

The Non-neutrality of Severance Payments with Incomplete Markets.

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Abstract

We study the equilibrium welfare effects of introducing mandated severance payments in a labor market with costly mobility, where self-insurance through a riskless asset is the only way to smooth fluctuations in labor income due to unemployment shocks. The framework allows for wage flexibility at the level of the individual firm-worker match. Wages vary with both tenure and productivity of the workers. When severance payments are introduced, the firm can potentially undo their effect by modifying the wage profile. Workers entry wages fall by the expected present value of the future payment. However, because of incomplete markets, workers are unlikely to be indifferent about the slope of the wage profile. Moreover, non trivial general equilibrium effects are also present, since the capital stock varies. On the one hand, the precautionary motive for savings is reduced by the introduction of severance payments, since agents are better insured. On the other hand, the change in the wage profile is likely to reduce the savings of young individuals and increase that of older ones. The model is solved numerically and calibrated to the US economy. We compare a welfare measure for the baseline economy, i.e. without severance payments, to those of a series of counterfactual economies where the severance payments are introduced at increasing levels. For reasonable values of the severance payments, Welfare gains and costs seem to be quantitatively small.

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<http://qed.econ.queensu.ca/pub/faculty/cozzi/Webpage/>

1 Introduction

Several labor market institutions are designed to provide insurance to workers facing shocks to their labor earnings, their employment status or their specific and general human capital. In this paper we consider a particular form of Employment Protection Legislation (EPL), namely Severance Payments (SP). Our contribution focuses on the equilibrium welfare effects arising from their introduction in a labor market with costly mobility and heterogeneous workers.

Severance payments represent a direct transfer from the employer to the employee, paid when an employer initiated separation takes place. In a set of European Countries government mandated severance payments have been a long lasting and distinctive feature of their labor markets. For the period 1956-1984, Lazear (1990) finds that (for a worker with ten years of tenure) the value of the severance payments in Italy, Spain, Norway and France was considerably high, being equal to 15.9, 13.6, 12 and 5.2 months of wages, respectively. Table 1 shows more recent data for workers with average tenure in a set of OECD Countries.

[Table 1 about here]

The debate on EPL is a long lived and rather extensive one. Several contributions, starting from the seminal paper by Lazear (1990), find large and negative effects of EPL.¹ More in detail, he finds that stricter EPL is responsible for a lower employment level and higher unemployment rates. His estimates suggest that in the United States an increase from zero to three months of severance pay would raise the unemployment rate by 5.5 percent.

Garibaldi and Violante (2005) argue that the most suitable conceptual framework to model firing costs is not a firing tax and, at the same time, provide evidence that the direct transfer component of EPL is quantitatively important. Garibaldi and Violante (2005) show, in the context of a search model with insider and outsider workers, the different results obtained when modeling the EPL as a firing tax as opposed to severance payments. They stress how the impact of severance payments on unemployment is qualitatively different from that of firing taxes, and find that it varies according to the bite of the wage rigidity.

A recent contribution, Ljungqvist (2002), analyses how lay-off costs affect employment in three prototype frameworks: a search model, a matching model and a model with employment lotteries. The aim of the paper is to single out the common economic forces at work in these general equilibrium models. The employment outcomes differ, depending on the specific framework used: search and

¹An entire issue of the *Economic Journal* was recently devoted uniquely to EPL: see, for example, Autor, Kerr and Kugler (2007), Boeri and Garibaldi (2007), Brügemann (2007), and Cahuc and Koeniger (2007).

matching models show a positive employment effect, while with employment lotteries lay-off costs tend to be detrimental. However, notice that: 1) welfare effects are not taken into consideration, 2) lay-off costs are specified as firing taxes.

This paper studies the equilibrium welfare effects of introducing mandated severance payments in a labor market with costly mobility, where self-insurance through a riskless asset is the only way to smooth fluctuations in labor income due to unemployment shocks. A similar set up has been analysed by Alvarez and Veracierto (2001). Alvarez-Veracierto assumed that there is only one market clearing wage for all types of workers in the economy, i.e. independently of their productivity.² In their set-up, the SP has an insurance role for unemployed workers and important general equilibrium effects: it reduces labor demand and wages, and since it insures workers it reduces precautionary savings with a further effect on the capital stock and wages. The novelty of our analysis is to allow for wage flexibility at the level of the individual firm-worker match. More precisely, wages vary with both tenure and productivity of the workers. When severance payments are introduced, the firm can potentially undo their effect by modifying the wage profile. In the absence of General Equilibrium effects, the introduction of severance payments is equivalent to the introduction of a compulsory actuarially fair insurance scheme. Workers entry wages fall by the expected present value of the future payment. However, because of incomplete markets, workers are unlikely to be indifferent about the slope of the wage profile. In particular, young workers in an economy with long unemployment durations and long tenures could be adversely affected because they spend a long period unemployed before finding a job, so they are likely to be constrained. Moreover, once they find a job, for an initial period their wage will remain low as they are pre-paying a large expected severance payment, so their borrowing constraint might remain binding. For this group of agents the welfare costs of severance payments are potentially high. The model is solved numerically and calibrated to the US economy. The measure of welfare we rely on is the change in consumption needed to equate the expected lifetime utilities in the stationary equilibria of several economies: the baseline economy, i.e. without severance payments, and a series of counterfactual economies where the severance payments are introduced at increasing levels. Non trivial general equilibrium effects are also present, since the capital stock in the various economies varies. On the one hand, the precautionary motive for savings is reduced by the introduction of severance payments, since agents are better insured. On the other hand, the change in the wage profile is likely to reduce the savings of young individuals and increase that of older ones.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 is devoted to the definition of the equilibrium concept used in the model. Section 4 presents the

²Though in their model severance payments are a priori non-neutral in so far as a unique market wage applies for both new hires and workers in surviving jobs.

calibration procedure. Section 5 provides the main results and predictions of the model, while Section 6 concludes.

2 The Economy

2.1 Demographics

Time is discrete. The economy is populated by a measure one of agents (workers). With probability $(1 - \lambda_i)$ an agent dies and is immediately replaced by an offspring of working age who starts life as an unemployed. The survival probability λ_i decreases with the age i of the individual.

2.2 Preferences

Agents' intraperiod utility function is defined over consumption c and search effort ψ as

$$U(c_t, \psi_t) = u(c_t) - v(\psi_t) \tag{1}$$

and the future is discounted at rate $\beta_i = \hat{\beta}\lambda_i$ where $\hat{\beta} \in (0, 1)$ is the discount factor. We assume that $u(\cdot)$ is strictly increasing, strictly concave, and satisfies the Inada conditions, and $v(\cdot)$ is strictly increasing, strictly convex. Effort choices are defined over the set $\Psi \equiv [0, 1]$, with $v(0) = 0$ and $v(1) = +\infty$. Agents do not value their offsprings' welfare.

2.3 Endowments

Agents can be employed (e) or unemployed (u). If employed they supply labor inelastically. Newly born agents are endowed with a_0 units of the consumption good. Every agent of working age goes through a stochastic life cycle of I labor productivity levels, $i \in \mathcal{I} = \{1, 2, \dots, I\}$. Let π_i be the transition probability between age level i and $i+1$ of workers. We only allow jumps between successive levels until $i = I - 1$, thus $\pi_I = 0$.

We index job tenure of an employed worker by t , with $t \in \mathcal{T} = \{0, 1, \dots, T\}$. During an employment relationship tenure increases with probability $\tau_t = \tau$ between successive tenure levels for all employed workers until $t = T - 1$, and let $\tau_T = 0$.

We assume that both tenure and age affect the productivity of a worker and denote the productivity level of a (i, t) -type worker as ε_{it} , where the pair stands for the agent's current age-tenure levels. The set of (labor augmenting) productivity levels is denoted as $\mathcal{E} = \{\varepsilon_{10}, \varepsilon_{20}, \dots, \varepsilon_{I0}, \varepsilon_{11}, \dots, \varepsilon_{it}, \dots, \varepsilon_{IT}\}$. Unemployed workers have zero tenure.

2.4 Technology

Each firm uses one worker and capital to produce output according to a common, constant returns to scale technology. The output of a firm employing a worker of productivity ε_{it} and K_{it} units of capital is $Y_{it} = F(K_{it}, \varepsilon_{it})$. The same production function in intensive units is $y_{it} = f(k_{it})$, with $k_{it} = K_{it}/\varepsilon_{it}$. Capital depreciates at the exogenous rate δ .

2.5 Search frictions and labor markets

Every period unemployed workers of age i meet a firm with an unfilled vacancy with probability $\phi(\psi)$.³ Keeping an open vacancy is costless. In every period, after production has taken place, employed workers of type (i, t) may be separated from their employer and enter the unemployment pool with exogenous probability $\sigma_{it} > 0$. Or, we can think of a competitive labor market with free entry of firms and workers who become unproductive with probability σ_{it} and productive again with probability $\phi(\psi)$, with $\phi(0) = 0$, $\phi(1) = 1$, and $\frac{d\phi(\psi)}{d\psi} > 0$.

The value of a firm with a filled vacancy, whose worker is of type (i, t) , is denoted with $J(i, t)$. Notice that the worker's type fully characterizes the firms' state space: once the employee's age-tenure pair is known, also the value of the firm can be computed.

The considerations above related to the free entry of firms justify the condition $J(i, 0) = 0, \forall i$. This set of equations imposes that the value of a firm who has just started an employment relationship with a worker of age i is equal to zero, irrespective of the labor market experience of the agent.

Tenure evolves stochastically and once the worker becomes an insider (i.e. has positive tenure) the firm is locked in: the SP needs to be paid to get rid of the worker. Job security legislation insulates insiders from competition from outsiders.

The value function of an employed agent of type (i, t) , whose current asset holdings are equal to a is denoted with $V(i, a, t)$. In general, the SP will depend both on the age of the worker and on his tenure with the firm he is working for. We denote the SP with θ_{it} . Since SP are unconditional and a worker that quits is still productive, an insider has threat point $V(i, a + \theta_{it}, 0)$ as she can quit, receive the severance payment and obtain a new job with zero tenure immediately. On the other hand the shadow value of a worker cannot fall below $J(i, t) = -\theta_{it}$ since the firm would optimally fire the worker otherwise. Any wage such that both the worker and the firm receive a payoff strictly above their respective threat points is compatible with the survival of the match. We assume that wages will be determined by bilateral ex-post bargaining over the value of the match.

³In the benchmark model we assume that the search effort is a constant, i.e. $\psi = \bar{\psi}$. It follows that the job finding probability $\phi(\psi) = \phi(\bar{\psi})$ is exogenous.

For tractability, we assume that the worker has all the bargaining power.

As a final note, notice that, in the absence of the SP, the value of each firm is equal to zero irrespective of the worker's tenure level. In particular, wages in this economy correspond to the competitive ones.

2.6 Mutual Fund

The SP are set by the government, hence there is nothing that prevents them to be higher than the output produced by a worker.⁴ It follows that, upon separation, a firm could incur some losses, determined by the size of the severance payment. In order to deal with this aspect of the problem, we assume the existence of a mutual fund (*MF*) that owns all the firms, covers their losses, pays out the severance payment upon separation and reinvests the flow profits into the asset market.

2.7 Other market arrangements

The final good market is competitive. Firms hire capital every period from a competitive market. Capital is supplied by rental firms that borrow from workers and the mutual fund at the risk-free rate r and invest in physical capital.

There are no state-contingent markets to insure against unemployment and income risk, but workers can self-insure by saving into the risk-free asset. The agents also face a borrowing limit, denoted as $d \geq 0$. There are perfect annuity markets where workers share their mortality risk.

2.8 Government

The government enforces an unconditional severance payment from the firm to those workers who enter unemployment. The severance payment is a lump sum payment specified as a function $\theta_{it} = \gamma_t w_{it}$.⁵ Such specification allows the severance payment to depend both on productivity ε_{it} and on tenure lengths t . We assume $\gamma_0 = 0$, or that a worker with zero tenure is not entitled to a severance payment.

⁴A paper dealing explicitly with the optimality of the severance payments in a matching framework is Fella (2007).

⁵In reality severance payments are usually proportional to the last wage. Our formulation makes the severance payment a function of the wage a worker would receive in the *current* period. The wage in the current period differs from the last wage whenever a state transition has taken place in the previous period. Making the severance payment proportional to the last wage would complicate notation substantially and require us to keep track of when the last state transition took place.

2.9 Wage setting

Wages are determined in every period before capital is rented. The wages of workers with zero tenure (outsiders) are determined competitively. We assume that workers with positive tenure (insiders) have all the bargaining power and make firms a take-it-or-leave-it offer.⁶ Therefore workers are going to extract all the surplus and the value of a firm employing a worker of productivity ε_{it} and tenure t is $J(i, t) = -\theta_{it}$.

3 Stationary Equilibrium

We first define the problem of an employed and unemployed worker and the problem of the firm. The individual state variables are the employment status $s \in \mathcal{S} = \{e, u\}$, experience $i \in \mathcal{I}$, asset holdings $a \in \mathcal{A} = [-d, \bar{a}]$ and tenure $t \in \mathcal{T}$.⁷ The stationary distribution of employed agents is denoted by $\mu_e(i, a, t)$ whereas the distribution of unemployed agents is $\mu_u(i, a)$.

3.1 Problem of the agents

In this Section we first define the problem of the agents in their recursive representation, then we provide a formal definition of the equilibrium concept used in this model, the recursive competitive equilibrium.

3.1.1 Problem of the unemployed worker

The value function of an unemployed agent of type $(i, t = 0)$ whose current asset holdings are equal to a is denoted with $U(i, a)$. The problem of these agents can be represented as follows:

⁶This assumptions implies that wages are determined only by productivity and severance payments. If firms had positive bargaining power wages would depend on workers' marginal utility of consumption and wealth. This would not only substantially complicate the problem but also imply that saving decisions have a strategic element in so far as they affect workers' future bargaining power and wages.

⁷A formal argument proving that $\bar{a} < \infty$ appears for a similar economy in Huggett (1993).

$$\begin{aligned}
U(i, a) &= \max_{c, a', \psi} \{u(c) - v(\psi) + \beta_i \phi(\psi) [(1 - \pi_i) V(i, a', 0) + \pi_i V(i + 1, a', 0)] \\
&\quad + \beta_i (1 - \phi(\psi)) [(1 - \pi_i) U(i, a') + \pi_i U(i + 1, a')]\} \\
&\quad s.t. \\
c + a' &= \frac{(1 + r)}{\lambda_i} a + b_i \\
a_0 \text{ given, } &\quad c \geq 0, \quad -a' > d, \quad 0 \leq \psi \leq 1
\end{aligned} \tag{2}$$

Unemployed agents enjoy utility from consumption, suffer some disutility from searching for a job, and face some uncertain events in the future. In the next period they can still be unemployed, or they can find a job and be employed. We interpret b_i as an unemployment benefit scheme possibly depending on the age of the agent (alternatively, we could interpret it as home production). Notice that the gross interest rate $(1 + r)$ is divided by the survival probability λ_i to "adjust" the returns from investing in the risk-free asset for the probability of death. This ensures that at the aggregate level there are no incidental bequests to be distributed: in steady state the average value of the asset holdings of people that die is zero.⁸

3.1.2 Problem of the employed worker

The recursive representation of the problem of the employed worker is as follows:

$$\begin{aligned}
V(i, a, t) &= \max_{c, a'} \{u(c) + \beta_i (1 - \sigma_{it}) [\pi_i \tau_t V(i + 1, a', t + 1) + \\
&\quad \pi_i (1 - \tau_t) V(i + 1, a', t) + (1 - \pi_i) \tau_t V(i, a', t + 1) \\
&\quad + (1 - \pi_i) (1 - \tau_t) V(i, a', t)] + \beta_i \sigma_{it} [(1 - \pi_i) U(i, a' + \theta_{it}) + \pi_i U(i + 1, a' + \theta_{it})]\} \\
&\quad s.t. \\
c + a' + l &= \frac{(1 + r)}{\lambda_i} a + w_{it} \\
c \geq 0, &\quad -a' > d
\end{aligned} \tag{3}$$

Employed agents enjoy utility from consumption and face several uncertain events in the future. In the next period they can still be employed, and if so they might see an increase in their tenure and/or their age, or they can be fired, receive the severance payments and be unemployed. Notice

⁸Notice that the Bellman equations need to be appropriately adjusted when age reaches its maximum value. When $i = I$, the object $U(i + 1, a')$ is not well defined. A similar comment applies for both the employed workers' and firms' value functions. The equations are trivially modified when tenure and/or age are at their upper boundaries. We do not report them in order to save on space.

that in case a separation occurs, the SP is paid to the worker at the end of the period: the amount of resources that she brings into the following period is equal to $a' + \theta_{it}$, the sum of accumulated wealth and the severance payment. Finally, notice that l stands for a lump-sum tax paid by the agents currently employed to finance the unemployment benefit scheme.

3.1.3 Problem of the firms

We assume that establishments are risk neutral. In every period, after wages have been set, an establishment matched to a worker of type (i, t) rents the amount of capital solving

$$J(i, t) = \max_{k_{it}} \left\{ f(k_{it})\varepsilon_{it} - w_{it} - (r + \delta)k_{it}\varepsilon_{it} + \frac{\lambda_i(1 - \sigma_{it})}{1 + r} [\pi_i\tau_t J(i + 1, t + 1) + \right. \quad (4)$$

$$\left. \pi_i(1 - \tau_t)J(i + 1, t) + (1 - \pi_i)\tau_t J(i, t + 1) + (1 - \pi_i)(1 - \tau_t)J(i, t)] - \frac{\lambda_i\sigma_{it}}{1 + r}\theta_{it} \right\}$$

where $k_{it} = K_{it}/\varepsilon_{it}$. In the firm's Bellman equation we need to take into account all possible transitions the worker currently employed could go through. Beside the transitions outlined above, we also need to take into consideration the death of the agent, which would destroy the match, with no SP paid to the worker. $J(i, t)$ represent the expected present discounted stream of the firm's revenues and costs.

3.1.4 Wage determination

Since the workers have all the bargaining power and make a take-it-or-leave-it offer to the firm, the wage w_{it} leaves the firm indifferent between continuing and terminating the employment relationship; i.e. $J(i, t) = -\theta_{it}$ for any pair (i, t) . Hence, w_{it} satisfies

$$-\theta_{it} = f(k_{it})\varepsilon_{it} - w_{it} - (r + \delta)k_{it}\varepsilon_{it}$$

$$- \frac{\lambda_i}{1 + r} \{ (1 - \sigma_{it}) [\pi_i\tau_t\theta_{i+1,t+1} + \pi_i(1 - \tau_t)\theta_{i+1,t}$$

$$+ (1 - \pi_i)\tau_t\theta_{i,t+1} + (1 - \pi_i)(1 - \tau_t)\theta_{it}] + \sigma_{it}\theta_{it} \}$$

To understand better how the wage determination (and their actual computation) works in our framework, consider a simplified example. In this illustration, severance payments do not depend on wages, that is $\theta(i, t) = \theta_t$, productivity is a constant, that is $\varepsilon_{it} = \varepsilon, \forall (i, t)$, and the survival probability is a constant, that is $\lambda_i = \lambda, \forall i$. By imposing the equilibrium conditions $J(i, 0) = 0, \forall i$ and $J(i, t) = -\theta_t, \forall (i, t \neq 0)$, and rearranging the firms' value functions we are able to derive the equilib-

rium expressions for wages:

$$\begin{aligned}
w_{i0} &= f(k)\varepsilon - (r + \delta)k\varepsilon - \frac{\lambda}{1+r}(1 - \sigma_{i0})\tau_0\theta_1 \\
w_{i1} &= f(k)\varepsilon - (r + \delta)k\varepsilon + \theta_1 - \frac{\lambda}{1+r}\{(1 - \sigma_{i1})[\tau_1\theta_2 + (1 - \tau_1)\theta_1] + \sigma_{i1}\theta_1\} \\
&\dots \text{ and similarly } \forall t
\end{aligned}$$

This example is interesting since it shows that every period the worker pre-pays the severance payment that she will receive next period if laid off, so that the expected present value of the wage bill does not depend on $\theta(i, t)$ at all, as expected. Only the time-profile of wages is affected.

If we consider a more general specification for the severance payments, namely $\theta(i, t) = \gamma_t w_{it}$, and we let productivity vary by type, then repeating the same steps gets a set of equations that the bargained wages need to satisfy:

$$\begin{aligned}
-\gamma_t w_{it} &= f(k_{it})\varepsilon_{it} - w_{it} - (r + \delta)k_{it}\varepsilon_{it} \\
&- \frac{\lambda_i}{1+r}\{(1 - \sigma_{it})[\pi_i\tau_t\gamma_{t+1}w_{i+1,t+1} + \pi_i(1 - \tau_t)\gamma_t w_{i+1,t} \\
&+ (1 - \pi_i)\tau_t\gamma_{t+1}w_{i,t+1} + (1 - \pi_i)(1 - \tau_t)\gamma_t w_{it}] + \sigma_{it}\gamma_t w_{it}\}
\end{aligned} \tag{5}$$

From (5) a system of $I \times T$ equations is originated, whose unknowns are the $I \times T$ wages. Notice however that the system is: 1) recursive, thanks to the fact that I and T are the maximum values of (i, t) , and 2) linear in w_{it} , hence it admits a unique solution. Notice that in general $w_{it} = W(w_{i,t+1}, w_{i+1,t}, w_{i+1,t+1})$. In the actual solution one can start solving $w_{IT} = W(w_{IT}, w_{IT}, w_{IT})$, next $w_{I-1,T} = W(w_{I-1,T}, w_{IT}, w_{IT})$, and $w_{I,T-1} = W(w_{IT}, w_{I,T-1}, w_{IT})$. Then, it is possible to obtain, recursively, the whole sequence of $\{w_{it}\}$. The consequence is that one never has to deal with a system of equations to get the equilibrium wages, which is computationally simple and efficient.

3.1.5 The mutual fund

The intertemporal budget constraint of the mutual fund is

$$\int \lambda_i \theta_{it} \sigma_{it} d\mu_e(i, a, t) + MF' = (1 + r)MF + \int p_{it} d\mu_e(i, a, t) \tag{6}$$

where p_{it} denotes the profit of a production unit of type (i, t) and MF denotes the asset-value of the fund. The quantity $\int p_{it} d\mu_e(i, a, t)$ represents the aggregate value of profits in steady state. The quantity $\int \lambda_i \theta_{it} \sigma_{it} d\mu_e(i, a, t)$ represents the aggregate value of the severance payments paid to the workers who got separated in the current period. In steady state, $MF = MF'$ so the fund has an amount of assets MF that guarantees a return which is large enough to cover the operating losses. A

natural question arises: "Where do these funds come from?" The intuition is the following: a job has initially positive profits, then possibly negative profits, but ex-ante it has zero value when the present value of profits are discounted at rate r . It follows that if the fund reinvests the initial profits in the risk-free asset, it will be able to repay, in expected terms, all the future losses. Basically, MF is the cumulated value of the reinvested initial profits for each job in the stationary distribution $\mu_e(i, a, t)$.

3.2 Recursive Stationary Equilibrium

Definition 1 For given policies θ_{it}, b_i a recursive stationary equilibrium is a set of decision rules $\{c_e(i, a, t), c_u(i, a), a'_e(i, a, t), a'_u(i, a), \psi(i, a), k_{it}\}$, value functions $\{V(i, a, t), U(i, a), J(i, t)\}$, a value of the mutual fund MF , prices $\{r, w_{it}\}$, a lump-sum tax l and a pair of stationary distributions $\{\mu_e(i, a, t), \mu_u(i, a)\}$ such that:

- Given relative prices $\{r, w_{it}\}$, severance payments θ_{it} , lump-sum tax l , and unemployment benefits b_i , the individual policy functions $\{c_e(i, a, t), c_u(i, a), a'_e(i, a, t), a'_u(i, a), \psi(i, a)\}$ solve the household problems (2)-(3) and $\{V(i, a, t), U(i, a)\}$ are the associated value functions.

- Given relative prices $\{r, w_{it}\}$, and severance payments θ_{it} , k_{it} solves the firm's problem (4) and satisfies

$$r + \delta = f'(k_{it}) \quad (7)$$

Since the LHS of equation (7) is equal for every firm in the economy, it follows that k_{it} (the capital stock per efficiency unit of labor) is the same across establishments, or $k_{it} = k$ for any pair (i, t) .

- The wage w_{it} leaves the firm indifferent between continuing and terminating the employment relationship; i.e. $J(i, t) = -\theta_{it}$ for any pair (i, t) . Hence, w_{it} satisfies the recursive system of equations (5).

- The stationary value of the mutual fund MF satisfies

$$rMF = \int \lambda_i \theta_{it} \sigma_{it} d\mu_e(i, a, t) - \int p_{it} d\mu_e(i, a, t)$$

which highlights how the operating losses are paid for with the asset income.

- The labor market is in flow equilibrium

$$\begin{aligned} & \int_{I \times A \times T} \lambda_i \sigma_{it} d\mu_e(i, a, t) + \int_{I \times A \times T} (1 - \lambda_i) d\mu_e(i, a, t) \\ &= \int_{I \times A} \lambda_i \phi(\psi(i, a)) d\mu_u(i, a) \end{aligned}$$

notice that we need to take into consideration that some people die and are substituted by the flow of newborns, who enter the job market as unemployed.

- The asset market clears

$$k \int_{I \times A \times T} \varepsilon_{it} d\mu_e(i, a, t) = \int_{I \times A \times T} a'_e(i, a, t) d\mu_e(i, a, t) + \int_{I \times A} a'_u(i, a) d\mu_u(i, a) + MF$$

notice that here we need to add the supply of capital of the mutual fund.

- The goods market clears

$$\begin{aligned} [f(k) - \delta k] \int_{I \times A \times T} \varepsilon_{it} d\mu_e(i, a, t) + \int_{I \times A} b_i d\mu_u(i, a) = \\ \int_{I \times A \times T} c_e(i, a, t) d\mu_e(i, a, t) + \int_{I \times A} c_u(i, a) d\mu_u(i, a) \end{aligned}$$

- For $b_i = bw_{i0}$ the lump-sum tax satisfies

$$l = \frac{\int_{I \times A} bw_{i0} d\mu_u(i, a)}{\int_{I \times A \times T} d\mu_e(i, a, t)}$$

- The stationary distributions $\{\mu_e(i, a, t), \mu_u(i, a)\}$ satisfy

$$\begin{aligned} \mu_u(i, a') = \lambda_i \left[(1 - \pi_i) \int_{a: a'_u(i, a) = a'} (1 - \phi(\psi(i, a))) d\mu_u(i, a) \right. \\ \left. + \pi_i \int_{a: a'_u(i, a) = a'} (1 - \phi(\psi(i - 1, a))) d\mu_u(i - 1, a) \right. \\ \left. (1 - \pi_i) \int_{T \times \{a: a'_e(i, a, t) = a'\}} \sigma_{it} d\mu_e(i, a, t) + \pi_i \int_{T \times \{a: a'_e(i, a, t) = a'\}} \sigma_{i-1t} d\mu_e(i - 1, a, t) \right] \\ + (1 - \lambda_i) \chi(i = 1) \chi(a' = a_0) \left[\int_{I \times A \times T} d\mu_e(i, a, t) + \int_{I \times A} d\mu_u(i, a) \right] \end{aligned} \quad (8)$$

and

$$\begin{aligned}
\mu_e(i, a', t) = & \lambda_i \left[\int_{a: a'_e(i, a, t) = a'} (1 - \sigma_{it}) (1 - \pi_i) (1 - \tau_t) d\mu_e(i, a, t) \right. \\
& + \int_{a: a'_e(i-1, a, t) = a'} (1 - \sigma_{i-1t}) \pi_{i-1} (1 - \tau_t) d\mu_e(i-1, a, t) \left. \right] \\
& + \lambda_i \left[\int_{a: a'_e(i, a, t-1) = a'} (1 - \sigma_{it-1}) (1 - \pi_i) \tau_{t-1} d\mu_e(i, a, t-1) \right. \\
& + \int_{a: a'_e(i-1, a, t-1) = a'} (1 - \sigma_{i-1t-1}) \pi_{i-1} \tau_{t-1} d\mu_e(i-1, a, t-1) \\
& + \chi(t=1) \int_{a: a'_u(i, a) = a'} \pi_i \phi(\psi(i-1, a)) d\mu_u(i-1, a) \\
& \left. + \chi(t=1) \int_{a: a'_u(i, a) = a'} (1 - \pi_i) \phi(\psi(i, a)) d\mu_u(i, a) \right]
\end{aligned} \tag{9}$$

where $\chi(\cdot)$ is an indicator function taking the value one if the condition in parenthesis is satisfied and zero otherwise.

In equilibrium the measure of agents in each state is time invariant and consistent with individual decisions, as given by the above two equations (8) and (9).

4 Parameterization

The complete parameterization of the model is reported in Table 2. We calibrate the model to the US, where there are no severance packages mandated by the government. Moreover, privately contracted SP are in place only for few categories of workers. It follows that the observed wages do not reflect the presence of the SP.

[Table 2 about here]

In order to properly capture the labor market dynamics, we need to work with a short time period: one model period corresponds to two months. We specify the survival probability as a one parameter exponential function, namely $\lambda(i) = 2 - e^{\lambda(\frac{i-1}{T})}$. λ is calibrated for the agents to have on average an active working life of 40 years.

The concavity of the utility function is pinned down by the CRRA coefficient η , which is set to 2.0, a common value in the literature. The borrowing limit d is set for the economy to have 15% of the

workers in debt, which is the value observed in the US. In the benchmark economy $d = 0.12$ achieves this target.

We assume that the newborns enter the economy without any asset endowment, or $a_0 = 0$. We allow for 11 points in the age grid: workers enter the economy at age 16 and reach at most age 66. The grid is evenly spaced, that is we allow for a jump in age occurring on average every 5 years. It follows that $\pi_i = 0.031$.

We allow for 11 points in the tenure grid as well, which starts at zero and reaches at most 20 years. The grid is evenly spaced, that is on average people experience an increase in tenure every 2 years. It follows that $\tau_t = 0.077$.

At this stage of the analysis, we allow for a constant job finding probability ϕ , whose value is pinned down by the average unemployment duration. This is approximately 12 weeks in the data, which dictates a value $\phi = 0.9$.

The constant separation probability is equal to $\sigma_{it} = 0.051$. This implies that on average a worker gets separated every three years, which is the value reported by Shimer (2005), among others. For the benchmark economy $\gamma_t = 0$ because it is meant to capture the US economy where SP are limited to few occupations. The depreciation of capital is set to replicate an investment/output share of 21%, on an annual basis. This is achieved when $\delta = 0.019$. We assume a Cobb-Douglas production function, hence the capital share is captured by the parameter $\alpha = 0.3$. The rate of time preference $\widehat{\beta}$ is calibrated to get an equilibrium interest rate equal to 5%, on an annual basis, obtained when $\widehat{\beta} = 0.09959$.

The computation of the efficiency units profile ε_{it} for each (i, t) worker type is no trivial task for this model. In order to do so, we take a stand on several dimensions. The first one, relates to the role of tenure and age on the productivity of the workers. Underlying our approach is the assumption that workers accumulate firm specific human capital, captured by tenure, and general human capital, captured by labor market experience. Every time a worker gets separated from his current employer, the tenure component of wages is lost. Differently, the age component is fully transferable across jobs.

As for the returns to tenure, given the pervasive selection and endogeneity problems, there is no consensus in the literature on their magnitude.⁹ Here we take a stand which is consistent with the model we are working with. In the model an increase in tenure with the current employer is a random event, which neither the firm nor the worker can affect. It follows that tenure is strongly exogenous and can be included in the right hand side of a log wage regression like the one in Table 3. The estimated returns to tenure on the February 1996 CPS data are approximately 2% on a yearly basis.

⁹See the seminal contributions by Altonji and Shakotko (1987), Ruhm (1991) and Topel (1991), and the discussion in Wolpin (1995).

This value seems to be on the high end of the estimated returns to tenure.

If one were to interpret literally the (i, t) pairs, the ε_{it} should be estimated in equilibrium. However, structurally estimating $(I \times T)$ efficiency units would represent an intractable problem. To reduce the dimensionality of the exercise, one could rely on additional parametric assumptions on how ε_{it} is related to i and t . However, we rely on a simple classical regression approach, and we will perform some robustness analysis on the returns to tenure.

In order to get estimates for the efficiency units, we need to rely on data that provide information on both age and tenure with the current employer. Both the NLSY and the February CPS include such information. We decided to use the CPS data, because they represent a random sample of the whole US labor force, unlike the NLSY that contains information on only one cohort.

We estimate a simple linear regression with OLS, where the dependent variable is the natural logarithm of earnings and the set of explanatory variables are the constant, and two third-degree polynomials in age and tenure.

Once we have the OLS estimates, we retrieve the $\{\varepsilon_{it}\}$ by simply considering the fitted values of the econometric model at all the (i, t) pairs implied by their grids.

Notice that in order to preserve consistency between the theoretical model and the data, we transformed the dependent variable and the explanatory ones to the same time period of the model, that is we estimated log wages on a bi-monthly basis. Table 3 reports the results of the OLS regression.

[Table 3 about here]

5 Results

This Section presents the main results. First we show how the equilibrium wage profiles are affected by the introduction of severance payments. Then we discuss the predictions of the model. Finally, we compute the welfare effects induced by the severance payments.

We consider the benchmark economy as the one without SP, and a series of counterfactual economies where the SP is set at an increasing level. More in detail, we proceed with two different specifications for the SP. In the first specification, we consider three constant values for SP, that is in the experiments we set γ_t at 3, 6, and 9 monthly wages, respectively. This implies that every fired workers get the same SP, irrespective of their characteristics. In the second one, we allow for a linear specification for γ_t , that is $\gamma_t = \gamma \cdot t$, and we set γ at 0.3, 0.4, and 0.5. This implies that every additional year of tenure accumulated by the worker maps into an increase in the severance payments

equal to 60%, 80% and 100% in terms of monthly wages (which mimics the system in place in Spain). Figure (1) represents graphically the second specification, with years of tenure on the horizontal axis and the severance payments on the vertical axis. Notice that, in order to prevent the wages for some workers to become negative, we cap the maximum value of SP at twelve monthly wages.

[Figure (1) about here]

5.1 Wage profiles

[Figures (2) and (3) about here]

Figure (2) plots the equilibrium effects on wages derived by introducing the severance payments at different levels. As discussed above, the workers pre-pay the SP with a low entry wage. This graph shows how untenured workers see their wage profile change during their life-cycle. These plots take into consideration also the General Equilibrium effects: the wage profiles associated to different severance payments are compared for the equilibrium interest rate r . From the figure, it is possible to appreciate that untenured workers suffer a large wage loss for every productivity level they might have. The effect is smooth in the level of the SP: for SP equal to 9 monthly wages the drop is substantial and wages in the competitive environment are one and a half times higher than in the counterfactual economy with SP. Another aspect of the introduction of SP is that the present value of wages would remain unaltered, if we were not to consider the General Equilibrium effect. Another way of interpreting this result is to say that higher SP imply faster wage growth in the first years of a job match. This effect is captured in Figure (3), which plots the wage profiles for tenured workers with tenure equal to two years. It is possible to appreciate how the SP have now the opposite effect on wages if compared to before. Wages of tenured workers rise with γ_t and the rise tends to get amplified during the life cycle.

Closely linked to the wage profile is the SP the workers are entitled to if a separation takes place. Since $\theta(i, t) = \gamma_t w_{it}$ their behaviour is similar to Figure (??), which is only rescaled by the factor γ_t .

[Figures (4), (5) and 5 about here]

One of the endogenous outcomes of the model are the stationary distributions of workers by employment status, age and tenure. Figures (4) and (5) report the equilibrium (marginal) distributions

of workers over age and tenure. As for the former, the share of workers employed decreases smoothly with tenure and captures the main features of the data, qualitatively and, for low tenure values, quantitatively as well. The results related to the latter are somewhat less satisfactory: the model predicts that young workers have the highest shares in the pool of employment, which is not a feature of the data. Notice that these results were obtained on the basis of a simple and parsimonious calibration strategy, which imposed a constant value for π_i^e , π_i^u , τ_t , ϕ_i and σ_{it} . Moreover, a feasible alternative is to estimate the transition probabilities with a simulated method of moments. More in detail, once we "integrate out" the asset level, the stationary distributions over tenure and productivity can be obtained without solving the model, since they depend only on a set of exogenous shocks. The corresponding distributions in the data are easily computed, and it would be possible to iterate on the parameters values until the squared deviations are minimized.¹⁰

Finally, we report in Figure (6) the unemployment distribution: the fit is almost perfect.

5.2 Equilibrium Effects

This section is devoted to discuss the equilibrium effects of SP on a set of relevant endogenous variables. Tables 4 and 5 present the same results in two different formats. Each column presents the results related to the economy with a level of the SP indicated in the top row. In Table 4 we report the values of the endogenous variables of the model in levels, while Table 6 reports the subset of endogenous variables that are not a share themselves divided by the value of output in the benchmark economy.

[Tables 4, 5 and 6 about here]

In Table 4 there several interesting findings. First, as expected, the values of the mutual fund, of the average profits and of the average disbursement in SP are all monotonically increasing in the level of SP. The equilibrium lump-sum tax is quantitatively small, and decreases in SP, both because output is increasing, but also because the average wage is falling, and the cost of the unemployment benefit scheme is decreasing. Notice that the borrowing limit is kept at its calibrated value during all the exercises. If we were to allow for a natural borrowing limit specification, since the lowest possible income is the unemployment benefit, and this is a fraction of the untenured wage, the borrowing limit would become more stringent for higher SP, exactly because those wages are decreasing. A

¹⁰However, this procedure might suffer from some identification issues. Unless we are able to pin down some of the parameters directly from the data, the same stationary distributions might be obtained with different combinations of shocks, in particular the ones related to the increase and decrease in productivity tend to offset each other.

more stringent borrowing limit, on the other hand, would influence the agents' saving behaviour, strengthening the precautionary saving motive and increasing the asset supply in the economy.

An interesting result is related to output. With respect to the benchmark economy, output increases monotonically in the SP, with a 8.2% change for SP equal to 9 monthly wages. The increase in output stems from the additional supply of capital arising from the higher steady-state value of the Mutual Fund, which drives the interest rate down and expands the stock of physical capital.

This result is clearly captured by the behavior of the investment-output ratio, which rises with the SP.

As for the labor share, we can think of two different definitions, depending on how we consider the SP. If the SP are included in the computation of the labor share, this increases monotonically in the level of SP, passing from 70% to 71.6%. Notice also the concavity of this relationship. Differently, if SP are excluded in the definition of labor share, this decreases considerably, falling to 59.9%. Here we can appreciate the General Equilibrium effects of the SP. In the absence of GE effects, the introduction of SP would be neutral for the labor share, once the SP are included in it. However, the change in the wage profile arising from the introduction of SP drives two effects: on the one hand the agents are better insured and decrease their savings, while on the other hand the value of the Mutual Fund must increase in order for the large operating losses of the firms facing a separation to be paid off. Overall, this drives a substantial drop in the equilibrium interest rate and to a large increase in the capital stock. This effect partially offsets the initial change in the wage profile: the productivity of workers benefit from a larger capital stock used by each firm in the economy, allowing for wages to increase (or decrease by a lower amount).

The percentage of people that are in debt changes substantially: it moves from 15% to 25.3%. This result is driven by the GE effects: the interest rate is decreasing, making it cheaper for young people and unemployed workers to borrow to better smooth their consumption.

To conclude with, the percentage of agents that are at the borrowing limit is small in the benchmark economy, being less than 1%. However, their share increases considerably with the SP, reaching more than 8% in the most extreme case. This result is not surprising in this framework: the labor income of the untenured workers when the SP is high becomes extremely low, making it more likely for them to be constrained.

Qualitatively, the same effects hold true also for the linear specification of the SP, which are reported in Table 5 and 6.

5.3 Welfare Effects

As shown by the previous results, the introduction of SP has important allocative effects, with several non trivial General Equilibrium forces being present at the same time. Here we present the results related to a measure of the equilibrium welfare effects of SP. More precisely, we first compute the welfare in the steady state of the benchmark economy using the equilibrium consumption functions. In order to compute the average welfare, we assume the existence of a utilitarian social welfare function. Then we consider as our measure of welfare cost/gain the percentage change in consumption that would equate the social welfare of the counterfactual economy to that of the benchmark one. The equilibrium welfare effects are reported in Table 7.

[Table 7 about here]

The first result is that, irrespective of the specification for SP, the average welfare is always higher in the counterfactual economies.

As for the flat SP scheme, for low values of SP, the average welfare change is relatively small. More precisely, for values of the severance payment equal to three and six monthly wages, we need to increase consumption in each possible state of the world by 0.677% and 1.04%, respectively. However, the effects of SP is non linear and start decreasing with nine monthly wages, the average welfare change being equal to 0.952% in this case.

However, regarding to the plausibility of these welfare gains some caveats are in order. It is worth stressing that the simple formulation for SP we are working with might over-estimate substantially their effects. More in detail, we are assuming that the number of monthly wages is the same for every worker that faces a separation, *irrespective* of their actual tenure with their employer. In reality the severance payments tend to be capped and, more importantly, they do depend on the tenure level. More in detail, the values reported for the OECD Countries in Table 1 refer to workers with average tenures. For example, the value for Portugal of 15 monthly wages applies to a worker with a tenure level of 15 years.

In order to get a better gauge of our results, from now on the analysis is going to focus on the economies where the SP grows linearly in the accumulated tenure.

As for the SP scheme increasing with the tenure of the worker, the average welfare change increases monotonically with the slope of the SP schedule. For the SP scheme granting a monthly wage for any additional year of tenure ($SP=0.5t$), the change in consumption needed to equate the average welfare in the two steady-states is 1.09%.

Interestingly, the average results hide different effects for different groups of workers. Figure (7) plots the welfare effects as a function of the workers' age. Perhaps surprisingly, in each of these simulations the young workers are the ones experiencing a positive welfare effects, irrespective of the wage cut. The explanation goes again through the decreased cost of borrowing. For the same reason, the old workers suffer a large welfare loss, which in the aggregate is more than compensated by the welfare gains of the young workers, given their larger share in the population.

[Figure (7) about here]

To summarize our results, notice that when the model implies a very large expenditure in SP the Mutual Fund has to increase by a sizeable factor to be able to cover the operating losses. This leads to an excess supply of capital, and to a substantial fall in the interest rate. In turn, this leads to an increase in the capital stock and in output. This in turn tends to mitigate the fall in wages caused by the higher SP. To conclude with, severance payments have important allocative effects; their welfare effects are quantitatively small for plausible values of the SP, while they get extremely large for high values of the SP.

6 Discussion and Conclusions

In this paper we proposed a quantitative framework to study the equilibrium effects of severance payments. These are an important labor market feature of several OECD Countries and have been proposed as a possible explanation of their high unemployment rates and durations.

The results show that the introduction of severance payments influences positively the average welfare. However, restricting the attention to this aggregate measure hides large losses for the older workers, but also large gains for the younger ones.

This paper has focused on stationary equilibria. It would be interesting to study the welfare effects of SP out of the steady-state, in a model with aggregate uncertainty. A recent contribution, Veracierto (2008), presents an analysis along those lines. Notice, however, that the techniques used to tackle the current problem would need to be amended since the whole distribution of assets would become a state variable. A feasible solution might be to rely on the approximation methods proposed by den Haan (1997) and Krusell and Smith (1998).

An important feature would be to allow for endogenous separations, arising for example from idiosyncratic shocks to the productivity of the employed workers. This extension would give the

model the ability to make meaningful quantitative statements on the equilibrium effects of SP on the unemployment rate. Notice also that the current framework does not allow for search/matching externalities in the spirit of Mortensen-Pissarides and included, for example, by Alonso-Borrego, Fernandez-Villaverde and Galdon-Sanchez (2006) in a model of temporary Vs. permanent contracts.

In order to give the Mutual Fund a less extreme role in our counterfactuals, the introduction of a retirement stage could prove helpful. The saving behaviour would reflect also the desire for consumption smoothing during retirement, possibly leading to changes in the equilibrium value of the Mutual Fund which would affect less drastically the interest rate and the accumulation of physical capital.

Finally, there is a large body of evidence discussed, for example, in Gottschalk and Moffitt (1999) and Neumark, Polsky and Hansen (1999) showing that the retention probability of a worker is heavily affected by some observables, such as age, and tenure. We could exploit this information to calibrate the separation probabilities and obtain a different response on the wage profiles, because this would reflect the different risks of separation. We leave these extensions and modifications for future work.

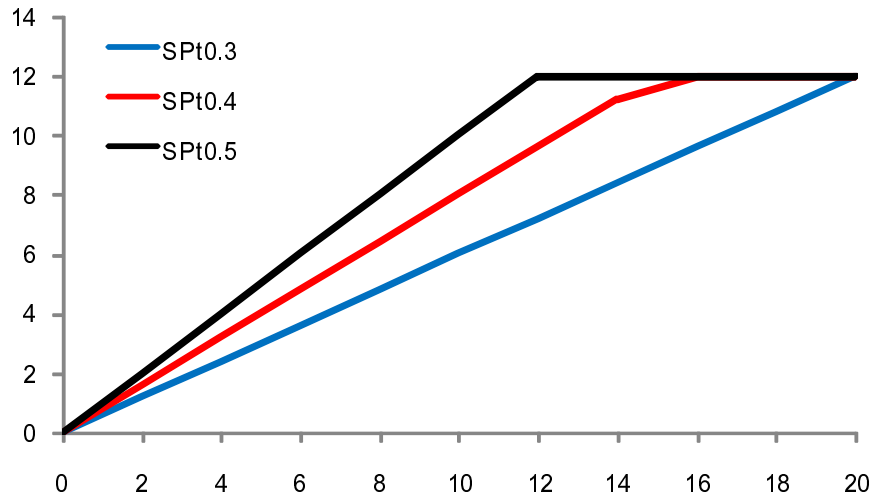


Figure 1: SP Profiles: Monthly wages as a function of tenure

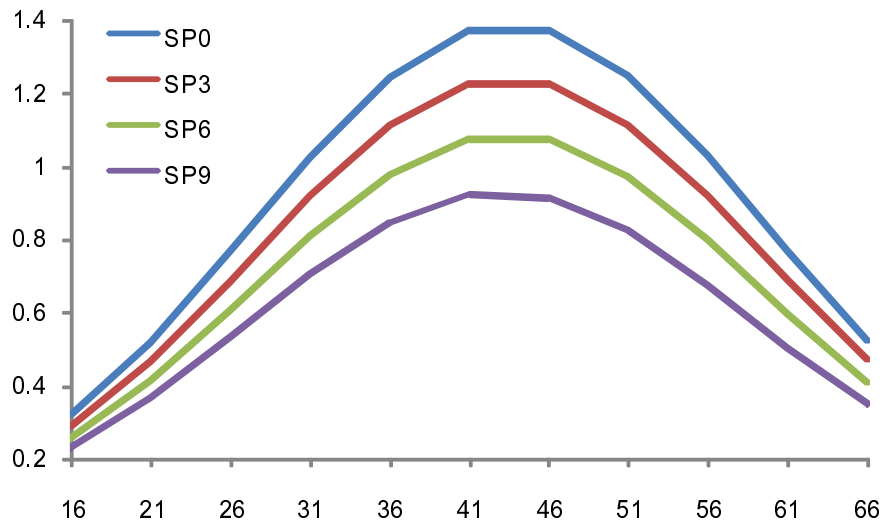


Figure 2: The effects of SP on the Wage Profile (No Tenure)

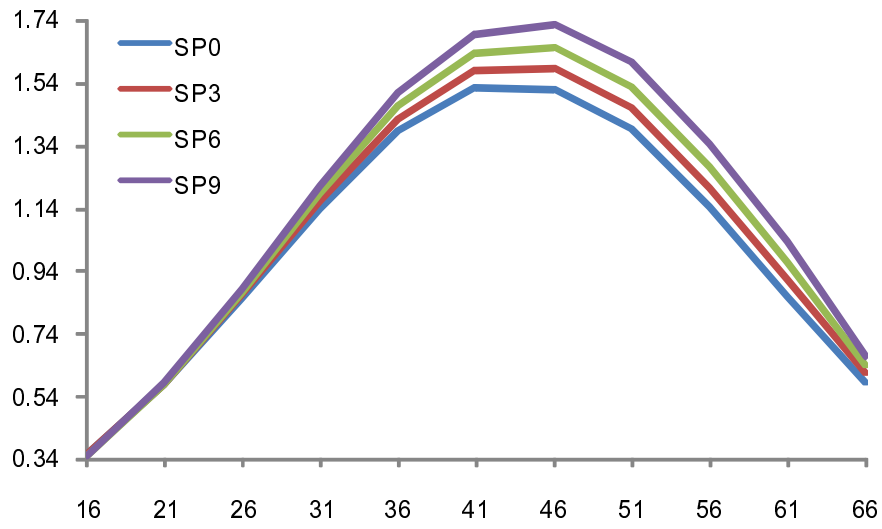


Figure 3: The effects of SP on the Wage Profile (Tenured)

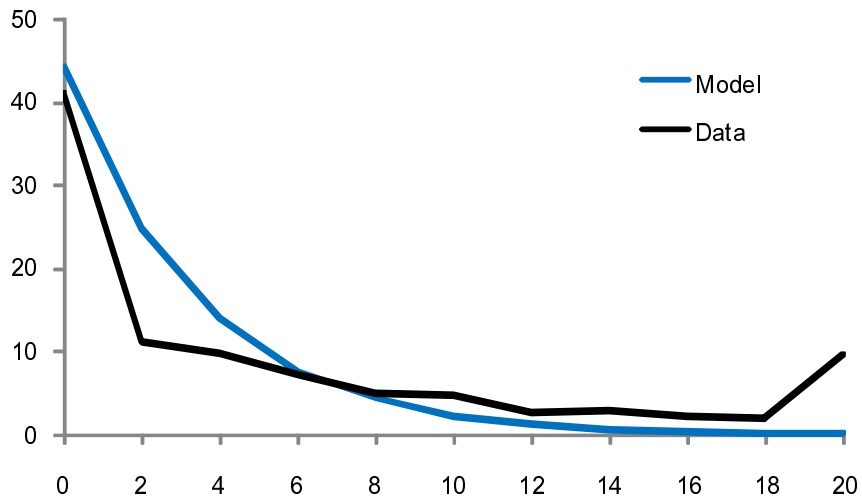


Figure 4: Marginal Distributions over Tenure

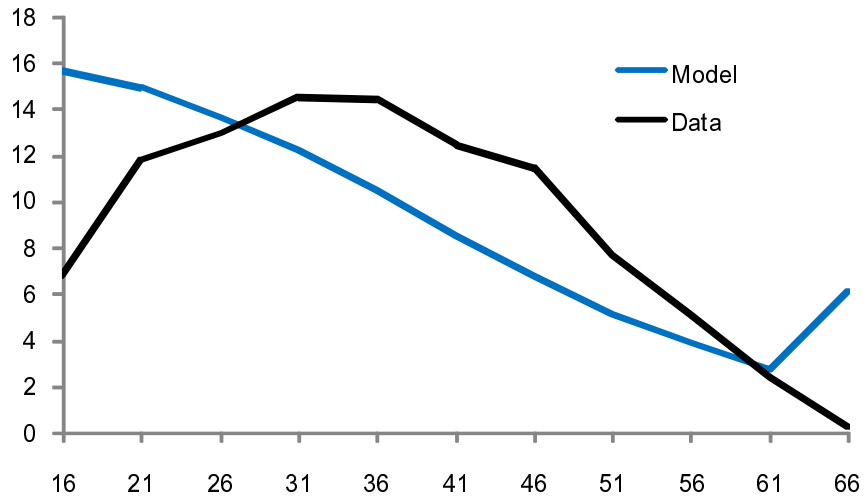


Figure 5: Age Distributions

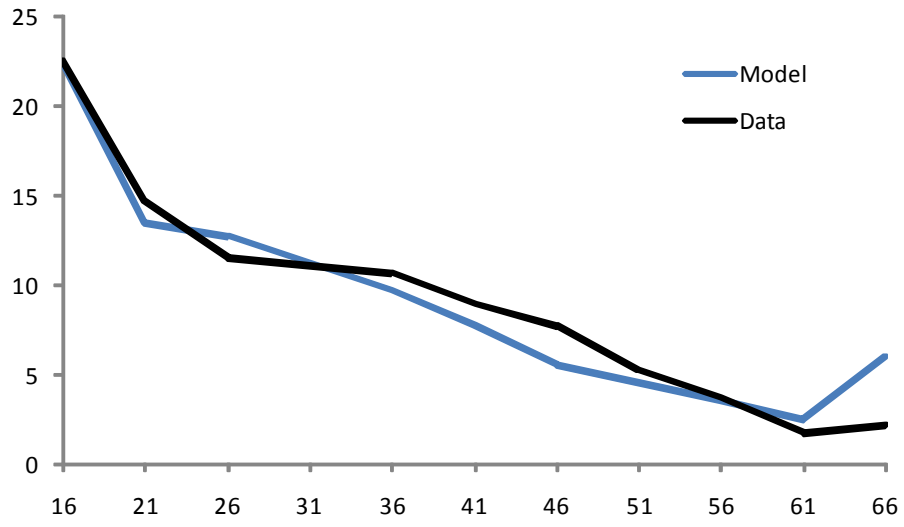


Figure 6: Unemployment Distributions

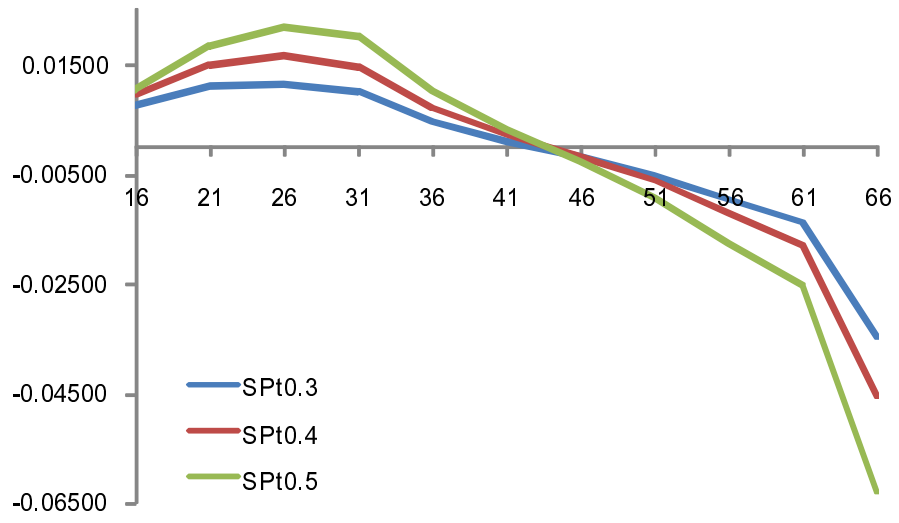


Figure 7: Welfare Effects of the SP - Age Profiles

<i>Country</i>	<i>Severance Payments</i>
<i>Italy</i>	20
<i>Portugal</i>	15
<i>Spain</i>	12
<i>Australia</i>	2
<i>France</i>	1.7
<i>Ireland</i>	1.4
<i>U.K.</i>	1.2

Table 1: Severance Payments in OECD Countries (Monthly Wages)

<i>Parameter</i>	<i>Value</i>	<i>Target</i>
<i>Model Period</i>	<i>Bimonthly</i>	
$\lambda(i) = 2 - e^{\lambda(\frac{i-1}{T})}$ - <i>Survival prob</i>	$\lambda = 0.014$	<i>40 years of active working life</i>
η - <i>CRRA</i>	2.0	<i>Standard</i>
d - <i>Borrowing limit</i>	0.12	<i>15% with Negative Net Worth</i>
a_0 - <i>Newborn asset endowment</i>	0	
I - <i>Productivity levels</i>	11; {16, 21, ..., 66}	<i>Work (possibly) from 16 to 66</i>
π_i - <i>Prob of aging</i>	$\frac{8}{5 \cdot 52} = 0.031$	<i>A jump every 5 years</i>
$T - T + 1$ <i>Tenure levels</i>	10; {0, 2, ..., 20}	<i>Maximum Tenure=20 years</i>
τ_t - <i>Prob of increasing tenure</i>	$\frac{8}{2 \cdot 52} = 0.077$	<i>A jump every 2 years</i>
ε_{it} - <i>Productivity values</i>	<i>See Table 3</i>	<i>From a regression on CPS data</i>
ϕ - <i>Job finding prob</i>	0.9	<i>Average unemployment duration</i>
σ_{it} - <i>Job losing prob</i>	$\frac{8}{3 \cdot 52} = 0.051$	<i>A separation every 3 years</i>
b - <i>Unemployment Benefit</i>	0.5	<i>UI replacement rate</i>
γ_t - <i>Severance Payment</i>	0	<i>Competitive Wages</i>
δ - <i>Capital depreciation rate</i>	0.019	<i>Investment/Output ratio $\approx 21\%$</i>
α - <i>Capital share</i>	0.3	<i>Labor Share</i>
$\hat{\beta}$ - <i>Rate of time preference</i>	0.9959	<i>Annual interest rate=5%</i>

Table 2: Calibration

<i>Parameter</i>	<i>Log Wage</i>
<i>Age</i>	0.04747 (0.00245)
<i>Age</i> ²	-0.00012 (8.15e - 06)
<i>Age</i> ³	9.47e - 08 (8.56e - 09)
<i>Tenure</i>	0.00395 (0.00069)
<i>Tenure</i> ²	-0.00001 (7.01e - 06)
<i>Tenure</i> ³	1.83e - 08 (1.82e - 08)
<i>Constant</i>	0.25533 (0.23070)
<i>N. Obs</i>	6160
<i>Adj. R</i> ²	0.332

Table 3: Log Earnings Regression, t-statistics in parenthesis (Source: CPS Feb 1996)

<i>Variable</i>	<i>SP=0</i>	<i>SP=3</i>	<i>SP=6</i>	<i>SP=9</i>
<i>Mutual Fund</i>	0	0.905	1.886	2.987
<i>Average Profits</i>	0	0.042	0.089	0.142
<i>Average SP</i>	0	0.048	0.099	0.153
<i>Tax (l-sum)</i>	0.028	0.025	0.022	0.019
<i>Borr Limit</i>	-0.12	-0.12	-0.12	-0.12
<i>Output</i>	1.209	1.235	1.267	1.308
<i>I/Y Ratio</i>	0.210	0.221	0.234	0.252
<i>L Share (SP)</i>	0.700	0.707	0.713	0.716
<i>L Share (no SP)</i>	0.700	0.668	0.635	0.599
<i>Net Worth<0 (%)</i>	15.0	25.33	23.77	22.78
<i>Borr Constr. (%)</i>	0.85	6.84	8.08	7.63

Table 4: Equilibrium - Flat SP

<i>Variable</i>	<i>SP=0</i>	<i>0.3t</i>	<i>0.4t</i>	<i>0.5t</i>
<i>Mutual Fund</i>	0	0.833	1.094	1.344
<i>Average Profits</i>	0	0.038	0.051	0.062
<i>Average SP</i>	0	0.044	0.058	0.071
<i>Tax (l-sum)</i>	0.028	0.027	0.027	0.027
<i>Borr Limit</i>	-0.12	-0.12	-0.12	-0.12
<i>Output</i>	1.209	1.229	1.236	1.244
<i>I/Y Ratio</i>	0.210	0.219	0.221	0.225
<i>L Share (SP)</i>	0.700	0.707	0.709	0.710
<i>L Share (no SP)</i>	0.700	0.671	0.662	0.653
<i>Net Worth<0 (%)</i>	15.0	28.66	27.95	27.05
<i>Borr Constr. (%)</i>	0.85	9.47	10.36	8.93

Table 5: Equilibrium - SP linear in tenure

<i>Variable</i>	<i>SP=0</i>	<i>SP=3</i>	<i>SP=6</i>	<i>SP=9</i>	<i>0.3t</i>	<i>0.4t</i>	<i>0.5t</i>
<i>Mutual Fund</i>	0	74.88	156.06	247.09	68.93	90.52	111.21
<i>Average Profits</i>	0	3.47	7.36	11.76	3.18	4.19	5.17
<i>Average SP</i>	0	3.98	8.19	12.65	3.66	4.80	5.87
<i>Tax (l-sum)</i>	2.33	2.09	1.84	1.59	2.26	2.24	2.22
<i>Borr Limit</i>	9.14	9.14	9.14	9.14	9.14	9.14	9.14
<i>Output</i>	100.00	102.14	104.80	108.17	101.67	102.24	102.91
<i>Average wage</i>	70.00	68.27	66.50	64.76	68.20	67.65	67.21
<i>Consumption</i>	78.97	79.53	80.18	80.78	79.43	79.60	79.75

Table 6: Equilibrium normalized by output in the benchmark economy

<i>Severance Payments</i>	<i>Average Welfare Change</i>
$SP=3$	0.677%
$SP=6$	1.04%
$SP=9$	0.952%
$SP=0.3t$	0.671%
$SP=0.4t$	0.907%
$SP=0.5t$	1.09%

Table 7: Welfare Effects of the SP

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Appendix A - Computation

In the actual solution of the model, we need to discretize the continuous state variable a (i, t and employment status are already discrete). We rely on an unevenly spaced grid, with the distance between two consecutive points increasing geometrically. This is done to allow for a high precision of the policy rules at low values of a , that is where the change in curvature is more pronounced.

The model with exogenous search effort is solved with a 'time iteration' procedure on the set of euler equations. In order to keep the computational burden manageable, we use 150 grid points on the asset space, the lowest value being the borrowing constraint and the highest one being a value high enough for the saving functions to cut the 45 degree line. Notice that we do not restrict the agents' asset holding to belong to a discrete set. As for the approximation method, we rely on a linear approximation scheme for the saving and consumption functions, for values of a falling outside the grid.

A collocation method is implemented, that is we look for the policy functions such that the residuals of the Euler equations are (close to) zero at the collocation points (which correspond to the asset grid). It follows that for all possible combinations of state variables we need to solve a non linear equation. A time iteration scheme is applied to get the policy functions, i.e. we compute the first order conditions with respect to a' and through the envelope condition we obtain a set of euler equations, whose unknowns are the policy functions, $a'_e(i, a, t), a'_u(i, a)$.

We start from a set of guesses, $a'_e(i, a, t)_0$ and $a'_u(i, a)_0$, and keep on iterating until a fixed point is reached, i.e. until two successive iterations satisfy:

$$\begin{aligned} \mathop{\text{Sup}}_a |a'_e(i, a, t)_{n+1} - a'_e(i, a, t)_n| < 10^{-6}, \forall i \text{ and } \forall t, \text{ and} \\ \mathop{\text{Sup}}_a |a'_u(i, a)_{n+1} - a'_u(i, a)_n| < 10^{-6}, \forall i. \end{aligned}$$

The model with endogenous search effort is solved with a 'successive approximation' procedure on the set of value functions.

We start from a set of guesses, $V(i, a, t)_0$ and $U(i, a)_0$. We compute the vector of parameters Ω representing the Schumaker spline approximations of the value functions. We solve the constrained maximization problems and retrieve the policy functions, $a'_e(i, a, t), a'_u(i, a), \psi(i, a)$. Notice that we do not restrict either the agents' asset holding or the search effort to belong to a discrete set. As for the approximation method, we rely on a linear approximation scheme for the saving, consumption and search effort functions, for values of a falling outside the grid.

We keep on iterating until a fixed point is reached, i.e. until two successive iterations satisfy:

$$\begin{aligned} \mathop{\text{Sup}}_a |V(i, a, t)_{n+1} - V(i, a, t)_n| < 10^{-6}, \forall i \text{ and } \forall t, \text{ and} \\ \mathop{\text{Sup}}_a |U(i, a)_{n+1} - U(i, a)_n| < 10^{-6}, \forall i. \end{aligned}$$

The stationary distributions are computed either relying on iterating on their definition, using a linear approximation of the distribution functions between grid-points, or by simulating a large sample of 100,000 individuals for 2,000 periods, which ensure that the statistics of interest are stationary processes.

Appendix B - Solution Algorithm

The computational procedure used to solve the baseline model can be represented by the following algorithm:

- Generate discrete grids over the asset space $[-d, \dots, a_{\max}]$;
- Guess on the interest rate r_0 ;
- Get the individual firms' capital demand k_{it} ;
- Guess on the lump-sum tax l_0 ;
- Get the wages w_{it} ;
- Get the consumption and saving functions $c_e(i, a, t), c_u(i, a), a'_e(i, a, t), a'_u(i, a)$;
- Get the stationary distributions $\mu_e(i, a, t), \mu_u(i, a)$;
- Get the value of the mutual fund MF ;
- Get the aggregate capital demand;
- Check asset market clearing; Get r_1 ;
- Update $r'_0 = \varpi r_0 + (1 - \varpi) r_1$ (with ϖ arbitrary weight);
- Update l_1 ;
- Iterate until market clearing;
- Check final good market clearing.