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## The effects of a bonus-malus workers' compensation system on the labor force structure, productivity, and welfare

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## Abstract

This paper investigates the economic impact of adjusting premiums of workers' compensation systems, according to the firms' absenteeism rates. We develop a search and matching economy where workers are identical, but firms differ in terms of their Occupational Safety and Health (OSH). We show that this policy allows productivity, employment, and welfare to be improved.

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# 1. Introduction

The social and economic burden of occupational illness and injuries is hard to estimate.[1] Nonetheless, it is widely recognized that those costs may affect productivity and economic growth, given the negative impact on workers, employers, and society. Thereby, several European countries have amended national legislations concerning safety and health regulations to give greater priority to prevention.

Insurance tariffs have proven to be an important incentive to motivate employers to comply with the law (Esler and Eeckelaert, 2010). This scheme is used in two broad ways: either employers are rewarded for efforts to improve Occupational Safety and Health (OSH) through, for example, premium variations based on experience-rating (bonus-malus system), or they receive some financial support from insurance bodies (public or private) for prevention activities (such as training or OSH investments).[2]

According to empirical work focusing on working conditions, absenteeism is in part attributed to a deterioration of health capital (Ose, 2005); moreover, several studies find moderate to positive effectiveness of the experience rating policy, either in reducing the injury outcomes (Lengagne, 2016; Philipsen, 2009) or in leading to improvements in workplace safety and health (Tompa, Cullen, and McLeod, 2012).

Given this context, in this paper we examine the theoretical effects of a bonus-malus policy on the labor force structure, productivity, and welfare, by considering that part of the absenteeism comes from jobs, not from workers; the workers are then identical, but firms differs according to their OSH.[3] By neutralizing the labor offer side, we can examine in a better way the intra-sectoral externalities on the labor demand side. Our work is a contribution to the broad literature on the health-absenteeism relationship, in which the role of firms has been little studied.

# 2. The Model

The model is built on the analytical framework proposed by Pissarides (2000). Time is continuous. The economy is populated by a constant labor force normalized to unity. Workers are ex-ante identical, so that they are subject to the same risks of unemployment and sickness, but firms differ according to their OSH. Agents are risk neutral, with discount rate $r$, and there is no moral hazard concerning workers' health.

## 2.1. The matching process and flows in the labor market

The labor market is segmented. Segment $B$ is composed of firms with poor OSH and bad jobs, that are on average less productive, since they imply higher health risks and more absenteeism. Conversely, Segment $G$ comprises of firms with high OSH and thereby good jobs, with higher average productivity.

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[1] The ILO estimates the annual economic burden of poor OSH at 4% of the global GDP (ILO, 2014).

[2] Experience-rating approaches can be found in both competitive and monopolistic markets. Besides, rewarding or subsidizing prevention activities is a sort of investment for insurers, who expect to receive fewer claims in the future. Then, for private insurance companies it is harder than for a public (monopoly) system to afford these costs, since enterprises can change their insurance providers at short notice and the original provider loss their investment. However, both insurance-related incentives are quite common since only 8 of the EU member states have a private competitive insurance market.

[3] This is the only source of heterogeneity considered; otherwise, we could not be able to disentangle the effects of introducing the experience rating. This kind of simplification is common in economic modeling. For instance, Amine and Lages Dos Santos (2010) and Strand (2000; 2002) make the inverse assumption, by considering that workers are heterogeneous, but firms are identical.

Unemployed workers can seek employment in both segments. The matching process on the segment $i = B, G$ is summarized by the following matching function:

$$M(U, V_i) = \nu U^{1-\xi} V_i^{\xi} \tag{1}$$

where $U$ represents the total number of unemployed workers, $V_i$ pertains to the disposable vacancies for each segment, ν, ξ respectively denote the efficiency of the matching and the elasticity with respect to vacancies. Vacancies are filled with probability $q_i = m(\theta_i)$, while unemployed workers find a job with probability $p_i = \theta_i m(\theta_i)$; $\theta_i = V_i/U$ is the labor market tightness.

We assume that jobs and workers have many unobservable characteristics that can influence the job match productivity (*match quality)*. The productivity $y$ of a job–worker pair is drawn from a distribution described by the cumulative distribution function $F(\cdot)$ with support $[\underline{y}, \bar{y}]$. The information about the match quality $(y, i)$ becomes available only after the firm and worker meet, but before signing the labor contract; $y$ and $i$ do not change until the job is destroyed.

Once a worker is recruited, with probability $\lambda_i$, where $\lambda_B - \lambda_G \geq 0$, he/she falls ill and takes a sick leave, during which the job is unproductive. We assume that absenteeism follows a Poisson process, so that the average span between two periods of absenteeism is $1/\lambda_i$. The healing probability $\psi$ is defined in the same manner, whereby the average duration of a healing period is $1/\psi$. Finally, let $s$ denote the exogenous job destruction rate; this probability is the same for all jobs and it is the unique source of dismissal.

### 2.2. Workers

In each segment of the labor market there are $e_i$ workers in their jobs and $a_i$ workers on sick leave. Consequently, the labor force can be decomposed as $\sum_{i=B,G} e_i + \sum_{i=B,G} a_i + U = 1$. At the steady state, the equilibrium flows for each category of workers are given as:

$$U \cdot p_i\big(1 - F(\tilde{y}_i)\big) + a_i \cdot \psi = e_i \cdot (\lambda_i + s) \tag{2}$$

$$e_i \cdot \lambda_i = a_i \cdot (\psi + s) \tag{3}$$

$$U = \frac{s}{s + \sum_{i=B,G} p_i\,(1 - F(\tilde{y}_i))} \tag{4}$$

We assume an incomplete market economy in which agents do not have access to capital markets. Therefore, they cannot self-insure against the risk of income fluctuations associated with unemployment or illness; but public authorities offer coverage against these risks, whereby workers on seek leave receive a compensation $z$ and unemployed workers receive an unemployment allocation $b$. To finance these insurance systems, firms pay a proportional tax $\tau_i$ on the wages.

Intertemporal utilities are denoted as: $V_{ai}(y)$: absent workers, $V_{ei}(y)$: workers in their jobs, and $V_u$: unemployed workers, with the corresponding Bellman equations:

$$rV_{ai}(y) = z + \psi[V_{ei}(y) - V_{ai}(y)] + s[V_u - V_{ai}(y)] \tag{5}$$

$$rV_{ei}(y) = w_i(y) + \lambda_i[V_{ai}(y) - V_{ei}(y)] + s[V_u - V_{ei}(y)] \tag{6}$$

$$rV_u = b + \sum_{i=G,B} p_i \int_{\underline{y}}^{\bar{y}} \max\left[V_{ei}(\epsilon) - V_u; 0\right] dF(\epsilon) \tag{7}$$

were $w_i(y)$ is the wage rate for workers in their jobs.

### 2.3. Firms

Firms may have occupied or vacant positions. A vacancy costs to the firm $c > 0$ per period. In addition, jobs require a maintenance cost $K_i$, which is higher for good jobs, i.e., $K_G \geq K_B$. One can think of these costs as the firms' investments on OSH. The present values are denoted as: $\Pi_{vi}$: vacant jobs, $\Pi_{ei}$: occupied job with a match quality $(y, i)$, and $\Pi_{ai}(y)$: temporary unproductive jobs. Then:

$$r\Pi_{vi} = -c + q_i \int_{\underline{y}}^{\bar{y}} \max\left[\Pi_{li}(\epsilon) - \Pi_{vi}; 0\right] dF(\epsilon) \tag{8}$$

$$\begin{aligned} r\Pi_{ei}(y) = y - w_i(y) \cdot (1 + \tau_i) - K_i + \lambda_i[\Pi_{ai}(y) - \Pi_{ei}(y)] + s[\Pi_{vi}(y) \\ - \Pi_{ei}(y)] \end{aligned} \tag{9}$$

$$r\Pi_{ai} = -K_i + \psi[\Pi_{li}(y) - \Pi_{ai}(y)] + s[\Pi_{vi}(y) - \Pi_{li}(y)] \tag{10}$$

Once the vacancy is filled, the productivity is worth $y$ and becomes zero either when the job is destroyed, or the worker is temporary absent. The free entry condition for open vacancies is $\Pi_{(v,i)} = 0$. At equilibrium, the labor demand in each segment is:

$$\frac{c}{q_i} = \int_{\tilde{y}_i}^{\bar{y}} \Pi_{li}(\epsilon) dF(\epsilon) \tag{11}$$

Using (9), (10), the job-creation for each segment is:

$$\frac{c}{q_i} = \int_{\tilde{y}_i}^{\bar{y}} \frac{(r + \psi + s)(\epsilon - (1 + \tau_i)w_i(\epsilon)) - (r + \psi + s + \lambda_i)K_i}{(r + s + \lambda_i)(r + \psi + s) - \lambda_i \psi} dF(\epsilon) \tag{12}$$

### 2.4. Wages

The wage results from a continuous negotiation between firms and workers, bearing in mind that in the case of sick leave jobs are not destroyed to avoid the search effort to both the firm and the worker. The wage contracts are the solution to the maximization of the generalized Nash criterion:

$$\max_{w_i(y)} < \beta \ln\left[V_{li}(y) - V_u\right] + (1 - \beta) \ln\left[\Pi_{li}(y) - \Pi_{vi}\right] > \tag{13}$$

Then:

$$w_i(y) = \frac{\beta}{1+\tau_i}(y - K_i) + (1 - \beta)rV_u + \frac{\lambda_i}{r+\psi+s}\left[-\frac{\beta}{1+\tau_i}K_i + (1 - \beta)(rV_u - z)\right]; \tag{14}$$

so, in bargaining, the firm enforces workers to support a portion of the tax burden through lower wages.

### 2.5. Equilibrium and threshold value for productivity

At equilibrium, the value of unemployment can be expressed as:

$$rV_u = b + \sum_{i=B,G} \frac{\beta c \theta_i}{(1-\beta)(1+\tau_i)} \tag{15}$$

Thereby, the wage equation becomes:

$$\begin{aligned} w_i(y) = {} & \frac{\beta}{1+\tau_i}(y-K_i) + (1-\beta)(b + \sum_{x=B,G} \frac{\beta c \theta_i}{(1-\beta)(1+\tau_i)}) \\ & + \frac{\lambda_i}{r+\psi+s}[-\frac{\beta}{1+\tau_i K_i} + (1-\beta)(b-z \\ & + \sum_{x=B,G} \frac{\beta c \theta_i}{(1-\beta)(1+\tau_i)})] \end{aligned} \tag{16}$$

Finally, we must determine the threshold value for productivity on each segment. The worker and the firm share the surplus $S(y,i) = \Pi_{li}(y) - \Pi_{vi} + V_{li}(y) - V_u$ generated from the job match. The job creation rule is given by the threshold value for productivity $\tilde{y}_i$ satisfying $S(\tilde{y}_i, i) \geq 0$:

$$\begin{aligned} \tilde{y}_i = {} & K_i + (1+\tau_i)(b + \sum_{x=B,G} \frac{\beta c \theta_x}{(1-\beta)(1+\tau_x)}) + \frac{\lambda_i}{r+\psi+s}[K_i + (1+\tau_i)(b-z \\ & + \sum_{x=b,G} \frac{\beta c \theta_x}{(1-\beta)(1+\tau_x)})] \end{aligned} \tag{17}$$

### 2.6. Endogenous taxation and balanced budget

The unemployment insurance fund is financed by a proportional flat tax $\tau_u$. However, to deal with the externality arising from maintaining a flat-tax-rate in health insurance, the workers' compensation fund is financed by a proportional flat tax $\tau_h$ and a modulation tax $\tau_e$, so that $\tau_e > 0$ for firms in Segment $B$ and $\tau_e = 0$ for those in Segment $G$. Then,

$$\tau_G = \tau_u + \tau_h \text{ and } \tau_B = \tau_u + \tau_h + \tau_e \tag{18}$$

We assume a balanced budget for each insurance fund. So:

$$b \cdot U = \tau_u \cdot \sum_{i=B,G} \int_{\tilde{y}_i}^{\bar{y}} e_i\,(\epsilon) w_i(\epsilon) dF(\epsilon) \tag{19}$$

$$z \cdot a_i = (\tau_h + \tau_e) \cdot \int_{\tilde{y}_i}^{\bar{y}} e_i\,(\epsilon) w_i(\epsilon) dF(\epsilon) \tag{20}$$

### 3. Calibration

The model cannot be solved analytically, so it is calibrated and simulated to study its qualitative implications. Although parameters are calibrated using French data, the simulation exercises should be understood as illustrations of the theoretical model, which is applicable to other countries in continental Europe. The reference period is a day. Since 2010, the average duration of a sick leave has been around seven days (hence, $\psi = 1/7$), and the average number of working days lost per employee per year is around 17 days (Commission des Comptes de la Sécurité Sociale, 2016), implying an average rate of absenteeism of 4.6%.

Since sector $G$ implies lower risks of work-related injuries, the probability $\lambda_G$ is mostly related to workers' individual risks rather than to risks derived from firms. Conversely, workers in sector $B$ face the same individual risks than workers in sector $G$ (since they are homogeneous), plus an additional risk only due to the OSH behavior of firms. Then, the difference $\lambda_B - \lambda_G > 0$ is assumed to be the risk linked to the firms' OSH.

There is no data on the number of companies offering good (bad) working conditions[4], but the size of sectors $G, B$ depends on $\lambda_G$ and $\lambda_B$, which are calibrated to reproduce the observable rate of absenteeism (which considers all causes of medical leaves, excepting maternity and chronic diseases). Since these probabilities are also unobservable, we assume that the difference between them is equivalent to an average period of sick leave (7 days): $\lambda_G = 1/180$ and $\lambda_B = 1/90$.

The matching function is parametrized using standard values (Petrongolo and Pissarides, 2001; Joseph, 2005), whereby $\xi = 0.5$, $\beta = 0.5$, $\nu = 0.0125$, $u = 10\%$, $s = 0.0005$, $r = 4\%$ per annum, and $K_G = 0.025$. $F(.)$ is assumed to be log-normal with average normalized to 1, and $b = 0.4$ and $z = 0.6$ are adopted to reproduce the replacement rate of 50% and a sickness coverage of 75%. With this reference calibration, the remaining steady state values are calculated. These are reported in Table I.

Table I. Calibration and steady State.

| Benchmark Calibration | | Steady State | |
|---|---|---|---|
| Parameter | Value | Variable/Parameter | Value |
| $\beta$ | 0.5 | $u$ | 10% |
| $\xi$ | 0.5 | $p_G$ | 0.0052 |
| $\nu$ | 0.0125 | $p_B$ | 0.005 |
| $r$ | 0.000125 | $q_G$ | 0.0140 |
| $s$ | 0.0005 | $q_B$ | 0.0146 |
| $b$ | 0.4 | $e_G$ | 0.8705 % |
| $z$ | 0.6 | $e_B$ | 0.8605 % |
| $\psi$ | 14% | $a_G$ | 0.034% |
| $c$ | 2.5 | $a_B$ | 0.042% |
| $m$ | 0.0085 | $\tilde{y}_G$ | 0.9736 |
| $\lambda_G$ | 0.55% | $\tilde{y}_G$ | 0.9985 |
| $\lambda_B$ | 1.10% | $T$ | 9.2% |
| $a$ | 4.5% | $\theta_G$ | 0.0765 |
| $K_G$ | 0.025 | $\theta_B$ | 0.1075 |
| $K_B$ | 0 | | |

## 4. The bonus-malus policy

The policy aims to foster the creation of good quality jobs, restore tax fairness, and improve economic productivity. The results yielded by numerical exercises, for the modulation tax $\tau_e$ taking values from 0% (flat-tax system) to 5%, are shown in Figure 1 to 4.

[4] The notion of good or bad, within an industry (intra-sectorial risks), should not be confused with the differences regarding the risks between different industries (inter-sectorial risks: for instance, construction is riskier than services).

In Figure 1, we observe that the absenteeism rate falls as the tax $\tau_e$ increases, since the payroll and firm profitability increase; thereby employment rises and unemployment declines until $\tau_e = 0.025$. Thereafter, the congestion effect in the good segment dominates and the creation of good jobs does not offset the destruction of bad jobs.

Figure 1. Unemployment, employment, absenteeism, and low-risk jobs.

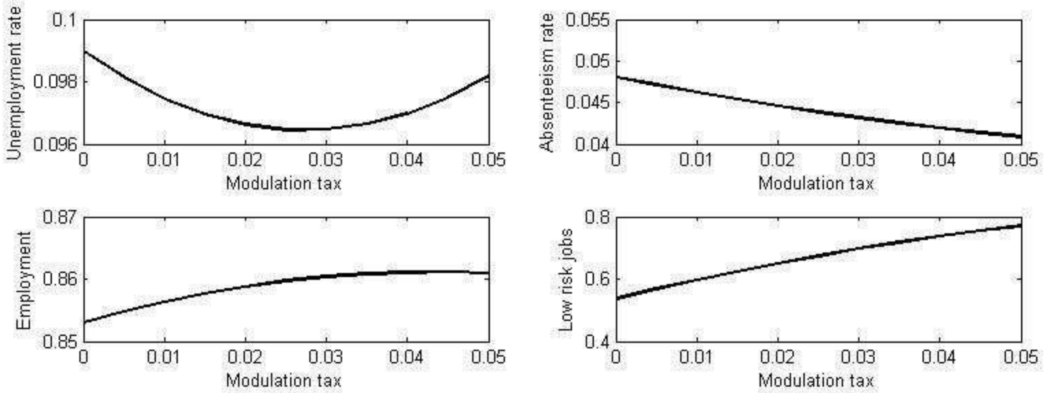
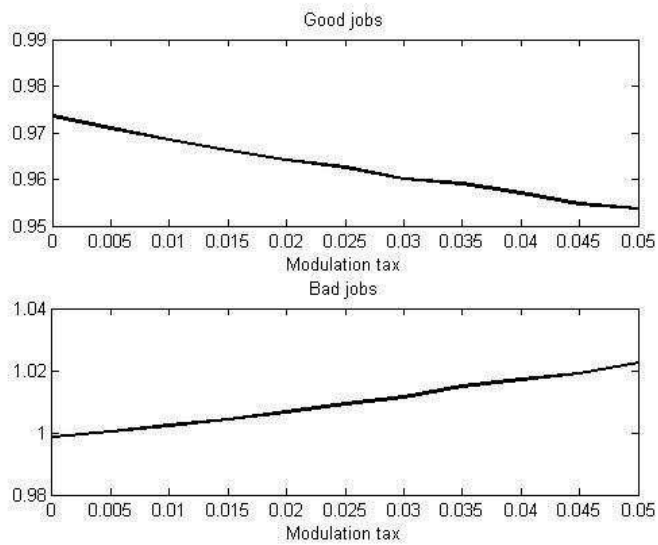



Figure 2 shows that firms in Segment $G$ have a lower productivity reservation threshold than those in Segment $B$. Since the former are more productive, they can hire workers even for low match qualities. This is at odds with the common view of experience rating as an incentive for firms to be more selective.

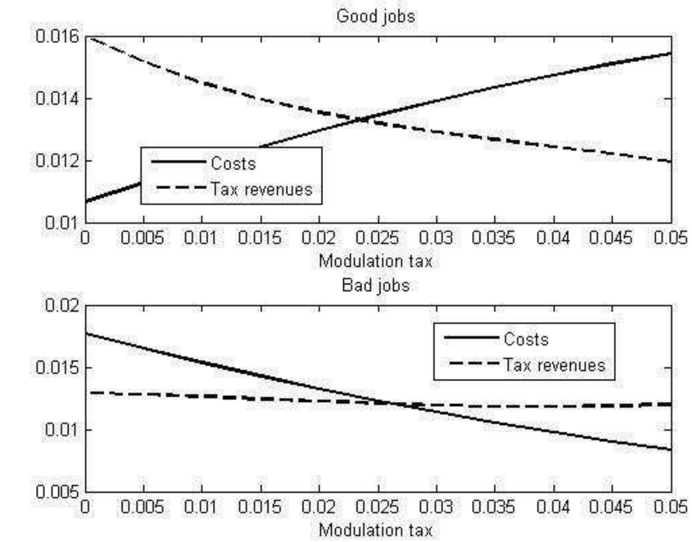
Figure 2. Productivity threshold.




From Figure 3, we note that in the flat-tax system, Segment $G$ subsidizes the deficit of the other firms until tax fairness is restored at $\tau_e = 0.025$. However, tax fairness does not ensure optimality in terms of welfare and production. Welfare is defined as the sum of all individual intertemporal utilities and profits. [5] Thus, it is expected that improvements in employment and absenteeism would improve welfare.

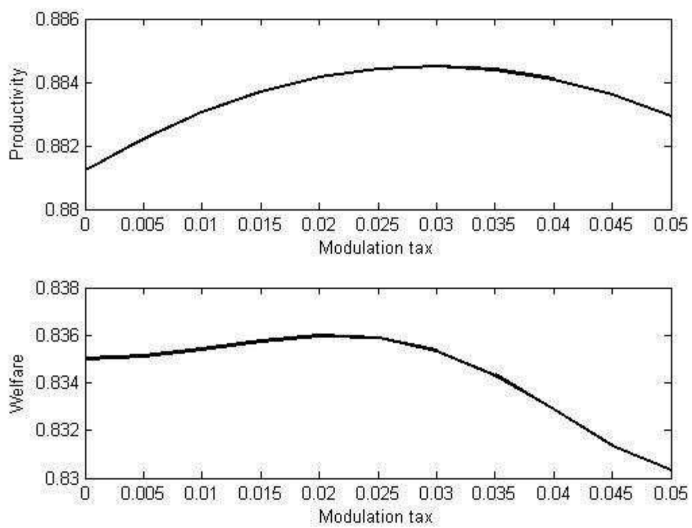
[5] Note that in the present context, optimality refers to the values that maximize the objective function, that is, the surplus S. Therefore, our exercise differs from those that use criteria of the "welfare economy" (Rawlsians, utilitarianism, etc.).

Figure 3. Modulating the workers' compensation fund.




However, since the maintenance costs are higher in Segment $G$, the optimal $\tau_e$ for welfare is lower than the optimal $\tau_e$ for productivity (see Figure 4).

Figure 4. Productivity and welfare.




## 5. Conclusion

The work presented in this paper aimed to elucidate the effects of introducing a simplified scheme of experience rating on the employers' contributions to the workers' compensation system. We find that this bonus-malus system reduces the externalities, thereby promoting the creation of highly productive jobs with low absenteeism rates. Consequently, employment, productivity, and welfare improve.

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