Project logo: TAXBEN

Project no. SCS8-CT-2004-502639

Project acronym TAXBEN

Project title: Tax/benefit systems and growth potential of the EU

Instrument: Specific Targeted Research Project

Thematic Priority: SSP Priority 8 Topic 3.1 Task 4

Deliverable reference number and title 6 A

A Quantitative Evaluation of Payroll Tax Subsidies: A Structural Approach
A Reform of the French Tax/Benefit System

Due date of deliverable: Month 12
Actual submission date: Month 16

Start date of project: 1.12.2004 Duration: 24 months

Organisation name of lead contractor for this deliverable: CEPREMAP

Revision [1]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

A Quantitative Evaluation of Payroll Tax Subsidies: a Structural Approach

A reform of the French Tax/Benefit system

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December 12, 2005

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Abstract

Since the mid-1990s, France has experimented with the strategy of maintaining a high minimum wage level with large, permanent subsidies to employer payroll taxes on low wages. This paper evaluates the effect of this policy on employment. In addition, it takes into account the productivity channel and considers whether the implemented reform lies on the optimal range of exempt wages. We first construct an equilibrium search model incorporating wage posting and specific human capital investment, where unemployment and the distribution of both wage and productivity are endogenous. We estimate this model using French data. Numerical simulations show that the prevailing minimum wage allows a high production level to be reached by increasing training investment, even though the optimal minimum wage is lower. Given that payroll tax subsidies are expected to lower labor costs and maintain the minimum wage legislation, we find that the French policy is welfare-improving. Moreover, its costs are relatively well managed by spreading the subsidies over a wide range of wages beyond the minimum wage level.

JEL codes : C51, J24, J31, J38

Keywords: Employment, productivity, wage posting model, labor costs

Introduction

High labor costs typically are considered the primary cause for high unemployment levels in continental European countries (see Blanchard and Wolfers (2000)). During the 1990s, these countries used a large set of policy tools to decrease the unemployment rate, in particular that of low-skilled workers. France experimented with an original strategy which consisted of a high minimum wage level[1] compensated by large, permanent payroll tax subsidies on low wage employment.

Research on the French labor market has pointed out extensively the negative role played by the minimum wage legislation due to increasing labor costs (for instance Laroque and Salanié (2000) and (2002)). In the mid-1990s, the introduction of payroll tax subsidies for low-wage workers was meant to compensate for the negative impact on minimum wage employment without exacerbating wage inequality. The policy is designed specifically to avoid a significant job reallocation towards poorly paid jobs. Subsidies are not concentrated at the minimum wage level and, instead, consist of a maximum reduction of 18.2 points at the minimum wage level and a decreasing reduction in payroll taxes up to 1.33 times the minimum wage. Several econometric papers have already highlighted the positive impact of this policy on employment (for example, Kramarz and Philippon (2001) and Crépon and Desplatz (2002)).

Malinvaud (1998), however, underscores a potential negative impact on productivity due to a bias in job creation at the bottom of the wage distribution. When the wage distribution is strongly interrelated with the productivity distribution, payroll tax subsidies that are concentrated at the bottom of the wage distribution could shrink productivity, which in turn could dampen the output. Figure 1 shows the downward shift and flattening of the wage distribution of manual workers since the 1990s.[2] The change in labor cost units during the period 1997-2002 supports this observation: at the minimum wage level, labor cost units increased despite the negative impact of payroll tax subsidies.[3]

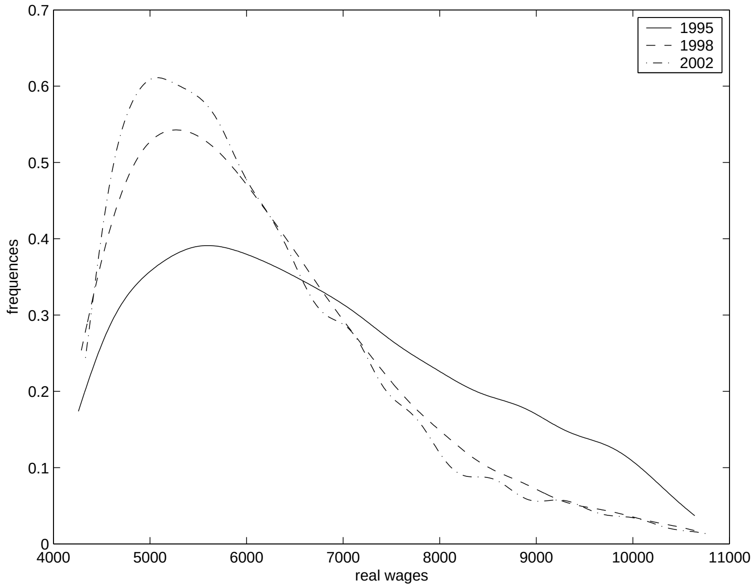
In this paper, we evaluate the payroll tax exemption policy and its impact

[1]France has the highest minimum wage/average wage ratio (known as the Kaitz ratio) in Europe: it is equal to 55%, whereas all the other European countries have a ratio lower than 50%.

[2]We retain only full-time manual workers from the Labor Force Survey ("Enquête emploi") provided by INSEE, as in the empirical part of our study. We estimate the wage distribution using a wage set of $N \in [14,100; 14,400]$ individuals: the size of this vector (N) varies every year, but the difference is not significant.

[3]During the period 1997-2002, the annual growth rates of labor cost units are 1.2%, 1.3%, 1%, 0.9%, 2% and 1.5%, respectively. (Sources: INSEE and DGTPE).

Figure 1: Observed Wage Distributions of Manual Workers (France)



on employment as we take into account the productivity channel. We propose a structural model of the French low-skilled workers labor market that enables us to evaluate quantitatively the employment-plus-productivity effects of the French labor cost reducing policy. This structural strategy differs from recent econometric exercises (see for instance Kramarz and Philippon (2001) or Crépon and Desplatz (2002)) and allows us to examine several policy experiments. We propose a wage posting model with specific human capital investments and a bilateral endogenous search, similar to Mortensen (2000), to consistently generate wage and productivity distributions and an unemployment equilibrium rate. In this framework, the expected job duration determines to what extent firms invest in specific human capital. In addition, we set that the wage posting strategies of firms and their training investments are strongly related, as suggested in Manning (2003). As such, the negative relationship between wage and labor turnover creates incentives for training employees. In equilibrium, firms choose different levels of training and wage offers, which result in endogenous within-market productivity differences and, consequently, a dispersed equilibrium wage offer distribution. Moreover, the wage posting approach is incorporated into the search equilibria in order to determine unemployment and vacancy rates in a consistent manner. This method leads to a joint theory of wage (as well as productivity) and employment, where the effect of labor market institutions are not determined *a priori* by job creation disincentives or the reduction of the monopsony power of firms.

This paper also incorporates lifelike features to analyze the efficiency of French labor market policies. First, we take into account the existence of a minimum wage which influences the cost of labor and the recruiting effort of firms. Second, we assume the existence of transition periods between short-term and long-term unemployment[4] as well as some heterogeneity in the search intensity of employees and of short- and long-term unemployed.[5] As such, we obtain a time-varying unemployment benefit system and differences in offer arrival rates per the status of individuals (in employment, short- or long-term unemployment). These features generate an endogenous distribution of the unemployed workers' reservation wage, which enhances the evaluation of the minimum wage legislation.

Our strategy relies on at least two key points:[6] the wage posting hypothesis and the fact that productivity is governed by specific human capital investments.[7] The former seems consistent with empirical findings for low-wage workers and the assumption that firms have monopsony power is not rejected for these workers in the French panel data set(see Cahuc, Postel-Vinay, and Robin (2003)). Regarding the second point, Postel-Vinay and Robin (2002) show that the productivity differential across firms explains about half of the French low-skilled wage variance. The remaining part is due entirely to search friction, leaving no room for individual fixed effects. We interpret this as general human capital,[8] which increases with the skill of workers (Postel-Vinay and Robin (2002)). We exclude physical capital from the analysis: Robin and Roux (2002) show that the introduction of physical capital in a model *à la* Burdett and Mortensen does not help match the observed French wage distribution.

We estimate key parameters of the model on French data using the Sim-

[4]Half of unemployed individuals are not eligible for the French unemployment benefit system and we qualify them as long-term unemployed for simplicity.

[5]As we focus on firms policies on wage and specific human capital investment (i.e. hiring decisions), we do not introduce an endogenous search effort, contrary to Christensen, Lentz, Mortensen, Neumann, and Werwatz (2005).

[6]We considered adding into our model that the probability of job-to-job transitions declines as one moves up the wage distribution. Yet, Bowlus and Neumann (2004) provide some empirical evidence against this prediction based on the existence of negative wage changes for high wage workers. By focusing on low-skilled workers, we avoid this problem.

[7]These two points receive some support in Manning (2003).

[8]Mortensen (2003) finds a similar result by using a simple calibrated model. This is consistent with previous empirical microevidences along the lines of Lynch (1992) and Black and Lynch (1996) who underline the significant role of specific firms' investments in human capital in the distribution of workers' wages and productivity. International evidence shows that the returns of firm-provided training are significant: 2% in Germany (see Pischke (1996)) and 12% in the US (Blanchflower and Lynch (1994)).

ulated Method of Moments. Based on statistical tests, we cannot reject the hypothesis that the theoretical wage distribution is generated by the same law as the observed one. In particular, because the productivity distribution plays a central role in the replication of the observed unimodal wage density,[9] it provides a powerful identification strategy to estimate the elasticity of productivity relative to human capital investment.

Hence, we investigate the various implications of a minimum wage on output. The optimal level for a minimum wage seems to be slightly lower than the observed one: a decrease in the minimum wage leads to an employment boost, but is not totally compensated by a decline in labor productivity. The opposite occurs when considering values below the optimal minimum wage level. If we remove the productivity channel, we obtain a very different conclusion and find that short-term unemployment benefits are binding. Despite the existence of long-term unemployed workers who would be willing to work for a lower wage, we show that no firms would propose a wage below the reservation wage of the short-term unemployed workers. In that sense, the minimum wage legislation is unnecessary. Alternatively, including the productivity channel emphasizes the importance of a minimum wage. Given that the payroll tax subsidies are implemented to lower labor costs without removing the minimum wage legislation, we show that this policy is welfare-improving. It is implemented relatively well because it allocates subsidies over a large range of wages, not only at the minimum wage level. Existing exemptions lead to an employment boost which is offset in part by a deterioration of the productivity level. Here again, removing the productivity channel from the analysis leads to an opposite recommendation, namely the concentration of exemptions at the minimum wage level.

This paper is organized in three sections. Section 1 is devoted to the presentation of the theoretical model, whereas section 2 presents the calibration and empirical performances of the model. Quantitative results for different policy experiments are discussed in section 3.

1 The Theoretical Model

Our theoretical framework is based on the Mortensen (2000) equilibrium search model with wage posting and training investment by firms. This

[9]Bontemps, Robin, and van den Berg (1999) not only provide some empirical evidence in favor of the wage posting approach concerning French wage distribution, but also show that the Burdett and Mortensen (1998) theory of pure dispersion cannot totally explain the unimodal wage density, unless the assumption of productive heterogeneity across employers is made.

framework is extended in three ways. First, we take into account the transition between short- and long-term unemployment.[10] Second, we introduce heterogeneity in the search intensity of employees and short- and long-term unemployed workers. Finally, we incorporate the minimum wage legislation.

The total labor force is composed of employed workers, unemployed workers entitled to unemployment benefits and unemployed workers excluded from the compensation system but entitled to a minimum income. We assume that these three components of the total labor force are not perfectly equivalent in the matching process. An employed worker accepts any offer in excess of the wage currently earned. Yet, all unemployed workers will accept the first offer that is higher than the common reservation wage of their sub-group. Differences in unemployment benefit compensation levels and the intensity of the job search process generate two distinct reservation wages in the economy.

Firms create "job sites" and each job is either vacant or filled. The equilibrium level of vacancies is endogenously determined by a free entry condition. For each job vacancy, firms also determine the associated wage and firm-specific training offered.

In the remainder of this section, we begin by presenting the conditions that characterize the equilibrium flows for the two unemployed worker populations and for each job relative to a given wage of the distribution. Then, we determine the reservation wages through the derivation of the optimal behavior of workers. Based on the firm's optimal decisions, we derive the vacancy rate, the wage offer distribution and the human capital investment distribution.

1.1 Labor Market Flows

1.1.1 Matching Technology

According to Pissarides (1990), the aggregate number of hirings, H, is determined by a conventional constant returns to scale matching technology:

$$H = h(v, h^e e + h^s u^s + h^l u^l)$$

where v is the number of vacancies, $h^e \geq 0, h^s \geq 0, h^l \geq 0$ are the exogenous search efficiencies (intensities) for employed workers and short-term and long-term unemployed workers, represented (in number) by e, u^s and u^l, respectively. We normalize $e + u^s + u^l$ to 1 and we denote $u \equiv u^s + u^l$ and $\overline{h} = h^e e + h^s u^s + h^l u^l$.

[10] See Albrecht and Vroman (2001) for a Pissarides (1990) style of matching model where the heterogeneity of the reservation wages is due to the exclusion of some unemployed workers from the unemployment benefit system.

If we set $\theta = \frac{v}{\bar{h}}$ as labor market tightness, the arrival rates of wage offers for workers are :

- for the employees

$$h^e \lambda(\theta) \equiv \frac{h^e}{\bar{h}} \frac{H}{e + u^s + u^l} = h^e \frac{H}{\bar{h}}$$

- for the short-term unemployed

$$h^s \lambda(\theta) \equiv \frac{h^s}{\bar{h}} \frac{H}{e + u^s + u^l} = h^s \frac{H}{\bar{h}}$$

- for the long-term unemployed

$$h^l \lambda(\theta) \equiv \frac{h^l}{\bar{h}} \frac{H}{e + u^s + u^l} = h^l \frac{H}{\bar{h}}$$

Accordingly, the average duration of a spell before a wage offer contact is $1/(h^e \lambda(\theta))$ for the employees, $1/(h^s \lambda(\theta))$ for the short-term unemployed and $1/(h^l \lambda(\theta))$ for the long-term unemployed.

The transition rate at which vacant jobs are filled is:

$$q(\theta) = \frac{H}{v} = h\left(1, \frac{\bar{h}}{v}\right)$$

The average vacancy duration is thus $1/q(\theta)$.

1.1.2 Entries and Exits from Unemployment

Let x_s and x_l denote the endogenous reservation wages of the short-term and long-term unemployed, respectively. The steady state level of short-term unemployment (u^s) is derived from the following equilibrium flows:

$$\underbrace{s(1-u)}_{\text{firings}} = \underbrace{h^s \lambda(\theta) \left[1 - F(x_s)\right] u^s}_{\text{hirings}} + \underbrace{\delta u^s}_{\substack{\text{flow into} \\ \text{long-term} \\ \text{unemployment}}}$$

where $s \in [0, 1]$ is the exogenous job destruction rate, $F(w)$ denotes the distribution function of wage offers w and $\delta \in [0, 1]$ is the probability of short-term unemployed workers transitioning to long-term unemployment. When δ is allowed to depend on the elapsed duration of unemployment, the model becomes non-stationary. For simplicity, we assume stationarity with δ constant as in Albrecht and Vroman (2001). The steady state level of long-term unemployment (u^l) is given by:

$$\underbrace{\delta u^s}_{\substack{\text{flow out of}\\\text{short-term}\\\text{unemployment}}} = \underbrace{h^l \lambda(\theta)\left[1 - F(x_l)\right] u^l}_{\text{hirings}}$$

These equations show that the fraction of long-term unemployed in the total unemployed population (u^l/u) decreases with the tightness of the labor market (θ): when θ increases, the expected duration of unemployment decreases, as does the probability of becoming long-term unemployed.

1.1.3 Entries and Exits from Employment at or Less than Wage w

Let $G(w)$ denote the fraction of workers employed at or less than wage w. This function is derived from the following equilibrium flows:

- If $x_l \leq w < x_s$,

$$\underbrace{(1-u)G(w)h^e\lambda(\theta)\left[1 - F(w)\right]}_{\text{volontary quits}} + \underbrace{s(1-u)G(w)}_{\text{firings}} = \underbrace{h^l\lambda(\theta)F(w)u^l}_{\text{hirings}}$$

- If $w \geq x_s$,

$$\begin{aligned} & \underbrace{h^e\lambda(\theta)\left[1 - F(w)\right](1-u)G(w)}_{\text{volontary quits}} + \underbrace{s(1-u)G(w)}_{\text{firings}} \\ = & \underbrace{u^s h^s \lambda(\theta)F(w) + u^l h^l \lambda(\theta) F(w)}_{\substack{\text{potential}\\\text{hirings}}} - \underbrace{u^s h^s \lambda(\theta) F(x_s)}_{\text{rejections}} \end{aligned}$$

1.2 Behaviors

1.2.1 Workers

The total income of workers is composed of labor market earnings and transfers (government budget surplus and firms' profits[11]) which are uniformly

[11] These two variables are defined more precisely in a later section.

distributed across households denoted by $\mathcal{T}$. Let $V^n(w)$ denote the value function for an employed worker who earns w, V^{us} the value function for a short-term unemployed person who is paid b unemployment benefits and V^{ul} the value function of a long-term unemployed individual who is paid a minimum social income msi. These functions are solved by:

$$\begin{aligned} rV^n(w) &= u((1-t_w)w+\mathcal{T}) + h^e\lambda(\theta)\int_w [V^n(\tilde{w}) - V^n(w)]\,dF(\tilde{w}) - s\,[V^n(w) - V^{us}] \\ rV^{us} &= u(b+\mathcal{T}) + h^s\lambda(\theta)\int_{x_s} [V^n(\tilde{w}) - V^{us}]\,dF(\tilde{w}) - \delta\left[V^{us} - V^{ul}\right] \\ rV^{ul} &= u(msi+\mathcal{T}) + h^l\lambda(\theta)\int_{x_l} \left[V^n(\tilde{w}) - V^{ul}\right] dF(\tilde{w}) \end{aligned}$$

where $r \geq 0$ and $t_w \in [0,1]$ stand for the real interest rate and employees' payroll taxes, respectively. The utility function $u(\cdot)$ is assumed to be a Constant Relative Risk Aversion (CRRA) and takes into account risk aversion in the determination of the reservation wage.

The reservation wage policies x_s and x_l are derived from the two conditions $V^n(x_s) = V^{us}$ and $V^n(x_l) = V^{ul}$, so that:

$$\begin{aligned} u((1-t_w)x_s+\mathcal{T}) &= u(b+\mathcal{T}) \qquad (1) \\ &\quad +(h^s-h^e)\lambda(\theta)\int_{x_s}^{\overline{w}} [V^n(\tilde{w}) - V^{us}]\,dF(\tilde{w}) - \delta\left[V^{us} - V^{ul}\right] \\ u((1-t_w)x_l+\mathcal{T}) &= u(msi+\mathcal{T}) \qquad (2) \\ &\quad +(h^l-h^e)\lambda(\theta)\int_{x_l}^{\overline{w}} \left[V^n(\tilde{w}) - V^{ul}\right] dF(\tilde{w}) - s[V^{us} - V^{ul}] \end{aligned}$$

¿From these equalities, if $h^s = h^l = h^e$ and $\delta = 0$ (as in Mortensen (2000)), then one finds $x_s = b/(1-t_w)$. The positive probability of losing the unemployment benefit ($\delta > 0$) then accounts for a decrease in the short-term unemployed workers' reservation wage, x_s.[12] In contrast, if one assumes that $h^s > h^e$, heterogeneity among search efficiencies accounts for a rise in wage claims by the short-term unemployed. Similarly, $h^l > h^e$ pushes up the reservation wage of the long-term unemployed, x_l. In that case, by accepting a wage offer, an unemployed worker anticipates a lower likelihood of earning higher wages in the future. Also, the possibility of becoming short-term unemployed through employment destruction, which occurs with s probability, implies a fall in the reservation wage of the long-term unemployed with the same magnitude as $V^{us} - V^{ul}$ is large.

[12] Of course, at equilibrium, $V^{us} \geq V^{ul}$. If this property is violated, the short-term unemployed workers would benefit by becoming long-term unemployed.

1.2.2 Firms

Let k be the match specific investment per worker and $f(k)$ the value of worker productivity which is an increasing concave function of this investment. It is assumed that whenever an employed worker finds a job paying more than w (voluntary quit), then the employer seeks another worker. When an exogenous quit (destruction) occurs, the job receives no value. Hence, the expected present value of the employer's future flow of quasi-rent once a worker is hired at wage w stated as $J(w,k)$, solves:

$$rJ(w,k) = f(k) - (1 + t_f(w))w - h^e\lambda(\theta)[1 - F(w)][J(w,k) - V] - sJ(w,k)$$

where $t_f(w) \geq 0$ is the employer's payroll taxes. This tax can be a function of the wage when employment subsidies are introduced.

In turn, the asset value of a vacant job solves the continuous time Bellman equation:

$$rV = \max_{w \geq x_l, k \geq 0} \{\eta(w)\left[J(w,k) - p_k k - V\right] - \gamma\}$$

where γ is the recruiting cost, p_k stands for the relative price of one unit of human capital, and $\eta(w)$ is the probability that a vacancy with posted wage w is filled. This probability is defined by:

$$\eta(w) = \frac{Prob(e|u^l)u^l}{v} + \frac{Prob(e|u^s)u^s}{v} + \frac{Prob(e|e)(1-u)}{v}$$

where the first, second and third term shows the acceptance rate of a job offer, respectively, for a long-term unemployed person, a short-term unemployed worker and an employed worker. These probabilities are:

$$\begin{aligned} Prob(e|u^l) &= h^l \frac{H}{\overline{h}} \quad \text{if } \ w \geq x_l \\ Prob(e|u^s) &= \begin{cases} h^s \frac{H}{\overline{h}} & \text{if } \ w \geq x_s \\ 0 & \text{if } \ w < x_s \end{cases} \\ Prob(e|e) &= h^e \frac{H}{\overline{h}} G(w) \end{aligned}$$

where $G(w)$ is the fraction of employed workers with earnings equal to or less than w. The probability functions of the reservation wages are given by:

$$\begin{aligned} \eta(w) &= \frac{H}{v}\left[\frac{h^l}{\overline{h}}u^l + \frac{h^e}{\overline{h}}(1-u)G(w)\right] \qquad \forall\ w \in [x_l, x_s] \\ \eta(w) &= \frac{H}{v}\left[\frac{h^l}{\overline{h}}u^l + \frac{h^s}{\overline{h}}u^s + \frac{h^e}{\overline{h}}(1-u)G(w)\right] \quad \forall\ w \in [x_s, \overline{w}] \end{aligned}$$

where $H/v = \lambda(\theta)/\theta$ gives the probability of having a contact with a firm.

Free entry conditions at each wage level imply that $V = 0$ and expected intertemporal profits are identical for $w \geq \underline{w}$, where $\underline{w}$ is the lowest wage level offered. Actually, $x_l \leq \underline{w}$, because it is not in the firms' interest to offer a wage rejected by all workers. Hence, labor market tightness θ, the wage distribution function $F(w)$ and firms' investment in human capital $k(w)$ can be derived from the system of equations defined by:

$$\gamma = \eta(w) \left[\max_{k \geq 0} \{ J(w,k) - p_k k \} \right] \quad \forall w \geq \underline{w} \tag{3}$$

with $F(\underline{w}) = 0$. Employers have two reasons for offering a wage greater than $\underline{w}$. First, the firm's acceptance rate ($\eta(w)$) increases with the wage offer, since a higher wage is more attractive. Second, the firm's retention rate increases with the wage paid by limiting voluntary quits that lead to an increase in $J(w,k)$. The wage strategy played by firms is strongly interrelated with human capital investment decisions.

As each employer pre-commits to both the wage offered and the specific capital investment in the match, it is easy to show that the optimal investment solves:

$$f'(k) = p_k(r + s + h^e \lambda(\theta)[1 - F(w)]) \implies k = k(w) \quad \forall w \geq \underline{w} \tag{4}$$

Therefore, the level of specific human capital increases with the level of the wage offer. Indeed, a higher wage reduces the probability that an employee will accept job offers from other firms. The negative relationship between wage and labor turnover creates incentives to train employees. When the wage is high, the expected duration of the match is longer and the period during which the firm can recoup its investment increases. Therefore, firm-specific productivity increases with wages.

1.3 Labor Market Equilibrium

Assumptions on Production Technology

We assume that the production function satisfies the following restrictions: $f'(0) = \infty$, $f'(k) > 0$ and $f''(0) < 0$.

Equilibrium Definition and Properties

A steady state search matching equilibrium defines a reservation wage policy, $\{x_s, x_l\}$, a vacancy rate ($v = \theta \overline{h}$), a long-term unemployment rate u_l, a short-term unemployment rate u_c, a wage offer distribution $F(w)$ and a specific human capital investment function $k(w)$. Appendix A presents the system of equations to solve this equilibrium in more detail.

PROPOSITION 1 **There is only one strictly positive level of vacancy rate.**

See Appendix B.1 for the formal proof of this proposition, which extends Mortensen (2000)'s work.

PROPOSITION 2 **There exists a wage interval $[w_l, x_s[$ over which there is no wage offer.**

Appendix B.2 shows a detailed proof. This equilibrium property suggests that, over $[w_l, x_s[$, the increase in temporary profits associated with a decrease in wages does not compensate for the loss due to higher rotation costs in the long-term unemployed worker segment.

COROLLARY **If $w_l > x_l$, then the support of the wage distribution is formed by two subsets $[x_l, w_l] \cup [x_s, \overline{w}]$. Otherwise, all posted wages are included in the set $[x_s, \overline{w}]$.**

This suggests that, if $w_l < x_l$, the increase in temporary profits when offering a wage lower than x_s is never compensated by the loss due to higher rotation costs.

The introduction of hiring costs implies that *ex ante* identical firms have the same strictly positive expected profits. As shown in Quercioli (2005), this ensures a unique wage offer distribution with no atoms.[13] The proofs provided in Appendix B are satisfied for all payroll tax rules.

The Incidence of a Minimum Wage

The introduction of a minimum wage (mw) may affect the properties of the equilibrium in the following ways:

- If the minimum wage is lower than x_l, it is not a constraint;
- If the minimum wage is greater than x_s, its value is the lower posted wage: $\underline{w} = mw$;
- If the minimum wage is included in $]x_l, w_l[$ then $\underline{w} = mw$;
- If the minimum wage is included in $]w_l, x_s[$, then $\underline{w} = x_s$; or
- If $w_l < x_l$ then $\underline{w} = \max\{x_s, mw\}$.

[13]Without hiring costs, the expected equilibrium profit could be equal to zero. In this case, Quercioli (2005) shows that multiple equilibria can occur.

1.4 Efficiency

To evaluate the impact of labor market policies on the equilibrium, we first focus on the steady state aggregate output flow net of the recruiting costs, as defined by:

$$
\begin{aligned}
\mathcal{Y} \quad = \quad & \underbrace{(1-u)\int_{\underline{w}}^{\overline{w}} f(k(w))dG(w)}_{\text{Output}} \quad - \quad \underbrace{\gamma v}_{\substack{\text{Hiring}\\ \text{costs}}} \\
- \quad & \underbrace{p_k h^s \lambda(\theta) u^s \int_{\underline{w}}^{\overline{w}} k(w)dF(w)}_{\substack{\text{training costs}\\ \text{short-term unemployed}}} \quad - \quad \underbrace{p_k h^l \lambda(\theta) u^l \int_{\underline{w}}^{\overline{w}} k(w)dF(w)}_{\substack{\text{training costs}\\ \text{long-term unemployed}}} \\
- \quad & \underbrace{p_k h^e \lambda(\theta)(1-u) \int_{\underline{w}}^{\overline{w}} \left(\int_{\underline{w}}^{w} k(w)dF(w) \right) dG(w)}_{\substack{\text{training costs}\\ \text{job-to-job mobility}}}
\end{aligned}
$$

We also compute aggregate welfare, which takes into account the risk aversion of workers and the distributive implications of different reforms. Here, we plan to capture the variations in the relative situation of workers and their impact on aggregate welfare for a degree of concavity given by the utility function u:

$$\mathcal{W} = (1-u)\left(\int_{\underline{w}}^{\overline{w}} V^n(w)dG(w)\right) + u^s V^{us} + u^l V^{ul}$$

This implies the need to determine the variations in the government budget surplus ($\mathcal{B}$) and firms' profits (Π) as well as the way they are distributed across households. We assume that they are uniformly redistributed *via* lump-sum transfers across all agents so as to not interfere with the direct distributive effects of policy reforms. As the size of the population is normalized to one, the instantaneous utility functions are $u((1-t_w)w + \mathcal{T})$ for the employed workers, $u(b+\mathcal{T})$ for the short-term unemployed and $u(msi+\mathcal{T})$ for the long-term unemployed, where total transfers $\mathcal{T}$ are defined by $\mathcal{T} = \mathcal{B}+\Pi$. More precisely, the budget surplus is defined by:

$$\mathcal{B} = (1-u)\left(\int_{\underline{w}}^{\overline{w}} [t_f(w) + t_w]wdG(w)\right) - (u^s \times b + u^l \times msi)$$

Aggregate firm profits are defined by:

$$\Pi = \mathcal{Y} - (1-u)\left(\int_{\underline{w}}^{\overline{w}} [1 + t_f(w)] w dG(w)\right).$$

2 Estimation and Test of the Model

This section describes the econometric method we used to estimate the deep parameters of the model. Because structural econometric models are doomed to misspecification, we choose an empirical strategy which ensures robust estimators of the unknown parameters. As the likelihood function cannot be derived analytically, it can be replaced by either an approximation of the exact function (see Bontemps, Robin, and van den Berg (1999) or Rosholm and Svarer (2004)) or by the exact likelihood function of an approximated model (Gouriéroux and Monfort (1994)). We choose the latter strategy and, more specifically, the Simulated Method of Moments, which allows us to run a simple global specification test of our model.[14] The benefit derived from testing the model, however, comes at the cost of making parametric assumptions on the model. Nevertheless, the preferred empirical strategy compounds the advantages of the inferential approach (estimation, confidence sets, specification testing) and the calibration approach (consistent estimation of another set of parameters in the context of a misspecified structural model).[15]

2.1 Estimation method

The Simulated Method of Moments (SMM hereafter) consists of replacing the computation of analytic moments with simulations. The moments underlying the estimation are based on wage distributions. We focus on a sub-sample of manual workers, who are affected by the minimum wage and the probability of being excluded from the unemployment benefit system. This enables us to detect the dimensions along which our simple structural model is capable of mimicking a set of moment restrictions.

The vector Φ ($\dim(\Phi) = 17$) contains all the parameters of the model:

$$\Phi = \{h^e, h^s, h^l, \zeta, \gamma, s, \delta, \sigma, b, msi, r, t_w, t_f, p_k, \alpha, A, A_1\}$$

where the parameters $\{\alpha, A, A_1\}$ characterize the production function such that $f(k) = A_1 + (k + A)^{\alpha}$. We choose this particular production function to

[14]See Gouriéroux and Monfort (1994) for a general statement of these methods. See Collard, Feve, Langot, and Perraudin (2002) for an applied study.

[15]See Dridi, Guay, and Renault (2005) for a general discussion of our empirical strategy.

simplify the estimation procedure. Indeed, it implies that a worker without training has a strictly positive inherited productivity. We choose a value of A such that $k(\underline{w}) = 0$. The normalization of $k(\underline{w})$ holds only for the initial equilibrium.

The parameter σ denotes the risk aversion of the workers: $u(x) = \frac{x^{1-\sigma}}{1-\sigma}$. Finally, the parameter ζ denotes the elasticity of the matching function $H = v^{\zeta}(h^e e + h^s u^s + h^l u^l)^{1-\zeta}$.

We restrict the size of the vector of unknown structural parameters:

$$\Theta = \{\alpha, p_k, h^e\}$$

The absence of empirical evidence for these key parameters of the model motivates this choice. The estimation of the vector Θ is conducted under the following set of restrictions:

- A first vector Φ_1, with $\dim(\Phi_1) = 7$, defined by

  $$\Phi_1 = \{s, \delta, \sigma, msi, r, t_w, t_f\}$$

  is fixed on the basis of external information.

  1. The destruction rate s comes from Cohen, Lefranc, and Saint-Paul (1997): $s = 0.0185$.
  2. The parameter δ is chosen so that the average short-term unemployment spell corresponds to the benefit duration, *i.e.* 30 months, ($\delta = 1/30$).
  3. Microdata suggest that $\sigma = 2.5$ is an admissible value (see Attanasio, Banks, Meghir, and Weber (1999)).
  4. The minimum income msi is fixed at its 1995 institutional value: FF 2,500 (French francs, FF hereafter).
  5. The annual interest rate is fixed at 4%.
  6. Payroll taxes on labor t_f and t_w for firms[16] and workers are set at, respectively, 40% and 20%.

- The second vector Φ_2, with $\dim(\Phi_2) = 6$, defined by

  $$\Phi_2 = \{b, h^s, h^l, A_1, \gamma, \zeta\}$$

  is calibrated, using the model restrictions, to reproduce some stylized facts and assumptions:

[16] Payroll subsidies are introduced when we examine the implication of the French policy.

1. The unemployment replacement rate ($b/E(w)$) is fixed at 0.6, according to Martin (1996).
2. The unemployment rate u equals 16.69%.
3. The ratio of long-term to short-term unemployed workers u^l/u is 46.84%.
4. The condition of free entry in the labor market is respected (no sunk costs linked to the creation of a vacancy).
5. Hiring costs $\gamma\theta/\lambda(\theta)$ equal 0.4 as in Mortensen (2003). These costs correspond approximately to 2.5% of wages (Abowd and Kramarz (1998)).
6. The minimum wage is fixed at a level consistent with the historical French experience (see CSERC (1999)). For a one percent fall in the minimum wage, 14,000 jobs are created. This leads to a value of ζ equal to 0.21.

Given the set of moments, calibrated parameters and policy functions, the estimation method is conducted as follows:

Step 1: The vector of moments ψ is estimated by minimizing the following loss function:

$$Q_N = \left[\sum_{i=1}^{N} g(w_i;\psi_N)\right]' \Omega_N \left[\sum_{i=1}^{N} g(w_i;\psi_N)\right]$$

where Ω_N is a positive definite weighting matrix and N denotes the size of the sample. $\{w_i\}'$ represents the s-dimensional set of wages paid to each manual worker i in the 1995 set of observed random variables. The choice of ψ moments is a critical step in the estimation method, but it is not driven by the model's specification. Rather, it should encompass as many data features as possible to avoid an arbitrary choice and reduce estimation biases. Therefore, we choose a set of moments that fully explain wage densities. In our case, $g(.)$ takes the form

$$g(w_i;\psi_N) = \begin{bmatrix} w_i - \mu \\ \mathbb{1}_{[w_i<D1]}(w_i - \mu_1) \\ \mathbb{1}_{[Dn\leq w_i<Dn+1]}(w_i - \mu_{n+1}) \\ \mathbb{1}_{[D8\leq w_i<D9]}(w_i - \mu_9) \end{bmatrix} \quad \text{for } n = 1,..,7$$

where Dn denotes the wage level for the decile $n = 1, ..., 9$. This minimal set of moments allows us to capture the shape of the observed wage density.

Step 2: Given the vector of structural parameters Θ, the simulated wage density is computed from the set of equations defining the labor market equilibrium.

Step 3: A SMM estimate $\tilde{\Theta}_N$ for Θ minimizes the quadratic form:

$$J(\Theta) = g_N' W_N \, g_N$$

where $g_N = \left(\widehat{\psi}_N - \widetilde{\psi}_N(\Theta)\right)$, W_N is a symmetric non-negative matrix defining the metric[17] and $\widetilde{\psi}_N(\Theta)$ denotes the set of moments implied by the model simulations.

Steps 2 and 3 are conducted until convergence *i.e.* until a value of Θ minimizing the objective function is obtained.[18]

A preliminary consistent estimate of the weighting matrix W_N is required for the computation of $\tilde{\Theta}_N$. It can be based directly on actual data and, here, corresponds to the inverse of the covariance matrix of $\sqrt{N}(\widehat{\psi}_N - \psi_0)$, which is obtained from step 1.

For the purpose of identification, we impose the condition that the number of moments exceeds the number of structural parameters. Thereby, we can conduct a global specification test along the lines of Hansen (1982), such that $J - stat = NJ(\Theta)$, which is asymptotically distributed as a chi-square, with a degree of freedom equal to the number of over-identifying restrictions.

2.2 The Empirical Performance of the Model

Results of the Estimation. We use data from the 1995 French Labor Force Survey ("Enquête emploi"). We consider this year which precedes large structural reforms of the French labor market and retain only full-time manual workers. Thus, in this particular case, $\{w_i\}$ consists of the wage set over $N = 14202$ individuals. Wages, minimum income and unemployment benefits are expressed in 1990 French francs (FF).

Table 1 reports estimates for the deep parameters and the global specification test statistic ($J - stat$). The model is not globally rejected by the data, as the P-value associated with the $J - stat$ is 97.16%. A second feature

[17] This matrix is given by the inverse of the covariance matrix of the moments, obtained from actual data.

[18] The minimization of the simulated criterion function is carried out using a Nelder-Meade minimization method provided in the *Optim* MATLAB numerical optimization toolbox. At convergence of the Nelder-Meade method, a local gradient search method was used to check convergence.

that emerges from the table is that all deep parameters are estimated with precision. In the following paragraph, we discuss the model implications for this set of parameter estimates.

Table 1: Parameters Estimates

Θ	$\widehat{\Theta}$	$\widehat{\sigma}(\Theta)$	$t-stat$
α	0.7299	0.0257	28.4222
p_k	18.8328	1.0790	17.4536
h^e	0.5143	0.0119	43.2492
$J-stat$	1.9425	P-value	97.16%

In the step following the global specification test, we checked the structural model's ability to reproduce empirical moments. We obtained observed and simulated values of moments (Table 2). First, all observed moments are significant so that this set of historical moments is a sufficient table of experience to test our model. Second, Table 2 shows that the simulated moments are also estimated with precision.[19] In addition, they match their empirical counterparts relatively well (confidence intervals based on $\widehat{\sigma}(\widehat{\psi}_N)$ and $\widetilde{\sigma}_N(\psi(\widehat{\Theta}))$).

Table 2: Estimated Moments for Simulated and Observed Data

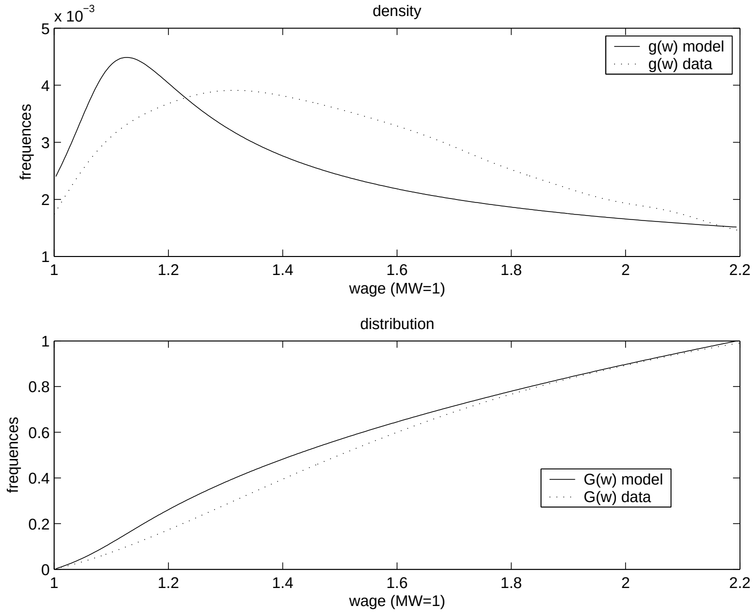
Moment	Observed Value			Simulated Value		
	$\widehat{\psi}_N$	$\widehat{\sigma}(\widehat{\psi}_N)$	$t-stat$	$\widetilde{\psi}_N(\widehat{\Theta})$	$\widetilde{\sigma}_N(\psi(\widehat{\Theta}))$	$t-stat$
μ	6304.6799	31.8464	197.9718	6326.7378	18.2335	346.9849
μ_1	4471.7044	293.7155	15.2246	4452.0913	13.6150	326.9986
μ_2	4872.3694	353.0800	13.7996	4756.0700	27.2536	174.5113
μ_3	5262.4871	333.6157	15.7741	5040.8162	43.8846	114.8654
μ_4	5587.0088	424.3939	13.1647	5373.9973	63.7304	84.3239
μ_5	5884.5128	405.4031	14.5152	5786.4729	87.9543	65.7895
μ_6	6253.6900	430.6652	14.5210	6279.0869	279.2906	22.4823
μ_7	6659.0716	458.8081	14.5138	6849.9954	292.6643	23.4056
μ_8	7141.5660	492.0757	14.5131	7506.7023	188.4035	39.8438
μ_9	7850.6070	538.7721	14.5713	8248.5618	231.5938	35.9849

[19] Wages are expressed in 1990 francs, using a deflator equal to 1.116.

This model's ability to match the observed wage distribution using French data is in keeping with the Rosholm and Svarer (2004) empirical study on Danish data, based on an alternative empirical methodology developed by Ridder and Van den Berg (1997) and Postel-Vinay and Robin (2002).

The Unimodal Wage Density and the Binding Minimum Wage. Figure 2 compares the wage distribution generated by the model and the kernel density estimation of the observed real wages.[20] The model seems close to the observed data and Figure 2 shows that the model is able to fit the observed wage cumulative distribution, and more importantly a unimodal wage density, as observed in the data. As suggested by Mortensen (2000),

Figure 2: Observed and Predicted Wage Distributions



the introduction of an endogenous productivity distribution enables the generation of a unimodal wage density without any exogenous heterogeneity. This theoretical result appears to match the shape of the observed wage distribution.[21] In reference to the estimated support of the wage distribution, we find that the lower bound of this support is the minimum wage (without

[20]Kernel density estimation is a nonparametric technique for density estimation in which a known density function (the kernel) is averaged across the observed data points to create a smooth approximation. We use SAS's KDE procedure.

[21]The gap between the model and the data can be explained by the low number of parameters introduced to generate a complete distribution. In Postel-Vinay and Robin (2002), for example, the exogenous distribution of productivity increases the degrees of

an imposition on our part). Indeed, the estimated results (see Table 3) show that the actual French minimum wage (mw) is above the highest reservation wage (x^s). It is a binding minimum wage, which implies $F(x^s) = 0$.

Table 3: Benchmark Equilibrium

b	msi	mw	$E(w)$	$med(w)$	$\underline{w}$	$\overline{w}$
4507	2500	4751	7051	6049	4751	10425
δ	t_f	t_w	$b/E(w)$	$(\gamma\theta)/\lambda$	u^l/u	
0.0333	0.4000	0.2000	0.60	0.3000	0.4575	
u	u^l	u^s	$h^e\lambda$	$h^s\lambda$	$h^l\lambda$	
0.1551	0.071	0.0841	0.0801	0.1520	0.0395	
Reservation Wages						
x^l	w_l	x^s	$F(x^s)$			
601	0	3896	0			
Employment and Unemployment Durations						
model	data	model	data			
32.22	34.00	14.50	17.00			
Human Capital and Welfare per Capita						
$E(k)$	$\mathcal{Y}$	$\mathcal{W}$				
323738	11352	-113.308				

Incomes and production are expressed in 1995 French francs

Contact probabilities. As reported in Table 3, the estimation of the model implies that the probability of having a contact with a firm when employed is lower than the average contact probability when unemployed. Moreover, the employed probability estimate is lower than the exogenous destruction rate. These results are consistent with other estimations: Ridder and Van den Berg (1998) (Dutch data), Bontemps, Robin, and van den Berg (1999) (French data), Rosholm and Svarer (2004) (Danish data) and Bowlus, Kieffer, and Neumann (2001) (US data). Our estimated rates of contact are

freedom. For a policy experiment, we prefer to have a lower fit, but an explicit choice in productivity for each job.

close to Postel-Vinay and Robin (2002) results: 0.0801 compared to 0.057 for the employees and 0.1520 compared to 0.124 for unemployed workers.

Finally, with the simulations of the estimated model, we compute the average duration of employment and unemployment. The results reported in Table 3 show that the model does a good job in replicating employment and unemployment duration, respectively 34 (32.2) and 17 (14.5) months in the data (model).

These results show that our original empirical strategy leads to results consistent with studies based on non-parametric estimation of the likelihood function.

3 Reassessing the French Labor Cost-Reduction Policy

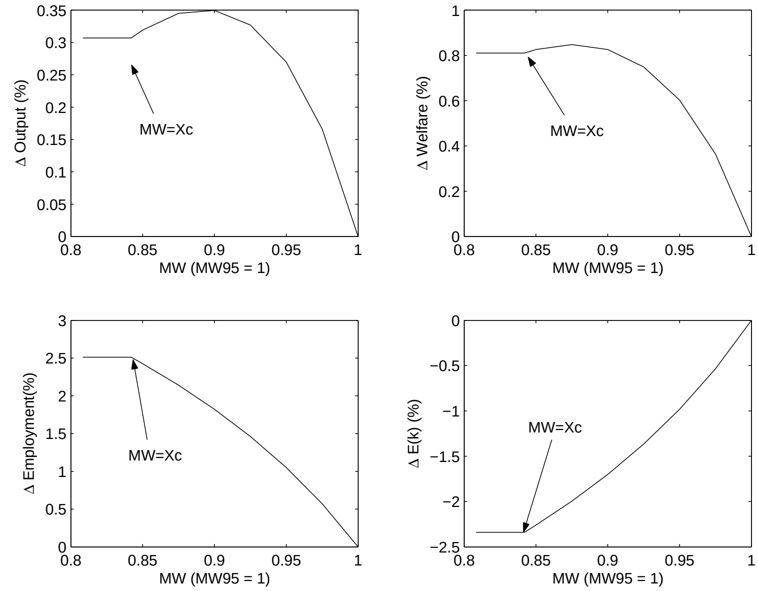
This section aims to reexamine the efficiency implications of the payroll tax subsidy policy traditionally assessed only under the employment dimension. In order to evaluate the welfare cost of the binding minimum wage, we first determine its optimal level with and without the productivity channel. We pay particular attention to this optimal level relative to the short-term unemployment reservation wage. We then investigate the efficiency implications of the recent payroll tax subsidy policy aimed at reducing the negative employment effect caused by minimum wage legislation. The policy is free of the reservation wage limit of a decreasing wage cost as employees do not suffer from earnings cuts. Perhaps, more interestingly, the subsidy could lead to very different distributive effects compared to the minimum wage policy.

3.1 The Optimal Minimum Wage

In the matching model, a decrease in the minimum wage leads to a higher vacancy rate and hence to a higher employment level (denoted N hereafter). Moreover, the magnitude of this effect is dampened by the monopsony power of the firms. But, at general equilibrium, it can be overcompensated by an increase in vacancy costs. As is often observed in matching models, a higher vacancy rate induces a standard congestion effect and potentially prohibitive hiring costs. In addition, and more specifically for this framework, it can lead to an underinvestment in human capital due to a reduction of the expected job duration and the increased probability of finding a better job.

By means of simulations, we show that the optimal minimum wage is *(i)* lower than its 1995 value and *(ii)* larger than the reservation wage x_s. Actually, the optimal level for the minimum wage is around 90% of its 1995 value when considering the output criterion (Figure 3, Δ Output) or 88% according to the welfare indicator (Figure 3, Δ Welfare). The large decrease in unemployment leads to more lump-sum transfers received uniformly by all agents. The evaluation of aggregate welfare takes this effect into account and leads to a lower minimum wage. The difference between the two indicators, however, is not significant (see Table 4).

Figure 3: Optimal Minimum Wage



The optimal minimum wage is output-increasing (see Table 4) because of the reduction in the unemployment rate (see Figure 3, Δ Employment). The decrease in human capital investment made by firms compensates in part for this last effect (see Figure 3, Δ $E(k)$). By considering the decision rule (eq. (4)), it appears that the decrease in the labor market tightness due to the fall in wage costs reduces the expected duration of jobs, regardless of the level of wages offered: the higher the number of vacancies, the higher the probability that employees have a contact with another firm. In turn, firms are deterred from investing in human capital as they anticipate shorter job duration. This negative productivity effect on net output is reinforced by the increase in training costs due to additional job-to-job transitions.

It is worth examining the case where the productivity channel is removed. First we set that the investment choice of firms for different wage levels is given by the benchmark calibration of the economy. In contrast with the previous case, a higher vacancy rate has a positive impact on average productivity (Table 5). Faced with potentially more frequent quits, firms react

Table 4: The Optimal Minimum Wage Level

mw	$\mathcal{Y}$	N	$E(k)$	$\mathcal{W}$	$\mathcal{B}$
10%	0.3496	1.8218	-1.7001	0.8260	1.6915
12%	0.3479	2.0798	-1.9394	0.8474	1.8704

Variations in % relative to the benchmark calibration

by offering higher wages. Thus, average productivity shifts up due to a considerable composition effect. For the optimal 10% decrease in the minimum wage, average human capital stock and average productivity increase respectively by 7.1446% and 3.8565% (Table 5). Of course, more vacancies induce additional costs. Considering production net only of hiring costs accounts for all these effects in a consistent manner. By using this net indicator, we verify that eliminating the human capital investment margin leads to additional gains (Table 5): 5.1980% compared to 0.2554%. Maintaining the human capital level constant on every job is not sufficient to eliminate the productivity channel in our theoretical setup. It is necessary to remove the wage offer game effect on productivity by considering the case where average productivity is given by its benchmark value (in Table 5, $E[f(k)]$ constant line). The matching effect internal to our model still applies. In this scenario, the rise in net production (1.2302%) is situated between the results of the previous two cases. This analysis reveals that there are two distinct productivity channels in our setup: an investment one and a distribution one due to changes in the wage offer distribution.

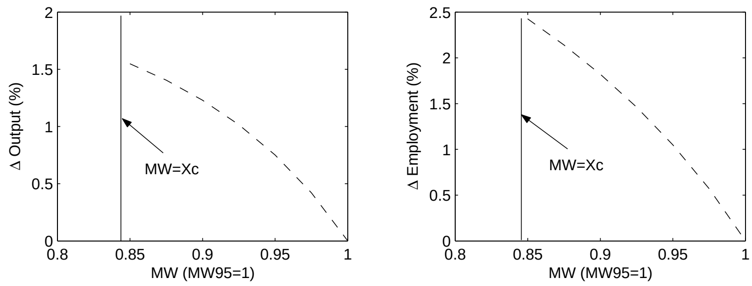
Table 5: Constant or Variable Productivity – $\Delta mw = -10\%$

	$(1-u)E[f(k)]$ $-\gamma v$	N	$E[k]$	$E[f(k)]$
k_i variable	0.2554	1.8218	-1.7001	-0.9474
k_i constant	5.1980	1.8218	7.1446	3.8565
$E[f(k)]$ constant	1.2302	1.8218	-	-

Variations in % relative to the benchmark calibration

When the productivity channel is totally ignored, it could be optimal to further reduce the minimum wage. As seen in Figure 4, $\Delta mw = -10\%$ is not the optimal fall in the minimum wage in this case. It appears, however, that a further reduction in the minimum wage is restrained by the short-term reservation wage: when $x^s = mw$ the net production gain is 1.5485%. Despite the existence of acceptable wage offers between the two reservation wages, firms do not make these offers in reality. Firms are not profitable given the range of wages included in this interval: the increase in temporary profits for a posted wage included in $[x_l, x_s[$ comes at the expense of the loss resulting from higher rotation costs for the long-term unemployed population. Production would not be improved by decreasing the minimum wage below x_s insofar as firms would not propose wages between the two reservation wages. The short-term reservation wage becomes binding, whereas firms potentially could make offers to long-run unemployed workers.

Figure 4: The Impact of Minimum Wage Variations when $E[f(k)]$ is Constant



Withdrawing the productivity channel leads to a very different conclusion about the optimal minimum wage level and the role of the unemployed workers'reservation wage. In this specific case, minimum wage legislation can be removed. In contrast, taking the productivity channel into account emphasizes the importance of its role.

Based on our optimal minimum wage analysis, labor costs reductions must be relatively weak to preserve high productivity levels. Moreover, decreasing the minimum wage is inherently limited by the high short-term reservation wage, despite the existence of acceptable lower wage offers. Hence, payroll tax exemption policies may have more dramatic consequences when they are not restricted by the reservation wage limit, given that employees do not suffer from a reduction in earnings.

3.2 Reexamining the Payroll Tax Subsidy Policy

During the 1990s, tax exemptions on employer-paid payroll taxes were introduced to lower labor costs. This policy aimed to counteract the negative impact of minimum wage legislation on employment without lowering wages earned by employees. The subsidy increased dramatically in October 1995 and September 1996 (hereafter PTE, for Payroll Tax Exemptions). In its current state, it corresponds to a linear reduction spanning from 1 to 1.33 times the minimum wage and ranging from 18.6 points at the minimum wage (mw) to roughly 0 points at the end point of the exemption interval. By and large, research finds that the policy generates very strong employment effects (Crépon and Desplatz (2002) and Kramarz and Philippon (2001)). The subsidies, however, tend to introduce a bias in favor of the creation of low-wage jobs and a potentially large decrease in aggregate productivity. Hence, a balance sheet drawn out in terms of output is particularly interesting compared to one based solely on employment.

Indeed, two fundamental motives exist for reexamining this subsidy policy through the productivity channel. The first reason is derived from similarities in the studied case (supra) regarding the decrease in the minimum wage and is based on the fact that lowering the labor cost leads to more vacancies and rotations and, hence, to less human capital investment (investment channel). The second motive is specific to the form of the subsidy policy. Tax exemptions made only between 1 and 1.33 times the minimum wage have the potential to induce a bias towards low wages (distribution channel). For instance, Malinvaud (1998) recommends widening the range of exemptions at the expense of lowering the tax reduction to the minimum wage level.

The remainder of this section examines the impact of the existing subsidy policy on employment and productivity. We then determine the optimal range of exemptions from a set of the same linearly decreasing exemptions scheme, which implies the same *ex ante* budgetary cost.

3.2.1 The Payroll Tax Exemption Reform

The PTE reform changed the wage distribution as depicted in Figure 1. We capture this effect quantitatively by computing the fraction of the jobs paid under 1.33 times the minimum wage before and after 1995. In the *Enquête emploi* database, this proportion appears to have increased from 37.83% in 1995 to 45.33% in 1998. It is particularly important to be able to generate similar changes with our estimated model. We find that this fraction is 41% for our benchmark pre-1996 estimated model and increases to 45% when the exemption policy is introduced. Faced with a new environment, the wage offer strategies lead to similar wage distribution changes as those observed. This result gives strong support to our inquiry.

Table 6 highlights the results relative to the PTE reform. The policy increases the net production in the economy brought about by the large employment boost (as evidenced by the 2 point drop in unemployment).

It also succeeds in generating additional vacancies and job creation in the economy. The employment scale effect obtained here is consistent with other econometric studies on this topic (Kramarz and Philippon (2001); Crépon and Desplatz (2002); Laroque and Salanié (2000) and (2002)). Human capital investment, however, contracts drastically and capital stock decreases by 2.03%.

Table 6: The PTE Reform

b	msi	mw	$E(w)$	$med(w)$	$\underline{w}$	$\overline{w}$
4507	2500	4751	70486	5955	4751	10410
δ	t_f	t_w	$b/E(w)$	$(\gamma\theta)/\lambda$	u^l/u	
0.0333	0.4000	0.2000	0.60	0.4651	0.428	
u	u^l	u^s	$h^e\lambda$	$h^s\lambda$	$h^l\lambda$	
0.1366	0.0586	0.0780	0.090	0.1708	0.0444	
Reservation Wages						
x^l	w_l	x^s	$F(x_s)$			
605	0	4002	0			
Employment and Unemployment Durations						
model	Bench.	model	Bench.			
31.76	32.22	12.45	14.50			
Variations (in %)						
$\mathcal{Y}$	N	$E(k)$	$\mathcal{W}$	$\mathcal{B}$		
0.3399	2.1834	-2.0399	1.0150	-1.0555		

Even if output is increased relative to the benchmark case, its level remains inferior to the value obtained with the decrease in the minimum wage. The endogenous variation in productivity explains this result and is also responsible for the strong negative composition effect via the distribution channel. We evaluate the magnitude of this effect by comparing the variable productivity case with the constant investment one. The composition effect decreases the average human capital $E[k]$ and the average productivity $E[f(k)]$ in the k_i constant case compared to the variable case (Table 7). This decline, due to the biased exemptions scheme, is particularly significant since higher rotations *per se* lead to a strong positive productivity effect (Table 5) when human capital investments are considered as given. The decline is further exacerbated if instead the investment varies, because of the decrease in human capital investments following higher rotations in the economy. It is worth emphasizing that this last effect dominates the composition effect. It is only when average productivity is maintained artificially unchanged that the PTE reform is as efficient in increasing the net (only of hiring costs) production (1.4275% gain) as the optimal decrease of the minimum wage (1.2302% gain).

Table 7: Constant or Variable Productivity

	$(1-u)E[f(k)]$ $-\gamma v$	N	$E[k]$	$E[f(k)]$
k_i variable	0.2625	2.1834	-2.0399	-1.1283
k_i constant	1.0962	2.1834	-1.3802	-0.3209
$E[f(k)]$ constant	1.4275	2.1834	-	-

Variations in % relative to the benchmark calibration

While the PTE reform implies some direct budget cost, the welfare criterion can lead to a less optimistic evaluation. The exemptions do not constitute the total budget cost: it is necessary to also take into account the reduction in unemployment benefits and the increase in payroll taxes collected from the employment boom. For the most part, it appears that the PTE reform is not self-financed: the average cost of a job creation ($\Delta\mathcal{B}/\Delta n$) is equal to FF 24,330 whereas the return ($\Delta\mathcal{Y}/\Delta n$) is of FF 22,492. Despite this budget cost, the PTE reform implies an increase in welfare ($\Delta\mathcal{W}$=1.0150%, Table 6) relative to the benchmark economy, but also, and more unexpectedly, compared to the optimal minimum wage level ($\Delta\mathcal{W}$=0.8474%, Table 4). As long as the minimum wage is reduced to its optimal value, the employee value falls because of the decrease in the average wage. Introducing payroll tax exemptions, however, requires taking into account the decrease in dividends and in government lump-sum transfers. This decrease is spanned over all agents, yet the decrease in the minimum wage only concerns those employees at the bottom of the wage distribution. If the instrument is payroll taxes subsidies, the fall in employment costs for low-wage workers is supported by all agents. Alternatively, if the instrument is the minimum wage, the incidence applies only to low-wage workers. Given the concavity of the utility function, these changes in the distribution of total earnings are not neutral: the tax exemptions policy is considered superior to a decrease in the minimum wage.

3.2.2 Policy Choices: Targeting Subsidies around the Minimum Wage or Spreading over a Larger Range?

Do the PTE reforms lie on the optimal range of exempt wages? We take as given the shape of the policy and its direct cost. Our model is particularly well-suited for studying the consequences of this kind of policy. There is an explicit trade-off for a given budget cost: either the subsidies cover a narrow range and greatly reduce labor costs or they are spread over a larger range to avoid a downwards distortion of the wage distribution.

The PTE reform is an intermediate scenario between a policy which concentrates all exemptions at the minimum wage level and one which spreads payroll tax exemptions over the entire wage distribution. The first case magnifies the positive employment effect and the negative productivity impact. Table 8 shows that the balance is clearly in disfavor of this policy. The second case tries to attenuate job allocation distortion, but at the expense of the magnitude of the labor cost decline: only 2.05 points of payroll tax exemptions are possible to maintain the same budget cost as the PTE reform. Thus, this policy is overshadowed by the PTE reform, even if the human capital stock is higher (Table 8).

Table 8: Comparison with Two Extreme Cases

	$\mathcal{Y}$	$\mathcal{W}$	N	$E[k]$
PTE Reform	0.3184	1.0560	2.2084	-2.0818
Uniform exemptions	0.1063	0.1705	0.3469	-0.3250
Exemptions at the mw	-0.4215	-0.0692	3.5951	-3.1394

Variations in % relative to the benchmark calibration

Given the same *ex ante* (direct) budget cost, the question remains whether we should further increase the subsidy at the minimum wage level or, on the contrary, spread out the subsidy over a wider range. It appears that the first strategy is output-reducing, whereas the second is output-improving (see Figure 5).

More precisely, with regard to the production criterion, the optimal subsidy scheme increases continuously from 0% for jobs paid more than 1.40 times the minimum wage to 13.5% for jobs paid at the minimum wage (see

Figure 5: The Optimal Subsidy Scheme

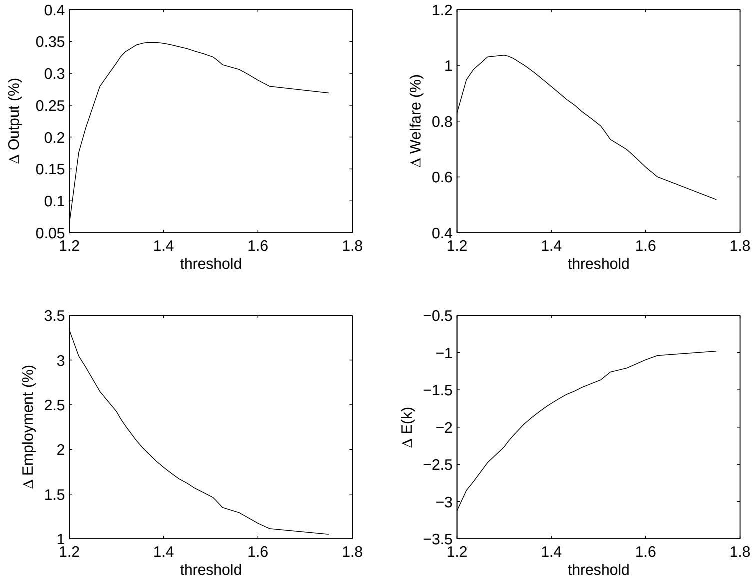


Figure 5). With respect to the PTE reform, this particular shape optimally solves the trade-off between employment and productivity: net output increases by 0.3461%. Employment rises less (1.7731% in this case, 2.1834% in the case of the PTE reform), but capital falls at a lower rate (-1.6559% in this case, -2.0399% in the case of the PTE reform). Limiting the analysis to the employment side only would suggest using concentrated exemptions around the minimum wage level. This paper shows that the conclusion dramatically changes when the productivity incidence is considered. In this framework, spreading out exemptions over a wider distribution range appears more efficient.

By adding the welfare criterion, the analysis considers the concavity of the utility function and grants more importance to the decline in unemployment. Accordingly, the optimal scheme ranges up to 1.3 times the minimum wage, allowing more exemptions at the minimum wage level.

Regardless of the selected criteria, the optimal profiles are extremely similar to that of the PTE. In conclusion, the balance between the reduction of labor costs and the wage range covered by exemptions is nearly perfect. This analysis lends strong support to the PTE reform implemented in France in the 1990s.

4 Concluding Remarks

The analysis of the French labor market illustrates the importance of taking into account both employment and productivity effects to evaluate properly labor market institutions and policies.

This paper shows that a wage posting model is able to replicate the heterogeneity of the observed wage distribution for low-skilled workers in France during the 1990s. The analysis gives some empirical relevance to the underlying endogenous productivity distribution generated by training investments at the firm level. We then proceed to analyze the role of the minimum wage legislation on this equilibrium outcome. It appears that the existence of a minimum wage creates more unemployment, but also stimulates specific human capital by increasing the expected duration of jobs. This well-known qualitative effect is validated quantitatively using French data. It explains why the optimal level of the minimum wage is only slightly inferior to its current level and remains superior to the (highest) reservation wage. As a result, employer payroll tax exemptions are not necessary to reduce the labor cost below the reservation wage. We show that the payroll tax subsidy policy which aimed to prevent increasing wage inequality leads to an output increase despite the productivity decline. This reform appears particularly well-balanced between the lowering of labor costs and the wage range covered by the exemptions. It provides an exemplary case for any labor market reform to consider the negative impact on human capital investment.

This research could benefit from future work to develop a more complex structural model which would take into account, first, the endogenous variations of the price of human capital investment and, second, the endogenous destruction rate of jobs.

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A An Extensive Definition of the Equilibrium

The equilibrium is defined by the following set of equations:

$$
\begin{aligned}
u &= \frac{s\left(h^l\lambda(\theta)+\delta\right)}{h^l\lambda(\theta)\left\{h^s\lambda(\theta)\left[1-F(x_s)\right]+\delta\right\}+s\left(h^l\lambda(\theta)+\delta\right)} \\
u^s &= u\frac{h^l\lambda(\theta)}{h^l\lambda(\theta)+\delta} \\
u^l &= u\frac{\delta}{h^l\lambda(\theta)+\delta} \\
& u((1-t_w)x_s+\mathcal{T}) \\
&= u(b+\mathcal{T})+(h^s-h^e)\lambda(\theta)\int_{x_s}^{\overline{w}}\left[V^n(\tilde{w})-V^{us}\right]dF(\tilde{w})-\delta\left[V^{us}-V^{ul}\right] \\
& u((1-t_w)x_l+\mathcal{T}) \\
&= u(msi+\mathcal{T})+(h^l-h^e)\lambda(\theta)\int_{x_l}^{\overline{w}}\left[V^n(\tilde{w})-V^{ul}\right]dF(\tilde{w})-s[V^{us}-V^{ul}] \\
\frac{\gamma\theta}{\lambda(\theta)} &= \frac{h^l}{\overline{h}}u^l\left(\frac{s+h^e\lambda(\theta)}{s+h^e\lambda(\theta)[1-F(w)]}\right)\times \\
&\left(\frac{\max_{w\geq x_l,k\geq 0}\{f(k)-(1+t_f(w))w-p_k k(r+s+h^e\lambda(\theta)[1-F(w)])\}}{r+s+h^e\lambda(\theta)[1-F(w)]}\right)\quad\forall\ w\in[x_l,x_s] \\
\frac{\gamma\theta}{\lambda(\theta)} &= \frac{s}{s+h^e\lambda(\theta)[1-F(w)]}\times \\
&\left(\frac{\max_{w\geq x_s,k\geq 0}\{f(k)-(1+t_f(w))w-p_k k(r+s+h^e\lambda(\theta)[1-F(w)])\}}{r+s+h^e\lambda(\theta)[1-F(w)]}\right)\quad\forall\ w\in[x_s,\overline{w}] \\
f'(k) &= p_k(r+s+h^e\lambda(\theta)[1-F(w)])\quad\forall\ w\in[x_l,\overline{w}] \\
\mathcal{T} &= \mathcal{B}+\Pi \\
\mathcal{B} &= (1-u)\left(\int_{\underline{w}}^{\overline{w}}[t_f(w)+t_w]w\,dG(w)\right)-(u^s\times b+u^l\times msi) \\
\Pi &= \mathcal{Y}-(1-u)\left(\int_{\underline{w}}^{\overline{w}}[1+t_f(w)]w\,dG(w)\right)
\end{aligned}
$$

This system allows us to determine the equilibrium unemployment rate u^l, u^s and $u \equiv u^l + u^s$, the vacancy rate given that $v \equiv \theta\overline{h}$, the reservation wages x_l and x_s, the distribution of the wage offer $F(w)$ and the associated investment in human capital for each wage $k = k(w)$.

B Proofs of the Propositions

B.1 Proof of Proposition 1

- If $\underline{w} = x_s$ and $F(x_s) = 0$, θ is given by the equation (3) and is such that
$$\frac{\gamma\theta}{\lambda(\theta)} = \left(\frac{s}{s + h^e\lambda(\theta)}\right)\left(\frac{f(k(\underline{w})) - (1 + t_f(\underline{w}))\underline{w} - p_k k(\underline{w})(r + s + h^e\lambda(\theta))}{r + s + h^e\lambda(\theta)}\right)$$
Evaluated for $w = \underline{w}$, we find that θ solves the following equation, stemming from the fact that $f(k(\underline{w})) = f(\mathcal{K}(\theta))$ where $k(\underline{w}) \equiv \mathcal{K}(\theta) = f'^{-1}(p_k(r + s + \lambda(\theta)))$:
$$\frac{\gamma\theta}{\lambda(\theta)} = \left(\frac{s}{s + h^e\lambda(\theta)}\right)\left(\frac{f(\mathcal{K}(\theta)) - (1 + t_f(\underline{w}))\underline{w} - p_k \mathcal{K}(\theta)(r + s + h^e\lambda(\theta))}{r + s + h^e\lambda(\theta)}\right)$$
Let us denote
$$\Phi(\theta) = \frac{\gamma\theta}{\lambda(\theta)}$$
$$\Psi(\theta) = \left(\frac{s}{s + h^e\lambda(\theta)}\right)\left(\frac{f(\mathcal{K}(\theta)) - (1 + t_f(\underline{w}))\underline{w} - p_k \mathcal{K}(\theta)(r + s + h^e\lambda(\theta))}{r + s + h^e\lambda(\theta)}\right),$$
then $\Phi(0) = 0$, $\Phi'(\theta) > 0$ due to the constant returns to scale of the matching function, $\Psi(0) = \left(\frac{s}{s+h^e\lambda(\theta)}\right)\left(\frac{f(\mathcal{K}(0)) - (1+t_f(\underline{w}))\underline{w} - p_k\mathcal{K}(0)(r+s)}{r+s}\right) > 0$ and $\Psi'(\theta) < 0$. As in Mortensen (2000), two solutions exist: the first is at $\theta = 0$ and the second at some strictly positive value $\theta > 0$. Only the positive solution is stable because a simple entry process starting with positive vacancies is sufficient to find the only one positive equilibrium value of θ. This implies that there exists only one positive equilibrium value of v.

- If $\underline{w} = x_l$, θ is given by the equation (3) but is now such that
$$\frac{\gamma\theta}{\lambda(\theta)} = \frac{h^l}{\overline{h}} u_l \left(\frac{f(\mathcal{K}(\theta)) - (1 + t_f(\underline{w}))\underline{w} - p_k \mathcal{K}(\theta)(r + s + h^e\lambda(\theta))}{r + s + h^e\lambda(\theta)}\right)$$
given than $k(\underline{w}) \equiv \mathcal{K}(\theta)$ is defined as in the preceding case. Let us denote
$$\tilde{\Psi}(\theta) = \frac{h^l}{\overline{h}} u_l \left(\frac{f(\mathcal{K}(\theta)) - (1 + t_f(\underline{w}))\underline{w} - p_k \mathcal{K}(\theta)(r + s + h^e\lambda(\theta))}{r + s + h^e\lambda(\theta)}\right)$$
Since u_l is decreasing in θ, then $\tilde{\Psi}(\theta)$ is strictly decreasing in θ. As in the previous case, this implies that there exists only one strictly positive vacancy rate v.

B.2 Proof of Proposition 2

The proof of the discontinuity of the wage distribution follows the one proposed in the seminal paper of Mortensen (1990). Let us denote by $\kappa(w) = (1 + t_f(w))w$ the wage costs and $\pi(w)$ the following profit flow:

$$\pi(w) = f(k(w)) - p_k k(w)(r + s + h^e\lambda(\theta)[1 - F(w)])$$

- For any $w \in [x_l; x_s[$, the intertemporal expected profit associated with a filled job is given by:

$$\frac{h^l}{\overline{h}}u^l \left(\frac{s + h^e\lambda(\theta)}{s + h^e\lambda(\theta)[1 - F(w)]}\right)\left(\frac{\pi(w) - \kappa(w)}{r + s + h^e\lambda(\theta)[1 - F(w)]}\right) \tag{5}$$

  Evaluating this expression for $w = x_s^-$,we have:

$$\frac{h^l}{\overline{h}}u^l \left(\frac{s + h^e\lambda(\theta)}{s + h^e\lambda(\theta)[1 - F(x_s^-)]}\right)\left(\frac{\pi(x_s^-) - \kappa(x_s^-)}{r + s + h^e\lambda(\theta)[1 - F(x_s^-)]}\right) \tag{6}$$

- Now, given that $w = x_s$ from the definition of $G(w)$ over $w \in [x_s, \overline{w}]$, the intertemporal expected profit turns out to be:

$$\frac{s}{s + h^e\lambda(\theta)[1 - F(x_s)]}\left(\frac{\pi(x_s) - \kappa(x_s)}{r + s + h^e\lambda(\theta)[1 - F(x_s)]}\right) \tag{7}$$

  Comparing equations (6) and (7) for $x_s^- \to x_s$, we find that (6)<(7) as long as $h^e\lambda(\theta)[1 - F(x_s)] + s > 0$ which is guaranteed until $s > 0$. This shows that there is no wage offer over the interval $[x_s^-, x_s[$.

- There must exist a critical wage offer w_l such that there is no wage offer over the interval $[w_l, x_s[$. This critical point of the wage distribution can be derived by equalizing the condition (5) evaluated for $w = w_l$ with the condition (7) and by taking into account the restriction $F(x_s) = F(w_l)$:

$$\begin{aligned}\frac{\gamma\theta}{\lambda(\theta)} &= \frac{h^l}{\overline{h}}u^l \left(\frac{s + h^e\lambda(\theta)}{s + h^e\lambda(\theta)[1 - F(x_s)]}\right) \times \\ &\left(\frac{pf(k(w_l)) - (1 + t_f(w_l))w_l - p_k k(w_l)(r + s + h^e\lambda(\theta)[1 - F(x_s)])}{r + s + h^e\lambda(\theta)[1 - F(x_s)]}\right)\end{aligned}$$