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 affected by the change in slope of the wage profile. Moreover, non trivial general equilibrium effects are also present, since the incentives to save are affected and the capital stock varies. On the one hand, with severance payments agents are better insured and the precautionary motive for savings is reduced. 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 in partial equilibrium seem to be: 1) heterogeneous in the population, with young and untenured workers being worse-off, 2) quantitatively in the order of 0.5-1% of consumption in the original steady-state.

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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 magnitude of SP appears to be non-negligible for several labor markets, which are likely to be affected by their presence. As a matter of fact, some countries (the Scandinavian ones in particular) have recently undertaken labor markets reforms which decreased the SP or eliminated them altogether. Strict EPL was considered at least partially responsible for persistently high unemployment rates and low productivity growth.

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.

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 matching models show a positive employment effect, while with employment lotteries lay-off costs tend

[1] An 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).

to be detrimental. However, notice that: 1) welfare effects are not explicitly taken into consideration, 2) lay-off costs are specified as firing taxes.

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.

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 and life-cycle shocks. A similar set up has been analysed by Alvarez and Veracierto (2001). Alvarez and 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. One of the novelties 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

[2] Though 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.

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. For reasonable values of the severance payments, welfare gains and costs in partial equilibrium seem to be: 1) heterogenous in the population, with young and untenured workers being worse-off, 2) quantitatively in the order of 0.5-1% of consumption in the original steady-state.

Finally, our set-up can be exploited in order to study what is the most effective way of providing insurance. We do so by computing the welfare effects induced by different configurations of two labor market institutions: unemployment benefits and severance payments. Preliminary results tend to suggest that the two schemes are complementary rather than being substitutes. In partial equilibrium workers on average are better off when facing a UI replacement rate of 50% and SP increasing linearly at the rate of one monthly wage per additional year of accumulated tenure, when compared to alternative schemes with lower replacement rates and without SP.

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 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 $\beta_i = \widehat{\beta}\lambda_i$ where $\hat{\beta} \in (0,1)$ is the discount factor. We assume that $u(.)$ is strictly increasing, strictly concave, and satifies the Inada conditions, and $v(.)$ is strictly increasing, and convex. Effort choices are defined over the set $\Psi \equiv [0,1]$, with $v(0) = 0$. Agents do not value their offsprings' welfare.[3]

2.3 Endowments

Agents can be employed (e), unemployed and eligible to collect unemployment benefits (u), or unemployed and ineligible to collect unemployment benefits (u_b). 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 age levels, $i \in \mathcal{I} = \{1, 2, ..., I\}$. 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 $t \in \mathcal{T} = \{0, 1, ..., T\}$. During a surviving employment relationship tenure increases with probability $\tau_t = \tau$ between successive tenure levels until $t = T - 1$, while we impose $\tau_T = 0$.

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 $\mathcal{E} = \{\varepsilon_{10}, \varepsilon_{20}, ..., \varepsilon_{I0}, \varepsilon_{11}, ..., \varepsilon_{it}, ..., \varepsilon_{IT}\}$. The part of productivity related to age (i) can be thought of as general human capital. Even if a job relationship is interrupted, the worker keeps the part of productivity related to his labor market experience in the next job spell. Differently, the part of productivity that accrues to tenure (t) is not transferable across jobs. Once a job is destroyed, what we interpret as specific human capital is lost forever.

Unemployed workers have zero tenure. An unemployment spell starts with the agent being eligible for unemployment benefits. These depend on the agent's past earnings. However, in order to capture in a parsimonious way the time limits of these measures, unemployed agents transit stochastically to a situation where they are no longer eligible to collect the unemployment benefits. In this case, they are endowed with a fixed amount f of the consumption good, which can be tought of as a safety net policy (e.g. food stamps) or some home production. These transitions happen with probability π^b.

2.4 Technology

Each production unit 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

[3] The analysis will focus on steady states, hence from now on time subscripts will be supressed and the t index will denote tenure instead.

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 $\phi(\psi)$. 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 he 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. For tractability, we assume that the worker has all the bargaining power.

As a final remark, 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: 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.[5]

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 $\theta_{it} = \gamma_t w_{it}$.[6] 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.

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

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

[5] Alternatively, we could assume that firms share their SP risk in a competitive market, and buy an insurance at a competitively set price. Or we could assume that whenever a separation occurs and the related output does not cover the SP, the government would step in by giving the worker the amount he's entitled to, financing those expenditures with a payroll tax.

[6] In 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.

all the bargaining power and make firms a take-it-or-leave-it offer.[7] 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 workers and the problem of the firm. The individual state variables are the employment status $s \in \mathcal{S} = \{e, u, u_b\}$, labor market experience $i \in \mathcal{I}$, asset holdings $a \in \mathcal{A} = [-d, \overline{a}]$ and tenure $t \in \mathcal{T}$.[8] The stationary distribution of employed agents is denoted by $\mu_e(i,a,t)$ whereas the distribution of unemployed agents are $\mu_u(i,a,t)$, and $\mu_{u_b}(i,a)$.

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 workers

The value function of an unemployed agent of age i, with accumulated tenure on the last job equal to t, whose current asset holdings are equal to a, and who is eligible for unemployment benefits is denoted with $U(i,a,t)$. The problem of these agents can be represented as follows:

[7] This 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.

[8] A formal argument proving that $\overline{a} < \infty$ appears for a similar economy in Huggett (1993).

$$U\left(i,a,t\right)=\max_{c,a',\psi}\left\{u(c)-v(\psi)+\beta_i\phi(\psi)\left[\left(1-\pi_i\right)V(i,a',0)+\pi_iV(i+1,a',0)\right]\right. \quad (2)$$
$$+\beta_i\left(1-\phi(\psi)\right)\left[\left(1-\pi^b\right)\left(1-\pi_i\right)U(i,a',t)+\left(1-\pi^b\right)\pi_iU(i+1,a',t)\right.$$
$$\left.\left.+\pi^b\left(1-\pi_i\right)U_b(i,a')+\pi^b\pi_iU_b(i+1,a')\right]\right\}$$
$$s.t.$$

$$c+a'=\frac{(1+r)}{\lambda_i}a+bw_{it}$$

$$a_0\ given,\quad c\geq 0,\quad a'>-d,\quad 0\leq\psi\leq 1$$

Unemployed agents have to set optimally both their consumption/savings plans and their search intensity to land a job. They 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 (with or without benefits), or they can find a job and be employed as an untenured employee.

While searching for employment this type of workers receive an unemployment benefit equal to bw_{it}. The unemployment benefit consists of the replacement rate b (a policy parameter) of the wage w_{it} an employed worker of type (i,t) is receiving.[9] The tenure accumulated on the last job is an important component of the unemployment benefits. The higher the past tenure, the higher the transfer the agent is entitled to and the lower the incentives to look for a new job. This point is made clear by Figure (10).

[Figure (10) about here]

This figure depicts the equilibrium optimal search effort choices as a function of wealth, for different unemployed workers, namely the youngest workers ($i=1$) and the ones whose productivity peaks in the age dimension ($i=5$). For both ages we report the policy functions for workers with the lowest and highest accumulated tenure on the last job.

The economic effect is clear: the higher the unemployment benefit, the lower the incentive to bear the utility cost of landing a new job. Agents with a higher income are going to save part of these additional resources, and consume the rest. On the one hand this decreases the marginal utility of

[9] See footnote 5 for a comment on the state transitions that applies here as well. Notice however that during an unemployment spell past tenure is fixed.

consumption, while on the other hand it allows to achieve a given future utility with a lower search effort.

For our quantitative analysis providing agents with the appropriate unemployment benefits is important for two reasons: 1) it gives the right incentives for people to look for a new job, 2) it radically affects the precautionary motive of savings.

In the budget constraint notice that the gross interest rate $(1+r)$ is divided by the survival probability λ_i. This is done to "adjust" the returns from investing in the risk-free asset for the death probability. This ensures that at the aggregate level there are no accidental bequests to be distributed: in steady state the average value of the asset holdings of people that die is zero.[10]

Unemployed agents whose search efforts are unsuccessful can find themselves in a less economically attractive situation. This set of workers can be interpreted as the long term unemployed. Their eligibility for the unemployment benefits can be expired. We denote the value function of the unemployed agents who have only access to a constant government transfer f with $U_b(i,a)$. Their problem in the recursive formulation can be represented as follows:

$$\begin{aligned} U_b(i,a) = \max_{c,a',\psi} & \{u(c) - v(\psi) + \beta_i \phi(\psi) \left[(1-\pi_i) V(i,a',0) + \pi_i V(i+1,a',0)\right] \\ & + \beta_i (1-\phi(\psi)) \left[(1-\pi_i) U_b(i,a') + \pi_i U_b(i+1,a')\right]\} \\ & s.t. \\ & c + a' = \frac{(1+r)}{\lambda_i} a + f \\ & a_0 \ given, \quad c \geq 0, \quad a' > -d, \quad 0 \leq \psi \leq 1 \end{aligned} \tag{3}$$

In this problem the only relevant difference from the previous case is that now the tenure in the past job ceases to play a role. the transfer f is a flat amount that does not depend on the age or the previous tenure level. However, age has still to be kept track of: it affects the level of general human capital and the productivity on a future job ε_{i0}, therefore it plays a role in setting the optimal search effort for the agent.

[10] Notice 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.

3.1.2 Problem of the employed worker

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

$$V(i,a,t) = \max_{c,a'} \{u(c) + \beta_i (1-\sigma_{it}) [\pi_i \tau_t V(i+1,a',t+1) + \tag{4}$$

$$\pi_i (1-\tau_t) V(i+1,a',t) + (1-\pi_i) \tau_t V(i,a',t+1)$$

$$+ (1-\pi_i)(1-\tau_t) V(i,a',t)] + \beta_i \sigma_{it} [(1-\pi_i) U(i,a'+\theta_{it}) + \pi_i U(i+1,a'+\theta_{it})]\}$$

$$s.t.$$

$$c + a' = \frac{(1+r)}{\lambda_i} a + (1-l) w_{it}$$

$$a_0 \ given, \quad c \geq 0, \quad a' > -d$$

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 that in case a separation occurs, the SP is paid to the worker at the end of the period: the amount of resources that he 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 proportional tax paid by the agents currently employed to finance both the unemployment benefit and the food stamps schemes.

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

$$J(i,t) = \max_{k_{it}} \left\{ f(k_{it})\varepsilon_{it} - w_{it} - (r+\delta) k_{it}\varepsilon_{it} + \frac{\lambda_i (1-\sigma_{it})}{1+r} [\pi_i \tau_t J(i+1,t+1) + \right. \tag{5}$$

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

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

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

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 $\theta(i,t) = \theta_t$ (with $\theta_0 = 0$), 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 equilibrium expressions for wages:

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

This example is interesting since it shows that every period the worker pre-pays the severance payment that he 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. It also highlights that whenever SP are zero for all workers, all wages boil down to $w_{i0} = f(k)\varepsilon - (r+\delta)\,k\varepsilon, \forall i$, which corresponds to the competitive wage setting outcome.

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 workers' type, then repeating the same steps gets a set of equations that the bargained wages need to satisfy:

$$\begin{aligned}-\gamma_t w_{it} &= f(k_{it})\varepsilon_{it} - w_{it} - (r+\delta)\,k_{it}\varepsilon_{it} \\ &\quad - \frac{\lambda_i}{1+r}\left\{(1-\sigma_{it})\left[\pi_i\tau_t\gamma_{t+1}w_{i+1,t+1} + \pi_i\,(1-\tau_t)\,\gamma_t w_{i+1,t}\right.\right. \\ &\quad \left.\left. + (1-\pi_i)\,\tau_t\gamma_{t+1}w_{i,t+1} + (1-\pi_i)\,(1-\tau_t)\,\gamma_t w_{it}\right] + \sigma_{it}\gamma_t w_{it}\right\}\end{aligned} \tag{6}$$

From (6) 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

$$\int \lambda_i \theta_{it} \sigma_{it} d\mu_e (i, a, t) + MF' = (1 + r) MF + \int p_{it} d\mu_e (i, a, t) \tag{7}$$

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 a recursive stationary equilibrium is a set of decision rules $\{c_e(i,a,t), c_u(i,a,t), c_{u_b}(i,a), a'_e(i,a,t), a'_u(i,a,t), a'_{u_b}(i,a), \psi_u(i,a,t), \psi_{u_b}(i,a), k_{it}\}$, value functions $\{V(i,a,t), U(i,a,t), U_b(i,a), J(i,t)\}$, a value of the mutual fund MF, prices $\{r, w_{it}\}$, a proportional tax l and a set of stationary distributions $\{\mu_e(i,a,t), \mu_u(i,a,t), \mu_{u_b}(i,a)\}$ such that:*

- Given relative prices $\{r, w_{it}\}$, severance payments θ_{it}, proportional tax l, and unemployment benefits bw_{it}, the individual policy functions $\{c_e(i,a,t), c_u(i,a,t), c_{u_b}(i,a), a'_e(i,a,t), a'_u(i,a,t), a'_{u_b}(i,a), \psi_u(i,a,t), \psi_{u_b}(i,a)\}$ solve the household problems (2)-(3)-(4) and $\{V(i,a,t), U(i,a,t), U_b(i,a)\}$ are the associated value functions.

- Given relative prices $\{r, w_{it}\}$, and severance payments θ_{it}, k_{it} solves the firm's problem (5) and satisfies

  $$r + \delta = f'(k_{it}) \tag{8}$$

  Since the LHS of equation (8) 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 (6).

- The stationary value of the mutual fund MF satisfies

$$rMF = \int_{I\times A\times T} \lambda_i \theta_{it}\sigma_{it} d\mu_e(i,a,t) - \int_{I\times A\times T} p_{it} d\mu_e(i,a,t)$$

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

- The labor market is in flow equilibrium

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

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

- The asset market clears

$$\begin{aligned} & k \int_{I\times A\times T} \varepsilon_{it} d\mu_e(i,a,t) \\ = & \int_{I\times A\times T} a'_e(i,a,t) d\mu_e(i,a,t) + \int_{I\times A\times T} a'_u(i,a,t) d\mu_u(i,a,t) + \int_{I\times A} a'_{u_b}(i,a) d\mu_{u_b}(i,a) + MF \end{aligned}$$

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

- The goods market clears

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

- The proportional tax satisfies

$$l = \frac{\int_{I\times A\times T} bw_{it} d\mu_u(i,a,t) + \int_{I\times A} f d\mu_{u_b}(i,a)}{\int_{I\times A\times T} w_{it} d\mu_e(i,a,t)}$$

notice that the tax covers for both types of transfers: unemployment benefits and food stamps.

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

$$
\begin{aligned}
&\mu_u\left(i, a', t\right) \qquad (9)\\
&= \lambda_i \left[\left(1-\pi^b\right)\left(1-\pi_i\right) \int_{a: a'_u(i,a,t)=a'} \left(1-\phi(\psi_u(i,a,t))\right) d\mu_u\left(i,a,t\right) \right.\\
&+ \left(1-\pi^b\right)\pi_i \int_{a: a'_u(i-1,a,t)=a'} \left(1-\phi(\psi_u(i-1,a,t))\right) d\mu_u\left(i-1,a,t\right)\\
&\left.\left(1-\pi^b\right)\left(1-\pi_i\right) \int_{T\times\{a: a'_e(i,a,t)=a'\}} \sigma_{it} d\mu_e\left(i,a,t\right) + \pi_i \int_{T\times\{a: a'_e(i,a,t-1)=a'\}} \sigma_{i-1t} d\mu_e\left(i-1,a,t\right) \right]\\
&+ \left(1-\lambda_i\right)\chi\left(i=1\right)\chi\left(a'=a_0\right)\left[\int_{I\times A\times T} d\mu_e\left(i,a,t\right) + \int_{I\times A\times T} d\mu_u\left(i,a,t\right) + \int_{I\times A} d\mu_{u_b}\left(i,a\right)\right]
\end{aligned}
$$

$$
\begin{aligned}
&\mu_{u_b}\left(i, a'\right) \qquad (10)\\
&= \lambda_i \left[\pi^b\left(1-\pi_i\right) \int_{T\times\{a: a'_u(i,a,t)=a'\}} \left(1-\phi(\psi_u(i,a,t))\right) d\mu_u\left(i,a,t\right) \right.\\
&+\pi^b\pi_i \int_{T\times\{a: a'_u(i-1,a,t)=a'\}} \left(1-\phi(\psi_u(i-1,a,t))\right) d\mu_u\left(i-1,a,t\right)\\
&\left.\left(1-\pi_i\right) \int_{a: a'_{u_b}(i,a)=a'} \left(1-\phi(\psi_{u_b}(i,a))\right) d\mu_{u_b}\left(i,a\right)\right]\\
&\left.\pi_i \int_{a: a'_{u_b}(i-1,a)=a'} \left(1-\phi(\psi_{u_b}(i-1,a))\right) d\mu_{u_b}\left(i-1,a\right)\right]
\end{aligned}
$$

$$
\begin{aligned}
&\mu_e(i,a',t') \qquad (11)\\
&= \lambda_i \left[\int_{a:a'_e(i,a,t)=a'} (1-\sigma_{it})(1-\pi_i)(1-\tau_t)\, d\mu_e(i,a,t) \right.\\
&\left. + \int_{a:a'_e(i-1,a,t)=a'} (1-\sigma_{i-1t})\, \pi_{i-1}(1-\tau_t)\, d\mu_e(i-1,a,t) \right]\\
&+ \lambda_i \left[\int_{a:a'_e(i,a,t-1)=a'} (1-\sigma_{it-1})(1-\pi_i)\, \tau_{t-1} d\mu_e(i,a,t-1) \right.\\
&+ \int_{a:a'_e(i-1,a,t-1)=a'} (1-\sigma_{i-1t-1})\, \pi_{i-1}\tau_{t-1} d\mu_e(i-1,a,t-1)\\
&+\chi(t'=1) \int_{a:a'_u(i-1,a,t)=a'} \pi_i \phi(\psi_u(i-1,a,t)) d\mu_u(i-1,a,t)\\
&+\chi(t'=1) \int_{a:a'_{u_b}(i-1,a)=a'} \pi_i \phi(\psi_{u_b}(i-1,a)) d\mu_{u_b}(i-1,a)\\
&+\chi(t'=1) \int_{T\times\{a:a'_u(i-1,a,t)=a'\}} (1-\pi_i)\, \phi(\psi_u(i-1,a,t)) d\mu_u(i-1,a,t)\\
&\left. +\chi(t'=1) \int_{a:a'_{u_b}(i,a)=a'} (1-\pi_i)\, \phi(\psi_{u_b}(i,a)) d\mu_{u_b}(i,a) \right]
\end{aligned}
$$

where $\chi(.)$ 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 three equations (9), (10) and (11).

4 Parameterization

The complete parameterization of the model is reported in Table 2. We calibrate the model to the US economy, 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 no 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 two parameters exponential function. It turns out that the results are equivalent to setting $\lambda_i = 1$ for all ages between 1 and 5, and $\lambda_i = 0.98$ for the remaining ages. This parameter is calibrated for the model to match the average age observed in the US active labor force. Another possibility could be to target an average working life of 35 years. However, in our set-up, this does not prove to be the right choice. As shown in Figure 7, following this alternative calibration strategy leads to clearly miss the age distribution by over-representing the 65 year old people. This result in turn heavily affects the welfare effects. With such a high share, older agents would receive a much higher weight in our utilitarian welfare function and the welfare gains and losses would be mainly driven by them.

[**Figure 7 about here**]

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 $d = 0.205$ achieves this target. Notice that this value is strictly lower than the natural borrowing limit of every agent type.

We assume that the newborns enter the economy without any asset endowment, or $a_0 = 0$. We allow for 10 points in the age grid: workers enter the economy at age 20 and reach at most age 65. The grid is evenly spaced, that is we allow for a jump in age occuring on average every 5 years. It follows that $\pi_i = 0.031$.

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

As for the job search aspect of the problem, we specify the following job finding probability $\phi(\psi) = \psi^{\xi}$, together with a linear disutility of search effort $v(\psi) = -\rho\psi$. The two parameter values for the concavity of the search technology $\xi = 0.53$ and the strenght of the disutility $\rho = 0.97$ are chosen to match both the average unemployment duration (approximately 12 weeks in the data) and an unemployment rate of 4.85%.

The constant separation probability is equal to $\sigma_{it} = 0.0382$. This value is chosen to match a median job duration of 4 years. This implies a lower value for the separation probability than the ones reported by Shimer (2005), among others: according to their computations, on average a worker gets separated every three years. Our lower value is dictated by our sample choice. We rely on CPS data for 1996, and in order to be consistent with our model, we restrict our analysis for workers between 20 and 65 years old. This calls for both a longer median duration of an employment spell and a lower unemployment rate.

The probability of losing the UI scheme eligibility is set to $\pi^b = 0.333$. This implies that on average unemployed workers that do not find a job collect benefits for a six months period: this is the rule implied by the UI scheme in place in the US. The transfer to the workers not covered by the UI is set to $f = 0.077$, which corresponds to a monthly payment of approximately \$140. This value matches the average transfer observed for people receiving food stamps in the US.

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 20%, on an annual basis. This is achieved with $\delta = 0.017$. 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 $\widehat{\beta} = 0.09919$.

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 workers' productivity. 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.[11] 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 earnings 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. This value seems to be on the high end of the estimated returns to tenure for some authors, e.g. Abraham and Farber (1987) or Altonji and Shakotko (1987), and on the low end for others, Topel (1991). However, they are in line with the most recent evidence, as reported in Altonji and Williams (2005). These authors find a 10 year tenure effect on wages of 27.11%.

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.

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

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. In the US the NLSY, the PSID 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 and the PSID that provides a tenure measure contaminated by measurement error, as discussed for example in Altonji and Williams (2005).

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, a third-degree polynomial in age and a quadratic one in 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 with SP=0, 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. In the experiments we set γ_t at 3, 6, and 9 monthly wages, respectively. This implies that every fired workers get the same number of monthly wages as SP, irrespective of their tenure. In the second specification we allow for a more realistic linear specification for γ_t, that is $\gamma_t = \gamma \cdot t$, and we set the slope γ at 0.3, 0.4, and 0.5. Under this specification 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 some countries, such as Spain). Figure (1) represents graphically the second case, 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 changing during their life-cycle. These plots do not take into consideration the General Equilibrium effects: the wage profiles associated to different severance payments are compared for the same interest rate r in the benchmark economy. 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 up to two times higher than in the counterfactual economy with SP. 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 twenty 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. The additional jumps in the wage schedules that occur from age 50 to 65 are induced by the positive death probability that is in place for these workers. Older workers are also compensated with a wage increase for their luck in terms of survival.

This equilibrium outcome of the model seems to be supported by some empirical evidence. For the two cases of Italy (an economy with high SP) and the US (an economy without SP) we compute the average earnings growth rates of Tenured Vs. Untenured workers over their life cycle. The values are plotted in Figure (4) and listed in Table 4. Average earnings do grow faster in Italy (34.1%) when compared to the US (22.3%).

[Figure (4) and Table 4 about here]

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 (3), which is only rescaled by the factor γ_t.

[Figures (5), and (6) about here]

One of the endogenous outcomes of the model are the stationary distributions of workers by employment status, age and tenure. Figures (5) and (6) 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. However, with the current calibration the model misses an important feature of the data: the high share of jobs that last for at least 20 years (this number is 10.64% in the data while the corresponding figure is only 0.31% in the model).

The results related to the latter are satisfactory: the model predicts well the share of older workers, while it overpredicts the shares of the youngest workers (age 20 and 25) and underpredicts the share of 30 to 40 years old in the pool of employment.

Notice that these results were obtained on the basis of a simple and parsimonious calibration strategy, which imposed constant values for λ_i, π_i, τ_t, and σ_{it}. Age and tenure specific separation rates can help in fitting better the tenure distribution. 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 significantly affected by a set of observables, such as age, and tenure. We can exploit this information to calibrate differently the separation probabilities and obtain a different response on the wage profiles, because this would reflect the different risks of separation. We already discussed the complications in setting λ_i above. Calibrating differently π_i and τ_t is a tricky issue. If we interpret the model literally, the values on the age and tenure grids are determined by the corresponding probability of a jump taking place between two adjacent levels. If we were to allow for non-constant π_i and τ_t we would be dealing with age and tenure grids (hence with productivity levels and ultimately wages, and endogenous distributions) that change at each trial. The calibration targets would be changing at each iteration, which is a very complicated and challenging procedure.

[Figures (8), and (9) about here]

In Figure (8) the unemployment distribution is plotted: the model gets the overall shape of the distribution, but misses the share of both the 25 and the 45 years old.

As for the unemployment rates over the life cycle, depicted in Figure (9), the model cannot match properly the main patterns in the data. When matching the average unemployment rate, it does succeed in generating a decreasing unemployment rate between the ages of 20 and 25, but it implies increasing unemployment rates for older agents.

It goes without saying that there are several ways that would allow to fix the problem. One possibility could be to introduce a utility cost of search which is decreasing in the labor market experience. Alternatively, we could allow for the job finding technology (namely the search frictions) to be more efficient for workers with longer labor market experience. However, these modeling choices would seem to be forcing the model's outcome. Figure (10) helps in understanding the pitfalls of the model. Older agents are more productive and optimally set a lower search effort while unemployed and entitled to UI. The reason lies in the higher unemployment benefits they are receiving. This makes their marginal utility of consumption lower and their unemployment spells less costly in utility terms. Notice that these choices are very different for the unemployed workers that can only collect food stamps. In this case, for the same asset holdings, more productive agents have the same marginal utility of consumption of less productive ones, but a higher value of search. These effects are partially mitigated for older workers that face a positive probability of leaving the workforce: the retirement probability dampens the continuation values and makes unemployment relatively more attractive for these workers.

5.2 (Partial) Equilibrium Effects

This section is devoted to discussing the equilibrium effects of SP on a set of relevant endogenous variables. Tables 5/6 and 7 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 5 and 6 we report the values of the endogenous variables of the model in levels, while Table 7 reports a subset of endogenous variables that are not a share themselves divided by the value of output in the benchmark economy.

All the results refer to partial equilibrium experiments. In all the counterfactual economies the interest rate is fixed to the benchmark value of 4.95% annually (that is 0.008084% bi-monthly).

[**Tables 5, 6 and 7 about here**]

In Table 5 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 proportional tax is quantitatively small (2.76%), and decreases slightly in the SP: the average wage is falling, and the cost of the unemployment benefit scheme is decreasing. On the other hand the unemployment rate is increasing, which could lead to a rising burden of the UI and food stamps policies. For the simple flat SP case this does not happen. The positive insurance properties of the SP are highlighted by the behavior of consumption. With a higher SP the average consumption in the economy rises: people need to save less for precautionary reasons and can enjoy more consumption. Notice that the PE analysis matters for this result for at least two reasons: 1) aggregate output is decreasing with the SP because of the reduced search intensity and the higher unemployment rate, 2) this reduction in output could be amplified or dampened if we were to allow for the interest rate to adjust (capital demand could decrease because of the push on the interest rate induced by the change in aggregate household savings. At the same time capital supply is increasing because of the supply of assets of the mutual fund).

The unemployment rate increases monotonically. However, this result is not unambiguous. Figure (11) is helpful to further discuss this point. After the introduction of the SP there are several effects being brought about. On the one hand, unemployed workers are better insured, because they have more assets once a job separation takes place. However, at the same time the wage profiles are changing, leading in turn to a change in the unemployment benefits. Altogether, these effects can go either way in changing the agents incentives to look for a new job.

As portrayed in the figure, following the introduction of SP, some workers (age 20) increase their search efforts, while others (age 40) decrease it. For the determination of the aggregate outcomes, in this specific calibration, what matters the most is the behaviour of older agents. They exert less search effort, and lead to an increase in the unemployment rate. Younger agents hold for the vast majority little assets both before and after the introduction of SP. The observed increase in their job search effort does not bring any aggregate change: they were already displaying the maximum effort anyway. On the other hand, older workers' change in their job search effort triggers the aggregate change in the unemployment rate: it happens for a region of the state space which is relevant for their actual asset holdings.

On a different note, it is important to stress that the borrowing limit is kept at its calibrated value during all the experiments.

An interesting result is related to output. With respect to the benchmark economy, in PE output decreases monotonically in the SP, with a 0.53% drop for SP equal to 9 monthly wages. As discussed above, the decrease in output stems from the higher unemployment rate.

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 72.4%. Notice also the linearity of this relationship. Differently, if SP are excluded in the definition of labor share, this decreases considerably, falling to 63.3%.

The percentage of people that are in debt changes substantially: when introducing SP equal to 3 monthly wages it moves from 15% to 24.8%. For higher SP levels this percentage starts decreasing. In the latter cases the decrease in wages is so strong that leads the agents to increase their precautionary savings and decrease their level of indebtedness.

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

Finally, in Table 7 we can appreciate how the mutual fund can partially shape the GE effects: its size becomes as large as 251% of output, and it accounts for up to 21.3% of the asset market.

5.3 Welfare Effects

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 and search effort 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 benchmark economy to that of the counterfactual one. The partial equilibrium welfare effects are reported in Table 8.

[Table 8 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 0.614% and 0.800%, respectively. However, the effects of SP is highly non linear and start decreasing with nine monthly wages, the average welfare change being equal to 0.637% in this case.

However, regarding 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 exaggerate 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 1.048%.

Interestingly, the average results hide different effects for different groups of workers.

[Table 9 about here]

Table 9 reports the average welfare gains by employment status. It is interesting to notice that employed workers do not see their welfare changing much if compared to the unemployed: at most the employed agents enjoy a 0.66% welfare gain. The long term unemployed agents are the ones that gain the most: their welfare increases by up to 17.94%. The reason is clear: their transfer f is not changing with the different SP schemes, while at the same time they have more assets gained when they got separated from their last employer. This leads them to consume more and exert a lower search effort. However, the measure of these agents in the economy is really small, accounting for less than 1% of the population in all the experiments. As for the unemployed agents eligible for unemployment benefits, things are more complex. Their welfare gains are non-linear in the SP and range from 1.94% to 4.38%. These are due to the interaction between the increased insurance provided by the SP and the decreased unemployment benefits induced by the new wage profiles. Some unemployed workers are better off, while other are not, due to their increased search efforts.

Figure (15) plots the welfare effects as a function of the workers' age. Perhaps not surprisingly, in each of these simulations the young workers are the ones experiencing a negative welfare effect, irrespective of the size of the wage cut. The explanation goes through their decreased ability to smooth consumption due to the binding borrowing constraint. For the specular reason, the old workers enjoy a large welfare gain, which in the aggregate more than compensates the welfare losses of the young workers, given their smaller shares in the population.

Figure (14) plots the welfare effects as a function of the workers' tenure. Quite surprisingly is the fact that untenured workers do show welfare losses, which however are very close to zero.

Finally, it is interesting to report that the non monotonicity of these welfare profiles is due to the endogenous job creation channel. In the same model with an exogenous job finding probability equal for every worker, these welfare profiles appear to be monotonically increasing in age and tenure, with their slope becoming steeper as the SP increase.

[Figures (15) and (14) about here]

To conclude with, severance payments seem to have important allocative effects; their welfare effects are quantitatively in the order of 0.5-1% for plausible values of the SP.

5.3.1 SP vs. UI

With our framework we can address an interesting question: which labor market institution is best suited to provide insurance to workers, UI or SP?

[Table 10 about here]

The results in Table 10 show that the two policies do not seem to be substitutes, rather complements, at least in a PE setting. In the simulations we compute the welfare effects induced by different configurations of these two labor market institutions: unemployment benefits and severance payments. In partial equilibrium workers on average are better off when facing a UI replacement rate of 50% and SP increasing linearly at the rate of one monthly wage per additional year of accumulated tenure, when compared to alternative schemes with lower replacement rates and without SP. The worst combination is the one with a 10% replacement rate and without SP: in this scenario we need to decrease consumption by 1.49% in all states of the world in order to equate the two average utilities.

5.3.2 Welfare Effects in GE

To be written

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 for 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 losses for a set of workers, namely the young and untenured ones.

The welfare effects that we have provided suffer from a potential problem: they are conditional on firms' firing decisions not changing in the counterfactual economies. This seems to be a strong assumption to be maintained, especially in light of the longer tenures observed in economies with strict SP legislations. Figure (16) displays these striking differences for the cases of Italy and the US. The tenure distributions are drastically different. The different firing decisions induced by the alternative SP regime could go a long way in accounting for these differences.

[Figure (16) about here]

However, here we are going to argue that we do not need to endogenize the job destruction margin in our framework in order to get values of the welfare effects that are free of job destruction bias.

The idea is to exploit the different institutional set-ups related to the SP that are in place in different economies (e.g. Italy Vs. US). By recalibrating the model to match the relevant features of this alternative economy we would be able to back-out the retention probabilities implied by this alternative institutional set-up, say σ_{it}^{ITA}. With some abuse of language, we would be estimating the equilibrium firing decisions that are consistent with the specific SP legislation in place. With this new retention probabilities there are two ways of correcting for the welfare bias we already computed:

- in the US model economy we can run the experiment of **introducing** the exact same SP scheme implemented in Italy (SP^{ITA}). Then we can compute the average welfare measure $W_0^{US}(\sigma_{it}^{US})$ implied by the US separation rates σ_{it}^{US} and compare it to the average welfare for the counterfactual economy obtained with the separation rates valid for the Italian case $W_\theta^{US}(\sigma_{it}^{ITA})$;
- in the Italian model economy we can run the experiment of **eliminating** the SP^{ITA}. Then we can compute the average welfare measure $W_0^{ITA}(\sigma_{it}^{US})$ and compare it to $W_\theta^{ITA}(\sigma_{it}^{ITA})$.

However, in order to achieve these results, there are some major challenges to be faced. In the economy with SP, say Italy, we cannot obtain the ε_{it}^{ITA} exogenously. They need to be estimated in equilibrium, which is a non trivial task.

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).

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.

Finally our productivity profiles are assumed to be policy invariant. By endogenizing the accumulation of specific human capital with an explicit investment decision we would be able to evaluate how much the SP contribute in shaping this variable.

We leave these extensions and modifications for future work.

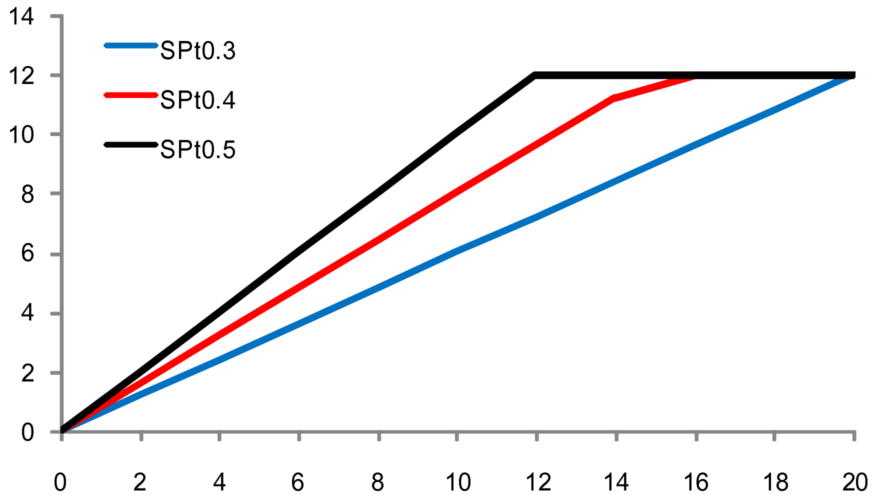

Figure 1: SP Profiles: Monthly wages as a function of tenure

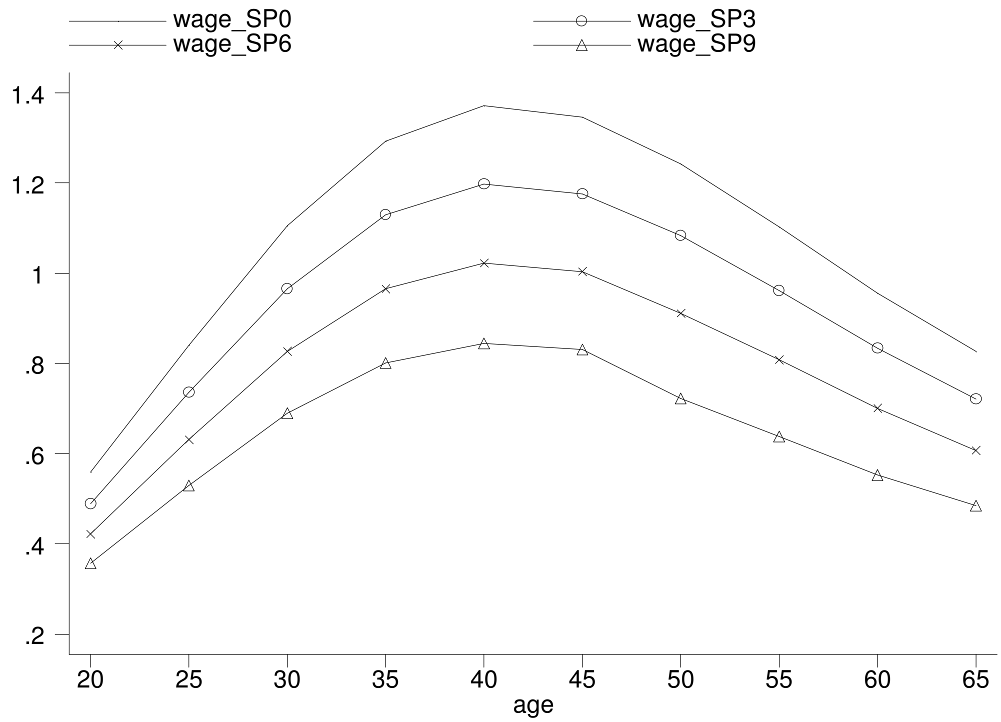

Figure 2: The effects of SP on the Wage Profile (No Tenure)

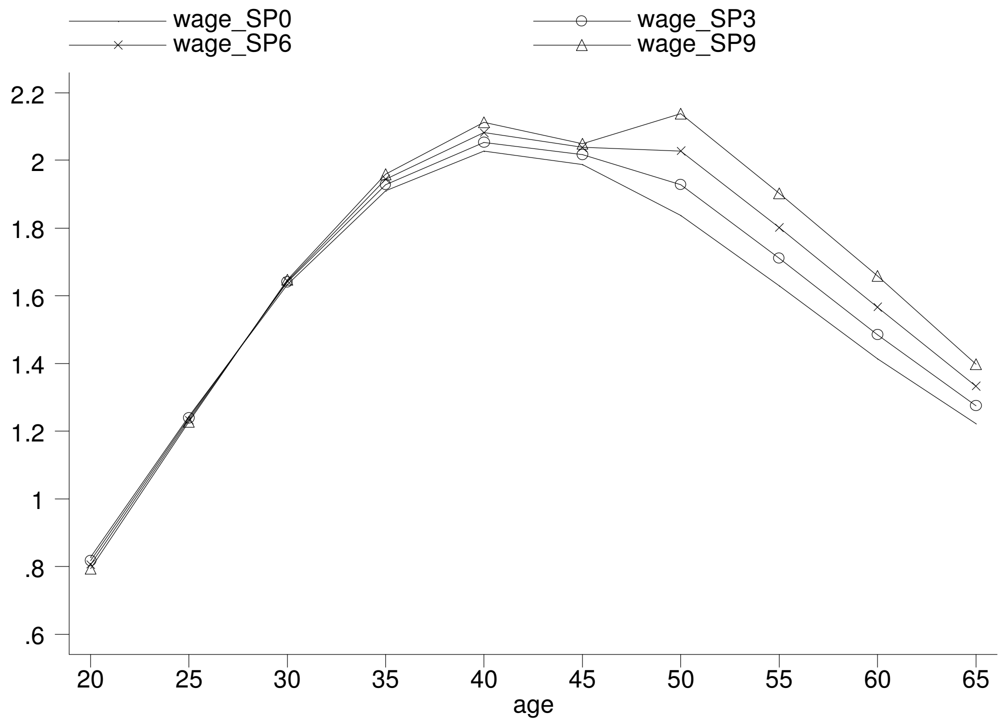

Figure 3: The effects of SP on the Wage Profile (Tenured)

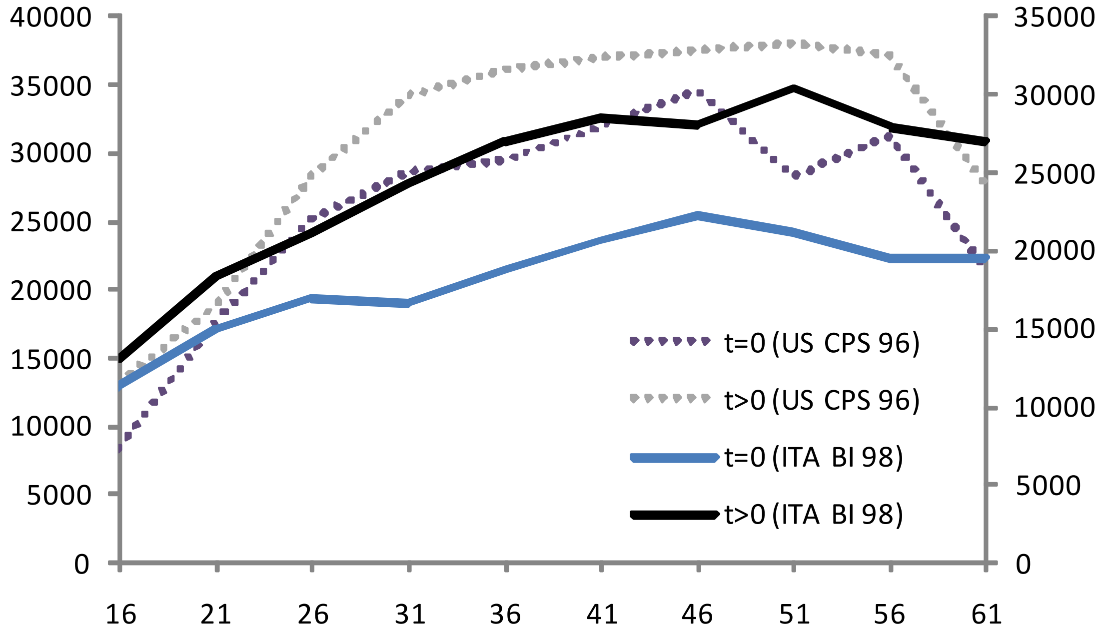

Figure 4: Average Earnigs Profiles (Tenured Vs. Untenured)

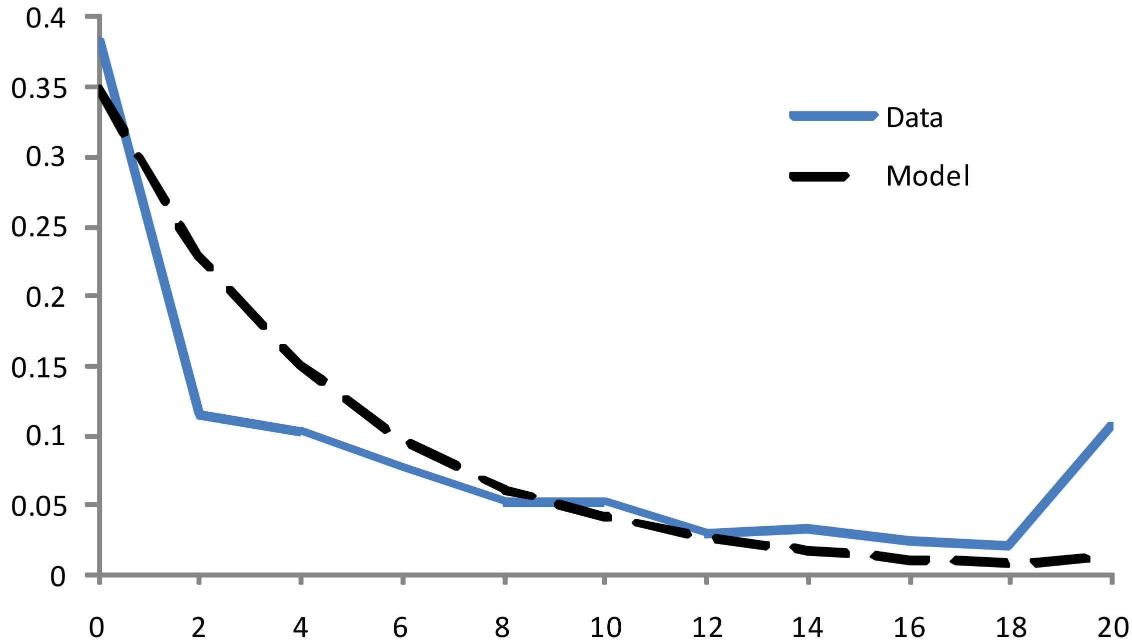

Figure 5: Marginal Distributions over Tenure

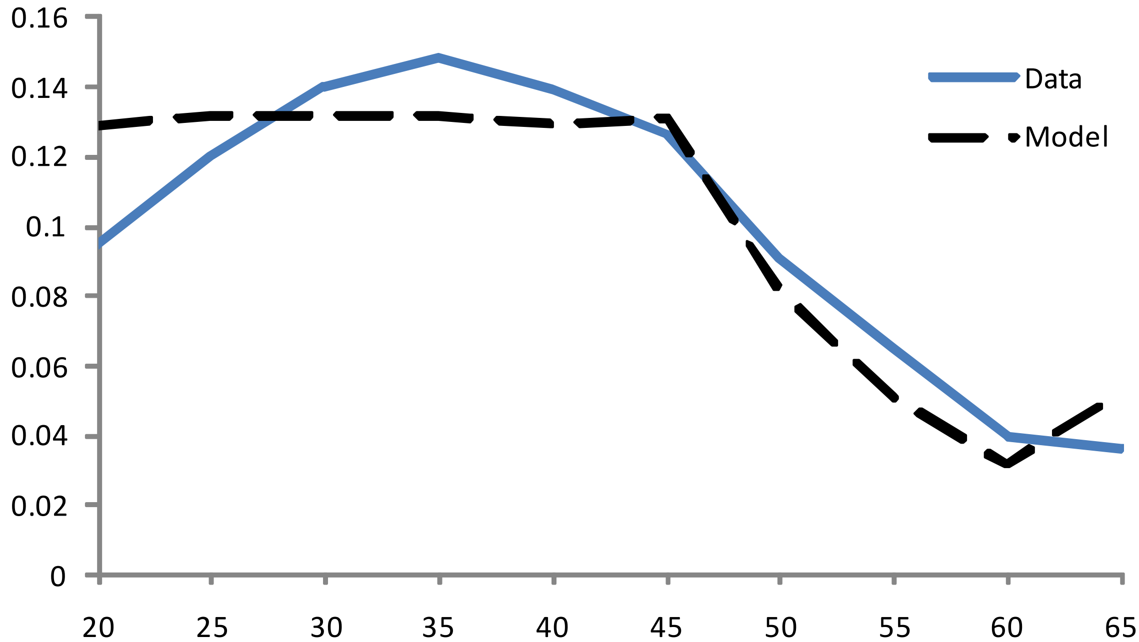

Figure 6: Age Distributions

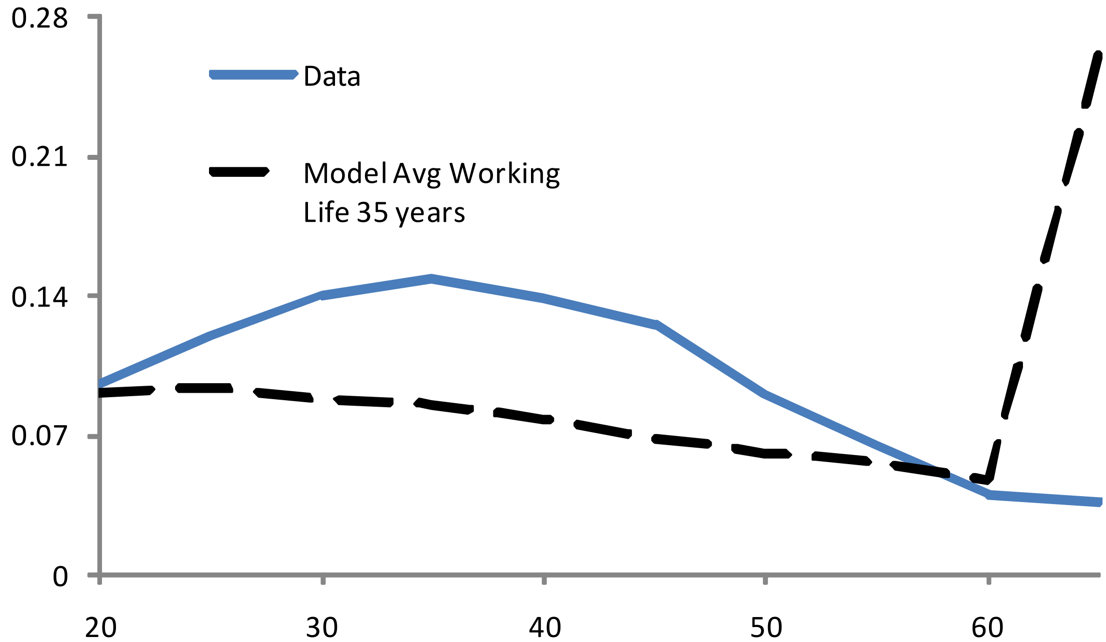

Figure 7: Age Distributions - Alternative Calibration

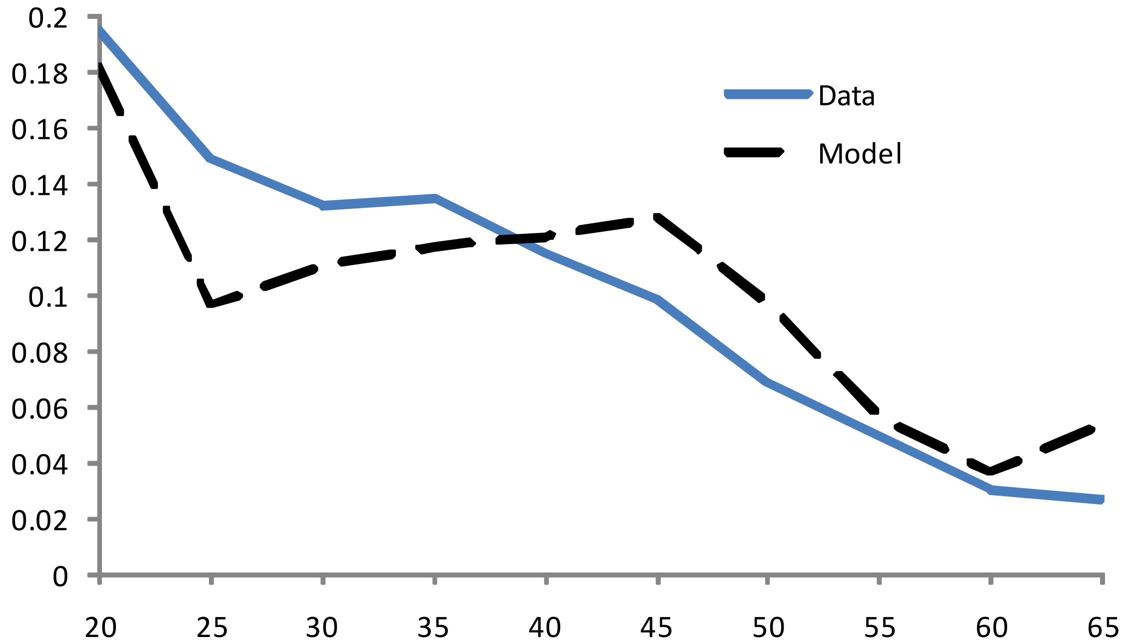

Figure 8: Unemployment Distributions

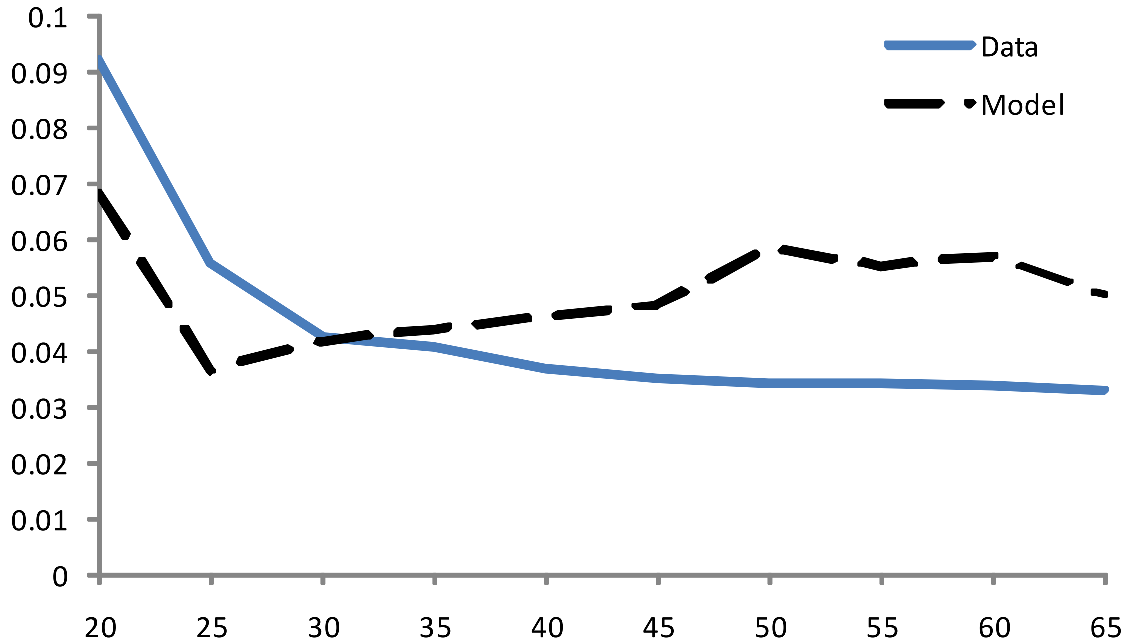

Figure 9: Unemployment Rates over the Life-cycle

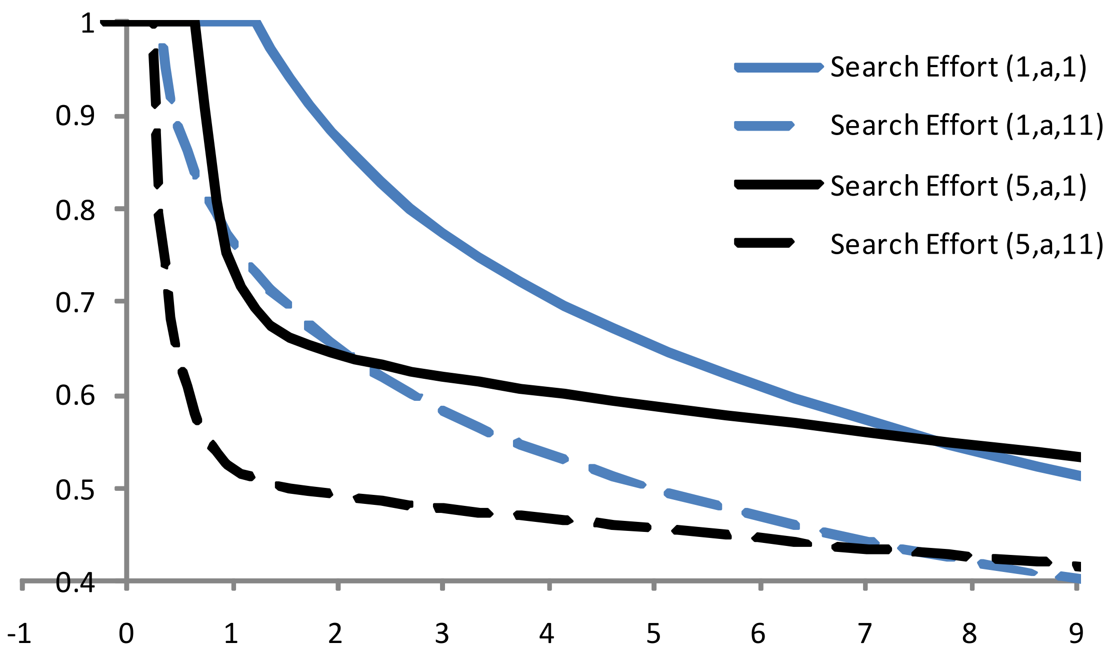

Figure 10: Search Effort Policy Functions (20 year old Vs. 40 year old)

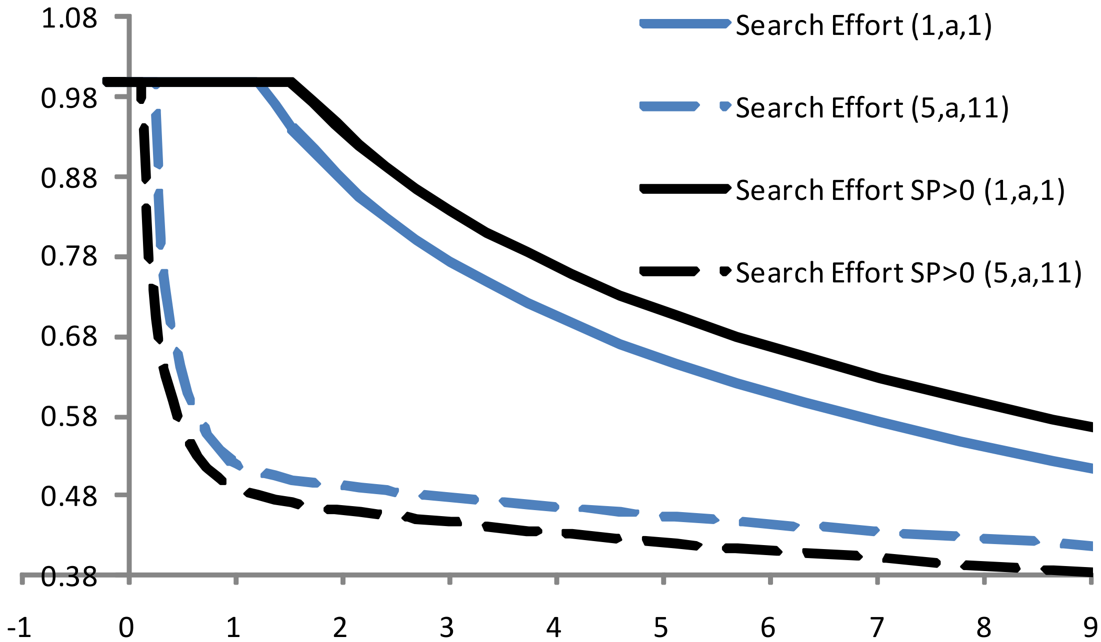

Figure 11: Search Effort Policy Functions and SP (20 year old Vs. 40 year old)

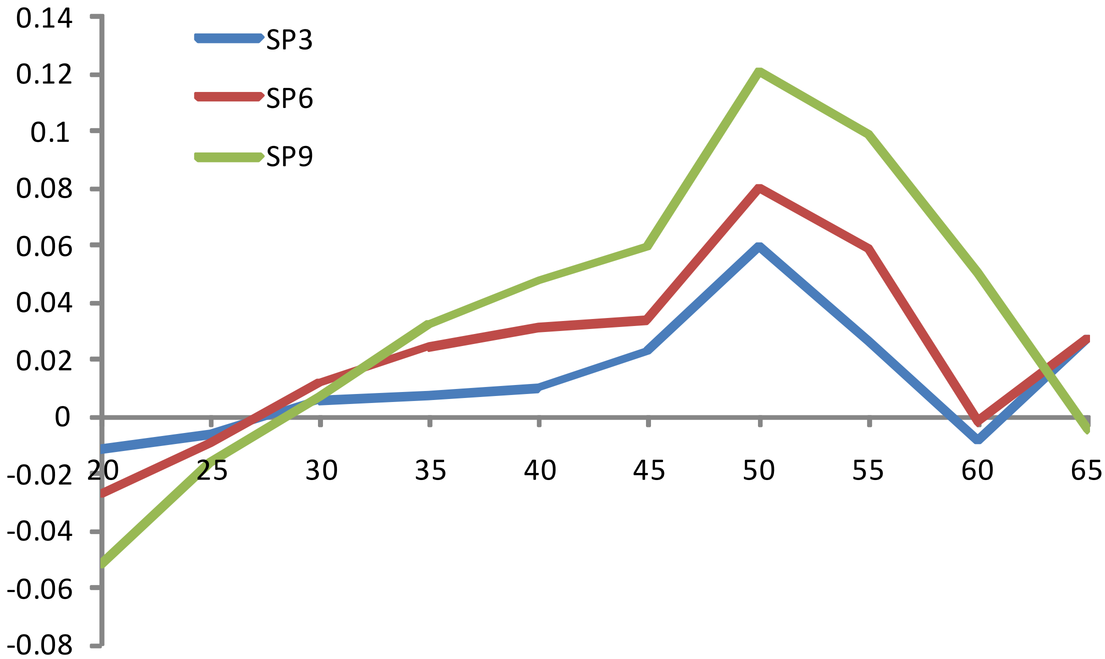

Figure 12: Welfare Effects of the SP - Age Profiles in PE

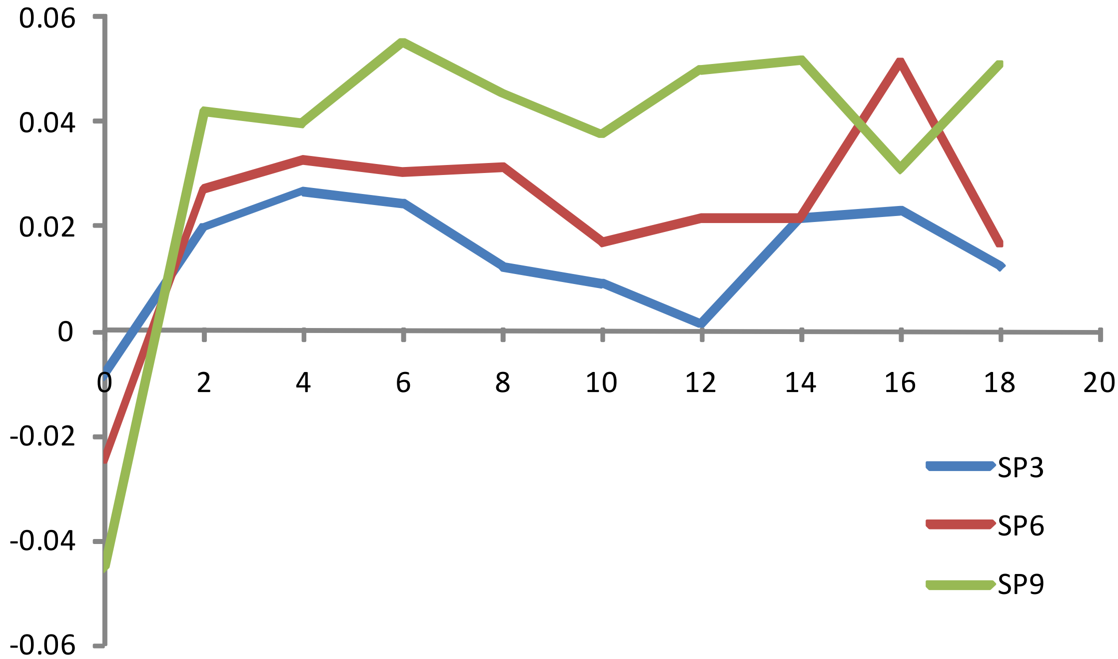

Figure 13: Welfare Effects of the SP - Tenure Profiles in PE

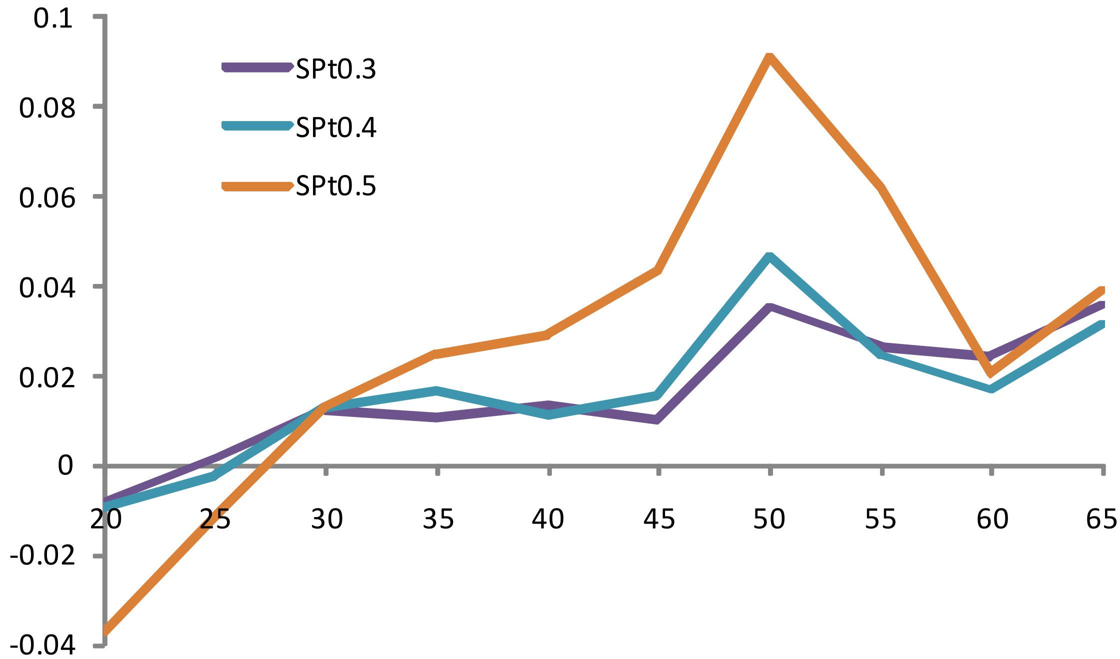

Figure 14: Welfare Effects of the SP - Age Profiles in PE

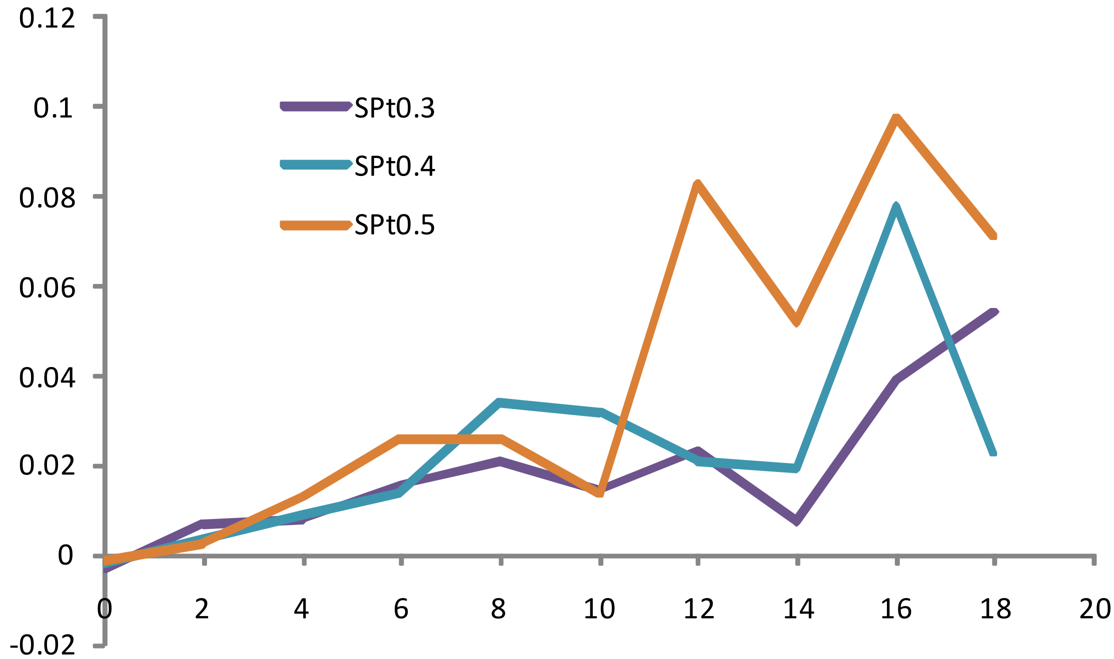

Figure 15: Welfare Effects of the SP - Tenure Profiles in PE

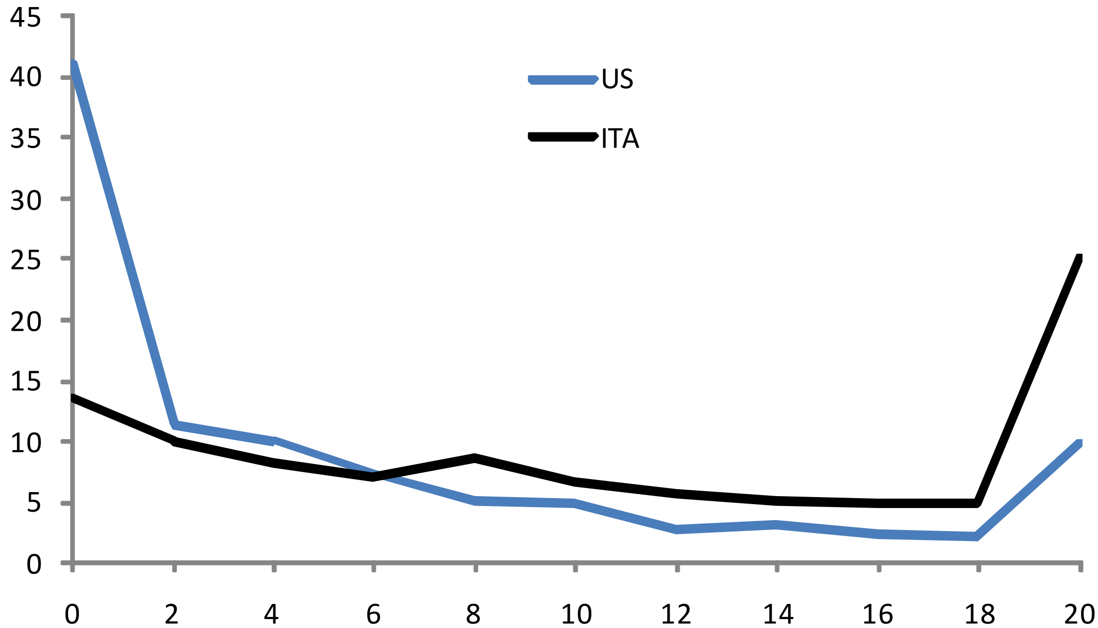

Figure 16: Marginal Distributions over Tenure: Italy Vs. US

Country	*Severance Payments*
Italy	20
Portugal	15
Spain	12
Australia	2
France	1.7
Ireland	1.4
U.K.	1.2

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

Parameter	*Value*	*Target*
Model Period	*Bimonthly*	
λ_i - *Survival prob*	$1\ (i < 50); 0.98\ (i \geqq 50)$	*Average Age*
η - *CRRA*	2.0	*Standard*
d - *Borrowing limit*	0.205	*15% with Negative Net Worth*
a_0 - *Newborn asset endowment*	0	
I - *Age levels*	$10; \{20, 25, ..., 65\}$	*Work (possibly) from 20 to 65*
π_i - *Prob of aging*	$\frac{8}{5 \cdot 52} = 0.031$	*A jump every 5 years*
T - *Tenure levels*	$11; \{0, 2, ..., 20\}$	*Maximum Tenure=20 years*
τ_t - *Prob of increasing tenure*	$\frac{8}{2 \cdot 52} = 0.077$	*A jump every 2 years*
ε_{it} - *Productivity values*	*See Table 3*	*From a regression on CPS data*
$\phi(\psi) = \psi^{\xi}$ - *Job finding prob*	0.53	*Avg. unemployment duration*
$v(\psi) = \rho\psi$ - *Effort disutility*	-0.97	*Unemployment rate* = 4.8%
σ_{it} - *Job losing prob*	0.038	*Average Tenure*
b - *Unemployment Benefit*	0.5	*UI replacement rate*
π^b- *UI eligibility prob*	$\frac{8}{0.5 \cdot 52} = 0.333$	*UI avg time limit of 6 months*
f - *Food stamps*	0.077	*Avg. transfer ($140 per month)*
γ_t - *Severance Payment*	0	*Competitive Wages*
δ - *Capital depreciation rate*	0.017	*Investment/Output ratio* $\approx 20\%$
α - *Capital share*	0.3	*Labor Share*
$\widehat{\beta}$ - *Rate of time preference*	0.9919	*Annual interest rate=5%*

Table 2: Calibration - US

Parameter	*Log Earnings*
Age	0.249675
	(8.55)
Age^2	−0.0045848
	(−6.13)
Age^3	0.0000251
	(4.08)
Tenure	0.026877
	(9.19)
$Tenure^2$	−0.00037
	(−3.49)
Constant	4.1598
	(11.43)
N. Obs	5699
Adj. R^2	0.2053

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

Age	*%Growth rate - ITA*	*%Growth rate - US*
16	41.67	62.96
21	19.23	15.38
26	5.0	20.07
31	54.84	24.80
36	38.89	28.0
41	54.76	29.44
46	40.26	9.979
51	42.11	47.46
56	30.0	33.79
61	28.20	33.54
All (Avg)	34.1%	22.3%

Table 4: Average Earnings Growth: Tenured Vs. Untenured

Variable	*SP=0*	*SP=3*	*SP=6*	*SP=9*
Mutual Fund	0	1.31	2.68	4.06
Average Profits	0	0.037	0.075	0.114
Aggregate SP	0	0.048	0.097	0.147
Average SP	0	1.245	2.517	3.812
Aggregate U Benefit	0.0257	0.0247	0.0249	0.0247
Average U Benefit	0.611	0.599	0.584	0.570
Food Stamps ($\times$100)	0.0584	0.0606	0.0635	0.0733
Consumption	1.158	1.166	1.181	1.199
Borr Limit	-0.205	-0.205	-0.205	-0.205
Output	1.618	1.616	1.615	1.610
I/Y Ratio (%)	20.33	20.33	20.33	20.33
L Share - with SP (%)	70.0	70.8	71.6	72.4
L Share - no SP (%)	70.0	67.8	65.6	63.3
Net Worth<0 (%)	15.0	24.8	22.3	19.9
U rate (%)	4.85	5.02	5.15	5.31

Table 5: Partial Equilibrium - Flat SP

Variable	*SP=0*	*0.3t*	*0.4t*	*0.5t*
Mutual Fund	0	1.58	2.01	2.35
Average Profits	0	0.045	0.057	0.067
Aggregate SP	0	0.057	0.073	0.085
Average SP	0	1.487	1.936	2.192
Aggregate U Benefit	0.0257	0.0251	0.0246	0.0255
Average U Benefit	0.611	0.593	0.587	0.586
Food Stamps (×100)	0.0584	0.0653	0.06329	0.07284
Consumption	1.158	1.166	1.169	1.180
Borr Limit	−0.205	−0.205	−0.205	−0.205
Output	1.618	1.617	1.617	1.609
I/Y Ratio (%)	20.33	20.33	20.33	20.33
L Share - with SP (%)	70.0	70.9	71.2	71.3
L Share - no SP (%)	70.0	67.4	66.7	66.1
Net Worth<0 (%)	15.0	28.0	27.7	17.6
U rate (%)	4.85	5.02	5.10	5.33

Table 6: Equilibrium - SP linear in tenure

Variable	*SP=0*	*SP=3*	*SP=6*	*SP=9*	*0.3t*	*0.4t*	*0.5t*
Mutual Fund	0	81.05	165.73	251.11	97.56	124.40	145.33
Average Profits	0	2.30	4.64	7.04	2.74	3.53	4.07
Average SP	0	2.96	5.98	9.07	3.53	4.53	5.24
Borr Limit	12.67	12.67	12.67	12.67	12.67	12.67	12.67
Output	100.00	99.91	99.81	99.47	99.98	99.97	99.47
Average wage	70.00	67.75	65.44	62.96	67.37	66.64	65.72

Table 7: Equilibrium normalized by output in the benchmark economy

Severance Payments	*Average Welfare Change*
SP=3	0.614%
SP=6	0.800%
SP=9	0.637%
SP=0.3t	0.569%
SP=0.4t	0.576%
SP=0.5t	1.048%

Table 8: Welfare Effects of the SP (PE)

Severance Payments	V Δ*Welfare*	U Δ*Welfare*	U_{No-UI} Δ*Welfare*
SP=0.3t	0.282%	3.148%	7.209%
SP=0.4t	0.487%	1.944%	7.638%
SP=0.5t	0.661%	4.376%	17.938%

Table 9: Welfare Effects by Employment Status

Average Welfare Change	*UI=50%*	*UI=25%*	*UI=10%*
SP=0	–	−1.01%	−1.490%
SP=0.5t	1.048%	−0.286%	−0.813%

Table 10: Welfare Effects - SP Vs. UI

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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 the 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, $a'_e(i, a, t), a'_u(i, a, t)$, and $a'_{ub}(i, a)$.

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

$\underset{a}{Sup}\, |a'_e(i, a, t)_{n+1} - a'_e(i, a, t)_n| < 10^{-6}$, $\forall i$ and $\forall t$,

$\underset{a}{Sup}\, |a'_u(i, a, t)_{n+1} - a'_u(i, a, t)_n| < 10^{-6}$, $\forall i$ and $\forall t$,

$\underset{a}{Sup}\, |a'_{ub}(i, a)_{n+1} - a'_{ub}(i, a)_n| < 10^{-6}$, $\forall i$.,

- The model with endogenous search effort is solved with a 'successive approximation' procedure on the set of value functions. In order to keep the computational burden manageable, we use 51 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.

We start from a set of guesses, $V(i, a, t)_0$, $U(i, a, t)_0$, and $U_b(i, a)_0$. 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, $a'_e(i, a, t), a'_u(i, a, t), a'_{ub}(i, a), \psi_u(i, a, t), \psi_{ub}(i, a)$.

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 the quadratic spline approximations for the future value functions, when evaluated at the chosen saving and search effort levels.

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

$\underset{a}{Sup}\,|V(i,a,t)_{n+1} - V(i,a,t)_n| < 10^{-6}$, $\forall i$ and $\forall t$,

$\underset{a}{Sup}\,|U(i,a,t)_{n+1} - U(i,a,t)_n| < 10^{-6}$, $\forall i$ and $\forall t$, and

$\underset{a}{Sup}\,|U_b(i,a)_{n+1} - U_b(i,a)_n| < 10^{-6}$, $\forall i$.

For some parameter values this procedure doesn't reach convergence, but show cycles instead. This issue does not manifest itself when we solve the agents' problems independently (i.e. when we prevent transitions between employment states). We believe the reason lies in the relatively big jumps in the continuation values that are sometimes obtained between iterations. When unemployed, if there is a relatively big gap between the future V_{n+1} and U_{n+1}, the agents choose to set their effort to a very high level. However, by doing so, the gap in the value functions is reduced. This leads to choose a lower search effort in the next iteration, which in turn could lead to an increased gap in the set of value functions. This sequence of updates sometimes results in a cycle.

In order to circumvent the problem, we implement a slow updating procedure. After having computed the set of updates $V(i,a,t)_{n+1}$, $U(i,a,t)_{n+1}$, and $U_b(i,a)_{n+1}$ we don't use them in the next iteration. We rely on their weighted version instead, with a weight ω. Namely in the next step we consider $\omega V(i,a,t)_{n+1}$, $\omega U(i,a,t)_{n+1}$, and $\omega U_b(i,a)_{n+1}$.

We use a weight that is close to zero when far from convergence, which reaches one when the error is sufficiently small (equal to 10^{-5}).

Notice also that usual methods to speed up the computation time, such as the Howard improvement algorythm, do not seem to reach convergence in our unweighted set-up.

- The stationary distributions are computed by simulating a large sample of 100,000 individuals for 2,000 periods, which ensure that the statistics of interest are stationary processes. 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.

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 $[-d, ..., a_{\max}]$;
- 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 saving functions $a'_e(i,a,t), a'_u(i,a,t), a'_{ub}(i,a)$;
- Get the stationary distributions $\mu_e(i,a,t), \mu_u(i,a,t), \mu_{ub}(i,a)$;
- 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;
- Get the consumption functions $c'_e(i,a,t), c'_u(i,a,t), c'_{ub}(i,a)$;
- Check final good market clearing.