average welfare effect within each age group as well as the average within each quintile of the distribution of welfare effects within this age group.[23] The goal is to appreciate the extent of heterogeneity in the impact of the EPL reform. Several comments are worth making. First, among young workers, the average welfare gain by 1.19 percent masks substantial cross-sectional dispersion. In the bottom quintile, the average gain is 'only' 0.61 percent, which is three times lower than the gain experienced by the top quintile (1.69 percent). Workers with a long tenure at their current job are more likely to be found in the bottom quintile, whereas labour-market outsiders – those who would benefit from the labour market being less dualised – tend to be concentrated in the top quintile of the treatment effects of the policy. Next, we report the same outcomes this time among older workers to provide a broader perspective of the distributional changes.[24] The vast majority of these workers (about two thirds) suffers from the policy change: the average loss is by 0.79 percent, and the loss incurred by the bottom quintile is 2.11 percent. Clearly, there is almost universal support across young workers, but most older workers who suffer non-negligible losses would have strong incentives to lobby against the reform. The source of this divide can be traced back to the dual EPL system, which makes employment situations highly uneven across workers.

[23] Obviously, there are many other distributional statistics that could be reported here – variance, Gini coefficient, etc. The statistics shown in Table 5 paint a clear picture of the distributions: centred around the mean for young workers, left-skewed for older workers. Among the latter, note that we only consider employed workers since older workers who are already non-employed at time $t_0$ are not affected at all by the policy change.

[24] Notice that the (expected) horizon underlying the calculation of permanent consumption units is 40 years for young workers and 10 years for older workers. For older workers, denote by $U_b^o$ (resp. $U_u^o$) their asset value under the benchmark (resp. unified) EPL scheme. Then

$$\left[\frac{(r+\chi)\,U_u^o + \frac{1+r}{1-\eta}}{(r+\chi)\,U_b^o + \frac{1+r}{1-\eta}}\right]^{\frac{1}{1-\eta}} - 1$$

gives the equivalent change in permanent consumption experienced by older workers.

## 5.3 Economics of the Results

Next, we perform a number of variations by allowing for alternative ways of implementing the EPL reform, relaxing the no-savings assumption and accounting for alternative parameter values. The goal is to gain additional insights into the economics of the results.

**Implementing the Reform.** Structural EPL reforms require fine-tuned rules for workers who are already employed at the time of reform. Our model sheds light on this issue. To illustrate this, we consider an alternative scenario to the partially non-retroactive reform analysed in the previous sections. We call this alternative scenario the *statu-quo* reform since it allows workers already employed at time $t_0$ to remain employed under the terms of the old EPL scheme. To change to the unified EPL scheme, they therefore have to dissolve their current employment relationship first and then search for a new job (thus, only young workers have the option of eventually being employed under the terms of unified EPL). Unemployed workers who become matched to a firm at any date $t \geq t_0$ are subject to the new EPL scheme, as in the benchmark reform.

Figure D1 in the Appendix presents the transition dynamics of the *statu-quo* reform. When compared to Figure 3, a number of results stand out. First, the transition phase is slower after a *statu-quo* reform. Second, there are some detrimental effects in the short run. Foremost, many job-matches with a short tenure are destroyed immediately to take advantage of the unified EPL scheme. This is also the case, albeit to a lesser extent, for low-productivity job-matches held by workers with longer tenure. These effects explain the sluggish decline in non-employment rates among both young and older workers. Third, as a result of these more gradual adjustments, the payroll tax rate falls more slowly under a *statu-quo* reform. Lastly, the welfare effects of the *statu-quo* reform shown in Table D2 in the appendix illustrate interesting properties. The *statu-quo* reform achieves a slightly higher gain for younger workers, mainly by reducing the heterogeneity of the impact: it avoids the welfare losses at long job tenure entailed by a partially non-retroactive reform. These results suggest that an appropriately designed implementation can go a long way towards limiting the losses entailed by EPL reforms.[25]

**Welfare Effects with Savings.** Workers in the model are prevented from saving their severance package in a risk-free asset, but they have access to a partial insurance vehicle: they are allowed to buy an annuity upon separation from the job with the proceeds of the severance package, so as to increase consumption until their next job arrives or until they leave the economy. Whether this is enough to capture the welfare effects that would arise in a more general settings with milder assumptions about savings is a key issue. We use our approximate model

[25]The results are also related to an aspect that has been ignored in our analysis: the possibility of on-the-job search. First, our analysis of a *statu-quo* reform has indicated the importance of regulation for potential switchers from dual to unified EPL. Job-to-job turnover may provide a natural way to transit from one regulation into the other, depending on the characteristics of the current match. If in addition worker-firm pairs could renegotiate the size of the severance package, then job-to-job reallocations would provide a way to terminate unprofitable matches without bearing the full costs of mandatory EPL (Postel-Vinay and Turon [2014]). Second, and more generally, the allocational and welfare consequences of an EPL reform may depend in non-trivial ways on the availability of outside job offers along the job tenure distribution. While long-tenured workers are disproportionately affected by the EPL reform, they are also less likely to receive outside job offers.

with savings to answer it. To begin with, we follow up on Table 3 by computing changes in the dispersion of consumption growth rates following the EPL reform. We find that they decrease by -21.5 percent in the approximate model with savings vs. -36.5 percent in the baseline model. Since the levels of consumption volatility are also higher in the baseline model (bottom panel of Table 3), and the decrease in consumption volatility is predicted to be larger, the baseline model overstates the gain from unified EPL. The bias, however, seems to be limited. For new entrants to the labour market, the welfare gain is 1.52 according to the baseline model vs. 1.26 percent in the approximate model with savings (see Table D1 in the appendix).

Next, we seek to understand how welfare figures within the cross-section of employed workers would be affected by the option to save in a risk-free asset. The main results are as follows. For older workers, quantitative results would not be much different (Table D1 in the appendix). The reason is that the consumption behaviour implied by the annuity scheme of the benchmark model provides a reasonable approximation of their behaviour in a more general setting with savings. On the other hand, for younger workers, the average welfare gain following the EPL reform would be discernibly lower. Table D1 in the appendix reports that the gain would amount to 0.43 percent in consumption-equivalent units. The difference is attributable to the fact that young worker start saving a larger share of their income after the EPL reform. The benchmark model is obviously unable to capture such changes in precautionary savings behaviour. To sum up, the model captures qualitatively, and to some (but only some) extent quantitatively, the welfare effects that arise in a richer environment with savings. It overstates the gain from unified EPL among young workers to the extent that the reform would lead to more insurance through private savings.

**The Rationales for EPL.** In our model, EPL can be justified on the grounds that it helps workers increase consumption during unemployment, as their other means to achieve this are limited. To understand how this role shapes the results, we repeat the analysis using different targets for the generosity of UI benefits. We consider a replacement ratio for young workers of either 50 percent or 65 percent vs. 58 percent in the benchmark equilibrium (see the online appendix). We find, first of all, that a unified EPL scheme has a shorter (resp. longer) initial eligibility period when UI benefits are less (resp. more) generous. For instance, under less generous UI benefits, the minimum service tenure for eligibility is 2 months vs. 5 months in the benchmark equilibrium. Second, the unified EPL scheme has a flatter slope when UI benefits are lower (17 d.w.y.s. rather than 20 d.w.y.s.), and a steeper slope in the converse scenario (24 d.w.y.s.). These are slight differences, but nevertheless we believe they are informative. When UI benefits are less generous, workers benefit from gaining access to some minimum level of job protection earlier in the employment relationship (lower $\tau_u$). Should they become unemployed, what matters most is to return to employment rapidly. To achieve this, one needs to promote job creation by reducing the expected costs of firing a worker (lower $\rho_u$). This seems to line up well with the so-called "flexicurity" paradigm.

The model also rationalises the increase of the stringency of EPL with job tenure, as workers who have been employed longer are more likely to face deteriorated employment opportunities. We investigate the role of this mechanism by changing the expected duration of the older-age phase (during which workers do not receive job offers). Shortening the expected duration of the no-search period from 10 years to 5 years leads to a flatter slope of 12 d.w.y.s, while increasing it to 15 years leads to a steeper slope of 32 d.w.y.s. The minimum service tenure required for eligibility is not much different across the two scenarios, as it changes from 7 to 9 months. These results confirm, first, that workers value EPL as a means to boost job security more highly if employment opportunities near retirement deteriorate more rapidly. Second, when considering a much less generous unified EPL scheme (namely the EPL scheme under an older-age phase with an expected duration of 5 years), we find that the cross-sectional dispersion of the welfare impacts of the EPL reform increases. In our view, these findings should motivate studying the sources of non-employment near retirement – loss of specific human capital, health shocks, etc. – which seem key to amplifying the heterogeneity of the impact of structural EPL reforms (see Chéron et al. [2011, 2013]).

# 6 Model Extensions

In this section, we study three extensions of the benchmark model to characterise conditions that affect the sign and magnitude of the effects of reforming a dual EPL system. Each of these extensions nests our benchmark model as a special case. To save on space and focus on the key results, we defer the detailed description of each model extension to the online appendix.

## 6.1 Wage Rigidity

As is well known, bargaining and the outcomes of the wage setting process are key determinants of the employment effects of severance pay (Lazear [1990]'s 'bonding critique'; see Footnote 8). This begs the question: how important is the assumption of Nash bargaining for our results?[26] To answer this question, we explore the implications of allowing for wage rigidity. We consider a simple form of wage rigidity: in each period, the wage paid to the worker is a weighted average between the wage inherited from the previous period (with weight $\alpha^r$) and the Nash-bargained wage (with weight $1 - \alpha^r$). We think of Nash bargaining as embodying the flexible wage setting case, nested in our model when $\alpha^r$ is set to 0. In this section, we set the degree of quarterly wage persistence, $\alpha^r$, to 0.90.

Figure 4 presents the transition dynamics towards unified EPL. A number of differences with respect to the benchmark experiment are worth pointing out. We begin with the dynamics of the job destruction rate in the bottom two panels of the figure. Among jobs with tenure longer than two years (Figure 4f), the separation rate overshoots during the first two quarters of the reform, and then converges to its new steady-state value.[27] The reason why job destruction rates

[26] Another important motivation for this section is that countries with dual EPL might also have high minimum wage standards, which should contribute to making wages rigid.

[27] The behaviour of the separation rate at short job tenures (Figure 4e) is very erratic: it drops initially, jumps up during the following quarter, and jumps again one year after the reform has been implemented. These movements are difficult to interpret partly because of the way the job separation rate is calculated: this is the probability of separation for each match productivity and job tenure weighted by the distribution of workers across productivity and tenure. Changes in this distribution can lead to large shifts in the job separation rate, even if workers' and firms' match decision rules remain unchanged. These compositional changes are of lesser

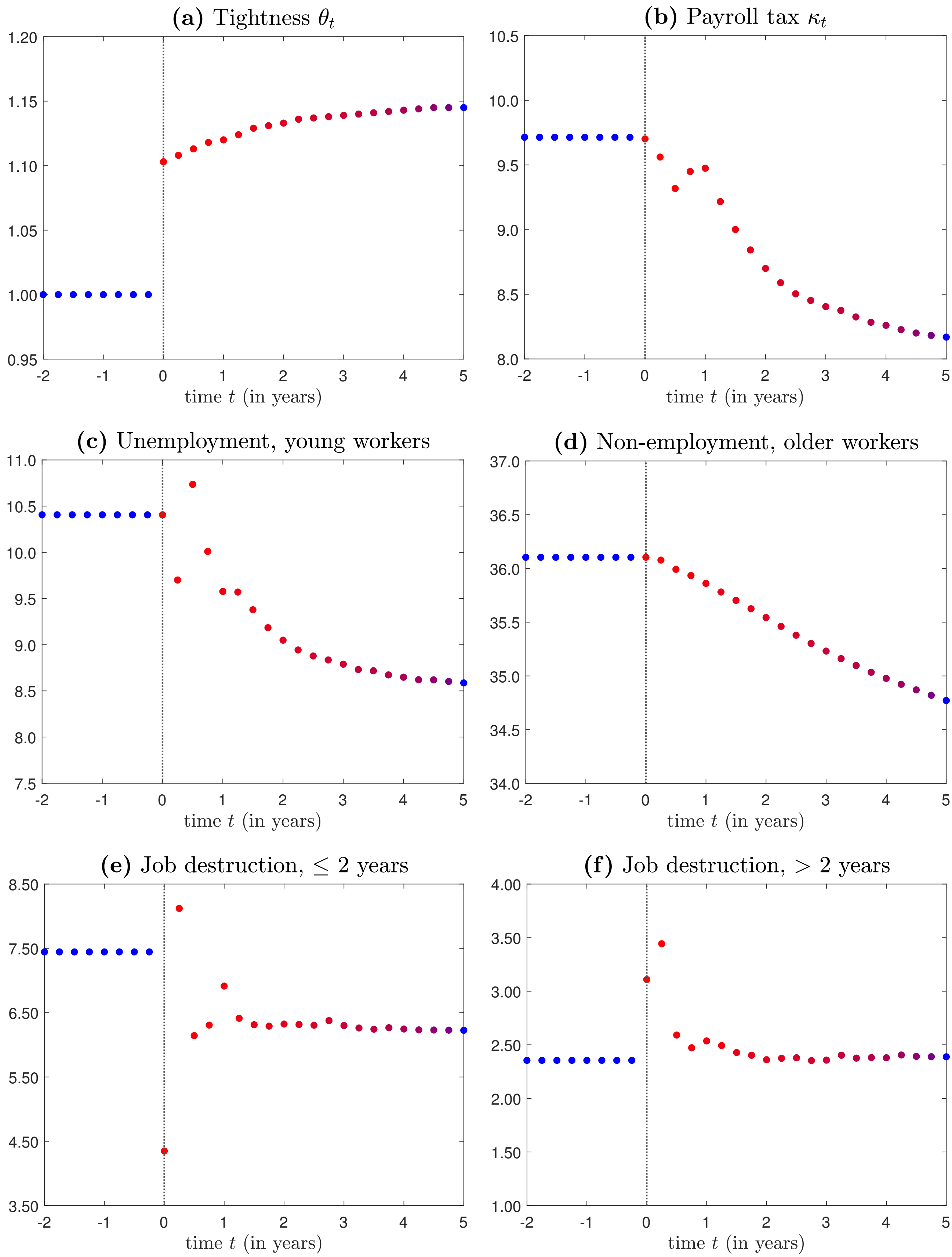


**Figure 4.** Transition dynamics with wage rigidities

**Notes:** The figure displays the time path of several labour market variables during the transition towards unified EPL under a partially non-retroactive reform. Figures on the vertical axis are expressed in percent, except for tightness $\theta$ (Figure 4a) which is reported in levels. On the horizontal axis, time is measured in years relative to the introduction of the unified EPL scheme, which occurs in period 0.

**Table 6.** Welfare effects with wage rigidities

| | | Average in each quintile | | | | |
|---|---|---|---|---|---|---|
| | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 2.93 | 2.35 | 2.64 | 2.92 | 3.18 | 3.56 |
| older workers | -0.54 | -1.51 | -0.88 | -0.51 | -0.03 | 0.30 |

**Notes:** The table reports the welfare changes (measured in consumption-equivalent units) arising from the transition towards unified EPL. All entries are expressed in percent.

are very responsive to the reform is that job separation decisions are no longer the joint outcome of bargaining between agents in this version of the model. Workers have a better outside option (since the job-finding rate is higher), yet due to wage rigidities their wages cannot be adjusted upwards instantaneously. Thus, some workers are better off transitioning through unemployment to find a new job rather than staying with their current employer. Along the transition path, unemployment adjusts more gradually than in the benchmark experiment and, as a result, the payroll tax decreases less rapidly, as shown in Figure 4b. Because of these slower adjustments, the dynamics of market tightness $\theta_t$ are more sluggish as well. Notwithstanding, its behaviour depicted in Figure 4a still looks very much akin to a jump variable.

Next, we study the welfare consequences among workers who are in the labour market at the time of the EPL reform. Compared to the benchmark experiment, Table 6 shows larger welfare gains among young workers: 2.93 percent vs. 1.19 percent in Table 5. Among older workers, on the other hand, the welfare effects are more similar to the benchmark. There are two reasons for the larger welfare gains, both related to the fact that wage rigidities lead to privately-inefficient job separations. With dual EPL, agents would bargain for lower wages before the discontinuous increase in severance pay, but wage rigidities limit this possibility and trigger additional separations. This occurs less with a unified EPL scheme. As firms benefit from facing fewer quits from workers, they post more vacancies, making the job-finding rate increase more in this experiment than in the benchmark one. Second, workers face a smoother wage profile when employed in jobs regulated by the unified EPL scheme. In sum, the findings from this experiment are consistent with the idea that wage rigidities tend to amplify the negative consequences of ill-designed EPL. On this note, it is interesting to see that policymakers introduced certain schemes to make wages more flexible (essentially giving more bargaining power to employers to adjust internal conditions, such as working hours, wages, etc.) when the 2012 reform of the Spanish EPL system was implemented.

## 6.2 Initial Match Heterogeneity

In the baseline model, all worker-firm matches initially start out at the same productivity, and we assume that there is perfect monitoring of the search behaviour of unemployed workers. These two assumptions are intimately related and they are important to making the model fully tractable (cf. Footnote 7). In the second variant of the model, we relax these assumptions in order to get a sense of how they shape our results. While in the baseline model all jobs start

importance for the job separation rate at longer tenures (Figure 4f), whose dynamics is thus more directly related to workers' and firms' match decision rules.

with the productivity level $z_0$, we now assume that this occurs only with probability $1-\alpha^i$. With probability $\alpha^i$, initial match productivity is drawn from a Normal distribution with mean $z_0$ and standard deviation $\sigma$. This affects the workings of our economy in several ways. To begin with, it introduces a match formation rule, that is, a decision whether to start producing or to continue searching for a better match. The choice to accept or reject a new work opportunity depends not only on the realisation of $z$, but also on the worker's option value of continued search (which is a function of the previous tenure via the annuity). Consequently, the expected duration of joblessness becomes heterogeneous across workers, and the free-entry condition for firms now depends on the whole distribution of unemployed workers across previous job tenures – which is a key difference to the baseline model.

Table 7 presents the steady-state effects of introducing unified EPL in an economy where half of all matches draw their initial productivity from a Normal distribution (i.e., $\alpha^i = 0.5$). Unlike in Table 4, we do not report wages and match productivity since their changes are similar to those in Table 4; instead we focus on unemployment duration for reasons that will become clear momentarily. Table 7 shows larger changes in equilibrium allocations relative to the benchmark experiments. Tightness and the job-finding rate increase by more than 25 percent. As a result, unemployment among young workers and the payroll tax fall by larger magnitudes than in the baseline model. To understand the mechanisms at work, it is useful to separate out two components of the job-finding rate: the probability of meeting $\theta q(\theta)$ and the probability of matching conditional on meeting. It turns out that the latter component drives most of the changes reported in Table 7. This is evidenced by the reduction in long (more than 1 year) and very long (more than 2 years) spells of unemployment, rendering the distribution of unemployment duration in the steady-state equilibrium with unified EPL closer to a geometric distribution. The lesson we draw from this experiment is that imperfect monitoring of the search behaviour of unemployed workers can go a long way impacting the effects of EPL reforms. Long-tenured workers who get laid off with a generous severance package are less inclined to accept new jobs. With better/perfect monitoring, this effect vanishes, and EPL becomes more desirable.

## 6.3 Human Capital

There is a rich literature discussing the relationships between EPL and human capital accumulation. With no pretence to contribute to this literature, in this section we study how (endogenous) human capital accumulation affects our results. The workings of this model extension are as follows. By devoting some effort $e$ to acquiring human capital, the worker-firm pair can increase the output flow to $z\left(1+\alpha^h\right)$, where $\alpha^h \geq 0$ is the parameter measuring the productivity gain from human capital. Effort $e$ is costly in terms of current match output and delivers human capital accumulation with probability $\pi(e)$. We assume that human capital is entirely firm- (or job-) specific, and therefore it is destroyed when the job ends. We set $\alpha^h = 0.50$, thus effectively assuming that firm-specific human capital can increase productivity by 50 percent.

Table 8 presents the steady-state effects of introducing unified EPL in economies with human capital accumulation. We report the same outcomes as those shown in Table 4. Interestingly, despite the difference in the levels of match productivity (which are higher in this version of

**Table 7.** Comparison between two steady states with initial match heterogeneity

| **Aggregate equilibrium variables** | **Dual EPL** | **Unified EPL** | **Change (%)** |
|---|---|---|---|
| tightness | 1.00 | 1.27 | 27.5 |
| payroll tax | 9.03 | 7.41 | -18.0 |
| **Non-employment and job turnover** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| unemployment, young workers | 9.52 | 7.51 | -21.2 |
| non-employment, older workers | 33.1 | 31.3 | -5.5 |
| job-finding rate | 40.0 | 50.1 | 25.3 |
| job destruction, $\leq$2 years | 7.44 | 6.36 | -14.5 |
| job destruction, >2 years | 2.22 | 2.38 | 7.3 |
| **Unemp. duration (young workers)** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| less than 6 months | 40.0 | 50.0 | 25.0 |
| 6 months to 1 year | 36.8 | 36.8 | 0.1 |
| 1 year to 2 years | 18.7 | 11.9 | -36.1 |
| more than 2 years | 4.48 | 1.16 | -74.1 |
| **Welfare in consumption equivalents** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| new entrants | – | – | 1.93 |

**Notes:** The table provides a comparison between the steady-state equilibrium with unified EPL and the steady-state equilibrium with dual EPL. Payroll taxes in the first panel and all entries in the second and third panel are expressed in percent. The fourth panel reports the change in the lifetime utility of new entrants between the two steady states, and is expressed in consumption-equivalent units. All entries in columns 'Change (%)' are expressed in percent.

**Table 8.** Comparison between two steady states with human capital

| **Aggregate equilibrium variables** | **Dual EPL** | **Unified EPL** | **Change (%)** |
|---|---|---|---|
| tightness | 1.00 | 1.20 | 19.8 |
| payroll tax | 9.18 | 8.06 | -12.1 |
| **Non-employment and job turnover** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| unemployment, young workers | 8.93 | 7.63 | -14.6 |
| non-employment, older workers | 34.3 | 32.7 | -4.8 |
| job-finding rate | 40.0 | 43.8 | 9.4 |
| job destruction, $\leq$2 years | 7.62 | 5.85 | -23.2 |
| job destruction, >2 years | 2.02 | 2.17 | 7.4 |
| **Wages and productivity** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| average wage, young workers | 0.51 | 0.53 | 5.0 |
| average wage, older workers | 0.51 | 0.43 | -15.2 |
| average match prod., young workers | 0.66 | 0.66 | -0.4 |
| average match prod., older workers | 0.75 | 0.75 | -0.8 |
| **Welfare in consumption equivalents** | **Dual EPL** | **Unified EPL** | **Change (%)** |
| new entrants | – | – | 2.23 |

**Notes:** The table provides a comparison between the steady-state equilibrium with unified EPL and the steady-state equilibrium with dual EPL. Payroll taxes in the first panel and all entries in the second panel are expressed in percent. The fourth panel reports the change in the lifetime utility of new entrants between the two steady states, and is expressed in consumption-equivalent units. All entries in columns 'Change (%)' are expressed in percent.

the model, because of human capital accumulation), the changes in labour-market outcomes across steady states are similar to those in the benchmark experiment. For instance, match productivity among older workers decreases by 0.8 percent in both models. The same holds true for wages among young and older workers. On the other hand, changes in tightness and in the job-finding rate are twice as large as in the benchmark experiment; as a result, the reduction in unemployment and in the payroll tax are also larger. These somewhat stronger allocational changes induce larger welfare effects as well. The welfare gain amounts to 2.23 percent vs. 1.52 in the benchmark experiment. On a broader level, the model with human capital confirms the robustness of one of our main results, namely that welfare gains are mostly driven by the reduction of turnover at short job tenures. We also find (not shown in Table 8) that the average effort to acquire human capital increases slightly after the EPL reform, more so for short-tenured than for long-tenured jobs. These findings are consistent with the view that enhanced job security can promote the acquisition of human capital and amplify the gains of moving to a unified EPL system.

# 7 Conclusion

This paper provides a computationally tractable approach to study the consequences of reforming employment protection legislation in dual labour markets. We advance a model rationalising the properties of the unified EPL scheme that features prominently in European policy debates. First, risk-averse agents value a smooth consumption stream, and therefore dislike the discontinuities in income flows coming from EPL gaps. Second, workers who have been employed longer are more likely to face deteriorated employment opportunities, meaning that the generosity of EPL should increase with job tenure. A unified EPL scheme meeting these requirements could replace the highly dual EPL systems that characterise segmented labour markets, which is the crux of our analysis. An important feature is that we can take account of the transition path between the two EPL systems, and thereby evaluate the consequences of a unified EPL scheme for workers who populate the dual labour market when the reform is introduced. Our framework is thus well suited to draw quantitative inference, and to provide figures that would inform real-life labour market policies.[28]

We focus on the Spanish labour market to illustrate our approach. We first show that replacing the dual EPL scheme with a unified scheme generates large welfare gains on average, which are chiefly driven by the decrease in turnover at short job tenures. Second, we find that the welfare effects are very heterogeneous across workers. Among workers who benefit from the policy change (mostly young workers in our model), the average welfare gain in the top quintile is about three times higher than that experienced by the lower quintile. Among older workers, the reform is largely detrimental. This cross-sectional dispersion could be key to understanding resistance to structural EPL reforms. Last, we examine several extensions of our model. They confirm the

[28] An alternative consists in using our model to study how the labour market of country A would behave if it adopted the EPL system of country B. Another possibility is to investigate the effects of non-linear relations between the stringency of EPL and job tenure, as our model can accommodate non-linear severance pay schedules, $\phi(\tau)$. We focus on piecewise-linear functions which seems to be the empirically-relevant case (e.g., OECD [2004], Boeri et al. [2017]).

robustness of our findings, but more importantly they provide indications on the extent to which our results would generalise to other settings (e.g., countries where institutions lead to more wage rigidity, tougher monitoring of the search efforts of the unemployed, etc.).

The analysis presented in this paper can be extended to address a number of related issues. One interesting question is how to limit the uncertainty associated with workers' appeal to labour courts in order to obtain higher redundancy pay for unfair dismissals. For example, exploring the possibility of having a fast-track compensation, as in the recent Jobs Act in Italy, and its implications could be a fruitful line of future research (see Sestito and Viviano [2018]). Another question worth pursuing is whether existing EPL schemes can be rationalised as maximising some particular social welfare function, and/or how to design a socially-optimal unified EPL scheme. We only get a first grip on this issue, by focusing on a criterion based on steady-state lifetime utilities, and leave a more comprehensive analysis for future work. Finally, our model can be used to delve into further political economy issues of reforming EPL in dual labour markets. Modelling political influence and lobbying by certain groups (e.g. trade unions) could help explain the observed inertia to reform the extant regulations, and shed new light on the interplay between insiders' and outsiders' preferences and actions.

# Appendix

## A Stock-flow Equations

The evolution of the cross-sectional distribution of the economy between $t$ and $t+1$ depends on market tightness $\theta_t$ and job separation decisions $\overline{z}_t^i(\tau)$ in period $t$. New hires are given by:

$$\lambda_{t+1}^y(z_0, 0) = \theta_t q(\theta_t)(1-\gamma)\sum_\tau \mu_t^y(\tau) \tag{A1}$$

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

$$\lambda_{t+1}^y(z', \tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}(1-\gamma)\lambda_t^y(z,\tau), \tag{A2}$$

$$\lambda_{t+1}^o(z', \tau') = \sum_z \mathbb{1}\left\{z' \geq \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_{t+1}^y(z,\tau) + (1-\chi)\lambda_{t+1}^o(z,\tau)\right). \tag{A3}$$

As for the dynamics of the pool of non-employed workers, recall that newborns enter the economy in every period. Our stochastic life-cycle setting implies there are $\frac{\gamma}{\chi+\gamma}$ older workers in the workforce. A fraction $\chi$ of them leaves the economy every period, and the same number of workers enters to keep the size of the workforce at a constant level. Therefore we have:

$$\mu_{t+1}^y(0) = \chi\frac{\gamma}{\chi+\gamma} + (1-\theta_t q(\theta_t))(1-\gamma)\mu_t^y(0) \tag{A4}$$

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

$$\mu_{t+1}^y(\tau') = (1-\theta_t q(\theta_t))(1-\gamma)\mu_t^y(\tau') + \sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^y(\tau')\right\}\pi_{z,z'}(1-\gamma)\lambda_t^y(z,\tau). \tag{A5}$$

Among older non-employed workers whose job tenure was $\tau'$ when they were dismissed from the previous job, the law of motion is:

$$\begin{aligned}\mu_{t+1}^o(\tau') = {}& \gamma\mu_t^y(\tau') + (1-\chi)\mu_t^o(\tau') \\ & + \sum_z \mathbb{1}\left\{z' < \overline{z}_{t+1}^o(\tau')\right\}\pi_{z,z'}\left(\gamma\lambda_t^y(z,\tau) + (1-\chi)\lambda_t^o(z,\tau)\right).\end{aligned} \tag{A6}$$

Last, the size of the workforce is equal to one, which means that in every period $t$ we have:

$$\sum_\tau\sum_z\left(\lambda_t^y(z,\tau) + \lambda_t^o(z,\tau)\right) + \sum_\tau\left(\mu_t^o(\tau) + \mu_t^y(\tau)\right) = 1. \tag{A7}$$

# B Proof of Proposition 1

At date $t_1$, the economy is at a steady-state equilibrium. Therefore equation (5) becomes

$$U_{t_1}^y(\Delta,\tau) = u(a^y(\Delta,\tau)+b^y) + \frac{1}{1+r}\Big[(1-\gamma)\big(\theta_{t_1}q(\theta_{t_1})W_{t_1}^y(z_0,0) + (1-\theta_{t_1}q(\theta_{t_1}))U_{t_1}^y(\Delta,\tau)\big) + \gamma\widetilde{U}_{t_1}^o(\Delta,\tau)\Big], \tag{B1}$$

which enables us to recover $U_{t_1}^y(\tau,\Delta)$ for *any* expected duration $\Delta$:

$$U_{t_1}^y(\tau,\Delta) = \frac{1}{r+\gamma(1-\theta_{t_1}q(\theta_{t_1}))+\theta_{t_1}q(\theta_{t_1})}\Big[(1+r)\,u(a^y(\Delta,\tau)+b^y) + (1-\gamma)W_{t_1}^y(z_0,0)+\gamma\widetilde{U}_{t_1}^o(\tau,\Delta)\Big]. \tag{B2}$$

$\widetilde{U}_{t_1}^o(\tau,\Delta)$ is trivial to compute and $W_{t_1}^y(z_0,0)$ can be computed using the approach described in Appendix C. Next, using the sequence $(W_t^y(z_0,0))_{t=t_0,\dots,t_1}$ and combining equations (5) and (B2) enables us to construct $(U_t^y(\Delta,\tau))_{t=t_0,\dots,t_1}$ backwards for any $\Delta$. Notice that, on the other hand, $\widetilde{U}_t^o(\tau,\Delta)$ does not change over time, i.e. $\widetilde{U}_t^o(\tau,\Delta)=\widetilde{U}_{t_1}^o(\tau,\Delta)$ for all $t$.

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

$$\Delta_t = (1-\gamma)\left[\theta_t q(\theta_t) + (1-\theta_t q(\theta_t))(1+\Delta_{t+1})\right] + \frac{\gamma}{\chi}. \tag{B3}$$

Thus, we can use the sequence $(\theta_t)_{t=t_0,\dots,t_1}$ to obtain $(\Delta_t)_{t=t_0,\dots,t_1}$: just like $\theta_t$, $\Delta_t$ is a forward-looking variable. Notice that equation (B3) yields the following relationship between $\Delta$ and $\theta$ when the economy is at a steady state:

$$\Delta = \frac{1-\gamma+\frac{\gamma}{\chi}}{\gamma(1-\theta q(\theta))+\theta q(\theta)}. \tag{B4}$$

# C Computational Details

**C.1 Computing Steady States** We omit the time subscript in this subsection to indicate that the economy is in steady state. Computing a steady state is not a trivial task because $U^y(\Delta,\tau)$, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$, $J^o(z,T)$, as well as $w^y(z,T)$, $w^o(z,T)$, can only be recovered by solving fixed-point problems. Our algorithm is as follows:

1. Solve for $W^o(z,T)$, $J^o(z,T)$, $w^o(z,T)$ using the following steps:
    (a) Set initial guesses $\widehat{W}^o(z,T)$, $\widehat{J}^o(z,T)$, $\widehat{w}^o(z,T)$, where we use $\widehat{\cdot}$ to indicate a guess.
    (b) Compute the reservation wage of the worker $\underline{w}^o(z,T)$ and that of the firm $\overline{w}^o(z,T)$ associated with $\widehat{W}^o(z,T)$ and $\widehat{J}^o(z,T)$ using equations (17) and (18).

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

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

and update $\widehat{w}^o(z,T)$ using this value (observe that $U^o(T)$ is pinned down by equation (6)). This first-order condition is a non-linear equation that can be solved using, e.g., the bisection method. If $\overline{w}^o(z,T) < \underline{w}^o(z,T)$, set $\widehat{w}^o(z,T) = \frac{1}{2}\left(\overline{w}^o(z,T)+\underline{w}^o(z,T)\right)$.

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

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

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

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

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

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

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

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

   (b) Solve for $W^y(z,T)$, $J^y(z,T)$, $w^y(z,T)$ using a methodology similar to step (1), i.e.: (i) Set initial guesses $\widehat{W}^y(z,T)$, $\widehat{J}^y(z,T)$, $\widehat{w}^y(z,T)$; (ii) Use equations (16) and (18) to obtain the reservation wages $\underline{w}^y(z,T)$ and $\overline{w}^y(z,T)$ implied by $\widehat{W}^y(z,T)$ and $\widehat{J}^y(z,T)$; (iii) Use the analogue of step (1c) to update the wage. Observe that $\widehat{U}^y(\Delta,T)$ is used as the outside option of the worker in the Nash bargain; (iv) Update $\widehat{W}^y(z,T)$ and $\widehat{J}^y(z,T)$ using equations (8) and (10); (v) Iterate until convergence.

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

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

The algorithm builds on the observation that, in a steady state, the asset values $U^y(\Delta,\tau)$, $W^y(z,T)$, $W^o(z,T)$, $J^y(z,T)$ and $J^o(z,T)$ are solutions to an infinite-horizon problem, whereas

$W^y(z,\tau)$, $W^o(z,\tau)$, $J^y(z,\tau)$, $J^o(z,\tau)$ for all $\tau < T$ solve a standard finite-period ($T$) problem, and $U^o(\tau)$ is completely determined.

A steady state also involves finding the equilibrium tuple $(\theta, \kappa)$ and the expected duration of a jobless spell $\Delta$. Therefore, the algorithm above is nested into two outer loops to iterate on the tuple $(\theta, \kappa)$. First, we fix the payroll tax $\kappa$ and iterate to solve for labour market tightness $\theta$. At a given $\theta$, the expected duration $\Delta$ is fixed and known since the economy is at a steady state (see equation (B4) in Appendix B). Second, we solve for the time-invariant distribution, calculate the budget-clearing payroll tax and update $\kappa$ accordingly. Finally, notice that the severance pay function $\phi(\tau)$ is specified as a function of the average wage $\widetilde{w}$. Since this is an equilibrium object, we must add an outer loop to iterate on $\widetilde{w}$.

**C.2 Computing Transition Paths** The transition path eliminates the infinite horizon problem analysed in Appendix C.1 because all continuation values depend on $t+1$. The other key observation is that the computation needs not keep track of all the sequences used to define the transition path (cf. Definition 2). The 'only' required objects are: the cross-sectional distribution of agents at $t_0$, the sequences $(W_t^y(z_0,0,1))_{t=t_0,\dots,t_1}$, $(w_t^y(z,\tau,\epsilon),\ \ w_t^o(z,\tau,\epsilon))_{t=t_0,\dots,t_1}$, $(\overline{z}_t^y(\tau,\epsilon),\ \ \overline{z}_t^o(\tau,\epsilon))_{t=t_0,\dots,t_1}$ and $(\theta_t)_{t=t_0,\dots,t_1}$, as well as the time path $(\kappa_t)_{t=t_0,\dots,t_1}$. In these notations, in line with Proposition 2, we introduce an additional state variable $\epsilon \in \{0,1\}$ indicating whether the worker-firm pair already exists when the reform is introduced ($\epsilon = 0$) or not ($\epsilon = 1$, which results in the $\phi_1$ function in equation (22)). Then, our algorithm works as follows:

1. Compute the equilibrium allocation of the economy in period $t_1$.
2. Guess a time 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 backwards from $t_1$ until $t_0$ as follows:
   (a) Compute the severance pay function $\phi_t(\tau)$ for workers in $\epsilon = 0$ using Proposition 2.
   (b) Compute market tightness $\theta_t$ consistent with free entry at time $t$, and store it.
   (c) Use Proposition 1 to compute $U_t^y(\Delta_t,\tau)$ and $U_{t+1}^y(\Delta_{t+1},\tau)$. Notice that these require the sequences of $\Delta_t$ and $W_{t+1}^y(z_0,0,1)$ from $t$ onwards, which we have at hand.
   (d) Solve for the wage functions $w_t^y(z,\tau,\epsilon)$ and $w_t^o(z,\tau,\epsilon)$ at time $t$, store them, and compute the asset values of employment. Finally, compute the job separation decisions $\overline{z}_t^y(\tau,\epsilon)$ and $\overline{z}_t^o(\tau,\epsilon)$ at time $t$ and store them.
4. Initialize the distribution using the cross-sectional distribution of agents at $t_0$.
5. Using $(\theta_t)_{t=t_0,\dots,t_1}$, $(w_t^y(z,\tau,\epsilon),\ \ w_t^o(z,\tau,\epsilon))_{t=t_0,\dots,t_1}$ and $(\overline{z}_t^y(\tau,\epsilon),\ \ \overline{z}_t^o(\tau,\epsilon))_{t=t_0,\dots,t_1}$ and the stock-flow equations (A1)–(A7) (augmented to include the state variable $\epsilon$), compute the evolution of the cross-sectional distribution from $t_0$ until $t_1$ . Each period, compute the budget-clearing value of the payroll tax $\kappa_t$ 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 coincides with the $t_1$ payroll tax, we allow for a very large number of periods between $t_0$ and $t_1$. In our applications, we set the number of period to 1,000 (250 years). After 500 periods, the measure of workers who remain in state $\epsilon = 0$ is 0.0001.

# D Additional Tables and Figures

**D.1 Welfare Effects with Savings** Table D1 presents the welfare effects of the unified EPL scheme in the approximate model with savings. Since the transition path of this model is too costly to compute, welfare changes for those who are employed at the time of the reform are based on steady-state approximations. These calculations are nevertheless informative because the EPL transition in our model is quickly completed.

**Table D1.** Welfare effects in the approximate model with savings

| | **Welfare change** | **Asset change** |
|---|---|---|
| new entrants | 1.26 | – |
| average, all workers | 0.31 | 14.6 |
| average, young workers | 0.43 | 18.2 |
| average, older workers | -0.73 | -0.40 |

**Notes:** The table reports steady-state welfare changes (measured in consumption-equivalent units) and steady-state changes in asset levels from introducing a unified EPL in the approximate model with savings. All entries are expressed in percent.

The first remark concerns changes in the steady-state welfare of newborn agents – the only 'legitimate' criterion for steady-state comparisons. We find that the benchmark model overestimates the welfare gain of reforming EPL only slightly (1.52 percent in Table 4 vs. in 1.26 percent Table D1). Second, average welfare losses among older workers are in the same ballpark (-0.73 vs. -0.79 in Table 5 describing the benchmark model). Third, by contrast, the welfare gain among young workers is smaller in the approximate model (0.43 vs. 1.19 in the benchmark model). As the rightmost column (displaying changes in asset levels) shows, the EPL reform induces young workers to build up additional wealth by saving a larger share of their income, at the expense of lower consumption. The benchmark model ignores this effect.

**D.2 Welfare Effects under a *Statu-quo* Reform** Table D2 presents the welfare effects of the transition towards unified EPL under a statu-quo reform. Figure D1 shows the time path of several variables during the transition. See the main text for a discussion.

**Table D2.** Welfare effects under a *statu-quo* reform

| | | **Average in each quintile** | | | | |
|---|---|---|---|---|---|---|
| | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 1.29 | 1.16 | 1.21 | 1.27 | 1.35 | 1.48 |
| older workers | 0.21 | 0.15 | 0.19 | 0.22 | 0.23 | 0.24 |

**Notes:** The table reports the welfare changes (measured in consumption-equivalent units) arising from the transition towards unified EPL. All entries are expressed in percent.

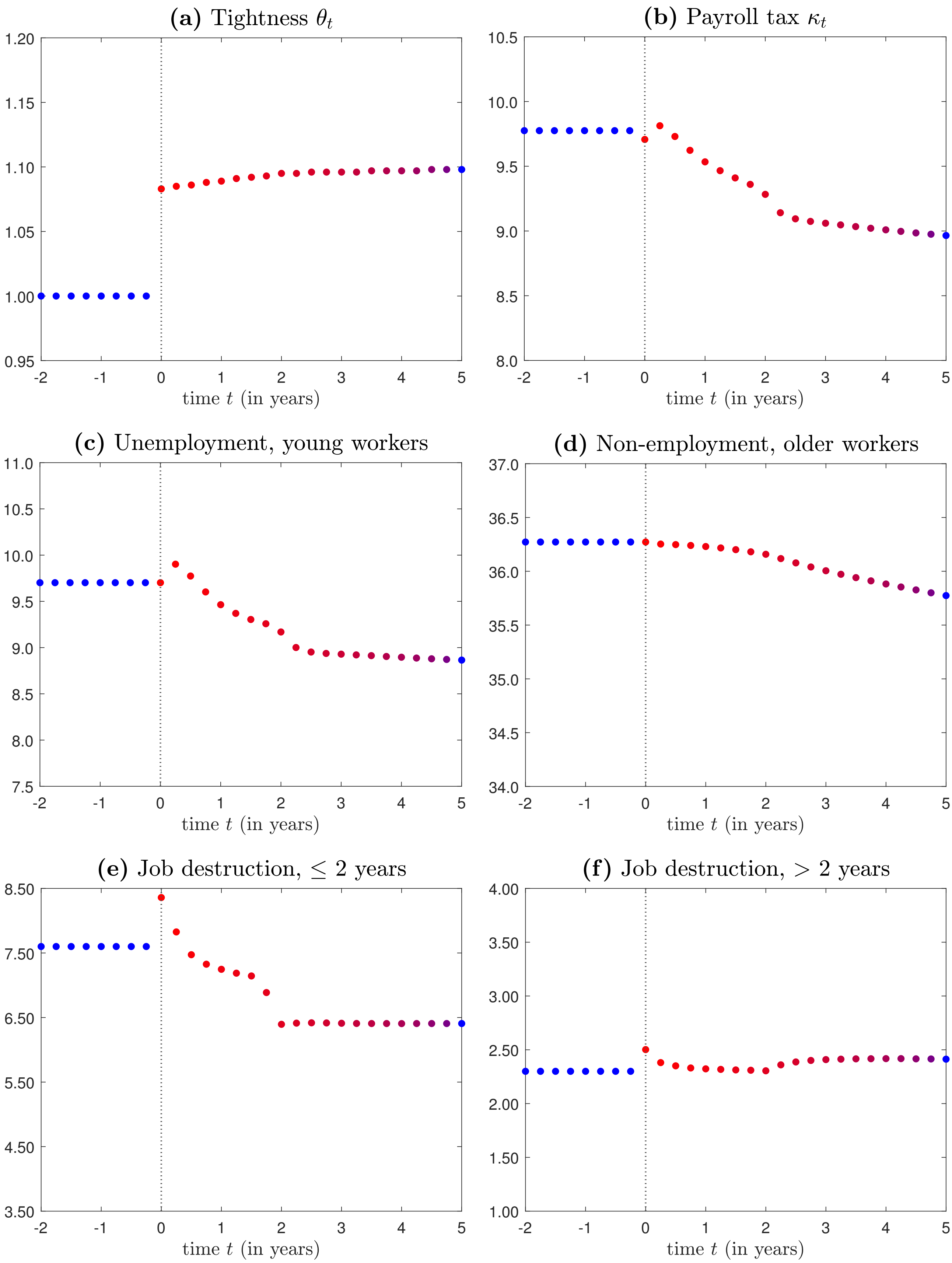


**Figure D1.** Transition dynamics under a *statu-quo* reform

**Notes:** The figure displays the time path of several labour market variables during the transition towards unified EPL under a partially non-retroactive reform. Figures on the vertical axis are expressed in percent, except for tightness $\theta$ (Figure D1a) which is reported in levels. On the horizontal axis, time is measured in years relative to the introduction of the unified EPL scheme, which occurs in period 0.

# References

Fernando Alvarez and Marcelo Veracierto. Severance payments in an economy with frictions. *Journal of Monetary Economics*, 47(3):477–498, 2001.

Javier Andrés, Samuel Bentolila, José J Dolado, and Florentino Felgueroso. Propuesta para la reactivación laboral en España. *Grupo de Discusión de Economía Laboral. FEDEA*, 2009.

Banco de España. The Spanish Survey of Household Finances (EFF) 2008: Methods, results and changes since 2005. *Economic Bulletin*, pages 90–123, July 2011.

Samuel Bentolila and Juan J Dolado. Labour flexibility and wages: Lessons from Spain. *Economic Policy*, 9(18):53–99, 1994.

Samuel Bentolila, Tito Boeri, and Pierre Cahuc. Ending the scourge of dual labour markets in Europe. *VoxEU, www.voxeu.org/article/ending-scourge-dual-labour-markets-europe*, 2012a.

Samuel Bentolila, Pierre Cahuc, Juan J Dolado, and Thomas Le Barbanchon. Two-tier labour markets in the Great Recession: France versus Spain. *The Economic Journal*, 122(562):F155–F187, 2012b.

Samuel Bentolila, Juan J Dolado, and Juan F Jimeno. Reforming an insider-outsider labor market: The Spanish experience. *IZA Journal of European Labor Studies*, 1(1):1–29, 2012c.

Giuseppe Bertola and Richard Rogerson. Institutions and labor reallocation. *European Economic Review*, 41(6):1147–1171, 1997.

Olivier Blanchard and Jean Tirole. Protection de l'emploi et procédures de licenciement. *Rapport du Conseil d'analyse économique, Octobre 2003*, 2003.

Olivier J. Blanchard and Augustin Landier. The perverse effects of partial labour market reform: Fixed-term contracts in France. *The Economic Journal*, 112(480):F214–F244, 2002.

Olivier J Blanchard and Jean Tirole. The joint design of unemployment insurance and employment protection: A first pass. *Journal of the European Economic Association*, 6(1):45–77, 2008.

Tito Boeri and Pietro Garibaldi. *Un nuovo contratto per tutti*. Chiarelettere Milano, 2008.

Tito Boeri, Pietro Garibaldi, and Espen R Moen. Inside severance pay. *Journal of Public Economics*, 145:211–225, 2017.

Antonio Cabrales, Juan J Dolado, and Ricardo Mora. Dual labour markets and (lack of) on-the-job training: PIAAC evidence from Spain and other EU countries. *SERIEs Journal of the Spanish Economic Association*, 8:345–371, 2017.

Pierre Cahuc. For a unified contract. *European Labour Law Journal*, 3(3):190–205, 2012.

Pierre Cahuc and Francis Kramarz. De la précarité à la mobilité: vers une sécurité sociale professionnelle. *Rapport au Ministre de l'Économie, des Finances et de l'Industrie et au Ministre de l'Emploi, du Travail et de la Cohésion Sociale, Décembre 2004*, 2004.

Pierre Cahuc and Fabien Postel-Vinay. Temporary jobs, employment protection and labor market performance. *Labour Economics*, 9(1):63–91, 2002.

Pierre Cahuc, Olivier Charlot, and Franck Malherbet. Explaining the spread of temporary jobs and its impact on labor turnover. *International Economic Review*, 57(2):533–572, 2016.

Arnaud Chéron, Jean-Olivier Hairault, and François Langot. Age-dependent employment protection. *The Economic Journal*, 121(557):1477–1504, 2011.

Arnaud Chéron, Jean-Olivier Hairault, and François Langot. Life-cycle equilibrium unemployment. *Journal of Labor Economics*, 31(4):843–882, 2013.

Marco Cozzi and Giulio Fella. Job displacement risk and severance pay. *Journal of Monetary Economics*, 84:166–181, 2016.

Juan J Dolado. EU dual labour markets: Consequences and potential reforms. In *Economics without Borders. Economic Research for European Policy Challenges, R. Blundell et al., eds.* Cambridge: Cambridge University Press, 2017.

Juan J Dolado, Carlos García-Serrano, and Juan F Jimeno. Drawing lessons from the boom of temporary jobs in Spain. *The Economic Journal*, 112(480):F270–F295, 2002.

Juan J Dolado, Etienne Lalé, and Nawid Siassi. From dual to unified employment protection: Transition and steady state. *IZA Discussion Paper No. 9953*, 2016.

Ignacio J García-Pérez and Fernando Muñoz-Bullón. Transitions into permanent employment in Spain: An empirical analysis for young workers. *British Journal of Industrial Relations*, 49(1): 103–143, 2011.

Ignacio J García Pérez and Victoria Osuna. The effects of introducing a single open-ended contract in the Spanish labour market. *Unpublished manuscript, U Pablo de Olavide*, 2012.

Ignacio J García Pérez and Victoria Osuna. Dual labour markets and the tenure distribution: Reducing severance pay or introducing a single contract. *Labour Economics*, 29:1–13, 2014.

Pietro Ichino. Disegno di legge per la transizione a un regime di flexicurity, n. 1481. *Senato Italiano, Rome*, 2009.

Per Krusell, Toshihiko Mukoyama, and Ayşegül Şahin. Labour-market matching with precautionary savings and aggregate fluctuations. *Review of Economic Studies*, 77(4):1477–1507, 2010.

Etienne Lalé. Labor-market frictions, incomplete insurance and severance payments. *Review of Economic Dynamics*, 31:411–435, 2019.

Edward P. Lazear. Job security provisions and employment. *Quarterly Journal of Economics*, 105(3):699–726, 1990.

OECD. Employment protection regulation and labour market performance. *OECD Employment Outlook*, 2004.

OECD. Pensions at a glance 2005: Public Policies across OECD Countries. *Organization for Economic Cooperation and Development*, 2005.

OECD. Chapter 4: Non regular employment, job security and the labour market divide. *OECD Employment Outlook*, 2014.

Barbara Petrongolo and Christopher A Pissarides. Looking into the black box: A survey of the matching function. *Journal of Economic Literature*, 39(2):390–431, 2001.

Christopher A Pissarides. Employment protection. *Labour Economics*, 8(2):131–159, 2001.

Fabien Postel-Vinay and Hélène Turon. The impact of firing restrictions on labour market equilibrium in the presence of on-the-job search. *The Economic Journal*, 124(575):31–61, 2014.

Yolanda Rebollo-Sanz. Unemployment insurance and job turnover in Spain. *Labour Economics*, 19(3):403–426, 2012.

Richard Rogerson and Martin Schindler. The welfare costs of worker displacement. *Journal of Monetary Economics*, 49(6):1213–1234, 2002.

Gilles Saint-Paul. *Dual labor markets: A macroeconomic perspective*. MIT press, 1996.

Gilles Saint-Paul. Employment protection, international specialization, and innovation. *European Economic Review*, 46(2):375–395, 2002.

Paolo Sestito and Eliana Viviano. Firing costs and firm hiring: Evidence from an Italian reform. *Economic Policy*, 33(93):101–130, 2018.

# Appendix – Not for Publication

## E The Approximate Model with Savings

To understand how workers faced with the wages and labour market trajectories of the baseline model would make unrestricted consumption-savings decisions, we use a so-called "approximate model with savings". This model consists of two components: (i) the labour-market part coming from the baseline model which generates the earnings processes (wages and transition probabilities of moving in and out of employment), and (ii) the incomplete-markets part of the model where the earnings processes are taken as exogenous and agents use a risk-free asset to smooth consumption. The next sections are devoted to presenting this model.[29]

**E.1 Economic Environment** The labour-market part of the model is almost identical to the baseline model, so we omit a detailed repetition of its equations. There are two modifications. First, workers discount future utilities by a subjective discount rate $\varrho$ (instead of $r$ as in the baseline model) which corresponds to the discount factor used in the incomplete-markets part of the model as well. Second, we assume that per-period consumption for a worker contains an interest income component $r\bar{a}$ as well, where $\bar{a}$ denotes the average asset level in the economy. Recall that the Nash-bargained wage depends on the marginal utility of consumption of the worker, $u'(c)$. Under these assumptions, the wage depends on the aggregate stock of savings in the economy, but not on the individual savings decisions of the worker.[30]

Given parameters and a value for $r\bar{a}$, the labour-market component of the model generates wage functions $w^y(z,\tau)$ and $w^o(z,\tau)$, separation decision rules $\overline{z}^y(\tau)$ and $\overline{z}^o(\tau)$, and a job finding rate $\theta q(\theta)$. These outcomes are used as inputs into the incomplete-markets part of the model which we now turn to describe in more detail.

**E.2 Bellman Equations** Since our focus is on stationary equilibria, we omit time indices in order to simplify the notation. We denote by $U^i$ (resp. $W^i$) the value of being non-employed (resp. being employed), with $i \in \{y, o\}$ indicating the age of the worker. For young workers who are unemployed, the only state variable is the current level of assets of the worker, denoted as $a$. Thus the value function $U^y$ solves

$$U^y(a) = \max_{c,a'} \left\{ u(c) + \frac{1}{1+\varrho}\left[(1-\gamma)\left(\theta q(\theta) W^y(z_0, 0, a') + (1-\theta q(\theta)) U^y(a')\right) + \gamma U^o(a')\right] \right\} \tag{E1}$$

[29] We must limit interactions between the labour-market and incomplete-markets parts of the model, since the model that combines fully these two setups is beyond computational reach. With endogenous savings, Nash-bargained wages become a function of the worker's assets, meaning that Nash bargaining becomes a functional fixed-point problem with respect to wages (which we cannot always solve). In addition, the firm's value of a filled job becomes a function of assets, which implies that the free-entry condition depends on the asset distribution of unemployed workers. The problem there is not only that this is an infinite-dimensional object, but also that it eradicates the forward-looking nature of the free-entry condition that enables us to compute transition paths.

[30] This is the only feedback force from the incomplete-markets part to the labour-market part of the model. In contrast, when wages depend on the asset of workers, as in Krusell et al. [2010], this creates an incentive for workers to save in the risk-free asset for the very purpose of bargaining for a higher wage.

subject to

$$c + a' \leq b^y + (1+r)\,a,$$
$$a' \geq 0.$$

As is standard in the literature, we add a retirement phase in order to obtain a realistic savings pattern over the life cycle. Letting $R$ denote the value of being retired, the value function of older non-employed workers, $U^o$, is given by

$$U^o(a) = \max_{c,a'} \left\{ u(c) + \frac{1}{1+\varrho} \left( (1-\chi)\, U^o(a') + \chi R(a') \right) \right\} \tag{E2}$$

subject to

$$c + a' \leq b^o + (1+r)\,a,$$
$$a' \geq 0.$$

Turning to the value of employment for a young employed worker, her state variables are match productivity $z$, current job tenure $\tau$, and assets $a$. A young employed worker solves

$$\begin{aligned} W^y(z,\tau,a) = \max_{c,a'} \Bigg\{ u(c) + \frac{1}{1+\varrho} \Bigg[ (1-\gamma) \Bigg( \sum_{z' \geq \overline{z}^y(\tau')} \pi_{z,z'} W^y(z',\tau',a') \\ + \Bigg(1 - \sum_{z' \geq \overline{z}^y(\tau')} \pi_{z,z'}\Bigg) U^y(a' + \phi(\tau')) \Bigg) + \gamma \Bigg( \sum_{z' \geq \overline{z}^o(\tau')} \pi_{z,z'} W^o(z',\tau',a') \\ + \Bigg(1 - \sum_{z' \geq \overline{z}^o(\tau')} \pi_{z,z'}\Bigg) U^o(a' + \phi(\tau')) \Bigg) \Bigg] \Bigg\} \end{aligned} \tag{E3}$$

subject to

$$c + a' \leq w^y(z,\tau) + (1+r)\,a,$$
$$a' \geq 0.$$

As is evident in equation (E3), the productivity thresholds $\overline{z}^y(\tau)$ and $\overline{z}^o(\tau)$ determine the continuation values of the worker when she is employed. Similarly, the recursive problem of an older employed worker reads

$$\begin{aligned} W^o(z,\tau,a) = \max_{c,a'} \Bigg\{ u(c) + \frac{1}{1+\varrho} \Bigg[ (1-\chi) \Bigg( \sum_{z' \geq \overline{z}^o(\tau')} \pi_{z,z'} W^o(z',\tau',a') \\ + \Bigg(1 - \sum_{z' \geq \overline{z}^o(\tau')} \pi_{z,z'}\Bigg) U^o(a' + \phi(\tau')) \Bigg) + \chi R(a') \Bigg] \Bigg\} \end{aligned} \tag{E4}$$

subject to

$$c + a' \leq w^o(z,\tau) + (1+r)\,a,$$
$$a' \geq 0.$$

Once a worker enters retirement, she receives a retirement benefit $b^r$ each period (we do not introduce taxes to finance the provision of $b^r$ to simplify the comparison to the baseline model) and dies with per-period probability $\iota$. The recursive problem is

$$R(a) = \max_{c,a'} \left\{ u(c) + \frac{1-\iota}{1+\varrho} R(a') \right\} \tag{E5}$$

subject to

$$\begin{aligned} c + a' &\leq b^r + (1+r)\, a, \\ a' &\geq 0. \end{aligned}$$

Dying retirees are replaced by an equally-large measure of new workers to keep the population measure at a constant unit level. Newborn workers start off their lives in unemployment with zero assets.[31]

**E.3 Stationary equilibrium** Let $\lambda^y(z,\tau,a)$, $\lambda^o(z,\tau,a)$ denote the distributions of young and older employed workers; $\mu^y(a)$, $\mu^o(a)$ denote the distributions of young and older non-employed; and $\mu^r(a)$ denote the distribution of retired workers. As is standard in the literature, one can construct transition functions describing how the distributions evolve between periods. These transition functions are generated by the separation decision rules $\overline{z}^y(\tau)$, $\overline{z}^o(\tau)$ and savings decisions rules $\overline{a}^y(z,\tau,a)$, $\overline{a}^o(z,\tau,a)$, $\overline{a}^y(a)$, $\overline{a}^o(a)$, $\overline{a}^r(a)$, and by the laws of motion for the exogenous stochastic processes. A stationary equilibrium is then defined by a list of value functions and policy functions solving the workers' problems (E1)–(E5), and population distributions $\lambda^y(z,\tau,a)$, $\lambda^o(z,\tau,a)$, $\mu^y(a)$, $\mu^o(a)$, $\mu^r(a)$ that are time-invariant.

**E.4 Computation** We implement the following fixed-point algorithm. First, we guess the average asset level in the economy, $\bar{a}$, to solve the labour-market part of the model. We then feed the resulting income processes into the incomplete-markets part of the model and compute its stationary equilibrium. We use $\lambda^y(z,\tau,a)$, $\lambda^o(z,\tau,a)$, $\mu^y(a)$, $\mu^o(a)$, $\mu^r(a)$ to update the value of $\bar{a}$, and we iterate until the difference between initial guess and equilibrium $\bar{a}$ is close enough to zero.

**E.5 Calibration and Model Outcomes** We set the expected length of the retirement period to 15 years, which implies $\iota = 1/60$. We keep the interest rate unchanged from the baseline model, meaning its value is 1.01 percent per quarter (4 percent per annum). The retirement benefit $b^r$ and the subjective discount rate $\varrho$ are calibrated internally to match two data moments. We set $b^r$ to be 80 percent of average gross earnings during working age.[32] This yields $b^r = 0.2800$. To select a value for the subjective discount rate, we target a wealth-to-income ratio that is consistent with Spanish data. According to the 2008 Spanish Survey of Household Finances (Banco de España [2011]), the ratio between average wealth and average income among working-age households was 2.3.[33] We find that $\varrho = 0.94$ percent (implying a subjective discount rate of 3.7 percent per annum) delivers this value in the model.

[31] We ran experiments where the assets holdings of the dead were redistributed as lump-sum transfers to newborns workers. The results were very similar to those presented here.

[32] See "Replacement Rates", in the "Pensions at a Glance" report from the OECD [2005].

[33] According to the Survey, the mean net wealth of Spanish households is €226,000 and mean income is €39,700. Housing wealth (primary residence) makes up for 59% of total net wealth. Therefore the mean non-housing wealth of household (which proxies assets that may be liquidated on short notice and with small transaction costs to smooth out shocks) is about 2.3 times the mean of household income.

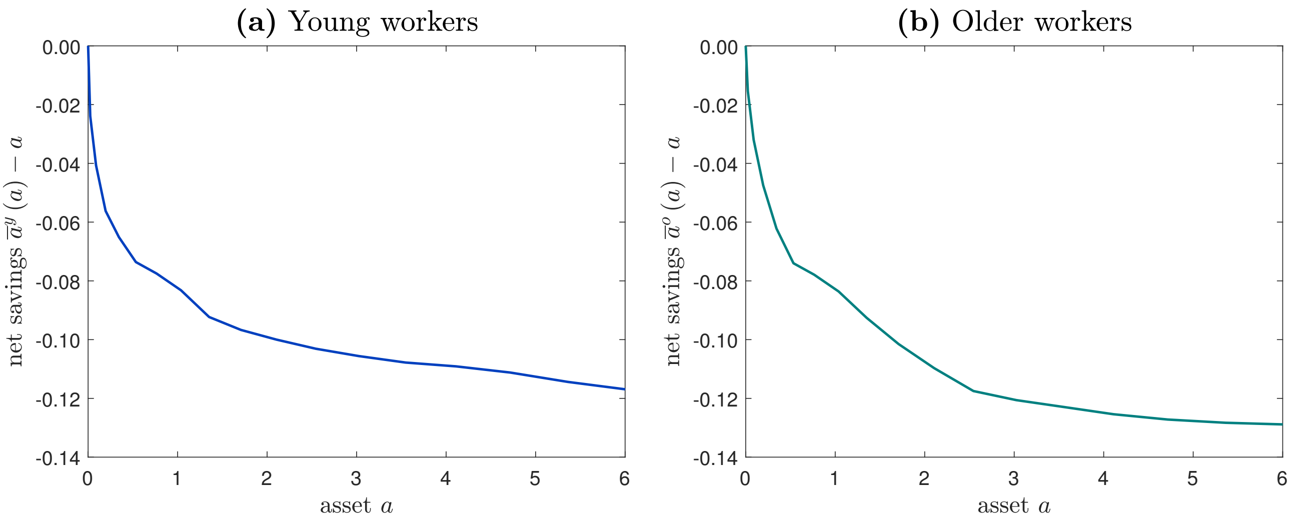


**Figure E1.** Net savings function of non-employed workers

**Notes:** The figure shows the net savings function (the policy function on assets in the next period minus asset in the current period) of workers during non-employment. Figure E1a displays the function for young workers while Figure E1b displays the function for older workers.

Figure E1 shows the policy function for net savings, $\overline{a}^y(a) - a$ and $\overline{a}^o(a) - a$ , for non-employed workers (young workers in Figure E1a, older ones in Figure E1b). As can be seen, workers run down their stock of assets for the purpose of smoothing consumption during spells of joblessness. Asset-poor workers are close to being hand-to-mouth, as their possibilities to draw on savings are limited.

The stationary distribution over assets is displayed in Figure E2. As is typical in this class of models, this distribution is skewed to the right, with many workers (8.8% of them) at or near the borrowing constraint. In the benchmark equilibrium, the Gini coefficient of the distribution of assets is 0.61.

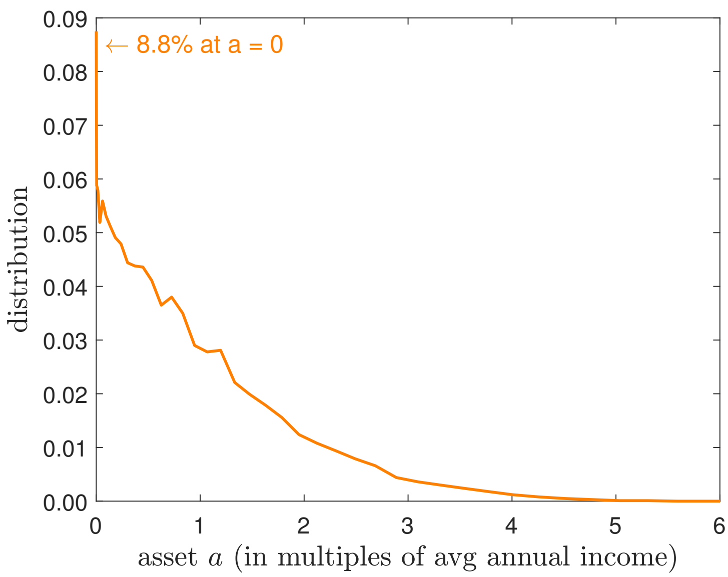


**Figure E2.** Stationary distribution over assets

**Notes:** The figure shows the stationary distribution over assets in the approximate model with savings.

# F Details of the Model Extensions

## F.1 Wage Rigidity

In this version of the model, wages are rigid in the sense that the wage during the current period partly depends on its value in the previous period. Therefore, we need to introduce a new state variable $w$ for ongoing worker-firm matches. Given $w$, the wage in the current period, which we denote as $w^*$, is

$$w^* = \alpha^r w + (1-\alpha^r)\, w_{\mathrm{NB}} \tag{F1}$$

where $0 \leq \alpha^r \leq 1$ is the parameter controlling wage rigidity, and $w_{\mathrm{NB}}$ denotes the wage that is implied by Nash bargaining (details follow). Notice that while $w_{\mathrm{NB}}$ is endogenous, the dynamics of rigid wages is governed by the exogenously-given law of motion from equation (F1). The baseline model corresponds to $\alpha^r = 0$.

A key feature of this environment is that job separation decisions are no longer the joint outcome of bargaining between agents, which implies that the worker must compute her continuation value by taking the separation decision of the firm as given, and vice versa. We thus introduce job separation decisions rules $\overline{z}^y_{W,t}(\tau, w)$ and $\overline{z}^o_{W,t}(\tau, w)$ (resp. $\overline{z}^y_{J,t}(\tau, w)$ and $\overline{z}^o_{J,t}(\tau, w)$) for the worker (resp. the firm). As should be evident, they depend not only on job tenure but also on the wage inherited from the previous period.

**Bellman Equations.** In newly-formed matches, we assume that the wage starts off at $w_0 = w^y_{\mathrm{NB}}(z_0, 0)$. Thus, the value of a young unemployed worker is given by:

$$\begin{aligned} U^y_t(\Delta,\tau) =& u(a^y(\Delta,\tau) + b^y) + \frac{1}{1+r}\Big[(1-\gamma)\big(\theta_t q(\theta_t)\, W^y_{t+1}(z_0, 0, w_0) \\ &+ (1-\theta_t q(\theta_t))\, U^y_{t+1}(\Delta,\tau)\big) + \gamma \widetilde{U}^o_{t+1}(\Delta,\tau)\Big]. \end{aligned} \tag{F2}$$

The other values of non-employment, namely $U^o_t(\tau)$ and $\widetilde{U}^o_t(\Delta,\tau)$, are unchanged from the baseline model. Then, for employed workers and firms with a filled job, the state variable of the wage evolves according to: $w' = w^*$, and the Bellman equations governing their behaviour are:

$$\begin{aligned} W^y_t(z,\tau,w) = u(w^*) + \frac{1}{1+r}\Bigg[&(1-\gamma)\Bigg(\Bigg(1 - \sum_{z' \geq \overline{z}^y_{J,t+1}(\tau', w')} \pi_{z,z'}\Bigg) U^y_{t+1}(\Delta_{t+1}, \tau') \\ &+ \sum_{z' \geq \overline{z}^y_{J,t+1}(\tau', w')} \pi_{z,z'} \max\left\{W^y_{t+1}(z',\tau',w'), U^y_{t+1}(\Delta_{t+1},\tau')\right\}\Bigg) \\ &+ \gamma\Bigg(\Bigg(1 - \sum_{z' \geq \overline{z}^o_{J,t+1}(\tau', w')} \pi_{z,z'}\Bigg) U^o_{t+1}(\tau') \\ &+ \sum_{z' \geq \overline{z}^o_{J,t+1}(\tau', w')} \pi_{z,z'} \max\left\{W^o_{t+1}(z',\tau',w'), U^o_{t+1}(\tau')\right\}\Bigg)\Bigg], \end{aligned} \tag{F3}$$

$$W_t^o(z,\tau,w) = u\left(w^*\right) + \frac{1-\chi}{1+r}\left(\left(1 - \sum_{z' \geq \overline{z}^o_{J,t+1}(\tau',w')} \pi_{z,z'}\right) U^o_{t+1}\left(\tau'\right)\right.$$

$$\left. + \sum_{z' \geq \overline{z}^o_{J,t+1}(\tau',w')} \pi_{z,z'} \max\left\{W^o_{t+1}(z',\tau',w'), U^o_{t+1}\left(\tau'\right)\right\}\right), \quad \text{(F4)}$$

$$J_t^y(z,\tau,w) = z - (1+\kappa_t)w^* + \frac{1}{1+r}\left[(1-\gamma)\left(-\left(1 - \sum_{z' \geq \overline{z}^y_{W,t+1}(\tau',w')} \pi_{z,z'}\right)\phi\left(\tau'\right)\right.\right.$$

$$\left. + \sum_{z' \geq \overline{z}^y_{W,t+1}(\tau',w')} \pi_{z,z'} \max\left\{J^y_{t+1}(z',\tau',w'), -\phi\left(\tau'\right)\right\}\right)$$

$$+ \gamma\left(-\left(1 - \sum_{z' \geq \overline{z}^o_{J,t+1}(\tau',w')} \pi_{z,z'}\right)\phi\left(\tau'\right)\right.$$

$$\left.\left. + \sum_{z' \geq \overline{z}^o_{W,t+1}(\tau',w')} \pi_{z,z'} \max\left\{J^o_{t+1}(z',\tau',w'), -\phi\left(\tau'\right)\right\}\right)\right], \quad \text{(F5)}$$

$$J_t^o(z,\tau,w) = z - (1+\kappa_t)w^* + \frac{1-\chi}{1+r}\left(\left(\sum_{z' \geq \overline{z}^o_{J,t+1}(\tau',w')} \pi_{z,z'} - 1\right)\phi\left(\tau'\right)\right.$$

$$\left. + \sum_{z' \geq \overline{z}^o_{W,t+1}(\tau',w')} \pi_{z,z'} \max\left\{J^o_{t+1}(z',\tau',w'), -\phi\left(\tau'\right)\right\}\right). \quad \text{(F6)}$$

In addition to computing these asset values, we also calculate $W_t^y(z,\tau)$, $W_t^o(z,\tau)$, $J_t^y(z,\tau)$, $J_t^o(z,\tau)$ through equations (8)–(11) in order to recover Nash-bargained wages, $w_{\text{NB}}$. When computing these, we use the unemployment value $U_t^y(\Delta,\tau)$ from equation (F2). The Nash-bargained wages used to set rigid wages are therefore different from the Nash-bargained wages of the baseline model because the outside option of the worker is taken from equation (F2) instead of equation (5) (which defines $U_t^y$ in the baseline model).

**Free Entry.** The free entry condition in period $t$ is:

$$\frac{k}{q(\theta_t)} = \frac{1}{1+r} J^y_{t+1}(z_0, 0, w_0). \quad \text{(F7)}$$

**Stock-flow Equations.** In the stock-flow equations of the model, we must take account of the new state variable $w$ and the separation decision rules $\overline{z}^y_{W,t}(\tau,w)$, $\overline{z}^o_{W,t}(\tau,w)$, $\overline{z}^y_{J,t}(\tau,w)$, $\overline{z}^o_{J,t}(\tau,w)$. The distribution evolves between $t$ and $t+1$ according to:

$$\lambda^y_{t+1}\left(z_0, 0, w_0\right) = \theta_t q\left(\theta_t\right)(1-\gamma)\sum_\tau \mu^y_t\left(\tau\right), \quad \text{(F8)}$$

$$\lambda_{t+1}^{y}\left(z',\tau',w'\right)=\sum_{w}\sum_{z}\mathbb{1}\left\{z'\geq\max\left\{\overline{z}_{W,t+1}^{y}\left(\tau',w'\right),\right.\right.$$
$$\left.\left.\overline{z}_{J,t+1}^{y}\left(\tau',w'\right)\right\}\right\}\pi_{z,z'}\left(1-\gamma\right)\lambda_{t}^{y}\left(z,\tau,w\right),\qquad\text{(F9)}$$

$$\lambda_{t+1}^{o}\left(z',\tau',w'\right)=\sum_{w}\sum_{z}\mathbb{1}\left\{z'\geq\max\left\{\overline{z}_{W,t+1}^{o}\left(\tau',w'\right),\right.\right.$$
$$\left.\left.\overline{z}_{J,t+1}^{o}\left(\tau',w'\right)\right\}\right\}\pi_{z,z'}\left(\gamma\lambda_{t+1}^{y}\left(z,\tau,w\right)+\left(1-\chi\right)\lambda_{t+1}^{o}\left(z,\tau,w\right)\right).\qquad\text{(F10)}$$

As for the pool of non-employed workers, the dynamics of $\mu_t^y(0)$ is unchanged from the baseline model (see equation (A5)) but that of $\mu_t^y(\tau)$ with $\tau > 0$ and $\mu_t^o(\tau)$ changes to:

$$\mu_{t+1}^{y}\left(\tau'\right)=\left(1-\theta_{t}q\left(\theta_{t}\right)\right)\left(1-\gamma\right)\mu_{t}^{y}\left(\tau'\right)+\sum_{w}\sum_{z}\mathbb{1}\left\{z'<\max\left\{\overline{z}_{W,t+1}^{y}\left(\tau',w'\right),\right.\right.$$
$$\left.\left.\overline{z}_{J,t+1}^{y}\left(\tau',w'\right)\right\}\right\}\pi_{z,z'}\left(1-\gamma\right)\lambda_{t}^{y}\left(z,\tau\right),\qquad\text{(F11)}$$

$$\mu_{t+1}^{o}\left(\tau'\right)=\gamma\mu_{t}^{y}\left(\tau'\right)+\left(1-\chi\right)\mu_{t}^{o}\left(\tau'\right)+\sum_{w}\sum_{z}\mathbb{1}\left\{z'<\max\left\{\overline{z}_{W,t+1}^{o}\left(\tau',w'\right),\right.\right.$$
$$\left.\left.\overline{z}_{J,t+1}^{o}\left(\tau',w'\right)\right\}\right\}\pi_{z,z'}\left(\gamma\lambda_{t}^{y}\left(z,\tau,w\right)+\left(1-\chi\right)\lambda_{t}^{o}\left(z,\tau,w\right)\right).\qquad\text{(F12)}$$

**Calibration and Model Outcomes.** It is instructive to study how the calibrated model parameters change with the degree of wage persistence, $\alpha^r$. To this end, Table F1 describes results with $\alpha^r$ ranging from 0 (the benchmark equilibrium) to 0.90 (which is our focus in Subsection 6.1). Foremost, when wages are rigid, the gap in EPL at $\tau > 8$ has a larger incidence on job separation at short job tenures. Thus $z_0$ increases to keep job destruction under 2 years at 7.5 percent (our calibration target). Average wages are higher, which implies that $b^y$ and $b^o$ become higher to match the calibration targets for UI replacement rates. Last, the vacancy posting cost becomes higher too as the expected gains from meeting a worker increase with $z_0$.

**Table F1.** Parameter values used in the model with wage rigidity

| **Parameters matching data moments** | **Bench.** | $\alpha^r = 0.25$ | $\alpha^r = 0.50$ | $\alpha^r = 0.75$ | $\alpha^r = 0.90$ |
|---|---|---|---|---|---|
| matching efficiency $A$ | 0.4000 | 0.4000 | 0.4000 | 0.4000 | 0.4000 |
| unemp. income, young workers $b^y$ | 0.2203 | 0.2295 | 0.2383 | 0.2462 | 0.2672 |
| unemp. income, older workers $b^o$ | 0.1616 | 0.1665 | 0.1717 | 0.1781 | 0.1946 |
| vacancy cost $k$ | 0.2204 | 0.2380 | 0.2540 | 0.2760 | 0.3015 |
| exogenous separation probability $\delta$ | 0.0050 | 0.0050 | 0.0050 | 0.0050 | 0.0050 |
| initial match prod. $z_0$ | 0.2800 | 0.3000 | 0.3200 | 0.3400 | 0.3900 |
| standard dev. of match prod. shock $\sigma$ | 0.0440 | 0.0440 | 0.0440 | 0.0440 | 0.0440 |
| **Parameters of the EPL scheme** | **Bench.** | $\alpha^r = 0.25$ | $\alpha^r = 0.50$ | $\alpha^r = 0.75$ | $\alpha^r = 0.90$ |
| entry phase (in months) $\tau_u$ | 5 | 4 | 2 | 1 | 1 |
| tenure profile (in d.w.y.s.) $\rho_u$ | 20 | 21 | 21 | 23 | 23 |

**Notes:** The top panel reports calibrated parameter values used in the benchmark equilibrium ('Bench.') and in several versions of the model with wage rigidity indexed by the parameter $\alpha^r$. The bottom panel reports the characteristics of the unified EPL scheme obtained for each set of parameter values.

## F.2 Initial Match Heterogeneity

In this version of the model, there is heterogeneity in match productivity upon meeting. It is assumed that $z$ is drawn initially from a distribution $\pi_{0,z}$ which is a mixture of two distributions: a Normal distribution with mean $z_0$ and standard deviation $\sigma$, and a degenerate distribution localised at $z_0$. The weight on the Normal distribution is $\alpha^i$, so that when $\alpha^i = 0$ all job-matches start at the same productivity level $z_0$, as in the baseline model. Agents observe the initial productivity draw and decide whether to start producing or walk away from one another. This introduces a new economic decision in the model, namely a match formation rule.

These modifications may seem benign at first sight, but they have important and non-trivial consequences for the definition and computation of an equilibrium. First, since the probability of matching conditional on meeting is not always equal to 1, the annuity of young workers needs to be adjusted. For example, an unemployment worker who obtained a larger severance package from her previous job has a longer duration of joblessness as she rejects more initial match draws. Thus, the expected duration of the annuity payment becomes a function of the previous job tenure of the worker. Second, and consequently, the value of holding a vacant job must account for the distribution of unemployed workers across previous job tenures. This follows from workers having heterogeneous reservation threshold for match formation, depending on their annuity. Third, there is a wage bargained over upon meeting, where the outside option of the worker is the value of continued search in unemployed with her current annuity. That is, workers can be compensated for giving up their annuity by bargaining for a higher wage upon meeting.

In this version of the model, the annuity payment received by a young worker is:

$$a^y\left(\Delta\left(\tau\right),\tau\right) = \frac{1}{1-\left(1+r\right)^{-\Delta(\tau)}}\frac{r}{1+r}\phi\left(\tau\right), \tag{F13}$$

where $\Delta\left(\tau\right)$ is the expected duration of joblessness of a worker with previous job tenure $\tau$. Note that workers with a large severance package will tend to be more picky in terms of accepting new job offers. On the flip side, because the annuity is actuarially fair, a longer expected unemployment spell reduces the size of the annuity which will induce workers to accept more job offers again. The annuity balances these forces, and, in our calculations, we never obtain allocations where certain workers would prefer to remain non-employed forever.

**Bellman Equations.** As should be evident, the transition path of this economy is beyond computational reach. To make vacancy posting decisions, firms would need to keep track of the distribution of unemployed workers across previous job tenure during the transition (see 'Free Entry' below). This a high-dimensional object, which we cannot include in our calculations. We therefore focus on the steady-state equilibrium. We omit time indices from the notations below.

There are two new asset values to be defined in this model: $W^0\left(z,\tau\right)$, the value for a young worker of starting a job at productivity level $z$ when her previous job tenure (which determines her current annuity pay) is $\tau$; and $J^0\left(z,\tau\right)$, the firm's value of employing such a worker. These asset values enable us to write the value of a young worker being unemployed as:

$$\begin{aligned} U^y\left(\Delta\left(\tau\right),\tau\right) =& u(a^y\left(\Delta\left(\tau\right),\tau\right)+b^y) \\ &+\frac{1}{1+r}\left[\left(1-\gamma\right)\left(\theta q\left(\theta\right)\sum_z \pi_{0,z}\max\left\{W^0\left(z,\tau\right),U^y\left(\Delta\left(\tau\right),\tau\right)\right\}\right.\right. \\ &\left.\left.+\left(1-\theta q\left(\theta\right)\right)U^y\left(\Delta\left(\tau\right),\tau\right)\right)+\gamma\widetilde{U}^o\left(\Delta\left(\tau\right),\tau\right)\right]. \end{aligned} \tag{F14}$$

Letting $w^0\left(z,\tau\right)$ denote the wage negotiated at entry, the values of employment for workers and firms are:

$$W^0(z,\tau) = u\left(w^0(z,\tau)\right) + \frac{1}{1+r}\left((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{W^y(z',1), U^y\left(\Delta\left(1\right),1\right)\right\}\right.$$
$$\left. + \gamma\sum_{z'}\pi_{z,z'}\max\left\{W^o(z',1), U^o\left(1\right)\right\}\right), \tag{F15}$$

$$J^0(z,\tau) = z - (1+\kappa)w^0(z,\tau) + \frac{1}{1+r}\left((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J^y(z',1), -\phi\left(1\right)\right\}\right.$$
$$\left. + \gamma\sum_{z'}\pi_{z,z'}\max\left\{J^o(z',1), -\phi\left(1\right)\right\}\right). \tag{F16}$$

The asset values for all the other states of the economy can be computed using the Bellman equations of the baseline model, namely equations (6)–(11).

**Wage Setting.** To set the wage upon entry, agents maximise the following Nash product:

$$w^0\left(z,\tau\right) = \arg\max_w \left\{\left(W^0(z,\tau;w) - U^y\left(\Delta\left(\tau\right),\tau\right)\right)^\beta \left(J^0(z,\tau;w)\right)^{1-\beta}\right\}. \tag{F17}$$

Again, notice that $\tau$ in $w^0\left(z,\tau\right)$ refers to job tenure in the previous job of the worker, which spills over into her outside option $U^y\left(\Delta\left(\tau\right),\tau\right)$ (via the annuity) when she bargains with a new firm.

**Free Entry.** The free-entry condition of this model with initial match heterogeneity depends on the distribution of unemployed workers across previous job tenures. The free-entry condition reads:

$$\frac{k}{q(\theta)} = \frac{1}{1+r}\sum_z\sum_\tau \pi_{0,z}\max\left\{J^0(z,\tau),0\right\}\frac{\mu^y\left(\tau\right)}{u}, \tag{F18}$$

where $u = \sum_\tau \mu^y\left(\tau\right)$ is the number of job seekers (i.e. young unemployed workers). That is, the returns to meeting a worker depend on $\mu^y\left(\tau\right)/u$, the conditional probability of the worker having job tenure $\tau$ in her previous job.

**Stock-flow Equations.** The stock-flow equations of the model are almost unchanged from the baseline model. The only changes relate to the stochastic draw of match productivity upon entry and the match formation decision, which we denote as $\overline{z}^0\left(\tau\right)$. Employment at the entry level is given by:

$$\lambda^y\left(z,0\right)' = \sum_z \pi_{0,z}\mathbb{1}\left\{z \geq \overline{z}^0\left(\tau\right)\right\}\theta q\left(\theta\right)\left(1-\gamma\right)\sum_\tau \mu^y\left(\tau\right) \tag{F19}$$

(note on the left-hand side of the equation that we use a prime ($'$) to denote the one-period ahead value of the distribution). The dynamics of the pool of young unemployed worker is now governed by:

$$\mu^y\left(0\right)' = \chi\frac{\gamma}{\chi+\gamma} + \left(1-\theta q\left(\theta\right)\right)\left(1-\gamma\right)\mu^y\left(0\right) + \sum_z \pi_{0,z}\mathbb{1}\left\{z < \overline{z}^0\left(0\right)\right\}\theta q\left(\theta\right)\left(1-\gamma\right)\mu^y\left(0\right) \tag{F20}$$

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

$$\mu^y(\tau')' = (1-\theta q(\theta))(1-\gamma)\mu^y(\tau') + \sum_z \pi_{0,z}\mathbb{1}\left\{z < \overline{z}^0(\tau')\right\}\theta q(\theta)(1-\gamma)\mu^y(\tau') + \sum_z \mathbb{1}\left\{z' < \overline{z}^y_{t+1}(\tau')\right\}\pi_{z,z'}(1-\gamma)\lambda^y_t(z,\tau). \tag{F21}$$

**Calibration and Model Outcomes.** Table F2 reports the calibrated parameter values when $\alpha^i$ ranges from 0.25 to 0.75. To complement the table, Figure F1 shows the expected duration of joblessness, $\Delta(\tau)$, as a function of the worker's previous job tenure.

**Table F2.** Parameter values used in the model with initial match heterogeneity

| **Parameters matching data moments** | **Bench.** | $\alpha^i = 0.25$ | $\alpha^i = 0.50$ | $\alpha^i = 0.75$ |
|---|---|---|---|---|
| matching efficiency $A$ | 0.4000 | 0.4318 | 0.4912 | 0.6445 |
| unemp. income, young workers $b^y$ | 0.2203 | 0.2358 | 0.2583 | 0.3038 |
| unemp. income, older workers $b^o$ | 0.1616 | 0.1689 | 0.1795 | 0.2015 |
| vacancy cost $k$ | 0.2204 | 0.2342 | 0.2446 | 0.2492 |
| exogenous separation probability $\delta$ | 0.0050 | 0.0050 | 0.0050 | 0.0050 |
| initial match prod. $z_0$ | 0.2800 | 0.3094 | 0.3500 | 0.4353 |
| standard dev. of match prod. shock $\sigma$ | 0.0440 | 0.0440 | 0.0440 | 0.0440 |
| **Parameters of the EPL scheme** | **Bench.** | $\alpha^i = 0.25$ | $\alpha^i = 0.50$ | $\alpha^i = 0.75$ |
| entry phase (in months) $\tau_u$ | 5 | 6 | 4 | 8 |
| tenure profile (in d.w.y.s.) $\rho_u$ | 20 | 20 | 11 | 6 |

**Notes:** The top panel reports calibrated parameter values used in the benchmark equilibrium ('Bench.') and in several versions of the model with initial match heterogeneity indexed by the parameter $\alpha^i$. The bottom panel reports the characteristics of the unified EPL scheme obtained for each set of parameter values.

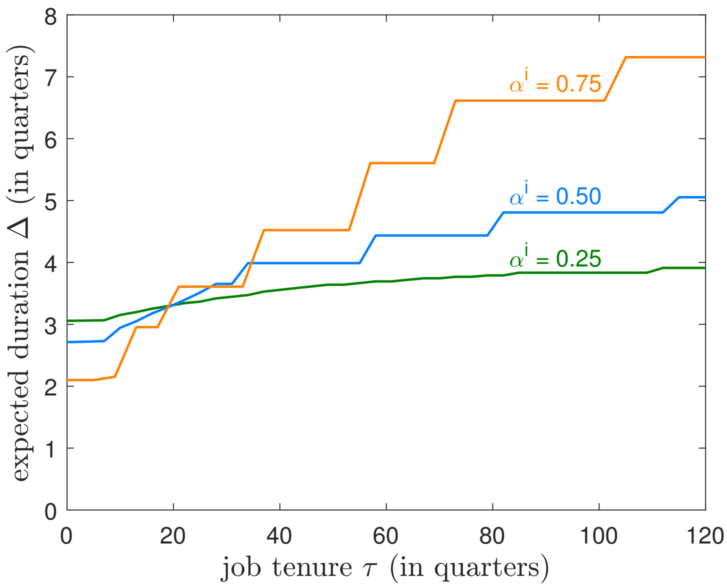


**Figure F1.** Expected duration of joblessness

**Notes:** The figure shows the expected duration of joblessness as a function of previous job tenure in three different parameterisations of the model: $\alpha^i = 0.25$, $\alpha^i = 0.50$ and $\alpha^i = 0.75$.

As can be seen, raising the probability of a stochastic initial draw increases heterogeneity in the duration of joblessness. In the scenario with $\alpha^i = 0.75$, a worker who has remained employed for 30 years prior to job loss faces an expected duration of joblessness of almost 2 years (8 quarters). By contrast, in the baseline model (corresponding to the special case $\alpha^i = 0$) the expected duration of joblessness is uniform across workers, and its value is 3.3 quarters in the benchmark equilibrium. These outcomes require higher matching efficiency, $A$, and a higher mean for initial productivity draws, $z_0$, to keep the quarterly job-finding rate equal to 40 percent (our calibration target). Average wages are higher, which implies that $b^y$ and $b^o$ become higher to match the calibration targets for UI replacement rates. Last, the vacancy posting cost becomes higher too as the expected gains from meeting a worker increase with $z_0$.

## F.3 Human Capital

In this version of the model, the worker-firm pair can devote some effort to acquiring human capital, which increases the flow of output. A job-match with no human capital produces $z\,(1-e)$ units of output, where $0 \leq e \leq 1$ is the (endogenous) effort level, while a job-match with human capital produces $z\left(1+\alpha^h\right)$ units of output. $\alpha^h \geq 0$ is the exogenous parameter controlling the productivity gain from human capital.[34] The probability that effort $e$ delivers human capital accumulation is a concave function $\pi\,(e)$. With probability $1-\pi\,(e)$, effort is unsuccessful and the worker-firm pair must continue to invest in human capital. All jobs start off with no human capital and human capital is firm-specific.[35]

We assume that the worker and the firm bargain over the effort level, $e$, in addition to bargaining over wages. Thus, we must introduce an additional binary state variable for both agents indicating whether or not the current job-match has acquired human capital.

**Bellman Equations.** Since newly-formed job-matches start with no human capital, the value of a young unemployed worker is given by:

$$\begin{aligned} U_t^y\,(\Delta,\tau) =& u(a^y\,(\Delta,\tau)+b^y) + \frac{1}{1+r}\Big[(1-\gamma)\left(\theta_t q\,(\theta_t)\,W_{t+1}^{0,y}\,(z_0,0)\right.\\ &\left.+\,(1-\theta_t q\,(\theta_t))\,U_{t+1}^y\,(\Delta,\tau)\right)+\gamma \widetilde{U}_{t+1}^o\,(\Delta,\tau)\Big]. \end{aligned} \tag{F22}$$

The other values of non-employment, namely $U_t^o\,(\tau)$ and $\widetilde{U}_t^o\,(\Delta,\tau)$, are unchanged from the baseline model. For employed workers, the asset values are given by:

$$\begin{aligned} W_t^{0,y}(z,\tau) =& u\left(w_t^{0,y}(z,\tau)\right) + \frac{1}{1+r}\Bigg[(1-\gamma)\Bigg(\pi\left(e_t^y(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\Big\{W_{t+1}^{1,y}(z',\tau'),\\ & U_{t+1}^y\left(\Delta_{t+1},\tau'\right)\Big\} + \left(1-\pi\left(e_t^y(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\Big\{W_{t+1}^{0,y}(z',\tau'),U_{t+1}^y\left(\Delta_{t+1},\tau'\right)\Big\}\Bigg)\\ & +\gamma\Bigg(\pi\left(e_t^y(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\Big\{W_{t+1}^{1,o}(z',\tau'),U_{t+1}^o\left(\tau'\right)\Big\}\\ & +\left(1-\pi\left(e_t^y(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\Big\{W_{t+1}^{0,o}(z',\tau'),U_{t+1}^o\left(\tau'\right)\Big\}\Bigg)\Bigg], \end{aligned} \tag{F23}$$

[34] When $\alpha^h = 0$, there are no gains from making any effort – $e = 0$ is optimal – so that the economy is identical to that of the baseline model.

[35] Since a job-match always starts with no human capital, human capital cannot be transferred across firms. It is in this sense that human capital is firm- (or job-) specific.

$$
\begin{aligned}
W_t^{1,y}(z,\tau) =& u\left(w_t^{1,y}(z,\tau)\right) + \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,y}(z',\tau'), U_{t+1}^{y}\left(\Delta_{t+1},\tau'\right)\right\} \\
&+\gamma\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,o}(z',\tau'), U_{t+1}^{o}\left(\tau'\right)\right\}\Bigg),
\end{aligned} \tag{F24}
$$

$$
\begin{aligned}
W_t^{0,o}(z,\tau) = & u\left(w_t^{0,o}(z,\tau)\right) + \frac{1-\chi}{1+r}\Bigg(\pi\left(e_t^{o}(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,o}(z',\tau'), U_{t+1}^{o}\left(\tau'\right)\right\} \\
&+\left(1-\pi\left(e_t^{o}(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{0,o}(z',\tau'), U_{t+1}^{o}\left(\tau'\right)\right\}\Bigg),
\end{aligned} \tag{F25}
$$

$$
W_t^{1,o}(z,\tau) = u\left(w_t^{1,o}(z,\tau)\right) + \frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,o}(z',\tau'), U_{t+1}^{o}\left(\tau'\right)\right\}. \tag{F26}
$$

Similarly, we write four Bellman equations describing the behaviour of firms in this environment:

$$
\begin{aligned}
J_t^{0,y}(z,\tau) =& z\left(1-e_t^{y}(z,\tau)\right) - (1+\kappa_t)w_t^{0,y}(z,\tau) \\
&+\frac{1}{1+r}\Bigg[(1-\gamma)\Bigg(\pi\left(e_t^{y}(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,y}(z',\tau'), -\phi\left(\tau'\right)\right\} \\
&+\left(1-\pi\left(e_t^{y}(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{0,y}(z',\tau'), -\phi\left(\tau'\right)\right\}\Bigg) \\
&+\gamma\Bigg(\pi\left(e_t^{y}(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,o}(z',\tau'), -\phi\left(\tau'\right)\right\} \\
&+\left(1-\pi\left(e_t^{y}(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{0,y}(z',\tau'), -\phi\left(\tau'\right)\right\}\Bigg)\Bigg],
\end{aligned} \tag{F27}
$$

$$
\begin{aligned}
J_t^{1,y}(z,\tau) =& z\left(1+\alpha^{h}\right) - (1+\kappa_t)w_t^{1,y}(z,\tau) + \frac{1}{1+r}\Bigg((1-\gamma)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,y}(z',\tau'),\right. \\
&\left.-\phi\left(\tau'\right)\right\} + \gamma\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,o}(z',\tau'), -\phi\left(\tau'\right)\right\}\Bigg),
\end{aligned} \tag{F28}
$$

$$
\begin{aligned}
J_t^{0,o}(z,\tau) =& z\left(1-e_t^{o}(z,\tau)\right) - (1+\kappa_t)w_t^{0,o}(z,\tau) \\
&+\frac{1-\chi}{1+r}\Bigg(\pi\left(e_t^{o}(z,\tau)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,o}\left(z',\tau'\right), -\phi\left(\tau'\right)\right\} \\
&+\left(1-\pi\left(e_t^{o}(z,\tau)\right)\right)\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{0,o}\left(z',\tau'\right), -\phi\left(\tau'\right)\right\}\Bigg),
\end{aligned} \tag{F29}
$$

$$
J_t^{1,o}(z,\tau) = z\left(1+\alpha^{h}\right) - (1+\kappa_t)w_t^{1,o}(z,\tau) + \frac{1-\chi}{1+r}\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,o}\left(z',\tau'\right), -\phi\left(\tau'\right)\right\}. \tag{F30}
$$

**Wage and Effort.** In job-matches where human capital has not been acquired yet, workers and firms bargain simultaneously on wages and effort. Thus, these variables solve:

$$\left(w_t^{0,y}(z,\tau), e_t^y(z,\tau)\right) = \arg\max_{w,e}\left\{\left(W_t^{0,y}(z,\tau;w,e) - U_t^y(\Delta_t,\tau)\right)^\beta \times \left(J_t^{0,y}(z,\tau;w,e)+\phi(\tau)\right)^{1-\beta}\right\}, \quad \text{(F31)}$$

$$\left(w_t^{0,o}(z,\tau), e_t^o(z,\tau)\right) = \arg\max_{w,e}\left\{\left(W_t^{0,o}(z,\tau;w,e) - U_t^o(\tau)\right)^\beta \times \left(J_t^{0,o}(z,\tau;w,e)+\phi(\tau)\right)^{1-\beta}\right\}. \quad \text{(F32)}$$

On the other hand, after human capital has been acquired, workers and firms bargain on wages only using the same protocol as that in the baseline model (see equations (12) and (13)).

Notice that equations (F31) and (F32) generate a direct relationship between wages and effort. For instance, for young workers the first-order condition for wages is

$$\beta\frac{u'\left(w_t^{0,y}(z,\tau)\right)}{W_t^{0,y}(z,\tau)-U_t^y(\Delta_t,\tau)} = (1-\beta)\frac{1+\kappa_t}{J_t^{0,y}(z,\tau)+\phi(\tau)}, \quad \text{(F33)}$$

while the first-order condition for effort is

$$\beta\frac{\pi'\left(e_t^y(z,\tau)\right)EW_t^y(z,\tau)}{W_t^{0,y}(z,\tau)-U_t^y(\Delta_t,\tau)} = (1-\beta)\frac{-z+\pi'\left(e_t^y(z,\tau)\right)EJ_t^y(z,\tau)}{J_t^{0,y}(z,\tau)+\phi(\tau)}. \quad \text{(F34)}$$

In this equation, $EW_t^y(z,\tau)$ (resp. $EJ_t^y(z,\tau)$) is the expected increase in the worker's (resp. firm's) asset value of employment from acquiring human capital.[36] Combining equations (F33) and (F34), we obtain:

$$\frac{\pi'\left(e_t^y(z,\tau)\right)EW_t^y(z,\tau)}{u'\left(w_t^{0,y}(z,\tau)\right)} = \frac{-z+\pi'\left(e_t^y(z,\tau)\right)EJ_t^y(z,\tau)}{1+\kappa_t}. \quad \text{(F37)}$$

The left-hand side is the ratio between the value of a marginal change in effort to that of a marginal change in the wage for the worker. This ratio is equated to the value of a marginal change in effort for the firm divided by that of a marginal change in the wage.

[36]We have:

$$\begin{aligned} EW_t^y(z,\tau) = \frac{1}{1+r}\Bigg[&(1-\gamma)\Bigg(\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,y}(z',\tau'), U_{t+1}^y(\Delta_{t+1},\tau')\right\} \\ &- \sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{0,y}(z',\tau'), U_{t+1}^y(\Delta_{t+1},\tau')\right\}\Bigg) \\ &+\gamma\Bigg(\sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{1,o}(z',\tau'), U_{t+1}^o(\tau')\right\} - \sum_{z'}\pi_{z,z'}\max\left\{W_{t+1}^{0,o}(z',\tau'), U_{t+1}^o(\tau')\right\}\Bigg)\Bigg] \end{aligned} \quad \text{(F35)}$$

and

$$\begin{aligned} EJ_t^y(z,\tau) = \frac{1}{1+r}\Bigg[&(1-\gamma)\Bigg(\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,y}(z',\tau'), -\phi(\tau')\right\} - \sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{0,y}(z',\tau'), -\phi(\tau')\right\}\Bigg) \\ &+\gamma\Bigg(\sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{1,o}(z',\tau') - \phi(\tau')\right\} - \sum_{z'}\pi_{z,z'}\max\left\{J_{t+1}^{0,o}(z',\tau'), -\phi(\tau')\right\}\Bigg)\Bigg]. \end{aligned} \quad \text{(F36)}$$

**Free Entry.** Since newly-formed job-matches start off with no human capital, the free entry condition in period $t$ is:

$$\frac{k}{q(\theta_t)} = \frac{1}{1+r} J^{0,y}_{t+1}(z_0, 0). \tag{F38}$$

**Law of motion.** The cross-section distribution of employment evolves between $t$ and $t+1$ according to:

$$\lambda^{0,y}_{t+1}(z_0, 0) = \theta_t q(\theta_t)(1-\gamma) \sum_{\tau} \mu^y_t(\tau), \tag{F39}$$

$$\lambda^{0,y}_{t+1}(z', \tau') = \sum_{z} \mathbb{1}\left\{z' \geq \overline{z}^{0,y}_{t+1}(\tau')\right\} \pi_{z,z'} \left(1 - \pi\left(e^y_t(z,\tau)\right)\right)(1-\gamma)\lambda^{0,y}_t(z,\tau), \tag{F40}$$

$$\begin{aligned}\lambda^{1,y}_{t+1}(z', \tau') = \sum_{z} \mathbb{1}\left\{z' \geq \overline{z}^{1,y}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[&\pi\left(e^y_t(z,\tau)\right)(1-\gamma)\lambda^{0,y}_t(z,\tau) \\ &+ (1-\gamma)\lambda^{1,y}_t(z,\tau)\Big],\end{aligned} \tag{F41}$$

$$\begin{aligned}\lambda^{0,o}_{t+1}(z', \tau') = \sum_{z} \mathbb{1}\left\{z' \geq \overline{z}^{0,o}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[&\left(1 - \pi\left(e^y_t(z,\tau)\right)\right)\gamma\lambda^{0,y}_{t+1}(z,\tau) \\ &+ \left(1 - \pi\left(e^o_t(z,\tau)\right)\right)(1-\chi)\lambda^{0,o}_{t+1}(z,\tau)\Big],\end{aligned} \tag{F42}$$

$$\begin{aligned}\lambda^{1,o}_{t+1}(z', \tau') = \sum_{z} \mathbb{1}\left\{z' \geq \overline{z}^{1,o}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[&\pi\left(e^y_t(z,\tau)\right)\gamma\lambda^{0,y}_{t+1}(z,\tau) + \\ &+ \gamma\lambda^{1,y}_{t+1}(z,\tau) + (1-\chi)\lambda^{1,o}_{t+1}(z,\tau)\Big].\end{aligned} \tag{F43}$$

As for the pool of non-employed workers, the dynamics of $\mu^y_t(0)$ is unchanged from the baseline model (see equation (A5)), but the dynamics of $\mu^y_t(\tau)$ with $\tau > 0$ and that of $\mu^o_t(\tau)$ change to:

$$\begin{aligned}\mu^y_{t+1}(\tau') = {} & (1 - \theta_t q(\theta_t))(1-\gamma)\mu^y_t(\tau'). \\ &+ \sum_{z} \mathbb{1}\left\{z' < \overline{z}^{0,y}_{t+1}(\tau')\right\} \pi_{z,z'} \left(1 - \pi\left(e^y_t(z,\tau)\right)\right)(1-\gamma)\lambda^{0,y}_t(z,\tau) \\ &+ \sum_{z} \mathbb{1}\left\{z' < \overline{z}^{1,y}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[\pi\left(e^y_t(z,\tau)\right)(1-\gamma)\lambda^{0,y}_t(z,\tau) \\ &\qquad + (1-\gamma)\lambda^{1,y}_t(z,\tau)\Big],\end{aligned} \tag{F44}$$

$$\begin{aligned}\mu^o_{t+1}(\tau') = {} & \gamma\mu^y_t(\tau') + (1-\chi)\mu^o_t(\tau') \\ &+ \sum_{z} \mathbb{1}\left\{z' < \overline{z}^{0,o}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[\left(1 - \pi\left(e^y_t(z,\tau)\right)\right)\gamma\lambda^{0,y}_{t+1}(z,\tau) \\ &\qquad + \left(1 - \pi\left(e^o_t(z,\tau)\right)\right)(1-\chi)\lambda^{0,o}_{t+1}(z,\tau)\Big] \\ &+ \sum_{z} \mathbb{1}\left\{z' < \overline{z}^{1,o}_{t+1}(\tau')\right\} \pi_{z,z'} \Big[\pi\left(e^y_t(z,\tau)\right)\gamma\lambda^{0,y}_{t+1}(z,\tau) + \\ &\qquad + \gamma\lambda^{1,y}_{t+1}(z,\tau) + (1-\chi)\lambda^{1,o}_{t+1}(z,\tau)\Big].\end{aligned} \tag{F45}$$

**Calibration and Model Outcomes.** Our focus is on $\alpha^h = 0.50$, meaning we assume that firm-specific human capital *per se* can increase productivity by 50 percent. The results are robust to increasing $\alpha^h$ further up to 0.66 and 0.75. To parameterise the model, we use: $\pi(e) = \pi_1 e^{\pi_2}$. Since $\pi_1$ and $\pi_2$ are intimately related to each other, our approach consists in exploring different values for the curvature $\pi_2$ and, for each of them, calibrate the scale $\pi_1$ so that half of all job-matches produce using human capital. Table F3 reports the results of this calibration exercise.

**Table F3.** Parameter values used in the model with human capital

| **Parameters matching data moments** | **Bench.** | $\pi_2 = 0.25$ | $\pi_2 = 0.50$ | $\pi_2 = 0.75$ |
|---|---|---|---|---|
| proba. $\pi(e)$ scale parameter $\pi_1$ | 0.0000 | 0.0370 | 0.0500 | 0.0580 |
| matching efficiency $A$ | 0.4000 | 0.4000 | 0.4000 | 0.4000 |
| unemp. income, young workers $b^y$ | 0.2203 | 0.2987 | 0.2945 | 0.2902 |
| unemp. income, older workers $b^o$ | 0.1616 | 0.2321 | 0.2298 | 0.2272 |
| vacancy cost $k$ | 0.2204 | 0.2445 | 0.2362 | 0.2261 |
| exogenous separation probability $\delta$ | 0.0050 | 0.0050 | 0.0050 | 0.0050 |
| initial match prod. $z_0$ | 0.2800 | 0.3400 | 0.3500 | 0.3600 |
| standard dev. of match prod. shock $\sigma$ | 0.0440 | 0.0440 | 0.0440 | 0.0440 |
| **Parameters of the EPL scheme** | **Bench.** | $\pi_2 = 0.25$ | $\pi_2 = 0.50$ | $\pi_2 = 0.75$ |
| entry phase (in months) $\tau_u$ | 5 | 13 | 13 | 8 |
| tenure profile (in d.w.y.s.) $\rho_u$ | 20 | 15 | 15 | 13 |

**Notes:** The top panel reports calibrated parameter values used in the benchmark equilibrium ('Bench.') and in the model with human capital with $\alpha^h = 0.50$ and different values of the curvature parameter $\pi_2$. The bottom panel reports the characteristics of the unified EPL scheme obtained for each set of parameter values.

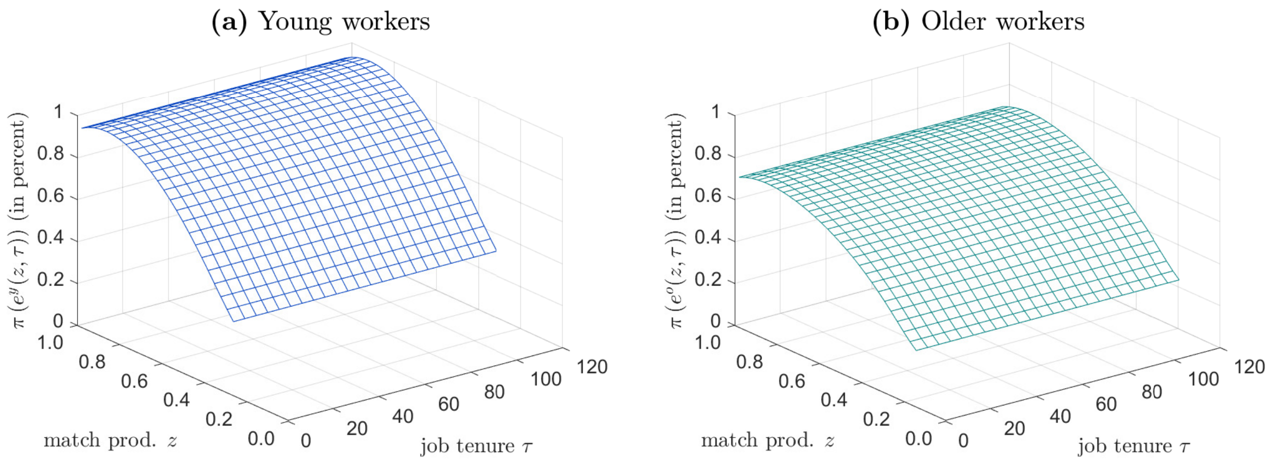


**Figure F2.** Probability of acquiring human capital

**Notes:** The figure shows the probability of acquiring human capital as a function of match productivity and job tenure among young (Figure F2a) and older workers (Figure F2b). The model parameters used to construct this figure are: $\alpha^h = 0.50$, $\pi_1 = 0.05$ and $\pi_2 = 0.50$.

Figure F2 displays the probabilities $\pi(e^y(z,\tau))$ and $\pi(e^o(z,\tau))$ to show the underlying policy function for acquiring human capital. Several comments are worth making. First, the effort to acquire human capital does not vary by job tenure – that is to say by the generosity of the severance package associated with job tenure. This is because the effect of job tenure is factored into the wage (see equation (F37)). Second, human capital effort displays an inverted U-shape with respect to match productivity. There are two countervailing forces at work. On the one hand, higher match productivity in the current period implies higher match productivity in the subsequent periods, which raises the returns to acquiring human capital. On the other, higher match productivity increases the opportunity cost of making efforts during the current period. Third, effort decreases with age (as shown by the downward shift from Figure F2a to Figure F2b, holding $z$ and $\tau$ constant). Older workers face a shorter distance to retirement, which lowers the returns to acquiring human capital. Fourth and last, the levels of the probabilities displayed in Figure F2 are low – less than 1 percent per quarter. Our target of having 50 percent of all job-matches produce using human capital implies a low value for the scale parameter, $\pi_1$ ($\pi_1$ is set to 0.05 for the computations reported in Figure F2; see Table F3). $\pi_1$ being close to zero implies low returns to making any effort. On average across all employed workers, the optimal effort level $e$ is under 0.10.

# G Additional Robustness Checks

Table G1 reports the parameter values used in several alternative calibrations of the model. These alternatives are numbered as follows: (1) the UI replacement rate for young workers is set to 50 percent; (2) the UI replacement rate for young workers is set to 65 percent; (3) the expected duration of the older-age phase (governed by $\gamma$) is shortened to 5 years; (4) the expected duration of the older-age phase is raised to 15 years; (5) exogenous separations (viz. job separations triggered by the shock $\delta$) do not entitle the worker to a severance payment; (6) red-tape costs waste half of the total severance package $\phi(\tau)$. In all these parameterisations of the model (as well as in the model extensions studied in Section 6 of the paper), we find that the criterion defining a unified EPL is concave with respect to $\tau_u$ and $\rho_u$.[37] The bottom panel of Table G1 displays the values for $\tau_u$ and $\rho_u$ obtained in each calibration.

**Table G1.** Parameter values used in robustness check exercises

| **Parameters matching data moments** | **Bench.** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|---|
| matching efficiency $A$ | 0.4000 | 0.4000 | 0.4000 | 0.4000 | 0.4000 | 0.4000 | 0.4000 |
| unemp. income, young workers $b^y$ | 0.2203 | 0.1635 | 0.2803 | 0.2600 | 0.1948 | 0.2370 | 0.2431 |
| unemp. income, older workers $b^o$ | 0.1616 | 0.1482 | 0.1753 | 0.2285 | 0.1336 | 0.1862 | 0.1445 |
| vacancy cost $k$ | 0.2204 | 0.2185 | 0.2234 | 0.2280 | 0.2356 | 0.2246 | 0.2624 |
| exogenous separation probability $\delta$ | 0.0050 | 0.0050 | 0.0050 | 0.0050 | 0.0050 | 0.0050 | 0.0050 |
| initial match prod. $z_0$ | 0.2800 | 0.2200 | 0.3400 | 0.3600 | 0.2400 | 0.3100 | 0.2900 |
| standard dev. of match prod. shock $\sigma$ | 0.0440 | 0.0440 | 0.0440 | 0.0440 | 0.0440 | 0.0440 | 0.0550 |
| **Parameters of the EPL scheme** | **Bench.** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| entry phase (in months) $\tau_u$ | 5 | 2 | 8 | 7 | 9 | 6 | 12 |
| tenure profile (in d.w.y.s.) $\rho_u$ | 20 | 17 | 24 | 12 | 32 | 16 | 28 |

**Notes:** The top panel reports calibrated parameter values used for the benchmark equilibrium and in sensitivity analyses. The bottom panel reports the parameters of the unified EPL scheme obtained for each set of parameter values. 'Bench.' denotes the benchmark equilibrium; (1) and (2) denote, respectively, lower and higher UI replacement rates for young workers; (3) and (4) denote, respectively, shorter and longer duration of the older age phase; (5) denotes exogenous separation with no severance package; (6) denotes severance packages with red-tape costs.

In Table G2, we report the welfare effects of the transition dynamics in each of the additional robustness check exercises. Robustness checks (1)–(4) are discussed in Subsection 5.3 of the paper, and so we focus on (5) and (6). In scenario (5), where exogenous separations do not entitle workers to severance pay, the minimum service for eligibility barely changes and the slope of the unified EPL scheme decreases only slightly to 16 d.w.y.s. Not surprisingly, the welfare effects shown in Table G2 are very similar to those of the benchmark model. In scenario (6), we consider the effects of adding red-tape costs by assuming that only half of the severance pay,

[37] It seems that, with only two instruments ($\tau_u$ and $\rho_u$) to define the EPL scheme, we reduce the likelihood of having local maxima in the objective function ($U^y$).

**Table G2.** Robustness checks: welfare effects of the transition dynamics

| **(1) Lower UI benefits** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
|---|---|---|---|---|---|---|
| young workers | 1.41 | 0.69 | 1.18 | 1.42 | 1.78 | 2.00 |
| older workers | -0.91 | -2.36 | -1.61 | -0.96 | -0.02 | 0.40 |
| **(2) Higher UI benefits** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 0.96 | 0.52 | 0.81 | 0.97 | 1.15 | 1.38 |
| older workers | -0.64 | -1.78 | -1.14 | -0.69 | 0.01 | 0.37 |
| **(3) Shorter older-age phase** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 2.61 | 1.94 | 2.29 | 2.66 | 2.94 | 3.22 |
| older workers | -0.55 | -1.87 | -1.07 | -0.60 | 0.10 | 0.68 |
| **(4) Longer older-age phase** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 0.53 | 0.08 | 0.40 | 0.57 | 0.73 | 0.91 |
| older workers | -0.23 | -0.97 | -0.52 | -0.18 | 0.19 | 0.32 |
| **(5) Quits vs. layoffs** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 1.23 | 0.64 | 1.02 | 1.27 | 1.46 | 1.76 |
| older workers | -0.58 | -1.65 | -1.09 | -0.63 | 0.064 | 0.40 |
| **(6) Red-tape costs** | **Average** | **1st** | **2nd** | **3rd** | **4th** | **5th** |
| young workers | 0.46 | 0.08 | 0.39 | 0.49 | 0.59 | 0.76 |
| older workers | -0.23 | -0.94 | -0.51 | -0.24 | 0.15 | 0.40 |

**Notes:** The table reports the welfare changes (measured in consumption-equivalent units) arising from the transition towards unified EPL. 'Average' denotes the cross-sectional average, while '1st', '2nd', '3rd', '4th' and '5th' denote the average within each quintile of the distribution of welfare changes. See text for a description of each panel and Table G1 for calibrated parameter values. All entries are expressed in percent.

$\phi(\tau)$, is rebated towards the worker (the other half of severance pay is sunk). We find that the entry phase increases to 12 months, and, more importantly, the slope of the unified EPL scheme becomes 28 d.w.y.s. (vs. 20 d.w.y.s. in the benchmark equilibrium). The intuition is that the severance package needs to be made more generous since the share that gets wasted does not help workers to increase consumption during unemployment. The welfare gains of introducing unified EPL, half of which will be lost in red-tape costs, are lower than in the benchmark model (0.46 in Table G2 vs. 1.19 in Table 5).