MATCHING FRICTIONS, SELF-INSURANCE AND SEVERANCE PAYMENTS

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[Preliminary, Do Not Quote – Comments Welcome]

ABSTRACT. This paper develops a general equilibrium model to study the employment and welfare implications of statutory severance payments. In the proposed setting, the labor market features congestion externalities, firms face stochastic production costs that cannot be passed onto wages and insurance markets are imperfect. Severance pay can thus enhance efficiency by making firms internalize the social costs of their firing decisions, and also workers' welfare by helping them cope with idiosyncratic employment risk. The model calibrated on U.S. data reveals the following implications of severance pay. First, their effect on welfare is hump-shaped, peaking for payments around three months' wages. In consumption terms, the welfare gains barely exceed half a percent, which is an order of magnitude lower than computed by previous studies. Second, workers do not benefit from reduced congestion externalities since those tend to be offset by diminished job creation. Third, the peak in welfare effects is obtained when the layoff rate is driven to a value only slightly below its constrained-efficient level, defined as the optimal layoff rate in the equivalent economy with complete-markets. This reflects the fact that workers smooth consumption well even in the absence of perfect insurance markets.

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1. INTRODUCTION

The desirability of statutory severance payments is and remains a contentious topic among scholars, policy makers and the general public alike[1]. Efficiency and welfare arguments have been put forward to justify this policy. The efficiency argument draws on the result that the layoff rate is generically too high when the social cost of dismissals exceeds its private cost. Depending on the social costs emphasized, the argument comes in various forms and has been an object of keen study (see e.g. Blanchard and Tirole, 2008; Cahuc and Zylberberg, 2008). The welfare argument is also well understood but systematic inquiries have been scarce, with the exception of the study by Alvarez and Veracierto (2001). The idea revolves around the need to help workers cope with shocks by reducing fluctuations in their labor market outcomes, since preventing layoffs may be instrumental for this purpose. On the other hand, severance payments are often blamed for distorting firms' decisions: they deter employers from dismissing their incumbent workers and also reduce their incentives to hire new workers (Bentolila and Bertola, 1990; Hopenhayn and Rogerson, 1993). Ultimately, evaluating the pros and cons of this policy is a quantitative issue. The goal of this paper is to carry out such an examination by means of a calibrated, general equilibrium model where the potential costs can be weighed against the potential benefits of severance payments.

The proposed framework for this study embodies three key elements: (i) matching frictions in the process that brings firms and workers together, (ii) stochastic production costs that cannot be passed onto wages and (iii) imperfect insurance markets faced by risk-averse workers. One of the contributions of the paper is to bring these ingredients together within a quantitative model.

The first feature of the analysis, matching frictions, is motivated by two considerations: it is a useful construct to model labor demand and also to capture congestion externalities in the labor market, which introduce a wedge between the social and private costs of separations. Policy intervention is thus needed to ensure an efficient allocation of labor. Shocks to production costs that cannot be internalized into wages, the second element of the analysis, determine the form taken by this policy intervention. By occasionally causing employers to dismiss their workers, they call for penalizing layoffs. The restriction that these shocks cannot be passed onto wages plays another role: it circumvents Lazear (1990)'s "bonding critique", i.e. the result that layoff payments can be neutralized by an adequately designed wage contract[2]. Finally, allowing for some inability on the part of workers to insure against idiosyncratic risk, the third element of this analysis, opens the way for potential welfare gains from severance payments. It follows from the observation that this policy, like unemployment insurance, aims at enhancing consumption smoothing. The framework developed here allows notably to single out a feature that distinguishes severance payments from conventional unemployment insurance programs: namely, that they may achieve their insurance role by preventing layoffs, which reduces the frequency at which workers transit through unemployment.

[1]Statutory severance payments refer to a government-mandated transfer from the employer to the employee paid at the time of dismissal. Figures reported in OECD (2004) reveal that the magnitude of these payments displays considerable variations across countries: for instance they amount to 1.2 monthly wage for workers with average job tenure in the United Kingdom while the corresponding figure increases to 12 monthly wages for Spain.

[2]See Fella (2007) for a discussion of this topic. The model does not take a stand on the reason why wages cannot incorporate stochastic production costs, but there are arguably many features of the institutional environment that would hinder wage flexibility. Garibaldi and Violante (2005) analyze such features in the context of statutory severance payments.

The Laissez-Faire version of the proposed model is calibrated on data for the U.S. labor market, where government-mandated severance payments are virtually zero. Starting from this benchmark economy, severance payments are then introduced at increasing levels and their implications are studied by comparing stationary equilibria[3]. The main finding is that their effect on welfare is hump-shaped, increasing until about 3 months' wages. The underlying reasons are as follows.

First, moderate levels of severance payments increase efficiency by preventing firms from firing their workers too often, and they enhance welfare by providing individuals with higher consumption levels. These improvements do not come free. On the one hand, reduced congestion externalities do not translate into a higher job-finding rate for the unemployed since they tend to be offset by falling job creation. On the other hand, imposing layoff penalties induce employers to bargain for lower wages[4]. When severance payments amount to less than 3 months' wages, these distortions are outweighed by efficiency gains from rebalancing hiring and firing costs in the aggregate. But they imply that welfare gains can only be modest: expressed in consumption terms, they barely exceed half a percent. This lines up with the welfare gains computed by Alvarez and Veracierto (2001) for payments by the same amount, but is more than six times lower than the maximum welfare improvements from statutory severance pay that these authors found.

Conversely, higher levels of severance payments that shift too much of the cost of labor reallocation on firms offset the gains in welfare aforementioned, and they may even deteriorate it relative to Laissez-Faire. This occurs in spite of a continued reduction of the unemployment rate when firms face higher layoff penalties. Indeed, in none of the numerical experiments is it desirable to eliminate all layoffs. Moreover, some of these experiments suggest that the negative effects of severance payments can be quantitatively sizeable: relative to Laissez-Faire, severance payments that amount to 12 months' wages may result in welfare losses by more than 2 percent of aggregate consumption. In a context where the primary effect of a tax on layoffs is to distort firms' employment decisions, Hopenhayn and Rogerson (1993) computed welfare losses of the same order of magnitude.

Finally, to understand why welfare peaks for severance payments around three months' wages in the calibrated economy, it is useful to consider its complete-market equivalent. That is, severance payments equal to three months' wages maximize welfare because they drive the layoff rate to a value close to the constrained-efficient level of the complete-market equivalent economy. The latter is relevant when the lack of perfect insurance markets is not a source of severe incompleteness, which holds true in the model: despite the absence of perfect insurance against idiosyncratic risk, workers can smooth consumption well since most unemployment spells are short. Hence the prevalence of the efficiency argument described in the opening paragraph of this paper in determining the welfare-maximizing level of severance payments.

[3]A proper treatment of the transition dynamics would deserve a paper in its own right since the first-order determinants of the transition path are likely to depend on the political economy of imposing such payments, which is abstracted from in this paper. For instance the outcomes may differ dramatically depending on whether changes in employment protection apply to all jobs in the economy or only to the newly-created ones, as illustrated by Blanchard and Landier (2002). Since the transition dynamics is likely to deteriorate welfare, one can interpret the welfare figures computed here as an upper bound to the effect of shifting the layoff tax regime in the economy.

[4]This does not reflect Lazear (1990)'s bonding critique because severance payments are not bargained over; in the model, they only affect wages trough their effects on the expected continuation value of employment.

The results aforementioned are robust to several perturbations of the calibrated economy. Because they hinge on the structure of shocks that trigger layoffs, three alternative scenarios explore the role of: (i) the magnitude of shocks to production costs, (ii) the incidence of layoffs among all job separations and (iii) the implications of unavoidable layoffs. Qualitatively, they confirm the findings based on the benchmark calibration. Quantitatively, these modifications sometimes alter the magnitude of the effects at work in the model, while confirming that the peak for the welfare effects is obtained for moderate levels of severance payments. Therefore, although this is a calibration exercise, the results are not too sensitive to parameter choices.

As indicated above, this paper closely relates to two prominent studies of layoff payments in a general equilibrium context: Hopenhayn and Rogerson (1993) and Alvarez and Veracierto (2001). They delivered contradictory messages about the employment and welfare effects of this policy: those were found to be negative in the former study while the latter emphasized large positive gains from mandatory severance payments. Because the present paper shares some conclusions from each of these two studies, a number of comments are in order here.

Like Hopenhayn and Rogerson (1993), this paper confirms that large layoff penalties can have sizeable negative implications for welfare. However, the model considered by Hopenhayn and Rogerson envisions this policy essentially as a distortion of the Pareto-optimal equilibrium, as shown by Ljungqvist (2002) and Alvarez and Veracierto (2001)[5], whereas the proposed setting gives room to potential gains from severance payments. One implication is that matching frictions and imperfect insurance markets do not overturn the diagnosis of Hopenhayn and Rogerson for high levels of severance payments. Conversely, this paper concurs with Alvarez and Veracierto (2001) on the conclusion that moderate levels of severance payments can enhance workers' welfare but finds that this does not carry over when this policy is made more stringent. That is, contrary to theirs, the framework analyzed in this paper predicts that changes in welfare are ambiguously signed. Moreover, the apparently similar conclusion for moderate levels of severance payments derives from much different results. In Alvarez and Veracierto, welfare gains follow from the difficulties of workers to smooth consumption across periods: in addition to imperfect insurance markets, they face large search costs when unemployed, rigid wages and, finally, stochastic life spans that exacerbate the precautionary saving motive. On the other hand, in this paper gains from severance payments connect to the fact that they correct the congestion externality caused by firms' firing decisions[6]. Finally, like Alvarez and Veracierto, the model indicates that the implications of severance payments follow mostly from their effect on layoff decisions; rebating the proceeds of layoff payments instead of allocating them to the financing of the unemployment insurance system does not yield significantly larger welfare gains.

[5]Hopenhayn and Rogerson (1993) relied on a model with employment lotteries, establishment-level dynamics and where layoff payments are handed back lump sum to households. Ljungqvist (2002) and Alvarez and Veracierto (2001) explain that the latter feature mitigates income effects since high layoff payments induce households to substitute away from work. This labor market policy therefore deteriorates employment and welfare under the assumptions of complete markets and in the absence of labor market frictions.

[6]In Alvarez and Veracierto (2001), the only source of externality comes from distorting taxes that are used to finance the unemployment insurance system. In quantitative terms, however, this distortion is typically negligible. For instance Hansen and Imrohoroglu (1992) find that average utility in the competitive equilibrium of an economy with an unemployment benefit optimally set (non negative) and with no moral hazard is the same as under the planner's preferred allocation to at least 4 decimal places.

On a different note, although the proposed model builds on the canonical Mortensen-Pissarides framework, it has little connections with studies that have used this construct to analyze severance payments. One reason is that most analyzes carried out within this framework restrict attention to the sunk portion of severance payments, i.e. to separation costs paid outside the worker-firm pair. This is because the bonding critique carries over when wages are flexible and utility is fully transferable between agents, as is standard in the Mortensen-Pissarides model. Yet, a few studies relax the usual wage-setting assumptions so as to analyze the transfer component of severance payments: those include Garibaldi and Violante (2005), Postel-Vinay and Turon (2013) and Fella and Tyson (2011), but those do not address the self-insurance and welfare issues that are the focus of this paper. This is the other source of departure between the paper and this vein of the literature: by assuming linear preferences, the vast majority of studies presume perfect insurance and thus cannot explain why severance payments should be introduced in the first place, as emphasized by Bertola (2004). Even in the study by Fella and Tyson (2011), risk-aversion and market incompleteness are introduced but they abstract from wealth effects to obtain tractability. Thus, none of these papers addresses the implications of severance payments within a general equilibrium model similar to the one developed here.

Finally, this paper features some methodological advances with regards to a recent and growing literature that introduces diminishing marginal utility of consumption and savings into the standard Mortensen-Pissarides model. Two recent papers by Krusell et al. (2010) and Mukoyama (2010) have drawn on this extended environment to study unemployment insurance. Unlike them, separations in the proposed setting are endogenous so as to capture the effect of severance payments on firing decisions. Bils et al. (2011) on the other hand allow for endogenous separations but they do not model physical capital and assume that all separations are efficient from the joint perspective of employers and workers. They use their model to investigate business cycle issues, not to study the employment and welfare effects of labor market policies.

The paper is organized as follows. Section 2 presents the economic environment. The competitive equilibrium is defined in section 3. Section 4 calibrates the Laissez-Faire model and characterizes the steady-state. Section 5 contains the main results. Section 6 shows their robustness to alternative calibrations. Section 7 concludes. A numerical appendix that presents the algorithm to compute the equilibria of section 3 accompanies the paper.

2. Economic Environment

The proposed economic environment borrows from various sources. First, it features a labor market subject to matching frictions à la Diamond-Mortensen-Pissarides. Second, it incorporates risk-averse preferences for workers and imperfect insurance markets. From a methodological standpoint, combining these elements has been been the advance made by Krusell et al. (2010). One key additional ingredient of the proposed model is the introduction of stochastic production costs that cannot be passed onto wages. They lead to endogenous separations in the form of layoff decisions and cause severance payments to have real effects.

Preferences. One side of the market is populated by a continuum of workers of total mass equal to one. Workers have their momentary utility function defined over consumption streams c and they maximize

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t u(c_t) \tag{1}$$

where $\mathbb{E}_0$ denotes mathematical expectation conditional on information at time 0, β is the subjective discount factor and $u(.)$ is a strictly concave function.

On the other side of the market, there is a continuum of risk-neutral entrepreneurs. They maximize the expected value of the discounted sum of profit streams π:

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \left(\frac{1}{1+i}\right)^t \pi_t \tag{2}$$

In equilibrium, the net real interest rate – and thereby entrepreneurs' discount factor – is determined endogenously.

Technology. The unit of production is a matched worker-entrepreneur pair. Unmatched individuals come together via search. A constant returns to scale matching function determines the probability that a randomly chosen employer with a vacant job meets a randomly-chosen unemployed person. The number of contacts per unit of time is given by

$$m(u_t, v_t) = M u_t^{\alpha} v_t^{1-\alpha} \tag{3}$$

where u is the number of unemployed persons and v is the measure of vacancies. Letting $\theta = v/u$ denote labor market tightness, the job-filling probability is $q(\theta) = M\theta^{-\alpha}$ and the job-finding probability is $\theta q(\theta) = M\theta^{1-\alpha}$.

Once matched, workers and entrepreneurs produce a homogeneous consumption good. Production requires only physical capital k and generates

$$f(k) = k^{\xi} \tag{4}$$

units of output per period. Since production units are all identical, they employ the same levels of physical capital $\tilde{k}$, which therefore corresponds to the capital-labor ratio in the economy. Physical capital depreciates at rate δ per unit of time.

Production costs. Profits are determined by different production costs that unfold as follows:

(1) Prior to meeting a worker, an entrepreneur opens a new vacancy that costs η units of consumption good per period of time until the vacancy is filled.
(2) Once matched to a worker and at the beginning of each production period, an entrepreneur rents physical capital at price $i+\delta$ from a competitive market and bargains with his/her current employee over a wage ω.
(3) By the end of each production period, an entrepreneur faces an additional, stochastic cost of $z \geq 0$ units of consumption good drawn from a distribution $H(.)$. He/she chooses either to terminate the job or to incur the cost z so as to continue production next period.

From an accounting point of view, the unit cost of vacancy and the stochastic cost z are two forms of intermediate goods: they are to be subtracted to the gross output produced in every period. Thus, the environment is similar to having a stochastic cost for job creation with one component incurred upfront and the remaining one spread over the lifetime of a job.

Under the timing of events just described, the stochastic production cost cannot be passed onto workers' wages, at least not beyond its value in expectation terms[7]. In turn, since the entrepreneur cannot recoup the cost z by the time of resuming production, he/she may prefer to severe the job relationship with the worker before the subsequent period. This decision is taken as given by the worker. Since the latter does not derive utility from leisure, it is only the entrepreneur who is made better off by the destruction of the job. Thus all separations in the model can be labeled layoffs[8].

Asset structure. To transfer wealth across periods, workers have access to a single risk-free asset a, which they can save but that they cannot borrow. The maximization of (1) is thus subjected to a sequence of intertemporal budget constraints:

$$(5) \qquad c_t + a_{t+1} \leq (1+i)\, a_t + y_t^d$$

where assets holdings a are constrained to be positive, y_t^d denotes disposable income at time t (to be determined below) and i is the net real interest rate.

As in Krusell et al. (2010), it is assumed that a is compounded from two types of assets: physical capital k and equity e. Equity e corresponds to a claim for the profits generated by firms, including those with an unfilled position. Claims are held for the aggregate profit, not the profit of individual jobs (firms are jointly owned by workers), and the total amount of equity is normalized to one. Denoting the unit price of equity by p and the dividend paid to the holders of equity by d, a no-arbitrage condition between holding assets in the form of physical capital vs. equity implies:

$$(6) \qquad \frac{p+d}{p} = 1+i$$

The right-hand side in (6) is the return to one unit of physical capital next period; the left-hand side is the return to buying one unit of equity at unit price p. In particular, since the two assets yield the same return, the asset composition of agents is irrelevant for the equilibrium[9].

Government. To help workers insure against labor market risk, the government combines two policy tools. First, it supplies unemployment benefits b to all unemployed persons. The provision of these benefits is financed by the proceeds of a flat-rate tax τ levied on all labor earnings. The purpose of these benefits is essentially technical: it ensures a non-zero level of consumption for workers whose assets have entirely depleted in unemployment, which is not impossible in the presence of matching

[7]As discussed in section 4, one should think of these costs as being potentially large (they induce job destruction) but also extremely infrequent. Their expected value should leave the value of a filled job to an entrepreneur above that of a vacant job, otherwise entrepreneurs will choose *ex ante* not to create vacancies.

[8]Upon aligning the model on the data, an additional separation shock which is exogenous for the worker-firm pair is introduced in order to account for the large number of separations that are not labeled as layoffs. It is omitted here so as to simplify the exposition of the model but it is perfectly taken into account by agents upon computing the equilibrium.

[9]The budget constraint (5) is a consequence of the no arbitrage condition: it is equivalent to $c_t + k_{t+1} + pe_{t+1} \leq (1+i)\, k_t + (p+d)\, e_t + y_t^d = (1+i)\,(k+pe) + y_t^d$ after defining $a_t = k_t + pe_t$.

frictions. With a slight abuse of language, the Laissez-Faire economy hereafter refers to the economy without layoff taxes but which nevertheless operates an unemployment insurance system.

Second, because the layoff rate will be generically too high in competitive equilibrium, the government may require employers to pay a layoff tax F for each job that is terminated. Consistently with the practicalities of this policy, the government can choose either to rebate the proceeds of the tax to the separated worker in the form of a severance payment S or to allocate them to the financing of the unemployment insurance system. From the perspective of the worker-firm pair, the sunk portion of layoff payments corresponds to $F-S$. When this is positive, the government combines it with the flat-rate tax τ to support the provision of unemployment benefits.

3. Competitive Equilibrium

The following assumptions underlie the competitive equilibrium for the economic environment of section 2. First, workers' asset holdings are observable. Second, firms' firing decisions are perfectly anticipated by workers. Third, wages are obtained through a bargaining game between the employer and the worker. Altogether, these assumptions imply that wages $\omega(.)$ depend on assets. In turn, entrepreneurs' profits also depend on the asset level of the worker with whom they are matched, and so do their firing decisions. $\lambda(.)$, the expected layoff probability for the worker, is hence a function of assets. It will turn out that wages and layoff decisions are almost independent of assets, but these assumptions are required to ensure consistency of the equilibrium.

3.1. **Bellman equations.** To formulate workers' and firms' decision problems in recursive form, denote by U the value of unemployment and by W the value of being employed to the worker. For firms, denote by J the value of being matched to a worker.

Beginning with unemployed persons, their asset value U solves the Bellman equation

$$U(a)=\max_{a'}\left\{u(c)+\beta\left(\theta q(\theta)W\left(a'\right)+(1-\theta q(\theta))U\left(a'\right)\right)\right\} \tag{7}$$

subject to

$$\begin{aligned} c+a' &\leq (1+i)a+(1-\tau)b \\ 0 &\leq a' \end{aligned}$$

For employed workers, the Bellman equation for a given wage ω and layoff probability λ is

$$W(a)=\max_{a'}\left\{u(c)+\beta\left(\left(1-\lambda\left(a'\right)\right)W\left(a'\right)+\lambda\left(a'\right)U\left(a'+\frac{S}{1+i}\right)\right)\right\} \tag{8}$$

subject to

$$\begin{aligned} c+a' &\leq (1+i)a+(1-\tau)\omega(a) \\ 0 &\leq a' \end{aligned}$$

Associated with (7) and (8) are a set of decision rules for asset holdings $\overline{a}_u(a)$ and $\overline{a}_e(a)$, respectively. Making use of the budget constraint yields the decision rules for consumption $\overline{c}_u(a)$ and $\overline{c}_e(a)$.

Turning to employers, the Bellman equation associated with a job paying a wage ω filled by a worker whose current asset level is a reads

$$J(a) = \max_k \{f(k) - (i+\delta)k - \omega(a)\} + \frac{1}{1+i}\int \max\{J(a') - z', -F\} dH(z') \tag{9}$$

where $a' = \overline{a}_e(a)$. The level of capital $\tilde{k}$ that is optimally chosen solves

$$f'(\tilde{k}) = i + \delta \tag{10}$$

Thus, an entrepreneur's choice of capital is a static decision, but to form expectations he/she recognizes that the worker's next period asset decision will be dictated by $\overline{a}_e(a)$. The maximization under the integral sign corresponds to the firing decisions when the asset value of an unfilled position is zero, which holds true in equilibrium.

3.2. **Job creation and job destruction.** Entrepreneurs create new vacancies until the net present discounted value of doing so is exhausted. At the time of posting a vacancy, an entrepreneur observes the distribution of unemployed persons across asset levels, but by the time of meeting the worker, asset holdings have evolved according to the decision rules $\overline{a}_u(a)$. The free-entry condition thus reads:

$$\eta = \frac{1}{1+i} q(\theta) \int J(a) d\widetilde{\mu_u}(a) \tag{11}$$

where $d\widetilde{\mu_u}(a) = \frac{1}{\overline{\mu_u}} \mu_u(\overline{a}_u(a)) da$, $\mu_u(.)$ is the distribution of assets among the unemployed and $\overline{\mu_u} = \int_A a d\mu_u(a)$ is the size of the unemployment pool.

Job destruction decisions are subsumed by the function $\overline{z}(a)$ given by:

$$\overline{z}(a) = J(a) + F \tag{12}$$

This corresponds to an entrepreneur's arbitrage between the continuation value of a filled job (the asset value J minus the production cost z) and the value of an unfilled position net of the layoff payment. Workers take this arbitrage as given to form expectations about their layoff probability: $\lambda(a) = \overline{H}(\overline{z}(a))$, with $\overline{H}$ the complementary cumulative distribution function of shocks to production costs.

3.3. **Prices determination.**

Wage-setting. Following much of the literature, the wage-setting mechanism is assumed to be a Nash bargain between the employer and the worker. The wage function $\omega(.)$ is thus given by

$$\omega(a) = \arg\max_w \left\{ (W(a,w) - U(a))^{\phi} J(a,w)^{1-\phi} \right\} \tag{13}$$

for all a. $\phi \in [0,1]$ denotes workers' bargaining power. For future reference, it is useful to write the first-order conditions associated with this program; this reads

$$\frac{1}{1-\phi} J(a) = \frac{1}{\phi(1-\tau)u'(\overline{c}_e(a))} (W(a) - U(a)) \tag{14}$$

where $u'(.)$ is the marginal utility of consumption and $\overline{c}_e(a)$ is the optimal consumption level of the worker, i.e. $\overline{c}_e(a) = (1+i)a + (1-\tau)\omega(a) - \overline{a}_e(a)$.

Interest rate. The asset market clearing condition pins down the interest rate. This requires the computation of equilibrium dividends, which correspond to the sum of profits across all production units distributed according to $\mu_e(a)$ and v:

$$d = \int_A \left(f\left(\tilde{k}\right) - (i+\delta)\tilde{k} - \omega(a) - \frac{\overline{H}\left(\overline{z}\left(\overline{a}_e(a)\right)\right)F + \int_0^{\overline{z}(\overline{a}_e(a))} z dH(z)}{1+i} \right) d\mu_e(a) - \eta v \tag{15}$$

The term under the integral sign corresponds to the periodic profit of an entrepreneur matched to a worker whose current asset level is a. The last term involving $H(.)$ follows from equation (9) (after making use of the reservation property for the layoff decision): entrepreneurs borrow against future realizations of the stochastic shock. Thus, the equilibrium can support high levels of severance payments even when entrepreneurs cannot pay them out of their pockets.

Given d, the unit price of equity p can be computed through the no-arbitrage condition (6). Finally, since the amount of equity sums to one, equilibrium on the asset market reads

$$\overline{k} + \frac{d}{i} = \int_A a d\mu_u(a) + \int_A a d\mu_e(a) \tag{16}$$

On the left hand side, $\overline{k}$ is capital aggregated across production units, which equates $\tilde{k}$ times the employment rate. The term d/i is the value of claims to the economy's firms: through (15), this incorporates borrowing against stochastic production costs and layoff penalties. Finally the right-hand side of equation (16) is total asset holdings among households.

3.4. **Government budget.** The government determines the flat-rate tax τ so as to balance its budget in every period. Given the policy instruments F, S and b the balanced-budget condition reads

$$\tau \int \omega(a) d\mu_e(a) + (F-S)\Omega = (1-\tau)\int b d\mu_u(a) \tag{17}$$

where Ω denotes the total number of jobs that are destroyed in equilibrium. This is given by $\Omega = \int_A \overline{H}\left(\overline{z}\left(\overline{a}_e(a)\right)\right) d\mu_e(a)$.

3.5. **Ergodic distribution.** Job creation and job destruction together with the decisions for asset holdings imply a law of motion for workers across the different states of the economy. This law of motion corresponds to:

$$\begin{aligned} \mu_u\left(A^0\right)' = & \int_{A^0}\int_A \overline{H}\left(\overline{z}\left(a'\right)\right) 1\left\{a' = S + \overline{a}_e(a)\right\} d\mu_e(a)\, da' \\ & + \int_{A^0}\int_A (1-\theta q(\theta)) 1\left\{a' = \overline{a}_u(a)\right\} d\mu_u(a)\, da' \end{aligned} \tag{18}$$

$$\begin{aligned} \mu_e\left(A^0\right)' = & \int_{A^0}\int_A H\left(\overline{z}\left(a'\right)\right) 1\left\{a' = \overline{a}_e(a)\right\} d\mu_e(a)\, da' \\ & + \int_{A^0}\int_A \theta q(\theta) 1\left\{a' = \overline{a}_u(a)\right\} d\mu_u(a)\, da' \end{aligned} \tag{19}$$

for all A^0 in the asset space.

3.6. Equilibrium.

Definition. A competitive equilibrium for the economic environment under study consists of a list of value functions $(U(a), W(a), J(a))$, a set of decisions rules for asset holdings $(\overline{a}_u(a), \overline{a}_e(a))$ and layoffs $\overline{z}(a)$, a list of wage and layoff probability functions $(\omega(a), \lambda(a))$, a distribution of workers across assets and labor market status given by $\mu_u(a)$ and $\mu_e(a)$ and a tuple (τ, i, θ) such that:

(1) Optimal asset holding decisions: Given (τ, i, θ) and the functions $(\omega(a), \lambda(a))$, the asset holding decisions $\overline{a}_u(a)$ and $\overline{a}_e(a)$ solve the inner maximization problem in the Bellman equation for U and W, respectively.
(2) Optimal layoff decisions: Given (τ, i, θ) and the wage function $\omega(a)$, the value functions J solves the Bellman equation of the entrepreneur and yields the layoff decision $\overline{z}(a)$ in (12).
(3) Perfect foresight of layoff decisions: Given (τ, i, θ) and the layoff decision $\overline{z}(a)$, the layoff probability in the Bellman equation for W is given by $\lambda(a) = \overline{H}(\overline{z}(a))$.
(4) Nash bargaining: Given (τ, i, θ) and the list $(U(a), W(a), J(a))$, the wage function $\omega(a)$ ensures that the first-order condition (14) holds.
(5) Time-invariant distribution: Given θ, the decisions rules for asset holdings $(\overline{a}_u(a), \overline{a}_e(a))$ and layoffs $\overline{z}(a)$, the distributions $\mu_u(a)$ and $\mu_e(a)$ are time-invariant for the law of motion stated by (18) and (19).
(6) Market-clearing: The tuple (τ, i, θ) ensures: (i) free-entry for firms in (11), (ii) the clearing condition for the asset market in (16) and (iii) a balanced government budget in (17).

A competitive equilibrium of this economy embeds two functional fixed-point problems because agents need to know $\omega(a)$ and $\lambda(a)$ in order to optimize. In addition, an equilibrium is also a fixed-point with respect to the tuple (τ, i, θ). Appendix A details the numerical methodology to handle these fixed-point problems and compute the model.

4. Calibration and Steady-State Analysis

This section describes the calibration of the Laissez-Faire economy ($F = S = 0$) and characterizes the steady-state equilibrium. This economy is disciplined by U.S. labor market data. This has two advantages. First, estimates of the matching function (which affects the response of labor market variables to changes in congestion externalities) are available for this country. Second, labor market dynamics as observed in the data is unlikely to be contaminated by severance payments since those are virtually non-existent in most U.S. states.

4.1. **Benchmark calibration.** The model period is chosen to be six weeks and $\beta = 0.995$ to target an (annualized) interest rate of 4%. The capital share ξ is set to 0.30 and the depreciation rate δ is set to 1 percent. The utility function is of the form: $u(c) = \log(c)$. This choice is motivated by two considerations. First, the model time period dictates a high elasticity of intertemporal substitution. Second, these are the preferences selected by Hopenhayn and Rogerson (1993) and Alvarez and Veracierto (2001): the welfare figures can thus be compared across studies.

The parameters pertaining to the conventional search-and-matching features the model are calibrated using standard values from the literature. Consistent with the long-run behavior of the U.S. labor market, the targeted values for the monthly job-finding rate and the unemployment rate are 45 percent and 6.25 percent, respectively. α, the elasticity of the job-filling rate with respect to labor market-tightness, is set to 0.70 which falls well within the range of estimates surveyed by Petrongolo and Pissarides (2001). M is chosen to be 0.592, which delivers the targeted job-finding rate when $\theta = 1$. The latter serves as a normalization to calibrate the unit cost of vacancy creation η. The value of unemployment benefits b is set equal to one: it turns out that, in equilibrium, this amounts to 40 percent of the average wage, which is the value of the replacement ratio in the U.S. unemployment insurance system. Finally, following the standard Hosios-Pissarides rule, the bargaining power of workers ϕ is set equal to α, i.e. $\phi = 0.70$.

There remains to calibrate $H(.)$, the distribution of stochastic shocks that trigger job separations. As indicated in section 2 (footnote 8), the fact that layoffs account for only a share of all job destructions in the data calls for introducing another source of job separations. $H(.)$ is thus constructed as follows: with probability π_0, the production costs z remains set equal to zero, with probability π_1 the job is destroyed exogenously and with probability $1-\pi_0-\pi_1$ the production cost is drawn from a uniform distribution over $[0, \nu]$. π_0, π_1 and ν are chosen to satisfy the following conditions. First, the targets for the job-finding rate and unemployment imply a monthly separation rate of 3 percent (4.47 percent on a semi-quarterly basis). Second, according to the Job Opening and Labor Turnover Surveys (JOLTS), layoffs account for one-third of all separations[10]. Third, shocks to production costs must be large relative to the asset value of jobs to make layoffs the preferred decisions of entrepreneurs in some circumstances. As a benchmark, it is assumed that they can be as large as 10 times the average value of a job (or, on average, they amount to 5 times the value of a job); this is the value assigned to ν. Because these shocks are weakly identified from the data, section 6 will explore alternative parametrizations of the shock process.

4.2. **Steady-state.** Table 1 summarizes the parameter values of the benchmark model. Key parameters are π_0, π_1 and ν which govern job-separations: altogether, they imply that the asset value of a job is close to 1.0, which explains the value of $\nu = 10.0$. The probability of being hit by a positive shock z given by $1-\pi_0-\pi_1$ is then 1.65 percent and the layoff probability is between 1.48 and 1.49. This makes the probability of dismissal conditional on a positive production shock equal to 90 percent. Finally, through the reservation property for the layoff decision $\bar{z}(.)$, these values imply that a layoff tax around 9 (i.e. ν minus the asset value of a job) would eliminate all layoffs[11].

[10] It is true that not all layoffs are followed by a transition to unemployment. Meanwhile, according to Survey of Income and Participation Program (SIPP), 25 percent of all unemployed persons report that they were laid off from their previous job. Besides, it is conceivable that the figure from the SIPP understates the actual number of layoffs due to, say, under-reporting by dismissed workers. This makes the figure of one-third for the fraction of layoffs among all job destructions from the JOLTS an empirically sensible choice.

[11] Table 1 also has implications for the relative costs of vacancy creation. Dividing η by gross output per worker (which amounts to 3.61 in equilibrium) yields a figure of 16 percent: this is in line with the cost of vacancies conventionally used in calibrated versions of the Mortensen-Pissarides model (see e.g. Fujita and Ramey, 2012).

Table 1. Benchmark Parameter Values

Comments	Value
Subjective discount factor	$\beta = 0.995$
Utility function	$\log(c)$
Capital share	$\xi = 0.30$
Depreciation rate of capital	$\delta = 0.01$
Unemployment insurance	$b = 1.00$
Efficiency of the matching function	$M = 0.592$
Elasticity of the job-filling rate	$\alpha = 0.70$
Bargaining power of workers	$\phi = 0.70$
Unit cost of vacancy creation	$\eta = 0.586$
Persistence of jobs	$\pi_0 = 0.954$
Exogenous separation rate	$\pi_1 = 0.029$
Magnitude of production shocks	$\nu = 10.0$

Figure 1 plots the wage function, layoff probability and ergodic distribution of wealth that characterize the steady-state equilibrium of the Laissez-Faire economy. Beginning with the wage function (upper graph), since the difference between the asset values of employment and unemployment decreases with consumption, and thereby assets, wages increase with assets in a concave fashion inherited from the utility function. The increase, however, is concentrated in the lower part of the asset space where workers avoid to reside in equilibrium, and wages are otherwise flat for most asset levels. By the same token, the layoff probability increases with assets and is almost independent of wealth (middle graph). That is, due to Nash bargaining the asset value of a filled job to the entrepreneur decreases with the current asset level of the worker with whom he/she is matched. A poor worker is thus less likely to be fired, but differences across workers with different levels of wealth are negligible. In sum, the model does not bear strong implications for the effect of financial wealth on individual's labor market outcomes.

The following patterns of accumulation and decumulation of assets characterize idiosyncratic trajectories across the different states of the economy: while employed, workers accumulate assets in order to cope with the risk of unemployment and, while unemployed, they consume their financial wealth. Since these trajectories are the only source of difference across workers, the model falls short of generating high levels of wealth dispersion (lower graph). In equilibrium, the interest rate is driven close to workers' subjective discount rate and makes them accumulate a large stock of financial wealth: the aggregate level of asset holdings is around 68 units. Given that unemployment spells are of short durations on average (around 10 weeks), workers achieve high levels of consumption smoothing in spite of a replacement income from the unemployment insurance system that is more than twice lower than the average wage. For instance the average consumption level among the unemployed is only one percent lower than among the employed. These features imply that severance payments cannot play too large an insurance role.

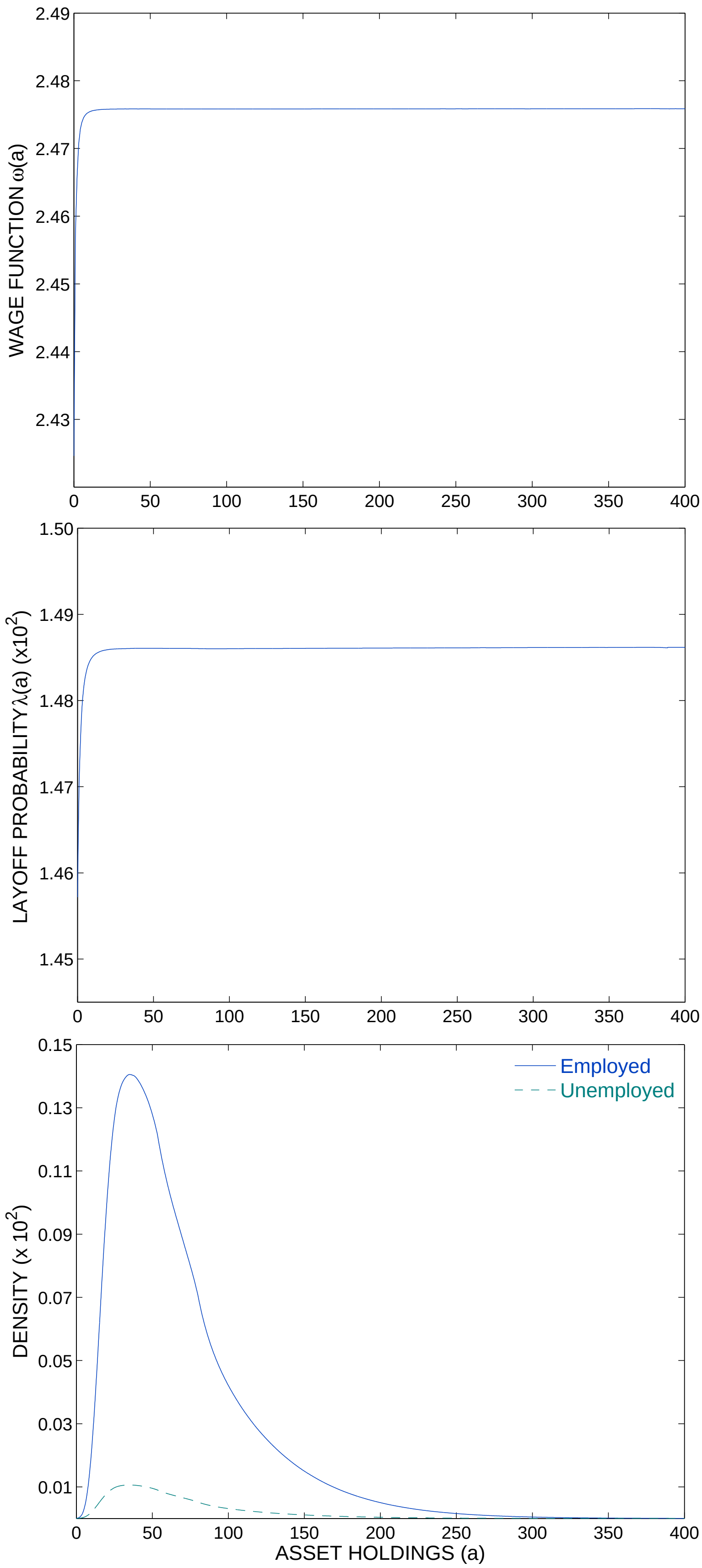

Figure 1. Properties of the Laissez-Faire Economy

NOTE: The upper graph plots the wage $\omega(.)$ as a function of a worker's assets. The middle graph plots the lay-off probability $\lambda(.)$ as a function of a worker's assets. The lower graph plots the ergodic distribution of wealth.

5. Quantitative Results

This section discusses the employment and welfare implications of increasing severance payments gradually from zero to higher levels in the benchmark calibrated economy.

5.1. **Main results.** Table 2 reports the main quantitative results of the paper. The first column is for the Laissez-Faire economy while the other columns characterize equilibria with different levels of severance payments relative to Laissez-Faire[12]. Severance payments are increased until $S = 10$, which corresponds to 6 months of the average workers wage under Laissez-Faire. This is because beyond this point, they do not have any effect under the benchmark calibration: as discussed in subsection 4.2, severance payments around 9.0 are sufficiently large to eliminate all layoffs.

Focusing first on the labor market, severance payments decrease the separation rate: the penalty imposed on employers who fire their incumbent workers has the effect to “lock” the latter into their jobs. This occurs until all layoffs are eliminated and drives the total separation rate to the exogenous separation rate π_1. By the same token, severance payments reduce the average wage in the economy since employers expect to retain their workers more often following an adverse shock to production costs. Overall, these changes tend to reduce the job-finding rate, although for moderate levels of severance payments labor market tightness increases slightly due to the decline in wages. What is noteworthy is that despite a large decline in the unemployment rate (from 6.25 percent to 4.29 percent), unemployed workers do not enjoy a reduction in the duration of unemployment spells (the latter increases by 3 percent). This is because vacancies diminish by about the same levels as the unemployment rate and crowd out the gains from reduced congestion externalities.

Turning to the consequences for aggregate output, table 2 indicates that the total amount of physical capital increases as employment rises. These changes occur at the same pace, which leaves the capital/labor ratio almost unchanged. As a result, gross output increases (there are more active production units), but so do the costs in the form of capital destroyed in every period and intermediate goods, i.e. the sum of the vacancy and stochastic production costs. As for the latter, higher severance payments shift the costs of achieving a given level of employment from the first to the second component: they cause entrepreneurs to post less vacancies but to incur larger costs after beginning production. One notices that the increase is slightly convex, which connects to congestion externalities on employers' side of the market. That is, the marginal cost of substituting away from vacancies increases when the number of vacant jobs diminishes[13]. This results in an inverted U-shape for net output: aggregate consumption initially increases but reverts to its Laissez-Faire level when mandatory severance payments amount to 6 months of the average workers wage.

[12]Statistics without meaningful units of measurement are normalized to 100.0 in the steady-state equilibrium of the Laissez-Faire economy. The separation rate and the job-finding rate are converted to monthly values. The levels of severance payments S are expressed in months of average workers' wage under Laissez-Faire. Underlying the table are computations of steady-state equilibria for each S in the $[0,10]$ interval where the step of the increase is 0.10. The same procedure is used for tables 3 to 6.

[13]It shall be noted that the choice of a uniform distribution for the stochastic component z is neutral in this respect. A positively-skewed distribution for instance would generate this convex association between severance payments and the costs in the form of intermediate goods even in the absence of congestion externalities on employers' side of the market. Unfortunately, labor market data does not offer much guidance about the structure of these shocks. This calls for proceeding with a distribution that does not introduce non-linearities in a potentially artificial way.

Table 2. Quantitative effect of severance payments: benchmark calibration

	Laissez-Faire	S (in months of workers' wages)					
		1	2	3	4	5	6
Separation rate	3.00	2.82	2.64	2.45	2.27	2.09	2.00
Job-finding rate	45.00	45.05	45.05	45.00	44.89	44.74	44.64
Unemployment rate	6.25	5.89	5.53	5.17	4.82	4.46	4.29
Gross output	100.0	100.43	100.86	101.29	101.71	102.13	102.35
Physical capital	100.0	100.42	100.86	101.28	101.71	102.13	102.35
Intermediate goods	100.0	101.01	102.66	104.37	106.51	108.96	110.21
Wage	100.0	99.11	98.40	97.87	97.52	97.35	97.33
Consumption	100.0	100.35	100.54	100.58	100.46	100.17	99.97
Welfare	100.0	100.39	100.60	100.62	100.49	100.20	100.01

The last row of table 2 shows the welfare implications of introducing severance payments in the benchmark calibrated economy. Denoting by c^0 and μ^0 the consumption levels and distribution of workers under Laissez-Faire and by $\widetilde{c}$ and $\widetilde{\mu}$ their counterparts for a given level of severance payments, the welfare figure corresponds to the value of ϑ such that

$$(20) \qquad \int \sum_{t=0}^{+\infty} \beta^t u\left((1+\vartheta)\, c^0_{i,t}\right) d\mu^0_i = \int \sum_{t=0}^{+\infty} \beta^t u\left(\widetilde{c}_{i,t}\right) d\widetilde{\mu}_i$$

On the basis of this metric, the welfare gains from severance payments amount to at most 0.60 percent when expressed in consumption terms and the welfare-maximizing level turns out to be three months' wages. Beyond this level, the gains vanish way and they are virtually zero for severance payments that amount to 6 months of the average workers wage.

The welfare figures are well accounted for once contrasted with changes in aggregate consumption across the different economies. Indeed, the figures line up so closely that differences would not be discernible with figures not reported with two decimal places. The discrepancy mostly reflects the fact that severance payments reduce the number of unemployed persons. But since workers smooth consumption well across their transitions in and out of employment, changes in the unemployment rate cannot generate large differences in welfare between two steady-state equilibria. As a result, changes in welfare stem predominantly from changes in consumption levels. The hump-shaped behavior thus reflects the behavior of net output: moderate levels of severance payments result in a more efficient allocation of labor and they thereby raise output, consumption and welfare.

Discussion. A tempting interpretation of the welfare effects of severance payments in table 2 is that they lie in between Hopenhayn and Rogerson (1993) and Alvarez and Veracierto (2001). On the one hand, they concur with the former on the existence of sizeable negative effects from large severance payments. In the present setting, this reflects the fact that they distort firms' decisions by inducing them to substitute away from vacancy creation. However, the negative implications cannot be as large as in their paper since severance payments have the potential to enhance efficiency and welfare in the environment under study.

Conversely, lower levels of severance payments increase welfare by altering firms' private decisions and thereby by balancing hiring and firing costs in the aggregate. This results in welfare gains that are similar to those computed by Alvarez and Veracierto (2001) for severance payments around 3 months' wages. These similar figures conceal a difference in mechanisms: in their framework, the efficiency argument is scant while, in light of table 2, it is predominant in this paper. In turn, this reflects the different premium that each study puts on labor demand and supply. Alvarez and Veracierto consider a labor market essentially driven by the costly search efforts of the unemployed, whereas standard matching frictions in this paper shift the emphasis on the value of hiring a worker for the prospective employer and the induced congestion externalities. The latter matter notably to explain the convex increase in costs in the form of intermediate goods, as higher severance payments prevent employers to take advantage of diminished crowding out when the number of vacancies declines. Hence the divergent diagnosis for these levels of severance payments: they produce negative allocative and welfare effects in the model while they keep increasing workers' welfare in their study.

The rest of this section provides further analysis of the findings from table 2 that highlight the role of the efficiency and welfare arguments.

5.2. **Layoff penalties vs. severance payments.** This subsection studies the effects of restricting severance payments to the layoff penalty component F. This is instructive for several reasons. First, if the efficiency argument prevails in determining the welfare-maximizing level of severance payments, then most of the effects in table 2 must originate from this penalty component. Conversely, if the transfer component S plays a significant role in helping dismissed workers cope with joblessness, then one expects to find significantly lower welfare figures when layoff penalties are not rebated towards dismissed workers. Finally, the experiment is also interesting from the perspective of existing studies of severance payments. As mentioned in the introduction, much of this literature envisions them as a sunk cost for the worker-firm pair (see Garibaldi and Violante, 2005). It is thus instructive to contrast the findings from table 2 with the results obtained under the more standard view of firing costs.

Table 3 reports the effects of increasing the layoff penalty F from zero to six months' wages while maintaining the transfer component S set equal to zero. This yields more fiscal resources for the government and allows the tax rate τ to be lowered. The latter effect however does not play a large role because only layoffs are taxed and they grow less numerous as the penalty is increased.

The results from comparing tables 2 and 3 are readily described: most of the effects of severance payments stem from the layoff penalty component, not from the transfer component. In line with the above discussion, the welfare figures are slightly lower than in table 2 because the resources from taxing layoffs benefit all workers (including the employed) instead of being rebated towards those who get fired and whose utility becomes lower after dismissal. The difference is nevertheless tiny: overall, the table agrees with Alvarez and Veracierto (2001) on the finding that the implications of severance payments follow mostly from their effect on firing decisions. There are thus two (non-exclusive) possibilities: this policy increases welfare either because they provide workers with higher job-security levels (workers face lower layoff risks) or because they increase consumption levels through a more efficient allocation of resources. The next subsection explains why the latter effect prevails in the environment under study.

Table 3. Quantitative effect of layoff penalties: benchmark calibration

	Laissez-Faire	F (in months of workers' wages)					
		1	2	3	4	5	6
Separation rate	3.00	2.82	2.64	2.46	2.27	2.09	2.00
Job-finding rate	45.00	44.83	44.70	44.62	44.59	44.61	44.64
Unemployment rate	6.25	5.92	5.57	5.22	4.85	4.48	4.29
Gross output	100.0	100.40	100.81	101.23	101.66	102.11	102.35
Physical capital	100.0	100.39	100.81	101.22	101.64	102.10	102.33
Intermediate goods	100.0	99.67	100.33	101.98	104.54	108.18	110.19
Wage	100.0	99.13	98.43	97.89	97.53	97.35	97.33
Consumption	100.0	100.33	100.52	100.55	100.43	100.16	99.96
Welfare	100.0	100.36	100.54	100.56	100.42	100.14	99.99

5.3. **Complete vs. incomplete markets.** To further understand the results in table 2, it is useful to consider the complete-market equivalent of the economic environment under study. With preferences dictated by equation (1), the social planner in the complete-market environment provides all workers with the same level of consumption[14]. Its objective is thus to maximize output subject to the constraint for labor reallocation stemming from matching frictions and stochastic shocks to production costs. The stationary solution boils down to the following problem: the planner determines the levels of capital and labor that maximize output while choosing the number of vacancies and the threshold level for stochastic shocks so as to minimize the cost of maintaining the targeted level of employment. The solution yields the constrained-efficient layoff rate[15] which is the focus of this subsection.

The table below displays the constrained-efficient layoff rate and the layoff rate obtained for the welfare-maximizing level of severance payments in the incomplete-market environment of section 2. For the complete-market economy, two optimal layoff rates are computed: one where the social planner uses the same amount of capital as in the incomplete-market economy ($k = \bar{k}$) and the other one where it uses the optimal capital stock ($k = k^*$). Anticipating on the robustness checks of section 6, the table also displays the results obtained for alternative parametrizations (columns I, II and III correspond to the calibrations in subsections 6.1, 6.2 and 6.3, respectively):

		Benchmark	Alternative calibration		
			(I)	(II)	(III)
Complete-market	$k = \bar{k}$	23.25	28.99	54.49	23.26
	$k = k^*$	21.06	28.14	51.12	21.68
Incomplete-market		19.86	26.89	49.73	21.60

Before comparing the complete- and incomplete-market economies, it is instructive to explain how the constraint on aggregate capital affects the optimal layoff rate in the complete-market economy.

[14]When considering the problem of the social planner, the effects of unemployment insurance and its provision through distorting taxes are abstracted from. As argued in footnote 6, they cannot play a quantitatively large role and they would therefore not add to the results of this subsection.

[15]The layoff rate is defined as the fraction of layoffs among all separations.

When this constraint is relaxed ($k = k^*$), the social planner is willing to maintain a higher employment rate. This lengthens the duration of the hiring process, which diminishes the opportunity cost of retaining workers in employment. Hence the lower layoff rates when $k = k^*$. One notices, however, that the differences with $k = \bar{k}$ are modest. This justifies using the complete-market environment without any constraint on aggregate capital as a reference point to study the incomplete-market economy, despite the fact that this economy faces less severe forms of imperfections.

According to the complete-market environment disciplined by the benchmark calibration, the layoff rate is optimal when it is set at 21 percent. In the Laissez-Faire economy, the actual layoff rate is 33 percent (see section 4) and when severance payments are introduced in this environment so as to maximize welfare, they bring this rate down to around 20 percent. Similarly in the other calibrations, the layoff rate induced by the welfare-maximizing level of severance payments under incomplete markets turns out to be only slightly below the constrained-efficient layoff rate. In sum, the optimal level of severance payments when insurance markets are incomplete almost implements the constrained-efficient layoff rate.

Two comments are in order. First, the relevance of the constrained-efficient level of the complete-market equivalent economy reflects the fact that the lack of perfect insurance markets is not a source of severe incompleteness in the model under study. Thereby, it confirms the prevalence of the efficiency argument in determining the welfare-maximizing level of severance payments. Second and relatedly, the welfare-maximizing layoff rate under incomplete markets lies under the constrained-efficient level because workers enjoy gains from severance payments beyond what they obtain from enhanced efficiency. Thus, if they were to face more difficulties to smooth consumption across periods, a lower layoff rate would be called for.

6. Robustness Analysis

As robustness checks to the results discussed in the previous section, this section analyzes three independent perturbations to the calibrated model. These alternative scenario check the sensitivity of the results with respect to the structure of shocks that trigger job separations. This is important because they determine the maximum level of layoff payments that may affect employers decisions, the fraction of workers who may benefit from these payments and also the behavior of the labor market through their impact on the separation rate. In each case, the model is recalibrated in order to match the targets discussed in section 4. The main results are found to be robust to these alternative calibrations.

6.1. **The magnitude of shocks to production costs.** This first robustness check allows for larger shocks to production costs by raising ν twofold, i.e. it is set to 20.0. Through equation (12), this makes the economy accommodate higher levels of severance payments. To maintain the separation rate equal to 3 percent in the Laissez-Faire economy, π_0 is increased to 0.955. Finally the free-entry condition requires to adjust the unit cost of vacancies η upwards to 0.587. The experiment is then to introduce severance payments twice larger than in section 5: they can be made as high as 12 months of the average workers wage.

Table 4. Quantitative effect of severance payments: the magnitude of shocks

	Laissez-Faire	S (in months of workers' wages)					
		2	4	6	8	10	12
Separation rate	3.00	2.83	2.65	2.48	2.31	2.14	2.00
Job-finding rate	45.00	45.03	44.97	44.81	44.55	44.19	43.80
Unemployment rate	6.25	5.91	5.57	5.24	4.92	4.61	4.36
Gross output	100.0	100.41	100.82	101.22	101.61	101.99	102.27
Physical capital	100.0	100.42	100.85	101.26	101.66	102.03	102.25
Intermediate goods	100.0	101.40	103.40	105.88	109.03	112.87	116.34
Wage	100.0	98.21	96.77	95.67	94.91	94.48	94.37
Consumption	100.0	100.26	100.22	99.88	99.23	98.27	97.26
Welfare	100.0	100.29	100.21	99.84	99.17	98.18	97.22

Table 4 reports the results obtained under this alternative calibration. Focusing first on the employment effects, the results reveal remarkably similar to those for the benchmark calibration. Higher severance payments reduce the separation rate and the average wage and leave the job-finding rate relatively unaltered. This reiterates the finding that lowered vacancy creation offsets the gains from reduced congestion externalities on workers' side of the market. As for production, the modified calibration also indicates that net output reacts in a hump-shaped fashion to the introduction of severance payments. Moreover, due to the larger magnitude of shocks, costs in the form of intermediate goods become larger than under the benchmark calibration when severance payments exceed six months' wages. Hence the negative welfare effects depicted in the right-hand side columns of table 4: higher levels of severance payment bring consumption and also welfare to levels that are more than 2 percent lower than under Laissez-Faire.

Another finding in table 4 is that it confirms the prevalence of the efficiency argument in determining the welfare-maximizing level of severance payments. That is, the table in subsection 5.3 describing the optimal layoff rate in the complete-market equivalent economy shows that in the presence of larger shocks to production costs, the layoff rate must be raised so as to spare these higher costs. This is the mechanism at play in table 4 behind the result that welfare peaks for moderate levels of severance payments. It shall also be noted that in this experiment too, the welfare gains are modest: they are only slightly above 0.25 percent.

Conversely, higher levels of severance payments have large negative welfare implications because they shift too much of the cost of labor reallocation on active firms: efficiency and welfare would be enhanced by allowing this firms to take advantage of the cheaper cost of vacancy creation. Relative to previous studies of severance payments, the figures in the last column of table 4 line up with the welfare losses computed by Hopenhayn and Rogerson (1993): they also find a reduction by over 2 percent. However, in the present setting, this occurs despite an improvement in the level of employment while the converse is true in their study. The divergence reflects the fact that the proposed setting embeds the equilibrium-unemployment model: the logic at play in this model implies that the unemployment rate should not be reduced under any circumstances.

Table 5. Quantitative effect of severance payments: the incidence of layoffs

	Laissez-Faire	S (in months of workers' wages)					
		1	2	3	4	5	6
Separation rate	3.00	2.63	2.27	1.91	1.54	1.18	1.00
Job-finding rate	45.00	45.09	45.09	44.98	44.77	44.46	44.26
Unemployment rate	6.25	5.52	4.79	4.06	3.33	2.59	2.21
Gross output	100.0	100.85	101.72	102.63	103.51	104.38	104.84
Physical capital	100.0	100.81	101.69	102.66	103.55	104.34	104.81
Intermediate goods	100.0	102.36	105.26	108.78	113.30	118.36	120.82
Wage	100.0	98.20	96.78	95.75	95.04	94.66	94.62
Consumption	100.0	100.70	101.09	101.18	100.94	100.36	99.95
Welfare	100.0	100.75	101.16	101.10	100.87	100.33	100.00

6.2. **The incidence of layoffs.** While according to the JOLTS layoffs account for one third of all separations, it is conceivable that a fraction of the remaining separations are not labeled layoffs but are nevertheless triggered by stochastic production costs that cannot be passed onto wages. This for instance would occur if it is in the interest of the worker-firm pair not to label these separations as layoffs[16]. This motivates this second robustness check that allows a larger portion of separations to be caused by shocks to production shocks. Specifically, π_1 is reduced twofold (it is set to 0.015) and π_0 is adjusted to 0.952. This maintains the separation rate equal to 3 percent but makes layoffs account for two-thirds of all separations in the Laissez-Faire economy. Finally, η is adjusted to 0.585 so as to ensure free-entry for firms.

Table 5 depicts the effects of increasing severance payments from 0 to 6 months' wages when layoffs have a larger incidence on the separation rate. As expected, severance payments bring the unemployment rate to a much lower level. They also reduce wages more than under the benchmark calibration since employers expect to incur layoff penalties more often. What is perhaps less expected is that under this calibration too, the job-finding rate reacts sluggishly and does not diminish significantly. This reflects the offsetting effect of falling vacancy creation. As a matter of fact, the average duration of unemployment spells increases by 6 percent when moving from the first to the last column of table 5. The result that workers do not benefit from reduced congestion externalities is hence a robust prediction of the model.

Turning to the effects on production, this alternative calibration reproduces the finding that net output initially rises and then declines, as illustrated by the row labeled "Consumption". As in the first robustness check, the increase in costs in the form of intermediate goods is of higher magnitude. In the scenario under study, this is due to the fact that stochastic production shocks are more frequent. This alters slightly the magnitude of the effects at work in the model. Indeed, the peak in welfare effect is now at one percent according to the metric of equation (20). Another difference is that changes in welfare and changes in aggregate consumption do not line up as closely as in section 5

[16]Postel-Vinay and Turon (2013) provide foundations for endogenous choices of labeling a job termination either as a layoff or as a quit in the presence of statutory severance pay.

due to more pronounced employment and wage effects of severance payments[17]. Meanwhile, the table confirms qualitatively the mechanisms uncovered by the benchmark model. Quantitatively, it reiterates the finding that welfare in the aggregate is maximized by moderate levels of severance payments while showing that the peak may be higher when layoffs have a larger incidence on entries into the unemployment pool[18].

Finally, with respect to the discussion of the efficiency argument in subsection 5.3, this second robustness check confirms that the welfare-maximizing level of severance payments under incomplete markets brings the layoff rate only slightly below the constrained-efficient level: 49.73 percent vs. 51.12 percent, respectively. These higher levels reflect the fact that, under Laissez-Faire, the layoff rate is as high as two-third. The close correspondence between the two figures shows that imperfect insurance markets are not a first-order reason for introducing statutory severance payments, even when layoffs are more prevalent. Thus, the results are not too sensitive to the assumption that the number of workers who may benefit from severance payments is bounded by the layoff rate observed under Laissez-Faire. What matters instead is that layoffs in the model do not cause important welfare losses for workers who get dismissed.

6.3. **Unavoidable layoff shocks.** This third robustness check adopts the view that, irrespective of their levels, severance payments cannot eliminate all layoffs. Specifically, it posits that only a portion of layoffs are triggered by shocks to production costs while the remaining ones cannot be avoided. Because the data does not offer much guidance about the fraction of unavoidable layoffs, the following experiments assume that those amount to 50 percent of all layoffs[19]. This requires adjusting downwards the magnitude of shocks to production costs for the remaining layoffs. It turns out that setting ν equal to 5.0 is sufficient to maintain the targeted moments described in section 4. Finally, it is assumed that all layoffs (including those that cannot be avoided) can be subjected to severance payments. In other words, the government only observes whether a layoff shock occurs but does not know whether the employer has the possibility to avoid a dismissal.

With shocks of a lower magnitude, more moderate levels of severance payments are sufficient to eliminate all unavoidable layoffs. As illustrated in table 6, this occurs with payments around 3 months' wages, as they make the separation rate reach its plateau of 2.55 percent. By the same token, wages diminish and this occurs beyond the point where the separation rate becomes constant: they incorporate the expected value of the future penalty incurred by the employer. This partly explains why vacancy creation does not fall significantly, as shown by the (almost) constant job-finding rate when severance payments exceed three months of the average workers' wage.

Table 6 shows that net output and thereby consumption peak for severance payments set equal to 3 months' wages and that they then remain roughly constant. This is because on the production side,

[17]This also holds true for table 4 where severance payment have a large impact on wages.

[18]This brings the results closer to Alvarez and Veracierto (2001) who assume that layoffs account for all separations. However, this does not overturn the result that higher levels of severance payments deteriorate welfare, which is an important difference between their conclusions and the findings analyzed here.

[19]More precisely, a shock that may cause a layoff occurs with probability $1-\pi_0-\pi_1$, as in the benchmark calibration. With probability one half, it is drawn from the uniform distribution $[0,\nu]$; with complementary probability, there is no such draw and the worker is dismissed.

Table 6. Quantitative effect of severance payments: unavoidable layoff shocks

	Laissez-Faire	S (in months of workers' wages)					
		1	2	3	4	5	6
Separation rate	3.00	2.82	2.64	2.55	2.55	2.55	2.55
Job-finding rate	45.00	45.05	45.05	45.03	45.04	45.05	45.05
Unemployment rate	6.25	5.89	5.53	5.37	5.36	5.36	5.36
Gross output	100.0	100.42	100.85	101.05	101.06	101.06	101.07
Physical capital	100.0	100.40	100.83	101.04	101.06	101.07	101.09
Intermediate goods	100.0	101.00	102.64	103.32	103.33	103.35	103.36
Wage	100.0	99.10	98.39	97.84	97.30	96.76	96.49
Consumption	100.0	100.35	100.54	100.58	100.58	100.58	100.58
Welfare	100.0	100.39	100.58	100.55	100.52	100.50	100.49

there are no further changes when one moves from the column corresponding to moderate levels of severance payments to the right columns of the table. That is, when all unavoidable layoffs have been eliminated, entrepreneurs are constrained to pay statutory severance pay whenever a layoff shock occurs. As this lowers the value of claims to the economy's firms, all the mechanisms at work from columns 3 to 6 go through the asset market. Hence the slight reduction in welfare: to achieve the same levels of consumption, workers need to hold more assets. This also account for residual changes in the job-finding rate and in production costs: the distribution of workers across asset levels affects the returns to filling a vacant job, and therefore the number of vacancies is not constant in columns 3 to 6. The same logic explains why the capital stock is non-constant as it is affected by changes in total assets held by households.

Finally, under the assumption that not all layoffs can be avoided, there is less room for efficiency improvements and, correlatively, this opens the way for more improvements originating from enhanced job-security. These arguments tend to balance each other out as they result in welfare figures in table 6 that are similar to those in table 2. On a related note, the comparison of the layoff rate in this economy and in its complete-market equivalent (subsection 5.3) may suggest that, on the contrary, the efficiency argument plays a more prevalent role under this alternative calibration. This logic is however flawed by the constraint that the layoff rate cannot be lowered below 21.6 percent. With this qualification in mind, it remains true that the efficiency role of severance payments outperforms their insurance role in table 6.

Overall, what this third robustness checks indicates is as follows. By construction of the proposed model, severance payments are effective in deterring employers from firing their workers following an adverse shock to production costs. This facilitates their use as a policy tool to implement the optimal layoff rate. In practice, it is conceivable that layoff decisions cannot be prevented so mechanically. This amounts to assuming that not all layoffs can be avoided. This last robustness scenario shows that under this assumption, the model does not yield much different predictions.

7. CONCLUSION

This paper studied the effects of statutory severance payments by means of a quantitative, general equilibrium model where the labor market is plagued by congestion externalities, wages cannot internalize stochastic shocks to production costs and insurance markets are imperfect. The conjunction of these imperfections allows the model to be relatively agnostic with regards to the efficiency and welfare implications of this labor market policy: it gives room to both potential gains and potential losses of severance payments. The model emphasizes the trade-off between allowing employers to fire their workers too often and inducing them to substitute away from vacancy creation. It shows that moderate levels of severance payments are best suited to address this trade-off. Moreover, it finds little support for the welfare justifications of this policy since workers smooth consumption well even in the absence of perfect insurance markets. Finally, another contribution of the paper was to develop a version of the Mortensen-Pissarides model with endogenous separations in the form of layoffs that are perfectly anticipated by workers and extend it to a general equilibrium environment where agents engage into precautionary savings.

A significant part of the analysis was devoted to discussing the results in relation with the studies by Hopenhayn and Rogerson (1993) and Alvarez and Veracierto (2001). The present paper can be understood as a middle course that provides foundations for the divergent findings of these two papers.

Like Hopenhayn and Rogerson (1993), the proposed model points to large negative implications of severance payments when they distort firms' decisions beyond what is socially optimal. The paper brings this result within the logic of equilibrium-unemployment theory, which makes these negative implications compatible with a reduced unemployment rate. Conversely, in the model positive effects prevail for moderate levels of severance payments: due to congestion externalities, the layoff rate is generically too high under Laissez-Faire and calls for policy intervention. Finally, assuming that insurance markets are imperfect is not sufficient to overturn the insights from the complete-market approach, which was adopted by Hopenhayn and Rogerson.

On the other hand, the model suggests that welfare gains from severance payments are an order of magnitude lower than computed by Alvarez and Veracierto (2001). Under the conditions of their analysis, large welfare gains follow from providing workers with higher job-security levels. Instead, in this paper the efficiency role of the labor market policy under study is prevalent. True, government-mandated severance payments reduce the frequency at which workers transit through unemployment but this has little welfare implications since workers self-insure well against shocks to their employment status. Thus, the similar welfare figures computed for moderate levels of severance payments result from different mechanisms.

The main results of the paper were shown to be robust to alternative assumptions about the production shocks that trigger layoffs. Data limitations prevented feeding the model with a more empirically-grounded structure for these shocks. Meanwhile, a question posed by this paper and an avenue for future research is: how large are the shocks that employers spare by firing their workers? Indeed, the proposed model suggests that the welfare-maximizing level of severance payments can be closely approximated by the optimal layoff rate. This rate follows from comparing the costs of vacancy creation (which can be computed using available estimates of these costs and of the parameters of the matching function) with the costs of retaining workers following an adverse shock to production costs. Information about the latter would thus deliver more informed predictions about the optimal level of statutory severance pay. This would be particularly relevant to replicate the analysis in this paper with data for European countries, where governement-mandated severance payments that exceed three months' wages are the rule rather than the exception.

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APPENDIX A. NUMERICAL METHODOLOGY

This appendix details the numerical methodology to compute steady-state equilibria as defined in section 3. The first step consists in discretizing the asset space. In practice, it is necessary to work with three distinct grids: one for the wage function, one for value functions and one for the support of the ergodic distribution. The first two grids are made more dense in the lower part of the asset space while the third one approximates the asset space with evenly-spaced points. The grids used for the computations of the paper have 100, 500 and 3500 points, respectively. The results are not significantly altered by these choices: for instance an asset grid with 2500 points for the distribution delivers virtually the same results. The upper limit for asset holdings is set equal to 400; this was never binding in the computations.

The algorithm to compute an equilibrium is then as follows:

(1) Guess a tuple $x^0 = \left(\tau^0, i^0, \theta^0\right)$.
(2) Given x^0, guess the wage function $\omega^0(a)$, where the superscript 0 indicates that this guess depends on the tuple x^0.
(3) Given $\omega^0(a)$, compute $J(a)$, $U(a)$ and $W(a)$ via the iterative method:
   (a) Since i^0 is known, $\tilde{k}$ can be solved for using the firms' first-order condition. $J(a)$ can then be obtained via value function iteration. This delivers $\lambda(a)$, the layoff probability that enters workers' expectations.
   (b) Solve the within-period maximization problem in equations (7) and (8) using linear interpolation and a golden-section search method. At this step, asset holdings and consumption decisions $\overline{a}_u(a)$, $\overline{a}_e(a)$, $\overline{c}_u(a)$ and $\overline{c}_e(a)$ are obtained.
   (c) When $S > 0$, knowledge of $U(a)$ above the upper limit of the asset space is required. In practice, regressing $U(.)$ against a cubic of asset for the last 25 grid points yield a R-square almost indistinguishable from 1. A highly accurate prediction can thus be obtained by using the associated OLS coefficients.
(4) Solve for the wage function implied by Nash bargaining using the first order conditions (14), i.e. solve for w in

$$\phi\left(f\left(\tilde{k}\right) - \left(i^0 + \delta\right)\tilde{k} - w + \frac{1}{1+i^0}\int \max\left\{J\left(a'\right) - z', -F\right\} dH\left(z'\right)\right) = \frac{1-\phi}{\left(1-\tau^0\right)u'\left(\overline{c}_e(a)\right)}$$
$$\times\left(u\left(\overline{c}_e(a)\right) + \beta\left(\left(1-\lambda\left(a'\right)\right)W\left(a'\right) + \lambda\left(a'\right)U\left(a' + \frac{S}{1+i^0}\right)\right) - U(a)\right)$$

for all a, where $\overline{c}_e(a) = \left(1+i^0\right)a + \left(1-\tau^0\right)w - \overline{a}_e(a)$ and $a' = \overline{a}_e(a)$. This is a non-linear equation which can be solved for using the bisection method. Denote by $\omega^1(a)$ the solution obtained at this step.
(5) If $\max_a\left|\omega^0(a) - \omega^1(a)\right|$ is close to zero, then move on to the next step. If not, update the wage function via

$$\omega^0(a) = \kappa\omega^1(a) + (1-\kappa)\,\omega^0(a)$$

and go back to step 3. Due to the sensitivity of the value functions to the probability $\lambda(a)$, it proves necessary to set $\kappa < 0.10$ to stabilize iterations over the wage function.

(6) Recover the location of asset decisions $\overline{a}_u(a)$, $\overline{a}_e(a)$ on the asset grid with many points. Also, use $J(a)$ together with linear interpolation to obtain the layoff decisions over this large grid. Then compute the invariant distributions $\mu_u(a)$ and $\mu_e(a)$ by iterating the laws of motion (18) and (19).

(7) Check whether the initial guess θ^0 is consistent with the free-entry condition. Specifically, compute

$$\theta^1 = q^{-1}\left(\frac{1}{\eta}\frac{1}{1+i^0}\int J(a)\, d\widetilde{\mu_u}(a)\right)$$

If necessary, update θ^0 using θ^1 and go back to step 1.

(8) Compute the market-clearing interest rate as the solution to

$$i\left(\overline{a}-\overline{k}\right) = \int\left(f\left(\tilde{k}\right)-(i+\delta)\tilde{k}-\omega(a)-\frac{\overline{H}\left(\overline{z}\left(\overline{a}_e(a)\right)\right)F+\int_0^{\overline{z}(\overline{a}_e(a))} z\,dH(z)}{1+i}\right)d\mu_e(a)-\eta v$$

with $\tilde{k} = f'(i+\delta)$ and $\overline{a} = \int_A a\,d\mu_u(a) + \int_A a\,d\mu_e(a)$ This is a non-linear equation which, again, can be solved for using the bisection method. Compare the solution i^1 with i^0 and, if necessary, update i^0 and go back to step 1. These updates should be very slow.

(9) Check whether the government balances its budget by computing

$$\tau_0\int\omega(a)\,d\mu_e(a)+(F-S)\,\Omega = (1-\tau_0)\int b\,d\mu_u(a)$$

If not, compute τ^1 that balances the budget, update τ_0 and go back to step 1. If the budget is balanced, then the computation is over.