MACROECONOMIC INFLUENCE OF THE MINIMUM WAGE IN FRANCE *

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June 1995

Abstract

A segmentation of the labour market into skilled and unskilled workers is considered for France with annual data covering the period 1962-1992. A theoretical model of imperfect competition is built in order to appraise the impact of the minimum wage on skilled/unskilled employment substitution and wage formation. Inference and simulation results suggest that the minimum wage has a small influence on wage formation and employment of unskilled workers. On the contrary the social security contribution rate has a much larger effect. The major effect is however contained in an exogenous differential of productivity between skilled and unskilled labour which governs in the long run the substitution of skilled for unskilled labour.

1 Introduction

In a way or another, an official minimum wage exists in the capitalists economies since the beginning of the century (Great Britain, Australia, New-Zealand) and in France since the beginning of the fifties. Let us note that a federal minimum wage exists in the United States, but that it has been suppressed in Great Britain at the end of 1993 [see BAZEN and BENHAYOUN (1994)]. The aim of a minimum wage is to protect vulnerable employees by warranting them a decent revenue. Most wages are determined by collective bargaining, at least in Europe. The minimum wage, when it exists, plays the role of a reference wage during the bargaining process and thus influences the whole wage scale.

What is the macroeconomic influence of the minimum wage? The first effect which comes to one's mind is an effect on employment. The existence of a lower bound can truncate the wage distribution. In a pure neoclassical view, this implies that some employees will be paid over their marginal productivity. In a slow down, these employees will be the first to be

*We thank Bénédicte Maillard for her work on the data, Richard Blundell and Pierre Ralle for comments and suggestions. This version of the paper is very preliminary and should not be quoted without permission.

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dismissed. However, most empirical studies existing on the topic suggest that the minimum wage has a small effect on employment and, when this effect occurs, it is mostly limited to young people [see BAZEN and MARTIN (1991)].

The influence of the minimum wage cannot affect the whole labour market. Empirical studies have detected effects for young people [BAZEN and MARTIN (1991), BROWN, GILROY and KOHEN (1983), van SOEST (1994)], or for certain sectors of the economy [KATZ and KRUEGER (1992)] where the proportion of low wages is important. Segmenting the labour market is thus useful to analyze the influence of the minimum wage. Various segmentations are possible; we are going to detail two of them.

- In an economy with rising openness to foreign markets, the external constraint (equilibrium of the trade balance) becomes of a prime importance and influences wage formation [see e.g. DELACROIX and LUBRANO (1992)]. In particular, the wage moderation observed in France since 1982 (and also in Belgium) can be explained in this framework. If we can distinguish between a protected sector (roughly services) and an exposed sector (roughly industry) as in the Scandinavian model, the impacts of the external constraint and of the minimum wage are going to be different according to the sector of the economy which is considered. This kind of market segmentation has been very popular in France for the good market [COURBIS (1980)]. But it does not seem to be very accurate when one is interested in the sole labour market. If traditionally, price formation in the two sectors of the economy (exposed/protected) relies on different mechanisms, it is easy to observe that low wages are present in both sectors. Besides, it become nowadays very difficult to statistically distinguish between the two sectors, and the sectorial classification implemented by INSEE in France is not very helpful. Finally, services (hotels and restaurants) is a sector of the economy where most of employees are paid at the minimum wage, and typically it is a protected sector in the sense of foreign competition.

- There is a very interesting line which separates the labour market in two segments and which is going to be the object of this paper in relation with the influence of minimum wage: that is the distinction between skilled and unskilled labour. Minimum wage has more certainly an impact on the unskilled labour market than on the skilled labour market. The recommendations contained in DREZE and MALINVAUD (1994) to lower the unskilled labour costs in order to stop the progression of unemployment have to be reinterpreted in this context.

The paper is organized as follows. In section 2, we shall review the characteristics of minimum wage regulations in France. In section 3, we shall detail the labour market segmentation in France between skilled and unskilled workers considering wage formation and unemployment rates. The aim of these two sections is essentially descriptive and are based on the data bank built by MAILLARD and SNEESSENS (1993) and which was extended to finally cover the period 1962-1992. Section 4 describes the building of a small theoretical model explaining wage formation and substitution between skilled and unskilled labour. This model is based on SNEESSENS and SHADMAN-METHA (1994). Section 5 presents the estimation results. Section 6 presents various simulation scenarios and their consequences on unskilled employment.

2 The SMIC: evolution

A minimum wage was introduced in France in 1950 and was called SMIG, "Salaire Minimum Inter-professionnel Garanti" (Guaranteed Inter-professional Minimum Wage). It was simply indexed on prices. The SMIG is transformed into SMIC, "Salaire Minimum Interprofessionnel de Croissance" (guaranteed is replaced by growth), with the Grenelle agreement in 1968. Its evolution then follows a complicated mechanism which can be summarized as follows:

- The SMIC is indexed on consumption prices (tobacco is put out of the index at the beginning of the nineties). When prices have risen by 2% since the last adjustment, the SMIC is raised by 2%.

- Every first of July the SMIC is adjusted in a systematic way. First on inflation in order to compensate for the delay on the fraction of the 2% which has not yet been incorporated. Then, the SMIC is raised by half of the raise in buying power of the worker mean wage rate. It is a form of indexation on productivity.

- Finally the SMIC can be raised directly by the Government. This is what is called the *coups de pouce* (thumb push). Thus, besides the rises resulting from the Grenelle agreements in 1968, the SMIC was raised by 25% between 1981 and 1983 and more slightly under the Government led by Michel Rocard in 1987. Since this period, no new *coup de pouce* was given.

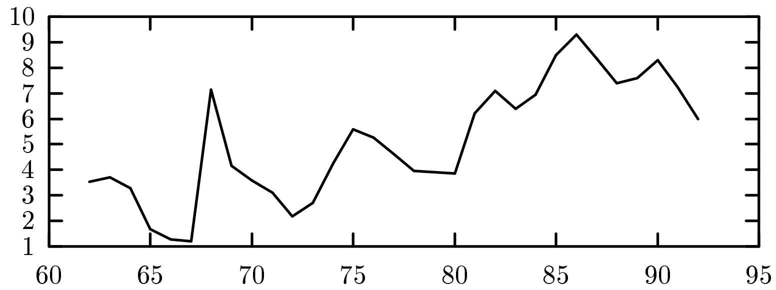

Figure 1: Percentage of workers paid at the SMIC

The percentage of workers paid at the SMIC (see figure 1) has varied a lot on the period which is considered in this paper. Before 1968, the SMIG concerns roughly 2% of the workers. Its sharp raise in 1968 boosts this percentage to 7%. But economic growth in the following period lower this percentage to 4%. In 1981-1982, the SMIC is again sharply raised and it concerns again 7% of the workers. This effect lasts till the end of the period. We can conclude than between 1981 and 1992 the SMIC played an active role as a lower bound on wage distribution. But we should also note the peak around 1975, where the oil shock made the minimum wage constraint active. However this effect was transitory.

3 An heterogeneous labour market

3.1 Unemployment rates and labour market segmentation

Every segmentation of an heterogeneous set searches for a division of the set into groups where the population is homogeneous against a certain criterion. Using the unemployment rate by socio-professional categories, MAILLARD and SNEESSENS (1994) have proposed a labour market segmentation between skilled and unskilled labour. The employment surveys led by INSEE detail seven categories in the active population, based on the occupied position:

1) agriculteurs exploitants (farmers)

2) artisants, commerçants and chefs d'entreprise (craftsmen, retailers and managers)

3) cadres and professions intellectuelles supérieures (middle management and highly qualified professionals

4) professions intermédiaires (techniciens, contremaîtres ...) (professionals) (technicians, foremen,...)

5) employés (white collars)

6) ouvriers (blue collars)

81) chômeurs n'ayant jamais travaillé (unemployed having never worked before)

Category 7 is retired persons, category 82 is other inactive people able to work (military, students...). Maillard and Sneessens have proposed the following classification:

- skilled workers: 3) and 4)

- unskilled workers: 1), 2), 5), 6) and 7)

This classification, even if it may appear surprising by some of its choices[1], induces an interesting segmentation of the labour market and leads to unemployment rates which are radically different, witness figure 2. The unemployment rate of unskilled paid workers is more important than that of skilled paid workers. It augments suddenly after 1974 and this augmentation lasts after this date.

Which kind of explanation can we find for this phenomenon? We can first compute, following SNEESSENS (1994), a mismatch index between supply and demand of labour qualifications:

$$\mu = \frac{L_Q/(L_Q + L_N)}{LS_Q/(LS_Q + LS_N)} \tag{1}$$

[1]It does not make the distinction between skilled and unskilled blue collars; firm managers are in the unskilled category. But these choices are the result of the INSEE main classification. A huge statistical work would have been necessary to split the categories into sub categories. Experiences made in MAILLARD and SNEESSENS (1994) show that such desegregation would not change very much the final results.

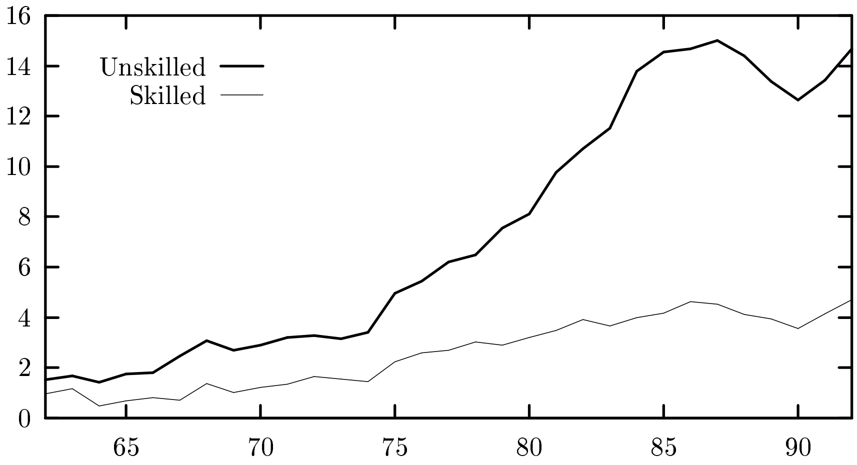

Figure 2: Unemployment rates of skilled and unskilled workers

where L is labour demand, LS labour supply and the subscripts Q and N stand respectively for qualified and unqualified. Figure 3 show the values of this index on the sample period. It shows the growing mismatch between demand and supply of qualifications after 1974. Skilled labour demand and supply have both risen on the period. Unskilled labour supply has remained stable, but demand has dropped. Thus there was a change in the technical coefficients of the production processes penalizing unskilled work.

3.2 Labour productivity and business cycle

It is very instructive to study the evolution of labour productivity for the two types of labour. Apparent labour productivity is defined as the ratio between real GNP and employment. We can compute this ratio, considering total employment, skilled employment or unskilled employment. Figure 4 is useful to compare these figures on the period. We can see that either the total productivity or the productivity of unskilled workers follow a rising trend with a break in 1974. On the contrary, the productivity of skilled workers seemed to be stationary. This means that less and less unskilled workers are necessary to obtain the same output, when the number of skilled workers remains the same. Technological changes which occurred in the period may explain this fact.

We can try to qualify this judgment on productivity stationarity with unit root tests. Let us first consider the unskilled productivity that we note $A_N = Y/L_N$:

$$\Delta A_{Nt} = \underset{[2.58]}{0.020} + \underset{[2.07]}{0.0012t} - \underset{[-2.03]}{0.26}\, A_{Nt-1}$$

This series incorporates a stochastic trend on top of a deterministic trend as the Dickey-Fuller test with -2.03 is lower than its critical value of -3.55 at 5% for 30 observations. If we compute a PERRON (1989) test, thus with a break in the deterministic trend in 1974:

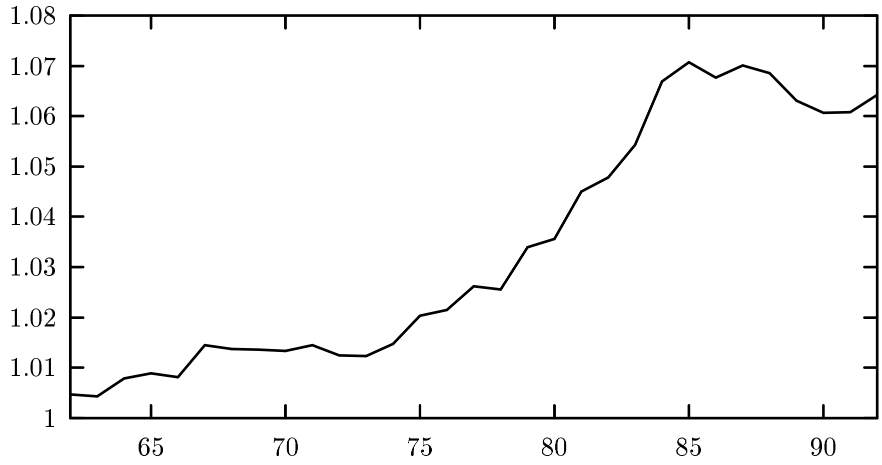

Figure 3: Mismatch index for labour qualifications

$$\Delta A_{Nt} = \underset{[4.54]}{0.028} + \underset{[4.44]}{0.0023t} - \underset{[-4.29]}{0.00023DT74} - \underset{[-4.07]}{0.43}\, A_{Nt-1}$$

a deterministic trend remains, but the presence of a stochastic trend is more hazardous as -4.07 is very near from the asymptotical critical value of -3.95 at 5%.

The structure of the series of skilled productivity, noted $A_Q = Y/L_Q$, is different:

$$\Delta A_{Q_t} = \underset{[3.13]}{0.19} - \underset{[-3.12]}{0.41}\, A_{Q_{t-1}}$$

There is no deterministic trend and the Dickey-Fuller test is slightly greater than its critical value at 5% (-2.95 for 30 observations). This series is thus stationary.

Could we reach the conclusion that skilled labour is nearly a fixed production factor, that is to say that the optimal ratio production/skilled labour is constant? If it were the case, we should be able to track the business cycle in the skilled labour productivity series. In order to extract the business cycle out of the GNP series, let us adjust an MA(1) process on real GNP, extract the stochastic trend and the cycle by mean of a Beveridge-Nelson decomposition (see the appendix for more details). We can see on figure 5 that the two series are very well correlated after 1974, less well before this date.

We can thus conclude that, on the considered period, the proportion of skilled labour per production unit remained roughly constant, but that the same ratio for unskilled labour dropped dramatically. What was the interaction between this phenomenon and wage formation when social security contributions are taken into account?

3.3 Wages and social security contributions

Many American studies have analyzed the evolution of wages in the USA, e.g. BOUND and JOHNSON (1992), LEVY and MURNAME (1992). These studies show that in the eighties

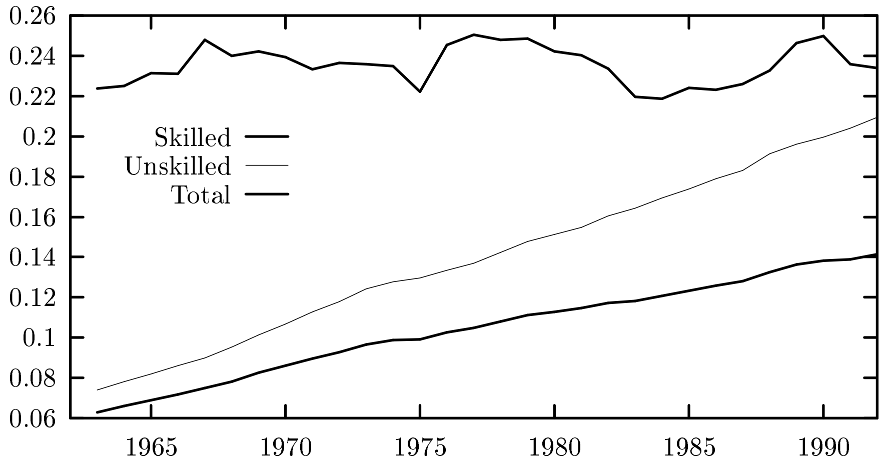

Figure 4: Apparent labour productivity
(The figures for skilled productivity was lowered by 0.2 for scaling)

the average wage rate remained stable when the wage rate of the most qualified workers rose tremendously. This implies a rousing inequality among earnings. Bound and Johnson found an explanation of this phenomenon in the drop of unskilled labour demand, which is linked to technological change. The unemployment rate being stationary in the USA, the adjustment took place with wages. A part of the less qualified workers, despite the fact they do have a job, live under the official poverty rate.

What append in France? We can first distinguish between net wages and cost wages. Figure 6 show the evolution of real net wages on the period. The SMIC follows a rising trend, with some breaks. There is a marked pause between 1982 and 1990. Unskilled wages rose regularly, but present a break in the trend after 1978. The evolution of skilled wages is more shaky. There is a drop between 1975 and 1985, but a sharp rise after 1985. If we compare the evolution of net real wages with the business cycle series, we realize that real net skilled wages follow fairly well that series when other real net wages do not. In fact wage formation is very different between the two labour markets: collective bargaining for unskilled workers, private bargaining for skilled workers.

We can complete this sketch by taking into account social security contributions by employers. First, figure 7 show that unskilled labour is much more taxed than skilled labour. This difference gradually vanished at the end of the period with the raising of the "plafond de la sécurité sociale". Next, the modification of the social security contribution rate for skilled wages renders the evolution of net skilled wages different from that of gross skilled wages (see figure 8). In particular, the drop which is in agreement with the business cycle slowdown between 1975 and 1985 is transformed into a simple stagnation. We can say a part of the increase of social security contributions was paid by workers.

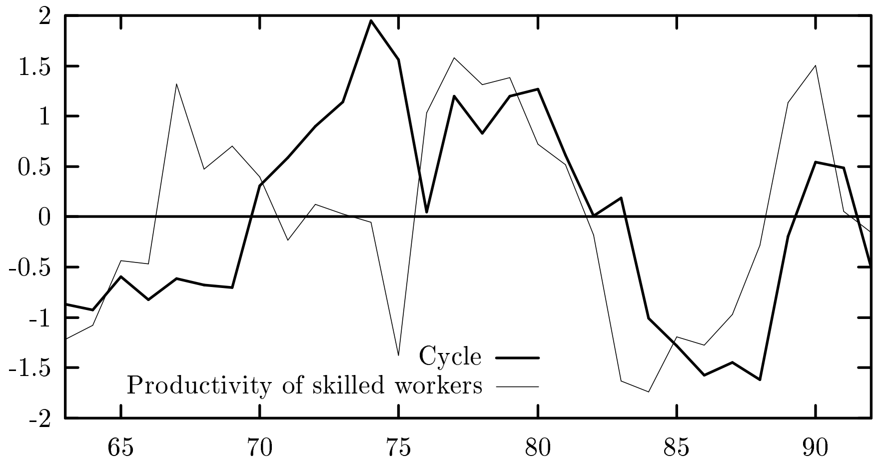

Figure 5: Business cycle and skilled labour productivity

3.4 Temporary conclusions

Compared to the United States, we cannot observe the same drop of unskilled real wages. We can say that the adjustment on the unskilled labour market was made on the quantities, France, as well as Europe presenting an unemployment which is more important than in the United States and moreover which is rising. What can we say about the influence of the minimum wage (SMIC) on unemployment? The SMIC has certainly an influence on wage formation for unskilled workers, but certainly none for skilled workers[2]. A theoretical explanation of the relation SMIC-wages-unskilled employment must take into account the evolution of the relative demand for unskilled labour and the evolution of unskilled labour productivity. Social security contribution rates play a major role in comparing wage costs. It is difficult at first sight to quantify the importance of the impact of the SMIC on unskilled employment. A theoretical model is necessary for that purpose.

4 The theoretical model: imperfect competition and real rigidities

The theoretical framework we shall use is that of imperfect competition with quantity rationing. It draws on models used in LUBRANO et al (1993) and SNEESSENS (1992) with homogeneous labour market and on SNEESSENS and SHADMAN-MEHTA (1993) who introduced heterogeneity in the labour market. We suppose a great number of identical firms which operate each on a separate micro market. They must take decisions in the short term on quantities to produce for given prices and wages. In the medium term, they fix their prices

[2]The percentage of workers paid at the SMIC was given in section 2. This percentage concerns the total number of workers. It is interesting to compute this percentage for unskilled workers alone. For instance in 1986 (which is the peak year of the series) this percentage was 9.3 for all the workers against 13.2 for unskilled workers alone. On average the partial percentage is 2 to 3 points over the total percentage.

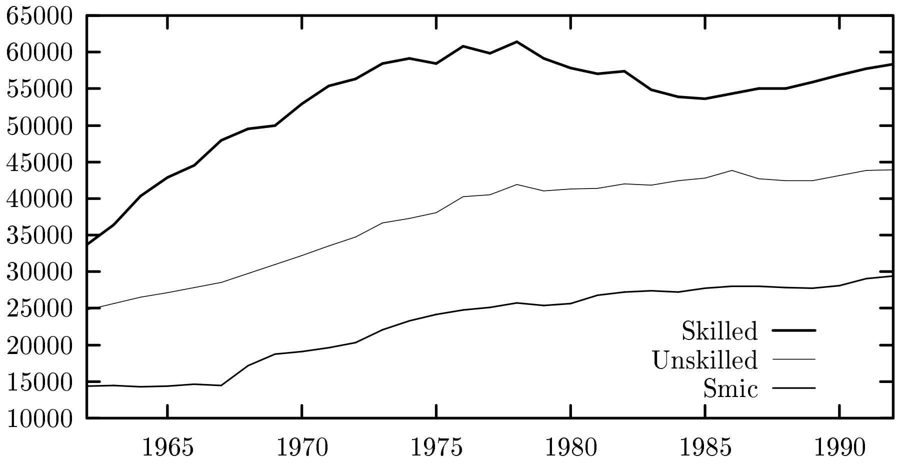

Figure 6: Annual real net wages
Wages for skilled workers was lowered by 30 000F for scaling reasons.

and the wages for skilled workers. Wages for unskilled workers are the object of a bargaining with a local trade union. Given prices and wages, firms decide for their employment level. Government decides for the change in the minimum wage (SMIC). In the long term, firms have to decide for a technical coefficient on the basis of a cost minimization program which determines the ratio between skilled and unskilled workers. Equilibrium can be qualified of symmetrical as all firms are ex ante identical. They experience different random shocks in the short term. Aggregation over the micro markets introduces the possibility of coexistence of excess supply and excess demand in the short term. In the long term, decisions are based on expectations, and thus all the firms become again identical.

4.1 Long term technological decisions

In the long term firms decide for a technological coefficient which determines the ratio between total unskilled labour L_N and total skilled labour L_Q. Neglecting the other production factors such as capital and energy, we shall consider the following aggregate CES production function:

$$\begin{aligned} Y &= \{(e^{\gamma_N t} L_N)^{-\rho} + (e^{\gamma_Q t} L_Q)^{-\rho}\}^{-1/\rho} && (2) \\ &= e^{-\gamma_N t} L_N \left\{1 + \left[\frac{e^{\gamma_N t} L_N}{e^{\gamma_Q t} L_Q}\right]^{\rho}\right\}^{-1/\rho} && (3) \end{aligned}$$

where Y is the aggregate production. As decisions in the long term are based on expectations, we do not have, at this stage, to distinguish between the individual firms and consider aggregation problems. By a labour cost minimization program at given production Y, firms decide for a ratio:

$$\frac{e^{\gamma_N t} L_N}{e^{\gamma_Q t} L_Q} = \left[\frac{e^{-\gamma_N t} W C_N}{e^{-\gamma_Q t} W C_Q}\right]^{-\sigma} \tag{4}$$

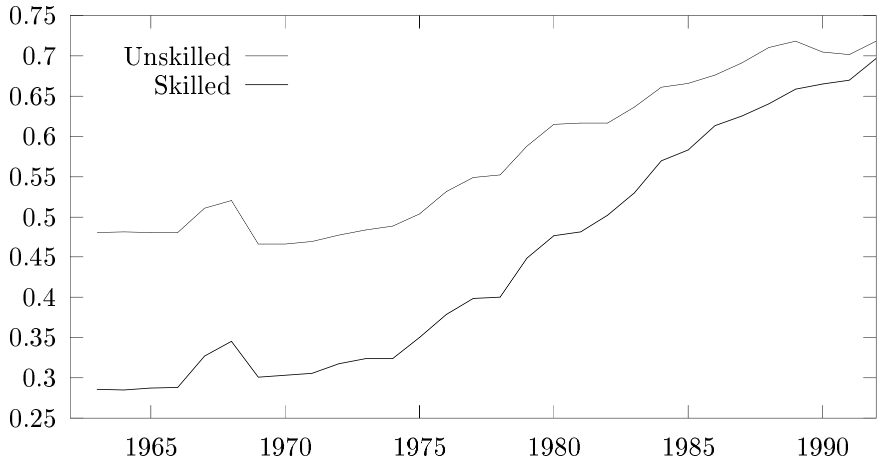

Figure 7: Rates of social security contributions

with:

$$\sigma = \frac{1}{1+\rho} \qquad \frac{1}{\rho} = \frac{\sigma}{1-\sigma} \tag{5}$$

Wages WC_N and WC_Q represent average unskilled and skilled cost wages for employers in the economy. The long term technical coefficient L_N/L_Q is thus defined as:

$$\log \frac{L_N}{L_Q} = b_0 - (1-\sigma)(\gamma_Q - \gamma_N)t - \sigma \log \frac{WC_N}{WC_Q} \tag{6}$$

The technological choice is a function of the deviation between exogenous productivity of unskilled and skilled labour and of the ratio between the two types of wage costs. In the short and medium term this ratio is fixed. If we call A_N and A_Q the apparent productivities of unskilled and skilled labour respectively, the long term technological choice determines the ratio A_Q/A_N. Combining (3) and (4), we find the aggregate demand for unskilled labour at given output:

$$L_N = e^{-\gamma_N t} Y \left\{ 1 + \left[\frac{e^{-\gamma_N t} WC_N}{e^{-\gamma_Q t} WC_Q} \right]^{\sigma - 1} \right\}^{\frac{\sigma}{1-\sigma}} \tag{7}$$

Dividing both sides by Y and rearranging the terms, we arrive to the determination of unskilled labour productivity:

$$A_N = e^{\gamma_N t} \left\{ 1 + \left[\frac{e^{-\gamma_N t} WC_N}{e^{-\gamma_Q t} WC_Q} \right]^{\sigma - 1} \right\}^{\frac{\sigma}{\sigma-1}} \tag{8}$$

4.2 The short term model with fixed prices

In the short run, prices and wages are given. There is a great number of firms which all have a specific micro market. They use a fixed coefficient technology where production factors are

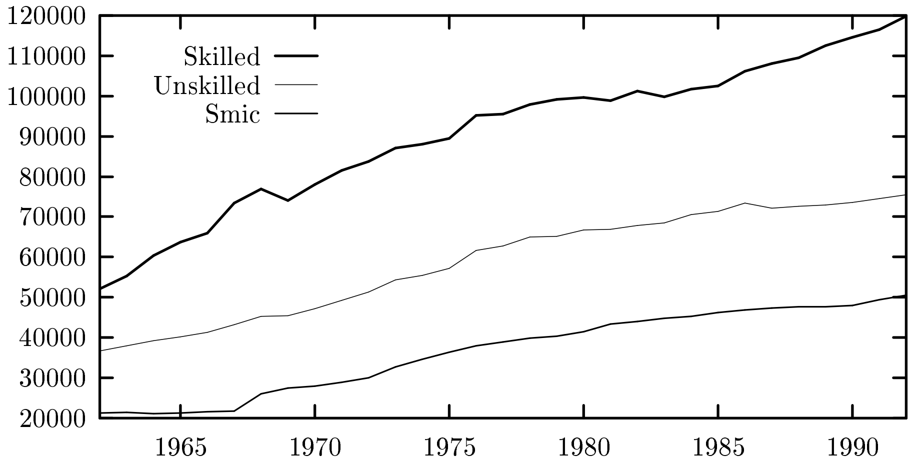

Figure 8: Annual real wages as a cost for employers
Skilled wages were lowered by 30 000F for scaling reasons.

skilled and unskilled labour. We neglect the problems which are linked to the use of capital stock by assuming that there is no capital shortage and that it is combined in the same proportion to skilled and unskilled labour. The demand for output YD_i which is addressed to each firm on its micro market is a fraction of the total final demand YD/N where N is the number of firms. If P_i is the price of the firm (fixed in the short run) and P the average price level in the economy, we have:

$$YD_i = \left[\frac{P_i}{P}\right]^{-\epsilon} \frac{YD}{N} u_i \tag{9}$$

This equation shows that final demand is shared out between the micro markets as a function the relative price of the firm with an elasticity[3] ϵ and a unit mean random term u_i.

The skilled labour supply which is addressed to each firm on its micro market follows the same type of repartition mechanism. There is a global skilled labour supply LS_Q which is shared out between the N firms according to the relative wage rate:

$$LS_{Qi} = \left[\frac{W_{Qi}}{W_Q}\right]^{\upsilon} \frac{LS_Q}{N} w_i \tag{10}$$

W_{Qi} is the skilled wage rate paid by firm i and W_Q is the average skilled wage rate paid in the economy. The labour supply elasticity to the relative wage rate is υ; w_i is a unit mean random term.

Both (9) and (10) represent a possible rationing scheme. Good demand and skilled labour supply can be lower than production and skilled labour demand. These equations represent how those quantities are shared between the N firms. On the contrary, unskilled labour

[3]supposed to be greater than one in absolute value, see SNEESSENS (1992).

supply is always greater than the needs of the firm. So there is no need of an allocation mechanism for this type of labour. The optimal production of the firm is thus given by the minimum of two quantities:

$$Y_i = \text{Min}(A_Q L_{Qi}, YD_i) \quad \text{and} \quad L_{Qi} \leq LS_{Qi} \tag{11}$$

Once production and skilled employment are determined, unskilled employment is given by the relation:

$$L_{Ni} = A_N^{-1} Y_i = \frac{A_Q}{A_N} L_{Qi} \tag{12}$$

which implies that the total employment of the firm is:

$$L_i = L_{Qi} + L_{Ni} = \left(1 + \frac{A_Q}{A_N}\right) L_{Qi} \tag{13}$$

Skilled labour supply and good demand deviate from their optimal level because of the presence of the two random terms w_i and u_i. If we suppose that these random terms have a log normal distribution, we can show [see GOURIEROUX and al (1984) and LAMBERT (1988)], that aggregation over micro markets leads to a CES function such that:

$$Y = \left\{(A_Q L_Q)^{-\rho}, (YD)^{-\rho})\right\}^{-1/\rho} \tag{14}$$

where ρ depends on the variances of the random terms. As aggregate employment can be decomposed in the same way as at the micro level, we have:

$$L = L_Q + L_N = \left(1 + \frac{A_Q}{A_N}\right) L_Q \tag{15}$$

We can thus convert the aggregate production relationship (14) into an aggregate employment relationship with:

$$L = \left\{((A_Q^{-1} + A_N^{-1})\, YD)^{-\rho}, (LS_Q/\mu)^{-\rho}\right\}^{-1/\rho} \tag{16}$$

where μ was defined in (1). The definition of regime proportions comes from the properties of the CES function. We have:

$$\Pi_D = \left[\frac{Y}{YD}\right]^{\rho} \qquad \Pi_L = \left[\frac{Y}{A_Q L_Q}\right]^{\rho} \tag{17}$$

4.3 Price and wage decisions in the medium term

Each firm has its own micro market. It fixes the price of its output and the wage rate of the skilled workers it wants to hire. As we have seen in the previous sections describing the French labour market characteristics, there are good reasons to to assume an asymmetric determination for wages. The firm has the possibility to modify the probability of being rationed on the skilled labour market by offering a wage rate which is more attractive than that of the other firms. On the contrary, the unskilled labour market is always in excess supply. The wage rate is determined by a bargaining process with a monopoly trade union. We can suppose that this wage rate is given to the firm for the while.

The firm tries to maximize its expected profit when determining its price and the skilled wage rate paid to workers, taking into account possible rationing on the skilled labour market and on the good market. Its maximization program is thus:

$$\begin{aligned}
\underset{[P_i, W_{Qi}]}{\text{Max}} \quad & \mathrm{E}\{P_i\, Y_i - WC_{Qi}\, L_{Qi} - WC_N\, L_{Ni} - \text{fixed costs}\} \\
& Y_i \leq YD_i \\
& L_{Qi} = A_Q^{-1} Y_i \leq LS_{Qi} \\
& L_{Ni} = A_N^{-1} Y_i
\end{aligned}$$

with $WC_{Qi} = W_{Qi}\,(1 + TX_Q)$ where TX_Q is the social contribution rate paid by the firms. If the price P_i and the wage rate W_{Qi} are announced at the beginning of the period before the realization of the shocks, the programme can be simplified into:

$$\begin{aligned}
\underset{[P_i, W_{Qi}]}{\text{Max}} \quad & \{P_i - A_Q^{-1}\, WC_{Qi} - A_N^{-1}\, WC_N\}\, \mathrm{E}(Y_i) \\
& \mathrm{E}(Y_i) = A_Q\, \mathrm{E}(L_{Qi})
\end{aligned}$$

It is then easy to show that we arrive at the following aggregate price and wage equations:

$$P = (1 + \pi)\, [A_N^{-1}\, WC_N + A_Q^{-1}\, WC_Q] \tag{18}$$

$$W_Q = (1 - \nu) \left[1 - A_N^{-1} \frac{WC_N}{P}\right] \frac{P}{A_Q^{-1}\,(1 + TX_Q)} \tag{19}$$

π is the mark up rate for prices and ν is the mark up rate for skilled wages. Their detailed expressions are given by:

$$\pi = \frac{1}{\Pi_D\, \epsilon - 1} \qquad \nu = \frac{1}{\Pi_L\, \upsilon + 1} \tag{20}$$

Thus the mark ups are function of the good demand elasticity to prices ϵ and the skilled labour supply elasticity to wages υ as well as the regime proportions.

4.4 The monopoly trade union behaviour

The unskilled wage rate is determined by a bargaining process between the firm and a local trade union. We shall suppose that the monopoly union determines the wage rate and the firm, knowing the wage rate, determines employment. The trade union of course knows the reaction function of the firm. Usually, the reaction function of the firm is simply its inverted price function (plus some algebraic manipulations). However, as there is a segmentation of the labour market and a short run complementary between skilled and unskilled labour, the answer is not so simple and will be discussed below. The utility function of the local trade union j incorporates the unskilled employment, the unskilled wage rate, the SMIC and the skilled wage rate:

$$U_{Nj} = U_N(L_{Ni}\,,\, W_{Ni}/P_C\,,\, W_{Qi}/P_C\,,\, SMIC/P_C) \tag{21}$$

These last two elements denote an envy effect which is analyzed as follows:

- on one side, the trade union wants to reduce the spread between skilled and unskilled wage rates. When the skilled wage rate increases, the trade union desires to rise also the unskilled wage rate such as to obtain a better share of the fruits of economic growth. When the skilled wage rate remains constant or decreases, the envy effect vanishes.

- on the other side, the SMIC plays the role of a reference for the unskilled wage rate. The latter has a tendency to be fixed as a certain percentage over the minimum wage rate. So an increase for the SMIC is often automatically translated into a general unskilled wage increase. The trade union wants to maintain or even increase the spread between the SMIC and the unskilled wage rate.

The trade union maximizes its utility function in the unskilled wages subject to the reaction function of the firm. We can essentially distinguish between a short run and a long run reaction functions.

- In the *short run*, skilled and unskilled labour are strictly complementary. Once the firm has hired a certain quantity of skilled labour at the W_Q wage rate, its current technology implies that it hires the corresponding unskilled labour using (12), whatever the unskilled wage rate may be. We reproduce here (12) for the ease of reading:

$$L_{Ni} = \frac{A_Q}{A_N} L_{Qi} = A_N^{-1} Y_i$$

- In the *long run*, things are of course different. The technology is adapted to the evolution of the relative labour cost (see the discussion about long term technological decisions). The price behaviour of the firms can be translated into an employment decision for unskilled labour. Let us combine the technical relation (7) and the aggregate price equation (18), we get the following aggregate employment function:

$$L_N = \Lambda(e^{-\gamma_N t} Y\,,\, e^{-\gamma_N t}\frac{WC_N}{P}\,,\, e^{-\gamma_Q t}\frac{WC_Q}{P}) \tag{22}$$

Using (12) for the trade union utility maximization is equivalent, at given output, to introduce the apparent labour productivity in the unskilled wage equation. The corresponding aggregate wage equation is:

$$\log \frac{W_N}{P_C} = a_0 + a_1 \log \frac{W_Q}{P_C} + a_2 \log \frac{SMIC}{P_C} + a_3 \log A_N \tag{23}$$

This equation suggests a simple wage indexation on productivity if a_3 is positive. A positive coefficient could also be interpreted as the effect of a reservation wage rate, the latter being a function of unskilled labour productivity. When this equation is imbedded in a complete model, A_N becomes an endogenous variable defined as Y/L_N. At given production, a rise in productivity means a decrease of employment. With a positive coefficient a_3, A_N moderates wage claims.

The previous equation denotes a short sighted optimization behaviour of the trade union. If the trade union wants to fully take into account the reaction function of the firm, it has to use the long term employment function (22). As a consequence, A_N will no longer enter the resulting wage equation. It will be replaced by variables coming the behaviour of the firm. More precisely, net wages and cost wages are linked by:

$$WC_N = W_N(1 + TX_N) \qquad WC_Q = W_Q(1 + TX_Q) \tag{24}$$

We have now to link P_C and P by a consumption price equation which is usually taken as:

$$\log P_C = \alpha \log P + (1 - \alpha) \log PE \tag{25}$$

where PE is the price of energy. The resulting alternative aggregate unskilled wage equation is:

$$\begin{aligned} \log \frac{W_N}{P_C} &= b_0 + b_1 \log \frac{W_Q}{P_C} + b_2 \log \frac{SMIC}{P_C} \\ &\quad + b_3 \log TX_N + b_4 \log TX_Q + b_5 \log \frac{PE}{P} + b_6 \log \frac{P}{P_C} \end{aligned} \tag{26}$$

The first line in (26) relates to the utility function of the trade union and the last line to the cost function of the firm.

4.5 Fixing the minimum wage

The laws concerning the minimum wage were deeply modified following the Grenelle agreement en 1968. Besides the automatic indexation on consumption prices, the SMIC is increased according to two separate mechanisms. First, a partial indexation on the *increases* of workmen wages. Second a discretionary *increase* by the government known as *coup de pouce*. These mechanisms suggest a SMIC equation written in differences rather than in levels. This equation is thus going to explain the variations of the SMIC and not its level:

$$\Delta \log SMIC/P_C = c_0 + c_1\, CDP + c_2\, \Delta \log W_N/P_C \tag{27}$$

CDP is a dummy variable representing the *coups de pouce*.

5 Estimation of the model

The purpose of the model is to investigate by simulation the influence of the minimum wage on the structure of wages, the rate of inflation and finally the unskilled employment and/or the rate of mismatch μ between demand and supply of qualifications. We have chosen to estimate only the medium and long term part of the model, leaving aside the good demand side which concerns the short run. So we shall estimate the technological equation, the SMIC equation, the wage equations for skilled and unskilled and the two price equations (production and consumption prices). Our variables (taken in logarithms) are trending and most presumable I(1) (see below). So we could use the two step method of ENGLE and GRANGER (1987) to estimate the model. However, as we have few observations (31 annual observations covering the period 1962-1992) this method is not enough feasible. The nonlinear error correction model promoted by BARNEJEE et al (1986) will be preferred. We had to introduce some dummy variables: D75 is obviously one in 1975 and D82 one in 1982 (and zero elsewhere); CD74 is zero till 1974 and one after, CD75 is zero till 1975 and one after. These last dummies are necessary because some of the equation will have a break in one parameter.

5.1 Properties of the series

We shall not detail the ADF tests we have done on the data, because it would be too long and this practice is now a routine. Let us simply classify our series taken in logarithms. Price and wage series are I(2): $\log WC_Q$, $\log WC_N$, $\log SMC$, $\log P_C$, $\log P$. The only price variable which is I(1) is the price of energy $\log P_E$. Some combinations of I(2) variables are I(1): The real minimum and unskilled net wages when deflated by consumption prices, the real cost skilled wage when deflated by production prices, and the ratio of wage costs $\log(WC_N/WC_Q)$. The other variables are I(1), such as $\log Y$, $\log A_N$, $\log A_Q$, $\log(1+TX_N)$, $\log(1+TX_Q)$, $\log L_N$, $\log L_Q$. The ratio $\log(L_N/L_Q)$ remains I(1), which means that these variables are not cointegrated. The only oddity is that $\log(W_Q/P_C)$ is I(0).

5.2 Technological choices

This equation was quite simple to specify. A break was detected in the differential of labour productivity as well as in the constant term after 1974. But there is no break in the other coefficients of this equation.

$$\begin{aligned}\Delta\log(L_N/L_Q)_t = {} & \underset{[3.68]}{0.99} - \underset{[-2.43]}{0.058}D75 - \underset{[-2.73]}{0.11}\,CD74 \\ & - \underset{[-3.91]}{0.71}\Big[\log(L_N/L_Q)_{t-1} - \Big(\underset{[2.89]}{0.53}\log(WC_N/WC_Q)_{t-1} \\ & \qquad + (1-\underset{[2.89]}{0.53})(\underset{[2.66]}{0.10}t - \underset{[-2.47]}{0.042}\,t\times CD74)\Big)\Big]\end{aligned}$$

$$\text{ss} = 0.00734 \quad \sigma = 0.0178 \quad \text{DW} = 1.70 \; R^2 = 0.997 \quad \text{Log likelhd.} = 82.168$$

This equation is cointegrated with a t cointegrating statistics of -3.91. The critical value at 5% is -3.78 with a constant, a trend and two variables. The measured elasticity of substitution is roughly one half. The adjustment to the long term solution is perhaps too quick with a mean lag of a quarter.

5.3 Wages

The unskilled wage equation was rather difficult to specify. We have tried to implement a nonlinear envy effect for skilled wages by mean of a smooth transition threshold based on $(W_Q - W_N)/W_N$, but without success. We thus have chosen a much more simple equation, where the only non-linearity consists in taking into account only the positive variations of the skilled wages. This is a short term mechanism. In the long run, the only wage comparison effect which is present concerns the SMIC. The incorporation of productivity experiences a change after 1974. It was impossible to introduce any other variables representing the price behaviour of the firm such as the rate of social contributions or the relative price of energy. This equation represent thus a shortsighted behaviour of the trade unions.

$$\begin{aligned}\Delta\log(W_N/P_C)_t = {}& \underset{[3.93]}{6.24} - \underset{[-4.52]}{0.58}\, CD74 + \underset{[2.56]}{0.55}\,\mathrm{Pos}(\Delta\log(W_Q/P_C)_t \\ & + \underset{[3.00]}{0.20}\,\Delta\log(SMIC/P_C)_t - \underset{[-4.66]}{0.65}\Big[\log(W_N/P_C)_{t-1} \\ & - \Big(\underset{[2.35]}{0.20}\log(SMCP/P_C)_{t-1} + \underset{[6.45]}{0.53}\log(A_N)_{t-1} - \underset{[7.21]}{0.46}\log(A_N \times CD74)_{t-1}\Big)\Big]\end{aligned}$$

$$\text{ss} = 0.00184 \quad \sigma = .00914 \quad \text{DW} = 2.25 \quad R^2 = 0.997 \quad \text{Log likelhd.} = 102.94$$

The t test for cointegration has a value of -4.66. The critical value at 5% for four variables and a constant term is -4.10. Thus there is cointegration. The mean lag of the adjustment to the long run solution is of seven quarters.

The skilled wage equation was simpler to estimate. It resulted quite directly from the theoretical equation. It is a cost wage equation where nominal skilled cost wages are partially indexed on nominal unskilled cost wages in the short run. In the long run, cost wages are indexed on production prices and productivity (which is not fully integrated).

$$\begin{aligned}\Delta\log(WC_Q)_t = {}& \underset{[4.49]}{2.32} + \underset{[2.50]}{0.022}\, D82 + \underset{[3.02]}{0.43}\,\Delta\log(1+TX_Q)_t + \underset{[16.62]}{0.69}\,\Delta\log(WC_N)_t \\ & - \underset{[-4.06]}{0.42}\Big[\log(WC_Q)_{t-1} - \Big(\log(P)_{t-1} + \underset{[28.14]}{0.53}\log(A_Q)_{t-1}\Big)\Big]\end{aligned}$$

$$\text{ss} = 0.00172 \quad \sigma = .00846 \quad \text{DW} = 2.27 \quad R^2 = 0.999 \quad \text{Log likelhd.} = 103.95$$

In the short run, nominal earning skilled wages have a tendency to decrease when the rate of social security contribution is increased (subtract 1 to 0.43), but this effect disappears in the long run. The equation is cointegrated with a t cointegration statistics of -4.06 as for a constant term and two variables the critical value is -3.34 at 5%. The mean lag for adjustment is of six quarters.

The SMIC equation comes from institutional mechanisms. We have to build a dummy variable CDP which should be an indicator of the famous *coups de pouce* of the Government. It is built starting from the series $PerSmc$ which gives the percentage of people paid at the minimum wage. We suppose that when a *coups de pouce* occurs, the number of people paid at SMIC is temporally increased. We then have:

$$CDP = \max(0, \Delta\log PerSmc)$$

The estimated equation over the period 1963-1992 is:

$$\Delta \log(SMIC/P_C) = \underset{[8.16]}{0.083} CDP + \underset{[5.00]}{0.66} \Delta \log(W_N/P_C)$$

$$\text{ss} = 0.00968 \quad \sigma = .0186 \quad \text{DW} = 1.847 \quad R^2 = 0.995 \quad \text{Log likelhd.} = 78.011$$

5.4 Prices

There are two price formations to explain: the production price and the consumption price. The production price equation should be similar to the skilled wage equation as it relies on the same type of mechanism. It is a mark-up on costs:

$$\begin{aligned}\Delta \log(P)_t = & - \underset{[-5.01]}{4.70} + \underset{[7.17]}{0.30} \Delta(\log(WC_N) + \log(WC_Q))_t \\ & - \underset{[-2.12]}{0.22} \Delta(\log(A_N) + \log(A_Q))_t - \underset{[-4.98]}{0.56} \Big[\log(P)_{t-1} \\ & - \Big(\underset{[43.18]}{0.46} (\log(WC_N) + \log(WC_Q))_{t-1}) - \underset{[7.37]}{0.21} (\log(A_N) + \log(A_Q))_{t-1})\Big)\Big]\end{aligned}$$

$$\text{ss} = 0.00207 \quad \sigma = .00928 \quad \text{DW} = 1.89 \quad R^2 = 0.999 \quad \text{Log likelhd.} = 101.16$$

Production prices are proportional to Wages and productivity, with the same coefficients for skilled and unskilled. There is cointegration as the critical value at 5% for three variables and a constant term is -3.74 to be compared to the -4.98 cointegration t statistics. Production prices are indexed on global wage costs and global productivity, but with unit indexation. The mean speed of adjustment is three quarters.

The consumption price equation is just an ECM approximation of what should be an accounting identity. Justification for this kind of approximation can be found in LUBRANO (1991).

$$\begin{aligned}\Delta \log(P_C)_t = & \underset{[2.84]}{0.13} + \underset{[13.72]}{0.78} \Delta \log(P)_t + \underset{[5.34]}{0.62} \Delta \log(P_E)_t \\ & - \underset{[-2.78]}{0.30} \Big[\log(P_C)_{t-1} - \Big(\underset{[51.73]}{0.96} \log(P)_{t-1} + (1 - \underset{[51.73]}{0.96}) \log(P_E)_{t-1}\Big)\Big]\end{aligned}$$

$$\text{ss} = 0.00126 \quad \sigma = .00709 \quad \text{DW} = 2.12 \quad R^2 = 0.999 \quad \text{Log likelhd.} = 108.635$$

The t value for the cointegration test is a bit low and cointegration could be rejected (critical value of -3.34 at 5% for two variables and a constant term to be compared to -2.58). However, for simulation purposes, it is better to keep this equation as given here with the long term solution.

6 Simulation evidences for the minimum wage

Starting from the six previous equations, we are going to build a simulation model and study various scenarios of economic policy. The aim is first to measure the influence of the minimum wage on unskilled employment and second to find a mean to reduce the unemployment rate of

equations	$\frac{L_N}{L_Q}$	$\frac{W_N}{P_C}$	WC_Q	$\frac{SMIC}{P_C}$	P	P_C	$\frac{WC_N}{WC_Q}$	L_N	A_N	$\frac{W_Q}{P_C}$	WC_N
L_N/L_Q	x						x				
W_N/P_C		x		x					x	x	
W_Q/P_C			x								x
$SMIC/P_C$		x		x							
P			x		x				x		x
P_C					x	x					
WC_N/WC_Q			x				x				x
L_N	x							x			
A_N								x	x		
W_Q/P_C			x			x				x	
WC_N		x				x					x

Table 1: Structure of the model

unskilled workers. There are eleven endogenous variables because of the accounting identities we had to introduce. The list of the endogenous variables is given in table 1. The accounting identities define:

$$\begin{aligned}
\log(WC_N/WC_Q) &= \log(WC_N) - \log(WC_Q) \\
\log(L_N) &= \log(L_N/L_Q) + \log(L_Q) \\
\log(A_N) &= \log(Y) - \log(L_N) \\
\log(W_Q/P_C) &= \log(WC_Q) - \log(1+TX_Q) - \log(P_C) \\
\log(WC_N) &= \log(W_N/P_C) + \log(P_C) + \log(1+TX_N)
\end{aligned}$$

The exogenous variables are:

$$TX_N \quad TX_Q \quad P_E \quad L_Q \quad Y \quad t \quad CD74$$

Taking into account the accounting identities make the model very interdependent as can be seen on table 1 which analyses its structure. This model has good simulation properties as the Theil coefficients associated to each equation are all very small as seen in table 2. This being said, the decomposition of simulation errors for the SMIC equation is not good due to the importance of the fraction of the bias and the variance.

We have imagined five different scenarios which evaluate the consequences of various measures of economic policy on the levels of the minimum real net wage, the real unskilled net wage, the real skilled net wage, the level of unskilled employment and the rate of inflation $\Delta \log P$. The first two scenarios are designed to compute two series of elasticities considering a shock on the minimum wage and a shock on the rate of social security contribution for unskilled workers. More precisely:

equation	$\frac{L_N}{L_Q}$	$\frac{W_N}{P_C}$	WC_Q	$\frac{SMIC}{P_C}$	P	P_C	$\frac{WC_N}{WC_Q}$	L_N	A_N	$\frac{W_Q}{P_C}$	WC_N
Theil	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00
bias	0.00	0.05	0.17	0.21	0.15	0.14	0.02	0.00	0.00	0.02	0.13
var	0.03	0.25	0.06	0.45	0.07	0.02	0.13	0.01	0.01	0.05	0.09
cov	0.97	0.70	0.77	0.33	0.77	0.84	0.85	0.99	0.98	0.92	0.79

Table 2: Simulation statistics for the model

1) a SMIC increase, over that due to inflation (the model is in real terms), obtained by increasing the otherwise zero constant term of the SMIC equation by $log(1.1)$. It is a way a simulate a *coup de pouce*.

2) a decrease of the social contribution rate over the unskilled wage rate obtained by subtracting log(1.1) to the variable $\log(1 + TX_N)$.

The model perfectly reached convergence for these two scenarios. Thus the desired elasticities are reproduced in table 3. We find that the impact of a SMIC increase is positive,

shock	$SMIC/P_C$	W_N	W_Q	L_N	$\%P$
$\partial SMIC/P_C$	1.0	0.21	0.03	-0.010	0.02
$-\ \partial TX_N$	-0.03	-0.04	-0.13	0.48	-0.02

Table 3: Elasticities computed with the model

but quite small, on the wage of unskilled workers (21%) and that it has a negative impact on unskilled employment, but that this impact is negligible (-1%). The impact is positive, but negligible on skilled wages (3%) and on the rate of inflation (2%).

On the contrary, a decrease of the social security contribution rate on unskilled wages has a rather strong effect on employment with an elasticity of 48% while decreasing slightly the real wage of unskilled workers as well as the SMIC in a slight and quasi identical proportion (3%). The impact on prices is negative and small. Skilled workers would be penalized by such a measure, as it implies a moderate decrease of their net real wages (-13%).

The other scenarios are not designed to compute elasticities. The model will not reach convergence as they do not implement simple shocks, but imply deep modifications of the economy. They try to answer to questions of the form: “What would be the new economic equilibrium if...?”

3) The minimum wage in France is not simply indexed on prices. It is also partially indexed on other wages. Moreover it can be increased by a discretionary action of the Government. When this action took place, its aim was to reduce the spread among wages. This action has been much criticized on the argument that it was a burden to the firms and generated unemployment. What would have happened in the absence of any *coups de pouce* of the government?

4) The first oil shock in 1974 introduced a tremendous change in relative prices which modified greatly the international game. Logically, wages should have been adjusted to this new international setting. And actually, they were, at least partly. The unskilled wage equation reckons a drop in the indexation of wages on productivity after 1974 as it introduces a negative change in the constant term after 1974. This adjustment was not enough important to stabilize the mismatch index for labour qualifications. How much wages should have been more decreased in order to reach such a stabilization?

5) The substitution between skilled and unskilled labour is governed by two factors: a comparison of wage costs and a differential in trend productivity. We have seen that the wage cost factor was quite important as a reduction in social security contributions for unskilled workers had a real impact. What is the role of the differential in productivity and how much this differential must be reduced in order to stabilize the mismatch index after 1974?

Scenario 3) is obtained by putting to zero the coefficient of the dummy variable CDP in the SMIC equation. Scenario 4) is obtained by multiplying by 1.10 the coefficient of $CD74$ (the constant term after 1974) in the unskilled wage equation. The last scenario is obtained by multiplying by 1.12 the coefficient of $TD74$ (the trend after 1974) in the technical coefficient equation. Results are regrouped in table 4. Nothing appends on prices

shock	$SMIC/P_C$	W_N	W_Q	L_N	$\%P$
$CDP = 0$	-0.38	-0.08	-0.01	0.04	-0.01
$CD74 \times 1.10$	-0.07	-0.11	-0.01	0.05	-0.01
$TD74 \times 1.12$	-0.00	-0.01	0.00	0.08	0.00

Table 4: Three "as if" simulations

and on skilled wages in all three scenarios.

Without a discretionary action of the government, the minimum wage would have been lower by 38% at the end of the period, unskilled wages lower only by 7%. Unskilled labour would have been increased of 4%. A very high price for a quite small result.

A 12% shift in technical trend differential after 1974 has no effect on wages and prices, but of course a mild effect on employment with 8% at the end of the period. The simulated series is reproduced in figure 9 and show that the mismatch index is really stabilized, despite

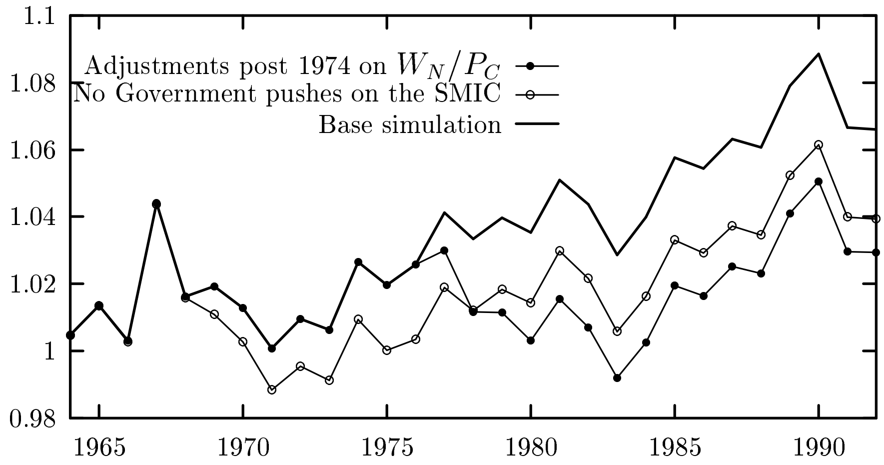

Figure 9: Stabilization scenarios for the mismatch index μ

some fluctuations. On the contrary, if unskilled real wages had been adjusted after 1974 more than that they were with a cumulated change of 11% at the end of the period (and 7% for the minimum wage), the mismatch index would have been stabilized between 1975 and 1985 as shown in figure 9, but the general negative trend would have reappeared after 1986. The cumulative effect on unskilled employment would have been nevertheless of 5%.

7 Conclusions

The simulations made with the model suggest a relatively negligible influence of the value of the SMIC on unskilled employment. On the contrary, the level of social security contributions seems to play a major role in the substitution between the two types of labour. A decrease of the rate of social security contributions on unskilled wages has a relatively important effects on employment. Thus it would seem natural at least to stop the present situation where unskilled labour is more taxed than skilled labour in percentage. The question is how to finance this change in the payment of social security contributions. An increase in the general taxation rate of all the earnings is quite suitable, but such changes are often rather difficult to be accepted by the society.

The second remark which is well being done in this conclusion concerns the influence of technical progress. The substitution between the two types of labour depends on the relative cost of these production factors. A decrease of the rate of social security contribution for unskilled labour leads to a decrease in the mismatch index (1). But the substitution equation includes an exogenous temporal trend which has a very strong effect. A durable reduction of the mismatch index (1) goes through a reduction of this trend, but such a reduction is out of reach from all the simple policy instruments. The only possible alternative consists in increasing the qualification level of the population.

We can conclude by a comment on the unskilled wage equation. It has not been possible, as it was nevertheless suggested by the theoretical model, to introduce "supply" variables in this equation. That is to say, are not included in this equation the rate of social security contributions of skilled and unskilled workers and also the relative price of energy. Unskilled wages mainly follow an indexation mechanism on productivity. They do not react to foreseen consequences on employment. We can image the following explanation. If the trade unions integrated these reaction variables of the firms, the wages that would be compatible with a constant level of employment would be so low, that they would not be socially acceptable. We are in Europe and not in the United States (see the analysis of section 3)! Unemployment benefits does not play their role of insurance against transitory unemployment. They play a role of earning redistribution, supporting the unemployed people who have been excluded by the rise in productivity.

This model and the simulations have definite limitations. It is macro model, even if there is a desegregation of the labour demand. In particular, the percentage of people paid at the minimum wage is exogenous. All the simulations are conditional on this hypothesis. And no change in the composition of the labour supply is allowed for. But we do not see how we could remove these limitations. On the contrary other limitations of the model could be removed:

- The model neglect the whole demand side. Integrating short term aspects in the econometric model with an estimation of demand for good and labour equations would enrich greatly the empirical results. These equations are necessary if we want to study alternative possibilities for financing the social security system.

- The SMIC equation, as it is specified, suggests the possibility of multiple equilibria as the level of the minimum wage is not determined. There could be other equilibrium for another level of the minimum wage. Lines contained for instance in RISAGER (1992) could also be used to develop this aspect.

So, as it can be seen, there are ample possibilities to enrich the paper. But a full stop had to be put somewhere in order to get a readable paper.

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The Beveridge-Nelson decomposition

It is always possible to decompose additively a non stationary series y_t between a non stationary part (the trend) and a stationary part (the cycle). If the series incorporates a unit root, it is possible to formulate the trend as random walk with a drift δ. The Wold representation of the series is then:

$$\Delta y_t = \delta + C(L)\,\epsilon_t \tag{28}$$

As Δy_t is stationary, the lag polynomial $C(L)$ has all its roots outside the unit circle and can be factorized into:

$$\Delta y_t = \delta + C(1)\,\epsilon_t + C^*(L)\,\Delta\epsilon_t \tag{29}$$

$C(L)$ contains all the dynamics of the model. It gives the propagation of a chock ϵ_t on the variable Δy_t. The coefficient $C(1)$ measures the global effect of a shock on Δy_t or, to say things in a different way, how the drift δ of the non stationary process y_t is modified in a permanent way. Let us now turn to a Wold representation in levels by inverting the lag polynomial $(1-L)$:

$$\begin{aligned} y_t &= \textstyle\sum_{j=0}^{t-1}(\delta + C(1)\epsilon_{t-j}) + \sum_{j=t}^{\infty}(\delta + C(1)\epsilon_{t-j}) + C^*(L)\epsilon_t \\ y_t &= y_0 + \delta t + C(1)\textstyle\sum_{j=0}^{t-1}\epsilon_{t-j} + C^*(L)\epsilon_t \end{aligned}$$

In this writing, the non stationary part is:

$$Z_t = y_0 + \delta\, t + C(1)\sum_{j=0}^{t-1}\epsilon_{t-j} \tag{30}$$

and the remaining stationary part is $C^*(L)\,\epsilon_t$. We can rewrite the series y_t as the sum of a trend Z_t and a cycle C_t with:

$$\begin{cases} y_t = Z_t + C_t \\ Z_t = Z_{t-1} + \delta + C(1)\,\epsilon_t \qquad \text{with } Z_0 = y_0 \\ C_t = C^*(L)\,\epsilon_t \end{cases}$$

The trend is modeled as a random walk with drift δ. $C(1)$ is usually taken as a measure of persistence. In the limiting case where $C(1) = 0$, the trend become deterministic. To obtain the Beveridge-Nelson decomposition, it suffices to adjust an ARMA model on the series y_t and to keep out an estimation of ϵ_t and δ.

In the case the real GNP series Y, estimating an MA(1) process gives:

$$\Delta Y = \underset{[9.12]}{66229.1} + \hat\epsilon_t + \underset{[-2.37]}{0.407}\,\hat\epsilon_{t-1}$$

The obtained measure of persistence (1.407) is much too strong. There are serious arguments to constraint it to be lower than one. So we shall take a as measure of the trend the following expression:

$$\hat Z_t = 66229.1\, t + 0.5\sum_{j=0}^{t-1}\hat\epsilon_{t-j}$$

The cycle is obtained by difference of the raw series. Figure 5 represents this stochastic trend once centered and normalized.