# Could workplace accidents foster employment? The incentive role of the tarification of workers' compensation

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# Introduction

When it comes to modeling firms' productivity and the impact of the various shocks by which it is being affected on equilibrium employment, economists usually consider technology shocks, demand and supply shocks in addition to several types of economic frictions, but workplace accidents are in general not included. However, not only is their quantitative impact on aggregate output far from being neglectable in major OECD countries[1], but their impact on key macro- and micro variables moreover differs greatly according to the structure of the compensation system for occupational injuries.

### Overview of OECD compensation system for occupational injuries

OECD countries' compensation systems for occupational injuries display a dramatic diversity, which can be captured by three main dimensions:

- The public, private or mixed nature of the system
- The degree of mandatory insurance coverage (total or partial)
- The method of computation of the contribution (full or partial experience rating, flat rate, some combination of the two)

In the US, each state sets its own workers' compensation law, and although workers' coverage is mandatory and must be financed by the employer, there exist a dramatic diversity of organizations. Private insurance is the most common method, but it can coexist with a governmental state fund. In five states, the state fund is monopolistic and private insurers are not allowed. In most states, big enough companies can also self insure themselves. In Germany, the compensation system is national and compulsory, but it is administered by decentralized public law corporations. Belgium has a private obligatory insurance system, while France and Italy have publicly managed and fully centralized systems.

Workers' compensation systems are also characterized by the principles on which firms' contribution is based, chiefly the degree of risk sharing among

[1] In the US, the cost of occupational injuries was estimated between 2% and 4,3% of GDP in the mid 90's (see Leigh et al. (2000)). In Europe, The European Agency for security and health at work estimated this cost between 2,6% and 3,8% of GDP in 1999.

firms which belong to the same risk category[2]. To create incentives for employers to reduce sinistrality, most systems are, to a certain extent, experience rated, which means that an individual firm's contribution is an increasing function of the cost it generates for the system.

In order not to impose a disproportionate burden on small firms whose workers suffered severe workplace accidents in a given years, some systems moreover apply a degree of experience rating which is increasing with the size of the firm, thereby allowing smaller firms to mutualise risk. Such is for instance the case in Quebec, where partial experience rating only applies to firms which premium is higher than \$7 000, and full experience rating to firms which premium is above \$300 000. The most common system in the US, which applies is about 40 states and is set after the recommendations of a private insurance service provider (the National Council of Compensation Insurance), displays similar features. In Belgium, experience rating only targets firms which total payroll is above a certain threshold[3], and the degree of experience rating increases with the payroll. In France, firms with more than 200 full time equivalent employees are fully experience rated while firms with less than 10 pay a flat rate, e.g. risk is fully mutualised. In between firms' contribution has a degree of experience rating which is increasing with the number of workers. Italy has a similar system: the degree of experience rating is increasing with the company size, measured in "man day", i.e. the ratio of total payroll divided by the average wage.

### Related literature

From a microeconomic point of view, numerous empirical studies[4] have shown that an increase in the degree of experience rating of firms' contribution lead to a significant decrease in firms' individual incidence (measured by the cost of workplace injuries) through an increase in safety investments on the one hand, and through a greater control of accidents' costs and reporting on the other hand. Risa (1995) however builds a theoretical model which shows that a welfare state insurance (which must be understood as a flat rate contribution) can generate an equilibrium with a lower injury severity than an insurance system based on experience rating under specific conditions on the relative magnitude of income and substitution effects. More precisely,

[2] Each system has its own definition of risk categories, but they all are set according to the industry to which the firm belongs and to the activity it performs

[3] Total yearly payroll has to be greater than €5 000 000 for wage earners and above €1250000 for salaried employers.

[4] See for instance Atkins (1993) or Lu, Oswalt and Shields (1999).

assuming a perfectly competitive labor market and perfect information of workers regarding firms' investments in safety, she shows that workers' trade off between higher wage but lower safety versus lower wage but higher safety is not necessarily in favor of the first alternative. This result however crucially relies on the assumption of a perfectly competitive labor market, which many empirical studies denies.

The literature on the macroeconomic impact of experience rated contributions for workplace accident benefits is relatively poor. However, such is not the case of experience rated unemployment insurance contribution, which has been extensively studied in the past few years. A first issue of interest is the extent to which an experience rated contribution to the unemployment insurance system could decrease the volatility of employment. In order to explain why firms usually prefer temporary layoffs to a decrease in the number of hours worked during economic downturns, Feldstein (1976) shows that unemployment benefit must in fact be understood as a subsidy which is part of the contract package. The insurance provided to workers can indeed be used as a substitute to wage during periods in which an individual firm needs less labor. The consequence is that firms in stable industries cross subsidize those which have a more volatile activity and use unemployment benefit as a substitute to wage more often. An experience rated contribution would consequently imply a redistribution from volatile firms toward more stable ones, thereby shifting the structure of unemployment accordingly.

Malherbet and Ulus (2003) come up with a similar result concerning the reallocation of labor, but with a different theoretical framework, namely a search model with heterogeneous firms. A more generous unemployment insurance increases the equilibrium size of the most volatile industry (in terms of labor turnover and productivity). The introduction of experience rating in firms' contribution tends to decrease the size of the latter. Whether this is desirable or not from a welfare point of view remains ambiguous since no industry exhibits uniformally better features than the others.

In another contribution, l'Haridon and Malherbet (2002) show that experience rating can lead to a decrease not only in the volatility, but also in the level of unemployment by comparing two alternative job protection measures: firing costs and an experience rated based contribution. If unemployment benefit was experience-based, firms would internalize its cost and lay-off less often. Alternatively, firing costs increase firms' reluctance to hire and therefore hinders the full transmission of the benefits of economic booms to the labor market.

The compensation system for workplace accidents has many features in common with the unemployment insurance system. Firstly, they both aim able-bodied working individuals temporary out of work. Secondly, firms contribute in both cases to the system[5]. Thirdly, benefits are conditioned on past earnings and stop upon the return to work. Fourthly, they both are contra-cyclical in the sense that they aim at maintaining the purchasing power of the unemployed.

Because of these similarities, they both affect labor demand and supply in a way which strongly depends on the design of the compensation system. Their respective impact on labor supply has already been extensively studied, the most investigated issue being the influence of the level and duration of benefits on the spell out of work. As already mentioned, the impact of unemployment insurance on labor demand (both in terms of volume of volatility) has also been extensively examined. What therefore remains unexplored is the impact of workers' compensation system on labor demand.

**Modeling the impact of the tarification of workers' compensation on labor market structure**

More precisely, we focus on systems which impose a different methodology to compute firms' premium according to their size, namely an experience rated contribution for big firms and flat rate contribution for small firms, and examine the impact of this heterogeneity on aggregate labor market structure. For the sake of simplification, we only consider big and small firms and disregard any "in between" firms.

In order to address this issue, we use the same theoretical framework as l'Haridon and Malherbet (2002) and Malherbet and Ulus (2003), namely a search and matching model with endogenous job destruction and heterogeneous firms in line with Mortensen and Pissarides (1993) and Mortensen and Pissarides (1994). We first study the equilibrium impact of an increase in firms' contribution to the workplace accidents compensation system in the case of a single labor market (ie all firms are either big or small). We then consider an economy in which two labor markets coexist to analyze the spillovers effects. For this purpose we introduce directed search in our previous model.

[5]Firms however share the burden of contribution with workers in the case of unemployment insurance, whereas they are the sole contributor for workplace accidents.

We consider a tarification policy in a single labor market economy efficient if the level of firm's contribution maximizes steady state employment. In an economy where big and small firms coexist, maximizing total employment in steady state may not be a first best solution if one type of firm is uniformally better[6]. Such a polarisation of jobs is however rather unlikely in general. Each type of firm indeed has its own advantages, eg a higher productivity due to economies of scale in big firms, versus more flexibility in small ones. In such a case welfare can be measured by the sum of workers' and firms' surplus that results from a match, and the decentralised optimum is achieved when the set of exogenous parameters maximises it. The Hosios-Pissarides condition[7] tells us that such is the case when workers internalize the negative externality that they generate on fellow workers by being present on the market[8]. We will use this condition in our calibration exercise and target the maximization of total employment as a second best interior solution.

Since the contribution affects firms' profitability significantly, it could be that the latter react by altering their organisation in order to achieve the best mix between contribution rate and production efficiency given the category of risk to which their activities belong. In that sense, size can be considered, at least in the medium run, as belonging to the set of firms' decision variables. Firms' organisational choices in terms of decentralisation and/or dropping certain activities can be captured by a size decision variable and potentially has a lot of welfare implications. The latter depend on the nature of firms' heterogeneity and on the type of uncertainty they are subject to.

The rest of the paper is organized as follows: section 1 will present the model, section 2 will derive the steady state equilibrium and determine how the policy parameters influence the level and structure of employment (i.e. the proportion of worker employed in each type of firm) in the case of a single labor market economy. Section 3 will solve the model for an economy in which big and small firms coexist. Finally, section 5 will calibrate the model for the French economy and quantify the impact of the tarification of firms' contribution on labor market structure.

[6] Uniformmaly better jobs can be called "good jobs" as opposed to "bad" ones, following the terminology of Acemoglu (2001).

[7] See Hosios (1990) and Pissarides (2000).

[8] More precisely, the Hosios Pissarides condition states that in order for the private surplus of the worker to be equal to his social surplus, the share of the total surplus that he gets from a match - whether new or continued - must be equal to the elasticity of the matching function.

# 1 The model

We study a production economy in which labor is the only input and where one numeraire good is produced and consumed. The labor force is composed of a continuum of homogeneous agents with measure one. They are homogeneous in the sense that they have the same preferences and their skills are identical. They can thus work either for big or small firms. In the case where both types of firms coexist, they apply only to one - that which ensures them with the highest expected surplus. Each worker supplies one unit of labor if he is employed; if he is not he looks for a job.

## 1.1 Firms' characteristics

Entrepreneurs can decide whether to open a vacancy or not and if both types of firms coexist, they also choose on which labor market to enter. Big firms are larger production units that differ from small ones in several aspects, some of them being the technological consequences of their organisation, some other coming from the legislation on labor accident compensation benefits.

### 1.1.1 Productivity and fixed costs

The productivity of a non previously injured worker in firm $i$, $i = b$ (standing for "big") or $i = s$ (standing for "small"), is equal to $p_i$. We assume that big firms are more productive than small ones, i.e. $p_b > p_s$. When an injury occurs, the productivity is reduced to a fraction $(1 - \epsilon)$ of what it previously was, $\epsilon$ being the severity of the injury.

Let $k_i$ be the flow cost of maintaining a vacancy in a firm of type $i$[9]. Theoretically, we could find a justification for both assumptions $k_b \geq k_s$ and $k_b \leq k_s$. In the first case, we could think of big firms as having more costly machines that depreciate when not in use. One further justification for the most capital intensive firms' being bigger could be that machines are not perfectly divisible such that several workers are required per machine[10]. On the other hand, it could be that big firms benefit from economies of scale and/ or learning by doing effects (if we admit that big firm are generally older), which would imply the opposite.

Since it is not clear which is more relevant empirically, let's not choose between these two assumptions at this stage. We must however keep in

[9]Another way to interpret $k_i$ is to say that $k_i$ is the hiring cost per unit of time

[10]Note that this interpretation is not incompatible with the assumption that $k_i$ units of capital are needed per worker.

mind that the welfare implications are very different depending on which assumption we make. Indeed, if $k_b \leq k_s$, then jobs in big firms are both more productive and less expensive to maintain, therefore they can be assimilated to "good jobs" in comparison to the "bad jobs" offered in small firms to use the terminology proposed by Acemoglu (2001). If on the other hand $k_b \geq k_s$, then there is no clear polarisation of jobs and the only potential clear cut welfare effect of modifying the policy parameters would be the one on the total unemployment rate.

All jobs in firm $i$ are assumed to be created with maximum productivity $p_i$, i.e. firms match with non injured workers only.

### 1.1.2 Contribution to the compensation system for workplace accidents

Big firms pay a proportion $\alpha$ of the cost of injuries caused by their workers to the system by being disabled. Their contribution is modeled by a firing tax which amount equals the average cost to the system of an injured worker. Small firms pay a flat tax $T$ unconditionally of the injury cost. $\alpha$, the degree of experience rating, and $T$ are the policy parameters we want to optimize.

Workers who loose their job receive either an unemployment benefit $z$ or a workplace compensation benefit $b$. They can't receive both. The unemployment benefit targets only non previously injured workers who can look for another job immediately[11]. Workers who get injured but don't loose their job don't receive $b$. In other words, we only consider temporary total benefit and disregard the other three benefits of the workplace compensation system, namely permanent total, permanent partial, and survivors' benefits[12].

Since empirically $b > z$[13], the workers who recovered from a temporary disability and are searching for a job could be tempted to keep declaring themselves as disabled in order to receive $b$ instead of $z$ until they find a

[11]The reason why we assume that only "healthy" workers can look for a job is related to our assumption of homogeneous searching workers, i.e. they all have the same ex ante productivity.

[12]Temporary total benefit compensates for temporary injuries which oblige the worker to stay out of work for a while, permanent total benefit compensates for permanent disabilities which make it impossible to work again, permanent partial benefit compensates for permanent injuries which still allow to work, and survivors' benefits are paid to the descendants of a worker who faced a lethal workplace accident.

[13]Martin (1996) estimates the average replacement rate of unemployment benefits to 60% of past income in France, whereas workplace accident compensation benefits vary between 60% and 80% according to the French ministry of health and social affairs.

job. This effect is however controlled for, to a certain extent, through random when not systematic inspections conducted by the insurance company or the public organization in charge of the compensation system. This moral hazard effect is completely banned in France since social security inspectors systematically control every three months whether temporary disabled workers are still unable to search or whether they should be switched to the unemployment benefit.

Because we focus on the incentives of the tarification of the workplace accident compensation system, we neglect the cost of the unemployment insurance to the firm. The latter is neither differentiated between firms' size nor experience rated, except in the US[14] and therefore does not impact firms' decision to open a vacancy in one type of firm or the other. Although the level of firms' contribution to the unemployment insurance may affect their hiring and firing decisions, we ignore this effect in order to isolate the incentives of the contribution to the workplace accidents compensation system. The latter is therefore modelized as a pure fixed cost that is normalized to zero for both types of firms[15].

### 1.1.3 Random matching functions

Matching between workers and firms is imperfect (an unemployed worker can coexist with a vacant job and generate no matching although all jobs and workers are the same) because of transaction costs.

More precisely, let $M_i(u_i, v_i)$ be the instantaneous flow of new matchings in firms i. $u_i$ is the rate of unemployed workers on search market $i$; $v_i$ denotes the vacancy rate on market $i$ and $\frac{v_i}{u_i} = \theta_i$ is a measure of market tightness. We make the usual assumptions on the matching functions, i.e. they are increasing, continuously differentiable, homogeneous of degree one and yield no hiring if the mass of unemployed workers or vacant jobs is zero.

Search is assumed to be more efficient in big firms, i.e. for given vacancy and unemployment rates $v$ and $u$, $M_b(u, v) > M_s(u, v)$ and $M'_b > M'_s$[16]. This assumption can be justified by the fact that big firms are more widely

[14] The literature on the impact of an experience rated contribution on equilibrium employment is rather rich in the US. See for instance Acemoglu and Shimer (1999) for an interesting survey on the topic.

[15] In order for the unemployment system to balance its budget, we can always change the cost borne by each firm to the average expected cost transmitted to the system by its workers.

[16] Notice that if $k_b < k_s$, this assumption strengthens the polarisation of jobs.

known among job seekers, have access to more efficient communication tools (such as campus recruiting events) and benefit from economies of scale in their recruiting process (eg. standardized assessment tests and contracts). They are moreover likely to react more efficiently to a change in the ratio of applicants to vacancies by adapting the resources used to completing a match, whereas small firms may not have such a flexibility.

Because of the linear homogeneity of matching functions, we can write the probability for a vacant job in a type $i$ firm to be filled as:

$$\frac{M_i(u_i, v_i)}{v_i} = M(\frac{1}{\theta_i}, 1) = q_i(\theta_i)$$

The flow out of unemployment is given by:

$$\frac{M_i(u_i, v_i)}{u_i} = \theta_i M_i(\frac{1}{\theta_i}, 1) = \theta_i q_i(\theta_i)$$

Clearly, $q_i(\theta_i)$ is a decreasing function of $\theta_i$ and $\theta_i q_i(\theta_i)$ is increasing in $\theta_i$.

## 1.2 Stochastic shocks and job destruction rules

All firms are subject to two different types of stochastic shocks: output shocks and industrial injury shocks. Both shocks are idiosyncratic and affect big and small firms similarly when they occur. This assumption comes from the fact that both types of firms belong to the same industry and therefore face a similar level of ex ante risk.

### 1.2.1 Productivity shocks

Firms' productivity is affected by exogenous idiosyncratic shocks that lead to job destruction at a Poisson rate $\delta$. These productivity shocks account for all exogenous and idiosyncratic economic events other than work accidents that affect a job's efficiency (e.g. technological shocks).

### 1.2.2 Injury shocks

Let $\lambda$ be the rate at which injuries occur each period. $\lambda$ can be interpreted as the frequency of injuries. When an injury occurs, its severity $\epsilon$ is distributed according to the cumulative distribution function $F$ over the support $[0, 1]$. If a worker in a firm $i$ is injured with a severity $\epsilon$, then productivity decreases to $p_i(1 - \epsilon)$.

After an injury, a worker recovers at a Poisson rate $\mu$. The average length of recovery is thus equal to $\frac{1}{\mu}$. Recovery takes place both on the job and while workers are temporary disabled at the same Poisson rate $\mu$.

Experience-rated firms contribute a fraction $\alpha$ of the average cost to the compensation system for workplace accidents generated by their workers. Since this cost materializes only after a worker lost his job, we model this contribution as a firing tax paid by the big firms when a worker leaves to "join" the disability state. This tax amounts to $\frac{\alpha b}{\mu}$.

### 1.2.3 Job destruction rules

We assumed that productivity shocks lead to a systematic job destruction whenever they occur, that is at a Poisson rate $\delta$.

As far as injury shocks are concerned, we assume an endogenous destruction rule: the job is destroyed only if the productivity of firm $i$ falls beyond $p_i(1-\epsilon_i)$. This threshold $\epsilon_i$ is defined such that the asset value $J_i(\epsilon)$ of a filled job in firm $i$ after an injury of severity $\epsilon$ is equal to the asset value of a vacant job in the same firm, namely $V_i$. Beyond that threshold, a firm makes less losses by destroying the job and returning to search than by maintaining it. The higher the endogenous threshold $\epsilon_i$, the lower the volatility of employment. We make the usual free entry assumption for all firms, therefore the expected profit from opening a vacancy in either type of firm must be equal to the expected cost of creating it, that is:

$$V_i = 0 \tag{1}$$

The job destruction threshold linked to injury shocks $\epsilon_i$ is consequently defined as follows:

$$J_i(\epsilon_i) = V_i = 0 \tag{2}$$

# 2 Derivation of the steady state equilibrium when there is a single labor market

In this section, we consider an economy in which there is only one type of firms, either big or small. By "big economy" (respectively "small economy") we mean an economy in which there are only big (respectively small) firms. We write all equations for both types of firms in order to compare the consequences of their differentiated contribution on the equilibrium labor market structure.

## 2.1 States of nature and transition probabilities

Workers can face four different states of nature:

- They can suffer no injury and be employed;
- they can face an injury but keep working (the severity of the injury then has to be less than $\epsilon_i$);
- they can become unemployed and receive unemployment benefit $z$ while they search for a job if not injured, even slightly;
- they can become temporarily disabled and receive disability benefit $b$ if they face either a severe injury shock or a productivity shock after they had been slightly injured.

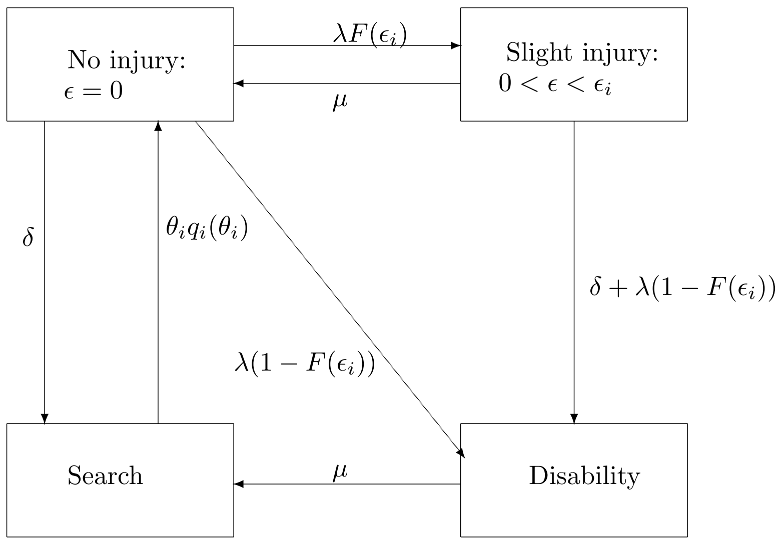


Fig. 1: States of natures and rates of transition on labor market $i$

If a worker is not injured at all, he can either become disabled, get slightly injured and keep his job, or loose his job without being injured and therefore go to search $z$. If a worker is slightly injured, he can either go to the disability state following a productivity shock or a severe injury shock, or he can recover from his previous injury. The latter can only happen in the absence of further shock. One can notice that disability characterizes people who can't go back to search immediately because they are still injured, either slightly or severely. Disabled people can recover and go back to search; unemployed workers can expect to find a job in the firm they choose to apply.

## 2.2 Bellman equations

Let $r$ be the exogenous interest rate and let's denote $W_i(\epsilon)$ the asset value for a worker of occupying a job in firm $i$ with an injury $\epsilon$, $\epsilon > 0$, and $w_i(\epsilon)$ the corresponding wage. $w_i(0)$ denotes the wage paid to the employed worker who is not injured. $D$ denotes the asset value of a disabled worker who cannot go back to search immediately, and $U_i$ is the asset value of a worker who is searching for a job of type $i$.

Since a big firm pays the contribution only when she lays off a previouly injured worker, the asset value of an occupied job in firm $b$ can be expressed as follows:

- When the worker is not injured :

$$rJ_b(0) = p_b - w_b(0) + [\delta + \lambda(1 - F(\epsilon_b))][V_b - J_b(0)] \tag{3}$$

$$+\lambda \int_0^{\epsilon_b} [J_b(x) - J_b(\epsilon)]dF(x) \tag{4}$$

(5)

- When the worker suffers an injury of severity $\epsilon$:

$$rJ_b(\epsilon) = p_b(1 - \epsilon) - w_b(\epsilon) + [\delta + \lambda(1 - F(\epsilon_b))][V_b - \frac{\alpha b}{\mu} - J_b(\epsilon)] \tag{6}$$

$$+\lambda \int_\epsilon^{\epsilon_b} [J_b(x) - J_b(\epsilon)]dF(x) + \mu[J_b(0) - J_b(\epsilon)]$$

(7)

Whether the worker was previoulsy injured or not when a small firm lays off does not make any difference regarding its contribution, therefore:

$$rJ_s(\epsilon) = p_s(1 - \epsilon) - w_s(\epsilon) - T + [\delta + \lambda(1 - F(\epsilon_s))][V_s - J_s(\epsilon)] \tag{8}$$

$$+\lambda \int_\epsilon^{\epsilon_s} [J_s(x) - J_s(\epsilon)]dF(x) + \mu[J_s(0) - J_s(\epsilon)]$$

In the absence of injury or productivity shock, the instantaneous profit of firm $i$ is equal to its output minus wage and contribution for small firms. If the job is destroyed, which happens at a rate $\delta + \lambda(1 - F(\epsilon_i))$, then its new value becomes $V_i = 0$. Firm $b$ must moreover contribute $\frac{\alpha b}{\mu}$ to the compensation system if the worker was previously injured. If the job is not destroyed but faces a slight injury shock, then its value switches to $J_i(k)$, $k$ being the new severity of injury, $\epsilon < k < \epsilon_i$. We assume that additional injury shocks are only taken into account if they are of greater severity than the existing injury. Finally, workers recover at a rate $\mu$, after what the asset value of the job becomes $J_i(0)$.

The asset value of a vacant job in firm $i$ can be written as:

$$rV_i = -k_i + q_i(\theta_i)(J_i(0) - V_i) \tag{9}$$

Indeed, a vacant job in firm $i$ costs $k_i$ per unit of time and is filled at a rate $q_i(\theta_i)$; then it is worth $J_i(0)$.

Since $V_i = 0$, equation (9):

$$J_i(0) = \frac{k_i}{q_i(\theta_i)} \tag{10}$$

Concerning workers, we have to distinguish the asset value of a job in firm $i$ depending on whether they are already injured or not. The reason is that if they are, both severe injury shocks and productivity shocks will lead them to disability, whereas if they are not, they will go to search $z$ after a productivity shock and to disability after a severe injury shock. The asset value for a worker of occupying a job in firm $i$ with injury severity $\epsilon$, $\epsilon > 0$, can be expressed as:

$$\begin{aligned} rW_i(\epsilon) = w_i(\epsilon) + \delta[D - W_i(\epsilon)] + \lambda(1 - F(\epsilon_i))[D - W_i(\epsilon)] \\ +\mu[L_i - W_i(\epsilon)] + \lambda \int_{\epsilon}^{\epsilon_i} [W_i(x) - W_i(\epsilon)] dF(x) \end{aligned} \tag{11}$$

An employed worker with an injury severity $\epsilon > 0$ receives a wage $w_i(\epsilon)$. He can become disabled following a productivity shock or after a severe injury shock. He can also keep his job but with a worse injury severity which however remains under the destruction threshold. Alternatively, he can simply recover.

Similarly, the asset value to a worker of a job in firm $i$ in the absence of previous injury, which is denoted $L_i$, can be expressed as follows:

$$rL_i = w_i(0) + \delta[U_i - L_i] + \lambda(1 - F(\epsilon_i))[D - L_i] + \lambda \int_0^{\epsilon_i} [W_i(k) - L_i] dF(k) \tag{12}$$

If not injured, the worker can become unemployed and go to search following a productivity shock. If a severe injury shock occurs, he can become temporarily disabled. Alternatively, in the case of a slight injury shock, he can keep his job but with a lower productivity.

The asset value of unemployment is equal to the unemployment benefit plus the expected value of being hired by the firm the worker is applying to. More precisely:

$$rU_i = z + \theta_i q_i(\theta_i)[L_i - U_i] \tag{13}$$

Finally, the asset value of being disabled is simply the sum of the disability benefit $b$ and of the expected gain if the worker actually recovers and becomes able to going to search, that is:

$$rD = b + \mu[U_i - D] \tag{14}$$

## 2.3 Wage equation, job creation and job destruction rules

### 2.3.1 Nash bargaining

We now derive the steady state equilibrium of our model in order to find the equilibrium values of our endogenous variables $\epsilon_i$ and $\theta_i$. Once we have this equilibrium, we can study the impact of an increase in $\alpha$ or $T$ on labor market $b$ and $s$ respectively.

We use the classical Nash bargaining result in order to derive wage equations: when a firm and a worker match, they share total surplus according to a pretermined - and fixed - bargaining power. It is assumed that wage negotiation occurs not only when a new match occurs, but every time the productivity is affected by a shock. Let $\beta$ denote the share of the total surplus that goes to the worker. Because the alternative state in which the worker would be if the agreement did not take place is not the same depending on whether he is already injured or not, we write a different sharing rule for continuing jobs depending on the worker's health status. The first order conditions give the following sharing rules:

- Nash bargaining conditions between a firm and a healthy worker:

$$(1 - \beta)(L_i - U_i) = \beta[J_i(0) - V_i] \tag{15}$$

- Nash bargaining conditions between a firm and a slightly injured worker ($\epsilon > 0$):

$$(1-\beta)(W_b(\epsilon) - D) = \beta \left[ J_b(\epsilon) + \frac{\alpha b}{\mu} - V_b \right] \quad (16)$$

$$(1-\beta)(W_s(\epsilon) - D) = \beta \left[ J_s(\epsilon) - V_s \right], \quad (17)$$

$$(18)$$

Renegotiation between a big firm and an already slightly injured worker leads to an additional term in big firms' surplus compared to small ones and to renegotiation between a healthy worker and either type of firm, namely $\frac{\alpha b}{\mu}$. By not suppressing the job, big firms indeed save this contribution, which therefore increases the surplus they get from a (renewed) match with an already slightly injured worker. When the worker is not already injured, suppressing the job does not save the contribution since the worker goes back to search and costs nothing to the workplace accidents' compensation system (he gets $z$ but not $b$).

### 2.3.2 Wage equations

By using the sharing rules (15) and equation (9), (13) can be rewritten as follows:

$$rU_i = z + \theta_i k_i \frac{\beta}{1-\beta} \quad (19)$$

By multiplying the Bellman equation for $L_i$ (12) by $(1-\beta)$, by substracting it to $\beta$ times equation (6) for big firms and equation (8) for small ones, each taken in $\epsilon = 0$, by using the sharing rule (15), we obtain the following expressions for the equilibrium hiring wage in each economy:

$$w_b(0) = \beta[p_b - \frac{\alpha b \lambda F(\epsilon_b)}{\mu}] + (1-\beta)[(r + \lambda - \frac{\mu\lambda}{r+\mu})(\frac{z}{r} + \frac{\theta_b k_b \beta}{r(1-\beta)}) - \frac{\lambda b}{r+\mu}]$$

$$w_s(0) = \beta(p_s - T) + (1-\beta)[(r + \lambda - \frac{\mu\lambda}{r+\mu})(\frac{z}{r} + \frac{\theta_s k_s \beta}{r(1-\beta)}) - \frac{\lambda b}{r+\mu}] \quad (20)$$

In the absence of previous injuries, workers receive a fraction $\beta$ of the output minus the contribution to the compensation system for workplace accidents[17]. Note that the wage in big firms is decreasing in the stability of

[17]In the case of big firm, it is the expected contribution.

employment, which can be understood as the price of job stability charged to workers. In addition to that, workers also receive a rent which is increasing in their market power (positively related to market tightness and unemployment benefits).

By performing a similar calculus with the Bellman equation (11)) for $W_i(\epsilon)$, by using the sharing rule (16) and (17) instead, we derive the following expression for the wage of workers with an injury $0 < \epsilon < \epsilon_i$:

$$\begin{aligned} w_b(\epsilon) &= \beta p_b(1-\epsilon) + (r+\mu)\frac{\alpha b \beta}{\mu} + (1-\beta)b \\ w_s(\epsilon) &= \beta[p_s(1-\epsilon) - T] + (1-\beta)b \end{aligned} \tag{21}$$

Workers still receive a fraction $\beta$ of the productivity minus the contribution $T$ in the small economy. In the big economy, the contribution appears positively in the wage in order to avoid workers declaring themselves as injured to receive the benefit $b$.

## 2.4 Impact of policy parameters on labor market structure

### 2.4.1 The small economy

The following steady state equilibrium expressions of the endogenous parameters $\theta_s$ and $\epsilon_s$ are derived by using the previous Nash equilibrium conditions and wage equations. Details are provided in the appendix:

$$\begin{aligned} \theta_s &= \frac{b(1-\beta)(r+\mu+\lambda)}{(r+\lambda)(r+\mu)-\lambda\mu}\frac{r}{\beta k_s} - \frac{z(1-\beta)}{\beta k_s} \\ \epsilon_s &= 1 - \frac{1}{p_s}\left[T + b - \frac{\mu k_s}{q_s(\frac{b(r+\mu+\lambda)}{(r+\lambda)(r+\mu)-\lambda\mu}\frac{r}{\beta k_s} - \frac{z}{\beta k_s})(1-\beta)}\right] \end{aligned} \tag{22}$$

**Proposition 1** *a) In equilibrium, market tightness does not depend on firms' contribution.*
*b) An increase in small firms' contribution has a constant adverse impact on employment volatility.*
*c) When market tightness on the labor market for small firms increases, they try to retain workers and wait for them to recover.*

Proposition (1-a) illustrates the absence of incentives conveyed by a flat contribution to firms' decision to create a job and to workers' decision to apply. The burden of the contribution is indeed split according to a constant proportion between the two parties, and its level therefore does not impact the ratio of recruiters to applicants.

Proposition (1-b) comes from from the fact that :

$$\frac{\partial \epsilon_s}{\partial T} = -\frac{1}{p_s} \tag{23}$$

An increase in the contribution decreases the profitability of keeping a job in small firms, therefore the latter begin to lay off workers for smaller severity of injuries. The flat rate contribution can be understood as a uniform tax on productivity.

As for proposition (2-c), it is obvious from equation (22) that $\frac{\partial \epsilon_s}{\partial \theta_s} > 0$.

### 2.4.2 Steady state equilibrium in the big economy

As for big firms, we can't derive the steady state expressions of the endogenous parameters analytically as we did for small firms.

By plugging the wage equations into the corresponding Bellman equation, we obtain the following job destruction rule (equation 24) and job creation rule (equation 25):

$$(1-\beta)p_b(1-\epsilon_b) + \frac{\mu k_b}{q_b(\theta_b)} = \frac{\alpha b}{\mu}\left[\delta + \lambda(1-F(\epsilon_b) + \beta(r+\mu)\right] + b(1-\beta) \tag{24}$$

$$(1-\beta)p_b(1-\epsilon_b) + \frac{\mu k_b}{q_b(\theta_b)} = (1-\beta)[(r+\lambda-\frac{\lambda\mu}{r+\mu})(\frac{z}{r}+\frac{\theta_b k_b \beta}{r(1-\beta})-\frac{\lambda b}{r+\mu}] - \frac{\lambda\beta F(\epsilon_b)\alpha b}{\mu} \tag{25}$$

Since $\epsilon_b$, $F(\epsilon_b)$ and $\theta_b$ appear in both equations, we can't solve the system analytically and need to turn to a numerical application.

## 2.5 Impact of the tarification system on each economy's labor market structure

Let's denote $e_i$ the share of employed workers in firms $i$, which is equal to the sum of the fraction of healthy workers ($e_i^h$) and slightly injured workers ($e_i^j$). $u_i$ is the fraction of unemployed workers searching on labor market $i$, and $d$ is the fraction of disabled workers. In the economy with a single labor market $i$, we have in equilibrium:

$$e_i^h + e_i^j + d + u_i = 1 \tag{26}$$

The flow into healthy employment is equal to the expected number of searching workers who match with a firm $i$ plus those who recover from a slight injury. The flow out of this stock is equal to the expected number of healthy workers who get injured (either slightly or severely) or face a productivity shock. Hence the expression of the change in the proportion of healthy workers:

$$\dot{e_i^h} = u_i\theta_i q_i(\theta_i) + \mu e_i^j - (\delta + \lambda)e_i^h \tag{27}$$

The flow into "unhealthy" employment in market $i$ is equal to the expected number of healthy workers who get slightly injured, and the flow out of this stock is equal to the expected number of workers who either recover or lose their job following a severe injury or a productivity shock:

$$\dot{e_i^j} = \lambda F(\epsilon_i)e_i^h - (\mu + \delta + \lambda(1 - F(\epsilon_i)))e_i^j \tag{28}$$

The change in the stock of searching workers is equal to the flow into search (healthy workers who experience a productivity shock plus disabled workers who recover) minus the flow out of search, namely the expected number of matches:

$$\dot{u_i} = \delta e_i^h + \mu d - u_i\theta_i q_i(\theta_i) \tag{29}$$

Finally, the flow into disability is equal to the expected number of total employed workers who face a severe injury plus the expected number of injured workers who face a productivity shock. The workers who leave the disability state are those who recover. Hence the evolution of the stock of disabled workers:

$$\dot{d} = \lambda(1 - F(\epsilon_i))e_i^h + [\lambda(1 - F(\epsilon_i)) + \delta]e_i^j - \mu i \tag{30}$$

In the steady state equilibrium, all these stocks remain constant. Hence, by using equations (26),(27), (28) and (29), we get the following expression for the fraction of searching workers on market $i$:

$$u_i = \frac{\mu}{\theta_i q_i(\theta_i)}\left\{\frac{\delta + \lambda}{\lambda + \mu} - \frac{\mu\lambda F(\epsilon_i)}{(\lambda + \mu)(\mu + \delta + \lambda(1 - F(\epsilon_i)))}\right\} \tag{31}$$

**Proposition 2** *a) In both economies, a greater market tightness decreases unemployment.*
*b) In both economies, a higher volatility of employment increases the equilibrium rate of unemployment.*
*c)A rise in firms' contribution $T$ worsens unemployment*[18].

[18]Indeed, an increase in $T$ is followed by a fall in $\epsilon_s$ and leaves $\theta_s$ unchanged.

Result a) reflects the greater chances for workers to match when market tightness is higher, and result b) result from the higher inflow into search that follows an increase in employment volatility. Finally, a rise in $T$ makes a given job less profitable for a firm and makes her keener to lay off.

# 3 General equilibrium analysis

We now consider an economy in which both labor markets coexist. Workers are still homogeneous but they must choose to which firm they apply (in other words: search is directed). Once workers are employed, they face the same rules of transition, but there is a single and common temporary disability state for the whole economy.

## 3.1 Steady state equilibrium in the dual labor market economy

All Bellman equations remain the same as before, except for those that involve an entry in search (equations (12) and (14)). Indeed, workers must yet decide to which firm they apply, namely the one which will give them the greatest expected asset value. (12) and (14) therefore become in the general equilibrium case:

$$rL_i = w_i(0) + \delta[\max(U_b, U_s) - L_i] + \lambda(1 - F(\epsilon_i))[D - L_i] + \lambda \int_0^{\epsilon_i} [W_i(k) - L_i] dF(k) \quad (32)$$

$$rD = b + \mu[\max(U_b, U_s) - D] \quad (33)$$

In the steady state equilibrium, workers must be indifferent between applying to either firm, therefore:

$$U_b = U_s \quad (34)$$

By plugging the sharing rule (15) into (34) and by using (13), the Bellman equation for search, we obtain the following relation between both labor markets:

$$\frac{\theta_b}{\theta_s} = \frac{1}{\frac{k_b}{k_s}} \quad (35)$$

The relative market tightness in big firms is all the bigger than the cost of creating jobs in these firms is relatively low. Intuitively, if such were not the case, then one could make profit by opening an additional vacancy in a big firm instead of a small one, which would in turn increase the relative market tightness. In equilibrium, equation (35) must consequently hold by the no arbitrage condition.

**Proposition 3** *There exist a steady state general equilibrium in which both big and small firms are active only if* $F(\epsilon_b) = \frac{\delta+\lambda+\beta(r+\mu)}{\lambda(\beta+1)}$ *or if* $\alpha = 0$.

A detailed proof of proposition (3) is given in the appendix. Since $\alpha$ can't reasonably be set equal to zero, proposition (3) gives us a unique equilibrium solution for the endogenous threshold $\epsilon_b$ and therefore for the market tightness $\theta_b$.

This condition defines a maximal macroeconomic level of accidents acceptable for both firms to coexist in equilibrium. Note that it is independent of the tarification system, both of the way contributions are set and of their levels. If workplace accidents are too frequent, too severe or if the recovery process is too slow (i.e if $F(\epsilon_b) < \frac{\delta+\lambda+\beta(r+\mu}{\lambda(1+\beta)}$), then big firms are driven out of the market and only small firms remain. In the opposite case, small firms are evicted by big ones.

Consequently, both big and small firms are incited to adjust their level of prevention to maintain their presence. This result seems to confirm what is empirically observed, namely the fact that big firms do invest in safety, but up to a certain threshold only. The existence of a ceiling in firms' investments in safety has a twofold interpretation, which are not mutually exclusive: either there is a natural minimum level of sinistrality that further investments could not lower, or firms choose rationally not to invest further because the return would not be profitable enough. Proposition (3) supports the second interpretation.

#### 3.1.1 A step backward to the partial equilibrium in the big economy

If we constrain $\epsilon_b$ to its value derived from proposition (3), then we can solve equations (24) and (25) for $\theta_b$ as we did for the small economy:

$$\theta_b = \frac{r}{\beta k_b} \frac{(1-\beta)b(r+\mu+\lambda}{(r+\mu)(r+\lambda)-\lambda\mu} - \frac{(1-\beta)z}{k_b\beta} \tag{36}$$

And by plugging the latter into equation (25), we get:

$$\epsilon_b = 1 - \frac{1}{p_b}\left[\frac{\alpha b\beta[\delta+\lambda+\beta(r+\mu)]}{\mu(1-\beta^2)} + b - \frac{\mu k_b}{(1-\beta)q_b(\theta_b)}\right] \tag{37}$$

**Proposition 4** *a) A marginal increase in big firms' contribution has a constant adverse impact on employment volatility, which is however proportionally less important than the adverse impact of similar increase in the small economy.*
*b) As it is the case in the small economy, firms tend to retain workers all the more than market tightness is high in the big economy, and this effect is relatively more important than it is in the small economy.*

Although the two effects put forward in proposition (4-a) and (4-b) are qualitatively similar to those in propositions (1-a) and (1-b) respectively, the first one is quantitatively less important and the second more important:

1. A marginal increase in $\alpha$ affects the profitability of big firms directly, comparably to how an increase in $T$ affects firms in the small economy. In addition there exists an opposite effect in the big economy which goes in the opposite direction, namely the incentive to retain workers longer than they used to for a given level of productivity in order to avoid paying the contribution. Proposition (4-a) says that the first effect dominates.

2. In the big economy, a high market tightness not only increases the cost of hiring but it also makes the firing tax more expensive than it used to, all other things equal, since it depends positively on the benefit $b$, which is itself a fixed proportion of the average wage.

### 3.1.2 Coming back to the general equilibrium analysis: spillovers between labour markets

**Proposition 5** *a) When the contribution of one firm increases, all other things equal, employment becomes more volatile on the other labour market as well (i.e.* $\frac{\partial \epsilon_s}{\partial \alpha} < 0$ *and* $\frac{\partial \epsilon_b}{\partial T} < 0$*).*
*b) The increase in one market's employment volatility increases the number of workers searching for a job on both labour market, thereby making the firm on the other labour market keener to lay off their own workers in order to benefit from more favourable matching conditions (i.e.* $\frac{\partial \epsilon_b}{\partial \epsilon_s} > 0$*).*

The proof of proposition (5) is derived straightforward from equation (35). Proposition (5) comes from the fact that an increase in one firm's contribution and hence of its employment volatility increases the number of searching workers relatively to vacancies on **both** labour market. Consequently, both labour markets are linked in equilibrium, such that increasing one contribution is equivalent to increasing the other one in some fixed proportion.

## 3.2 General equilibrium

We now derive the steady state size of each labor market and therefore write the following equation system:

$$\begin{cases} \dot{e_b^h} = u_b\theta_b q_b(\theta_b) + \mu e_b^j - (\delta+\lambda)e_b^h \\ \dot{e_s^h} = u_s\theta_s q_s(\theta_s) + \mu e_s^j - (\delta+\lambda)e_s^h \\ \dot{e_b^j} = \lambda F(\epsilon_b)e_b^h - (\mu+\delta+\lambda(1-F(\epsilon_b))e_b^j \\ \dot{e_s^j} = \lambda F(\epsilon_s)e_s^h - (\mu+\delta+\lambda(1-F(\epsilon_s))e_s^j \\ \dot{d} = \lambda(1-F(\epsilon_b))e_b^h + \lambda(1-F(\epsilon_s))e_s^h + [\delta+\lambda(1-F(\epsilon_b))]e_b^j + [\delta+\lambda(1-F(\epsilon_s))]e_s^j - \mu d \\ u_b \dot{+} u_s = \delta(e_b^h + e_s^h) + \mu d - u_b\theta_b q_b(\theta_b) - u_s\theta_s q_s(\theta_s) \\ e_b^h + e_s^h + e_b^j + e_s^j + d + u_b + u_s = 1 \end{cases}$$

The differences compared to the previous partial equilibrium analysis are threefold. Firstly the disability state is common to both labor markets, therefore the flow into it comes from the four existing stocks of employed workers. Secondly, since search is directed, workers apply only to one firm and we can therefore only express the global flow into search. Finally, it is the sum of all stocks on both labor markets that is now identically equal to one.

By writing $e_i = e_i^h + e_i^j$ for each market and solving the system, we obtain the following equation that links $e_b$ and $e_s$:

$$\Gamma_b e_b + \Gamma_s e_s = 1 \tag{38}$$

where $\Gamma_i = 1 + \frac{\delta+\lambda(1-F(\epsilon_i))}{\theta_i q_i(\theta_i)} + \frac{(\lambda+\mu)\lambda(1-F(\epsilon_i))+\delta\lambda}{\mu(\mu+\delta+\lambda)}$ and $e_i = e_i^j + e_i^h$

The sixth equation of the system turns out to be a linear combination of the others and therefore creates an indeterminacy. If we constrain the total level of unemployment $u_b + u_s$ to be constant and equal to $u$, we have obtain the following additional equation :

$$\Phi_b e_b + \Phi_s e_s = 1 - u \tag{39}$$

where $\Phi_i = 1 + \frac{\lambda[\mu+\delta+\lambda(1-F(\epsilon_i)] - \mu\lambda F(\epsilon_i)}{\mu(\mu+\delta+\lambda)}$.

Since we can't solve equations (38) and (39) simultaneously and determine analytically[19] the influence of an increase of either tarification parameter $\alpha$ or $T$ neither on the relative size of each labor market nor on total employment, we turn to an empirical simulation exercise to answer empirically.

# 4 Empirical simulation

In this section, we calibrate the model for the French economy and use deterministic simulation exercises to gain insights on the equilibrium size of each labor market and of global unemployment reached with given policy parameters.

## 4.1 The French compensation system for labor accidents

The French compensation system for workplace accidents was integrated to the social security system in 1947 and its tarification has since then been explicitly designed in order to encourage safety prevention.

Two major principles are underlying the tarification. Firstly, industrial activities are classified by category of risk. Secondly, the rate paid by firms applies to production units and not to firms as legal entities. What matters here is the main activities of one particular production unit. However, the methodology of computation of the rate depends on the size of the firm as a whole, and not on the unit's size. By size we mean number of full time equivalent employees.

Three methods of computation of the contribution rate must be distinguished: full individualisation, full mutualisation, and an intermediate between the last two. The first one is equivalent to full experience rating and applies to big firm, i.e. firms that have more than 200 employees. The second one applies to small firms who employ strictly less than 10 workers, and the last one applies to firms which number of workers stands between the two. The gross contribution rate is defined as follows:

$$\frac{\text{Cost of the risk } * 100}{\text{Total wages paid}}$$

[19]Solving the system indeed gives the following results : $e_b = \frac{\Phi_s+u-1}{\Gamma_b\phi_s-\Gamma_s\Phi_b}$ and $e_s = \frac{\Phi_b+u-1}{\Gamma_s\phi_b-\Gamma_b\Phi_s}$

For big firms, the cost of the risk for year $t$ is computed on the basis of this very unit's past cost for years $t-2$ to $t-4$. For small firms however, the cost of the risk is based on the total cost of risk computed over all firms that belong to the same risk category. Medium firms contribute a linear combination of the two previous rates computed for the same category of risk, where the weight put on the experience rated part is increasing with the number of employees of the given firm[20]. The net rate is then equal to the gross rate plus three lump sum surcharges[21].

The heterogeneities in the tarification are consequently twofold: between production units of a firm on the one hand, and between firms of different sizes on the other hand. In the first case, a firm can have an incentive to split activities with different levels of risk into different units such that a secondary non risky activity originally taking place in the same location as a more important (in terms of employees) and more risky one is not charged a high rate. This incentive to decentralize would be particularly high if the low risk secondary (in terms of workers again) activity pays low wages. In the second case, a firm could be tempted to split in the legal sense by externalizing certain activities in order to enter the category of either intermediate firms or small ones. This could apply to building and public works sector firms which activity is anyway often divided into several independent projects.

The incentives to decentralize generated by the tarification system could impact labor market structure by shifting the relative proportion of employment in big and in small firms. Depending on the other features of each type of firms (productivity, cost structure, etc.), the effect could be more or less significant and most importantly more or less socially desirable (depending on the relative efficiency and jobs' characteristics in each firm). Finally, investments in safety, which are a direct measure of welfare, could also be affected by the tarification system.

## 4.2 Specification and calibration

In line with the empirical literature on matching models (see Petrongolo and Pissarides (2001)), the matching functions are represented by a Cobb-

[20]More precisely, the rate paid by a medium firm with $E$ workers is equal to: $\frac{E-9}{191}\tau_{big} + (1-\frac{E-9}{191})\tau_{small}$.

[21]These lump sum surcharges include among others the cost of accidents incurred on the way to work; their amount is computed with the same methodology on a national basis regardless of the size and category of risk of the firm.

Douglas with constant return to scale :

$$M_i(u_i, v_i) = m_i u_i^{\gamma} v_i^{1-\gamma}$$

Several values of $m_b$ and $m_s$ are tested for and in order to compare the effects of the tarification policy in a well functionning economy with those in a more sluggish one, we performed the partial equilibrium simulations by first setting $m_b = m_s = 1$ and then $m_b = m_s = 0,5$. For the general equlibrium simulation and in order to have $m_b > m_s$, we took $m_b = 1; m_s = 0,9$ and $m_b = 0,5; m_s = 0,45$.

In order to respect the Hosios-Pissarides condition and in accordance with Petrongolo and Pissarides (2001), we take $\gamma = \beta = 0,5$.

Small firms' productivity is assumed to amount 84% of big firms', which reflects the gap in the average full time gross wage between firms of more than 250 employees and firms with 10 to 19 employees in France in 2000[22]. Hiring costs are assumed to be higher in big firms', and small firms' are set equal to 60% of big firms'. This percentage is taken from Abowd and Kramarz (2003), which finds that hiring costs for permanent jobs amount to around 60% of those spent on temporary jobs, by assimilating jobs in big firms to the first category and jobs in small firms to the second one. We also follow Pissarides (2000) by assuming that recruiting costs $k_i$ are proportional to aggregate productivity $p_i$. In order to reflect the relative rigidity of the French labor market and to increase the difference between both labor markets, recruiting costs are set equal to ten times productivity.

Injuries are assumed to be distributed according to the cumulative distribution function $F_a(x) = \frac{-2}{x^a+1} + 2$, where $a \in [0; 1]$. This distribution is a fairly satisfactory approximation of the empirical distribution of the severity of workplace injuries. We test the model for different values of $a$ and present the results for $a = 0,1$.

The replacement rates for unemployment and workplace compensations are set equal to 60% and 80% of the average wage respectively, the usual values used in the literature[23]. The average wage is the weighted average of the wages in big and small firms computed in $\bar{\epsilon}$ such that $F(\bar{\epsilon}) = \frac{1}{2}$. We use a weighting of 50% for each type of firm to calibrate the general equilibrium case with both firms. Although only 25% of employees work in firms with more than 200 workers, the share of workers in very small firms (which pay a fully mutualized contribution) also amounts to about 25%, the remaining

[22] Data from INSEE.

[23] See for instance l'Haridon and Malherbet (2002).

50% working in intermediate firms who are partially experience rated. We therefore assimilated the biggest of these intermediate firms to the big ones of our model assuming that their contribution had a high enough degree of experience rating for them to take it into account in their strategic decisions.

The speed of recovery $\mu$ is set equal to 0,127, corresponding to an average of 46 days out of work following a workplace accident[24]. The annual interest rate is set at 4%, and $\delta$ is set at 0,06 an in l'Haridon and Malherbet (2002).

Finally, the rate of arrival of workplace accidents $\lambda$ is set equal to 0,15 in order to find an acceptable $\epsilon$ which solve the condition of proposition (3)[25].

| | |
|---|---|
| $\lambda$ | 0,15 |
| $\delta$ | 0,06 |
| $\mu$ | 0,12 |
| r | 4% |
| $\beta$ | 0,5 |
| b (replacement rate) | 80% |
| z (replacement rate) | 60% |

Table 1: Calibration parameters

### 4.3 Empirical results

The following results only intend to give an insight of how each type of firm would adjust its employment policy in case of a change in the level of contributions to the workplace accidents' compensation system or in the efficiency of the labour market, both in partial and in general equilibrium. They are not to be interpreted as quantitative forecasts. Indeed, although we tried to calibrate our model in order to replicate the French economy as faithfully as possible, some parameters had to be set more or less arbitrarily in order to find an interior solution.

[24]The data on workplace accidents used in this paper stem from the 2004 report of the Inspection Générale des Affaires Sociales, "Tarification des Accidents du Travail et des Maladies Professionnelles".

[25]According to the previously mentionned report of the Inspection générale des affaires sociales, the ratio of the number of accidents over the number of full time equivalent employees was equal to 0,085 in 2002. The overestimation of the frequency of workplace accidents also contributes to the overestimation of the rate of unemployment.

### 4.3.1 Partial equilibrium

For different matching technologies and level of contributions, we compute the equilibrium rates of employment and unemployment in each economy separately. Note that the rate of unemployment we find is much higher than it truly is because all workers who were slightly injured and then faced a productivity shock were laid off. Although these have to recover before they search for a job, they eventually end up there, whereas in the "real economy "they would have remained employed. Once again, we are testing for the significance and sign of the reaction of each firm's employment policy to a change in its contribution and in the efficiency of the labour market, rather than in the precise level of each variable.

| $m_b$ | 0,5 | 0,5 | 1 | 1 |
|---|---|---|---|---|
| $\alpha$ | 1,5 | 1 | 1,5 | 1 |
| $u_b$ | 36% | 42% | 18% | 21% |
| $e_b$ | 62% | 54% | 85% | 81% |
| d | 2% | 4% | -3% | -2% |

Table 2: "Big economy" equilibrium market structure for different levels of contribution and labour market efficiency

| $m_s$ | 0,5 | 0,5 | 1 | 1 |
|---|---|---|---|---|
| T | 0,5% | 0,1% | 0,5% | 0,1% |
| $u_s$ | 58% | 55% | 30% | 29% |
| $e_s$ | 0% | 4% | 36% | 37% |
| d | 42% | 41% | 34% | 34% |

Table 3: "Small economy" equilibrium market structure for different levels of contribution and labour market efficiency

**Proposition 6** *An increase in the contribution results in a rise in the rate of employment in big firms, but in a fall in the small economy.*

This differentiated impact comes the fact that big firms internalize the cost of their lay offs, whereas small firms don't. Big firms indeed react by maintaining existing jobs for more severe injuries than they used to in order to avoid paying a more expensive contribution. Small firms only take the decrease in their profit, all other things equal.

**Proposition 7** *When the labour market becomes sluggish (i.e. the matching technology is poor), employment decreases in both economies.*

A deterioration of labour market's efficiency mechanically reduces the flow out of search and results in a relatively greater rate of unemployment. Note that the rate of temporary disabled workers also increases when the labour market becomes less efficient, which can be surprising since neither the flow out of disability nor the flow into are directly related to the matching technology. This can be explained by the negative relation between market tightness and employment volatility in both economies (i.e. $\frac{\partial \epsilon_i}{\partial \theta_i} > 0$): when matching is less efficient, firms open less vacancies, thereby decreasing market tightness and hence increasing employment volatility, which in turn results in higher inflow into temporary disability.

### 4.3.2 General equilibrium

Having examined how each economy reacts to a change in a modification of the rate of contribution and to a deterioration of labour market efficiency, we now turn to the analysis of how an economy in which both labour markets coexist would react to such changes in equilibrium.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $m_b$ | 1 | 1 | 0,5 | 0,5 | 1 | 1 | 0,5 | 0,5 |
| $m_s$ | 0,9 | 0,9 | 0,45 | 0,45 | 0,9 | 0,9 | 0,45 | 0,45 |
| u | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| $\alpha$ | 1,5 | 1 | 1,5 | 1 | 1,5 | 1 | 1,5 | 1 |
| T | 0,5% | 0,1% | 0,5% | 0,1% | 0,1% | 0,5% | 0,1% | 0,5% |
| $e_b$ | 17% | 24% | 37% | 42% | 16% | 24% | 37% | 42% |
| $e_s$ | 40% | 34% | 22% | 19% | 41% | 34% | 23% | 19% |
| d | 33% | 32% | 30% | 30% | 33% | 32% | 30% | 30% |

Table 4: General equilibrium market structure for different levels of contribution and labour market efficiency

**Proposition 8** *When both contributions increase, all other things equal, employment in big firms decreases and employment in small firms increases. The temporary disability rate remains stable, meaning that the total rate of employment remains constant. The only change is consequently a shift from big firms to small ones.*

This result is very interesting and must be compared to what we found in the partial equilibrium case (proposition 6), i.e. the fact that an increase in $\alpha$ (respectively in $T$) results in an increase in $e_b$ (respectively in a decrease in $e_s$). When both contributions are raised simultaneously, the increase in each labour market's volatility comes both from a direct effect ($\frac{\partial \epsilon_b}{\partial \alpha} < 0$ and $\frac{\partial \epsilon_s}{\partial T} < 0$) and from an indirect effect ($\frac{\partial \epsilon_i}{\partial \epsilon_j} > 0$). As a result, the employment volatility has become significant enough for big firms to prefer to pay the contribution, despite the raise in the rate of experience rating, and to change their organization in order to reopen vacancies on the other labour market, namely as a smaller structure.

**Proposition 9** *When the labour market becomes less efficient for both firms, all other things equal, employment in big firms increases and employment in small firms decreases. The temporary disability rate remains stable, meaning that total employment is not affected.*

Maintaining both labour markets in equilibrium seems to curb the increase in unemployment that results from a decrease in labour market efficiency: whereas each sector tends to decrease employment following a fall in matching efficiency in a single sector economy (see proposition 7), big firms change their strategy when they coexist with small ones and employ more workers. In other words, maintaining both labour markets has a countercyclical effect that could help smooth growth during economic downturns.

The reason why firms tend to shift their organization following a decrease in labour market efficiency could lay in the greater incentives of big firms to retain their workers in order not to pay the contribution. Both firms do face greater difficulties to match and are consequently more reluctant to lay off, but this reluctance is reinforced for big firms who see a further motive to decrease the volatility of their jobs. Consequently, small firms are incited to lay off and change their organization in order to post new vacancies as big firms.

**Proposition 10** *When only small firms' contribution increases, all other things equal, the total rate of employment as well as the relative size of each labour market remain unchanged. When only big firms' contribution increases, all other things equal, the total rate of employment remains unchanged but the relative size of big firms' labour market decreases.*

This result must be interpreted with caution as it could be that the absence of change, both of the total rate of employment and of the relative size of each labour market in case of an increase in T, could only come from the fact that we tested for too small a variation in the contribution.

# Conclusion

By using a matching model with an endogenous job destruction threshold and two types of stochastic shocks (productivity as well as workplace accidents), we have shown that an experience rated contribution to the workplace accidents compensation system impacted both the level and the volatility of employment in a different way than a flat rate contribution in equilibrium. More precisely, because an experience rated contribution is similar to a firing tax, an increase in the degree of experience rating not only reduces firms profitability but also increase their incentives to retain workers longer. Consequently, whereas an increase in a flat rate contribution unambiguously causes firms to increase the volatility and reduce the size of their workforce, experience rated firms could react countercyclically and keep their workers.

In order for firms facing both types of tarifications to coexist in equilibrium, they must invest in safety equipments in order to reach a given level of incidence, i.e. accidents' frequency, severity, and rates of recovery must neither be too high, nor too low. This given level does not depend on the tarification system. This result could explain why big firms don't increase their investments in safety equipments above a certain level[26].

The coexistence of firms facing an experience rated contribution and a flat rate one does cause each type of firm to react differently than they used to when they were alone on the market. Consequently, if we assume that big firms are experience rated and small firms pay a flat rate contribution, their coexistence could create incentives to shift their organization (by merging to grow big or by externalizing some activities to shrink), depending on the economic background.

More precisely, an increase in both contribution rates does not affect the total rate of employment but shifts employment from experience rated firms toward flat rate firms. The reason is that there are spillovers between firms

[26]An alternative explanation, which is not exclusive of ours, is that there exist a natural minimum level of incidence that further investments could not lower.

which cause flate rate firms to increase their turnover and reduce their workforce to such an extent that the ratio of vacant jobs to applicants significantly increases on the other labour market as well. Consequently, experience rated firms can hire more easily and their incentive to return to search becomes greater than the one to retain their worker in order to avoid paying the contribution. Once they are looking for a match, they are moreover to externalize some activity in order to become "small" and pay a flat rate contribution, which is more adapted when labour market turnover is high.

In order to draw precise policy implications from these results, we should take a closer look at the potential substitution effect between unemployment insurance and workplace benefits. Firms reaction to a change in the level of their contribution as well as to the relative contribution of big and small ones could indeed be altered if their contribution to the unemployment insurance system were also to change. The next step of our research will therefore focus on this issue and will try to incorporate firms' contribution to the unemployment insurance system into our framework.

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# Appendix

## Derivation of the steady state equilibrium expressions of $\epsilon_s$ and $\theta_s$

In order to obtain equilibrium expressions of the endogenous parameters, we plug the wage equations into the corresponding Bellman equations (8). We first derive job destruction rules, and for that purpose we plug the expression of $w_s(\epsilon)$ into the asset value of a filled job in firm $s$ and take the resulting expression in $\epsilon_s$. We obtain the following equations for the big and the small economy respectively:

$$(1-\beta)b = \frac{\mu k_s}{q_s(\theta_s)} + (1-\beta)[p_s(1-\epsilon_s) - T] \tag{40}$$

The expected value received when the job is destroyed (namely a share of the disability benefit plus the contribution to the compensation system for big firm) must equal the expected value obtained by keeping it (current productivity plus the expected one if the worker recovers, minus the contribution to the system for workplace accidents for small firms). If the endogenous threshold increased, then jobs would be kept longer.

We then plug the expression of $w_s(0)$ into equation (8) taken in 0 in order to derive job creation conditions. The equations we obtain are the following[27]:

$$(1-\beta)[p_s(1-\epsilon_s) - T] + \frac{\mu k_s}{q_s(\theta_s)} = \tag{41}$$

$$(1-\beta)[r+\lambda-\frac{\mu\lambda}{r+\mu}][\frac{z}{r} + \frac{\theta_s k_s \beta}{r(1-\beta) - \frac{\lambda b}{r+\mu}}] \tag{42}$$

These equations say that the expected value from a new match must be equal to the expected value from opening a vacancy. Indeed, the left hand side of each equation is the social asset value of a new match (the one for the firm and the new right to a potential disability benefit for the worker), and the right hand side is the net social value of a new vacancy (hiring cost and lost of the asset value of searching to workers).

[27] In order to find a tractable expression of the integral $\int_0^{\epsilon_s} J_s(k)dF(k)$ that appears when we plug $w_s(0)$ into the Bellman equation $J_s(0)$, we write $J_s(\epsilon)$ in $\epsilon_s$ and substract the resulting equation from $J_s(\epsilon)$. We then take the limit of the resulting expression in 0. See Pissarides (2000) for more details.

Then, we solve equations (40) and (42) simultaneously and find the following equilibrium expression for $\theta_s$:

$$\theta_s = \frac{(1-\beta)b(r+\mu+\lambda)}{(r+\lambda)(r+\mu)-\lambda\mu}\frac{r}{\beta k_s} - \frac{z(1-\beta)}{\beta k_s}$$

By plugging the previous expression of $\theta_s$ back into equation (40), we obtain an equilibrium expression for the endogenous market tightness $\epsilon_s$:

$$\epsilon_s = 1 - \frac{1}{p_s}\left[T + b - \frac{\mu k_s}{q_s(\frac{(1-\beta)b(r+\mu+\lambda)}{(r+\lambda)(r+\mu)-\lambda\mu}\frac{r}{\beta k_s} - \frac{z(1-\beta)}{\beta k_s})(1-\beta)}\right]$$

## Proof of proposition 4

By solving equations (24) and (25) simultaneously, we obtain the following expression of $\theta_b k_b$ :

$$\theta_b k_b = \frac{r}{\beta}\frac{r+\mu}{(r+\lambda)(r+\mu)-\lambda\mu}\left\{\frac{\alpha b}{\mu}\left[(1+\beta)\lambda F(\epsilon_b) - \delta - \lambda - \beta(r+\mu)\right] + \frac{(1-\beta)b(r+\mu+\lambda)}{r+\mu}\right\} - \frac{(1-\beta)z}{\beta}$$

By comparison, recall that:

$$\theta_s k_s = \frac{r}{\beta}\frac{(1-\beta)b(r+\mu+\lambda)}{(r+\lambda)(r+\mu)-\lambda\mu} - \frac{(1-\beta)z}{\beta}$$

Consequently, in order for equation (35) to hold, $\alpha$ must be null or the following equation must also hold:

$$\frac{\delta+\lambda+\beta(r+\mu)}{\lambda(\beta+1)} = F(\epsilon_b)$$