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Real Wages, Skill Mismatch and Unemployment Persistence France, 1962-1989

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ABSTRACT. – We develop a model of equilibrium unemployment with endogenous real wages and productivity. We use a framework with explicit quantity constraints and aggregation over micromarkets to derive a Beveridge curve and discuss the relationship between shifts in the Beveridge curve and equilibrium unemployment. We also distinguish skilled and unskilled labor, so that shifts in the aggregate UV-curve can be the outcome of either frictions on the skilled labor market or skill mismatch. Frictions are assumed to be exogenous and are estimated by a linear trend. Skill mismatch is endogenous and depends, a.o., on the skilled/unskilled relative wage. There is a tight relationship and interaction between skill mismatch and equilibrium unemployment. We estimate the model on French annual data, over the period 1962-89. We exploit these results to propose tentative explanations of observed unemployment rises and Beveridge curve shifts, and to discuss a few economic policy options.

Salaires réels, inadéquation offre-demande de qualification et persistance du chômage

RÉSUMÉ. – Cet article propose un modèle de taux de chômage d'équilibre dans lequel prix, salaires et choix technologiques sont endogènes. Le modèle distingue deux types de main-d'œuvre, qualifiée et non-qualifiée, et permet l'existence de contraintes d'offres en main-d'œuvre qualifiée. L'importance de ces contraintes peut varier dans le temps, en particulier en fonction de la conjoncture (contraintes de débouchés) et du taux d'utilisation des capacités de production disponibles. La fonction d'emploi agrégée est obtenue par agrégation sur micro-marchés et peut alternativement être réécrite sous la forme d'une courbe de Beveridge. Les déplacements de cette dernière résultent de deux facteurs, soit des frictions accrues sur le marché de la main-d'œuvre qualifiée, soit une inadéquation grandissante entre offres et demandes de qualifications ("skill mismatch"). L'inadéquation entre offres et demandes de qualifications est bien sûr endogène. A évolution technologique donnée, elle reflète l'évolution des salaires relatifs et celle de la composition de la population active. Les salaires sont déterminés par négociation entre entreprises et travailleurs ; les prix sont fixés par les entreprises en concurrence monopolistique.

Ce modèle est ensuite estimé sur données annuelles françaises, de 1962 à 1989. Les résultats obtenus sont utilisés pour interpréter les évolutions observées du chômage et de la courbe de Beveridge, et pour évaluer les effets de politiques économiques visant à modifier le coût relatif de la main-d'œuvre non-qualifiée.

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1 Introduction

The persistence of unemployment in European countries is usually explained by real wage and labor market rigidities (see for instance Layard-Nickell-Jackman, 1991). Until recently, most theoretical and empirical studies had been based on highly aggregated concepts and data. The huge shifts observed in the aggregate Beveridge curve together with the concentration of unemployment in certain areas or work groups have motivated more disaggregated studies where the causes and consequences of structural problems could be better accounted for (see for instance the papers published in PADOA-SCHIOPPA, [1990]). Interest in disaggregated studies was also stimulated by the finding that in the United-States the changes in relative wages observed over the last ten or twenty years might have been the result of non-neutral technological changes (see for instance BOUND-JOHNSON, [1992], and LEVY-MURNANE, [1992]). The aim of this paper is to examine whether such structural changes may be held responsible for the persistence of unemployment. To this end, we construct a model of equilibrium unemployment with two kinds of labor, skilled and unskilled, and estimate it on French annual data over the period 1962-1989.

Several approaches can be used to test for the presence of structural effects. JACKMAN *et al.* [1990] constructed a model wherein price and wage decisions are taken separately in different segments of the economy, so that the equilibrium unemployment rate can be affected by structural push factor changes. The appropriate mismatch indicator in this setup is the variance of relative unemployment rates. In European countries, the value of this mismatch indicator has usually not increased (in many cases, it actually decreased) over the last twenty years, which seems to indicate that structural push factor changes cannot have been the cause of rising unemployment. Similar results are obtained when the model is extended to account for the coexistence of vacancies and unemployment. The authors still point out that the rigidity of relative wages in European countries "may be a partial clue to high European unemployment" (LAYARD *et al.*, [1991], p. 316). BEAN-PISSARIDES [1990] constructed an econometric model with two kinds of labor (non-manual and manual), which they estimate on British manufacturing sectoral data over the period 1970-86. Beveridge curve phenomena are introduced via a matching function. The authors obtain some evidence of non-neutral technological progress at the sectoral level, in favor of skilled labor. They conclude however that, with an elasticity of substitution not significantly different from unity, structural changes can hardly have caused an unemployment rise, even though relative wages are not competitively determined. This result of course leaves open the possibility that sectoral shifts (towards sectors demanding relatively more skilled labor) might have had a positive impact on equilibrium unemployment. JACQUES-LANGOT [1992] analyzed the determinants of the UV-curve shifts observed in France, Germany and the United-Kingdom with a methodology similar to that of BLANCHART-DIAMOND [1989]. They conclude that these UV-curve shifts cannot be explained by dynamic adjustment processes following stochastic demand or structural shocks; these shifts seem to be best represented by deterministic trends, the economic interpretation of which remains to be examined.

The approach used in this paper is close to that of BEAN-PISSARIDES [1990], in that we explicitly distinguish two kinds of labor (skilled and unskilled), and estimate labor demand and wage equations for both, so as to be able to examine the structural determinants of the equilibrium unemployment rate. There are differences however. On the theoretical side, we introduce the Beveridge curve via an explicit representation of quantity constraints, rather than via a matching function. This allows us to take explicitly into account the effects of quantity constraints on individual and unions behaviors; this will turn out to be crucial in explaining relative wage changes. On the empirical side, one main difference is that we use aggregate rather than sectoral data. One reason for using aggregate data is that they do reflect the effects, on average productivity growth and labour demand, of sectoral changes and of out-sourcing as well of pure technical progress. We of course have to keep in mind that, as a consequence, our index of so-called "exogenous technical progress" will actually measure a mixture of these three effects. Let us also stress that our definition of skilled vs unskilled labour will not be based on the usual manual vs non-manual distinction. With aggregate data, such a definition would be most inappropriate, given the increasing relative importance of the service sector.

Our model actually generalizes previous models of the EUP variety (see SNEESSENS-DRÈZE, [1986], DRÈZE *et al.*, [1990]). The employment function is extended to the case with two labor inputs, skilled and unskilled. Standard imperfect competition representations of wage and price behaviors can easily be introduced in this setup (see SNEESSENS, [1987]). These models can thus be used to analyze both UV-curve shifts and equilibrium unemployment changes, and the relationship between the two. Empirical results based on European data, without using official vacancy figures, do suggest significant (although limited) shifts in the aggregate UV-curve (see DRÈZE *et al.*, [1990]). These shifts do not simply reflect transitory dynamic effects of demand or supply disturbances (FRANZ-SMOLNY, [1993]) and seem to be well correlated with standard structural variables like the proportion of long term unemployment, the variance of regional unemployment rates, turbulence index... (BENTOLILA-DOLADO, [1990]) [1]. Our objective in this paper is to build on these previous works, and examine the relationship between real wage rigidities, skill mismatch, UV-curve shifts and equilibrium unemployment.

The paper is organized as follows. It is made of three parts, theoretical underpinnings (Section 2), empirical estimates on French aggregate annual data (Section 3) and interpretation of the results (Section 4). Because the emphasis is on the relationship between technological progress, relative employment and relative wages for skilled and unskilled workers, the theoretical model developed in Section 2 will be made of three main blocks,

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1. There is no evidence of a significant UV-curve shift in BEAN-GAVOSTO [1990], probably because long-term unemployed workers have been excluded from the effective labor supply. These authors conclude to the need for a model with two kinds of labor, skilled and unskilled.

corresponding respectively to (i) the choice of the optimal input-output ratios (Section 2.1), (ii) the effect of sales, capacity or skilled labour constraints on aggregate employment decisions (Section 2.2), the determinants of prices and of real skilled and unskilled wages. The motivation for the econometric exercise of Section 3 is twofold. We first want to check whether the proposed theoretical structure is generally compatible with observed facts; we also want to obtain realistic estimates of some key parameters of the model in order to be able, in a third step, to examine the quantitative as well as qualitative implications of the proposed theoretical model. This is precisely the objective of Section 4. The latter is written in such a way that the reader not interested in the econometrics may skip Section 3 and jump from Section 2 to Section 4.

Our main conclusions are summarized in Section 5.

2 Theoretical Model

We consider an economy with imperfect competition on both the goods and the labor markets. On the goods market, there is a large number N of monopolistically competitive firms producing each a good that is an imperfect substitute for the others. There are four inputs: two types of labor (skilled and unskilled), energy and capital. Our model is made of three main building blocks, respectively the productivity equations (which determine the technical coefficients and relative labor demands), the aggregate employment function and Beveridge curve (taking into account the distinction between skilled and unskilled workers), and finally the wage and price equations. Because the emphasis is on structural technological shocks and equilibrium unemployment rather than demand, we shall not detail the demand side.

2.1. Technological Choices

We assume that the firm first chooses the production technology that minimizes its production costs; it next seeks to hire (if no supply shortages) as much (skilled and unskilled) workers as needed to produce what is demanded, taking of course into account its own productive capacity. We consider in this subsection the determination of the cost-minimizing technology.

Let us denote by L_u, L_s, E and K the quantities of unskilled labor, skilled labor, energy and capital respectively, and by W_u, W_s, P_e and V the corresponding prices. The quantity and price of output will be represented by Y and P respectively. Starting from a standard cost function and using Shephard's lemma, we obtain the following (log-linearized) equations for unskilled and skilled employment and for energy respectively:

$$\log \frac{L_u}{Y} = \text{cst} + \eta_{uu} \log \frac{W_u}{P} + \eta_{us} \log \frac{W_s}{P} + \eta_{ue} \log \frac{P_e}{P} + \eta_{uk} \log \frac{V}{P},$$
$$\log \frac{L_s}{Y} = \text{cst} + \eta_{su} \log \frac{W_u}{P} + \eta_{ss} \log \frac{W_s}{P} + \eta_{se} \log \frac{P_e}{P} + \eta_{sk} \log \frac{V}{P},$$
$$\log \frac{E}{Y} = \text{cste} + \eta_{eu} \log \frac{W_u}{P} + \eta_{es} \log \frac{W_s}{P} + \eta_{ee} \log \frac{P_e}{P} + \eta_{ek} \log \frac{V}{P},$$

where $\eta_{ij} = \sigma_{ij} \,.\, s_j$ represent constant output cost elasticities, σ_{ij} is the elasticity of substitution between inputs i and j, and s_j denotes the output share of factor j, with of course $\sigma_{ii} < 0$, $\sigma_{ij} = \sigma_{ji}$ (symmetry) and $\Sigma_j \, s_j = 1$. By homogeneity, we also have $\Sigma_j \, \sigma_{ij} \,.\, s_j = 0$, $\forall i$ (a similar expression of course holds for capital; for more details, see HAMERMESH, [1986]).

The lack of data on the capital usage cost and on output prices and quantities prevents direct estimation of these (inversed) productivity equations. Computing real interest rate values is unlikely to provide a reliable information on capital usage costs. An alternative procedure (see for instance RISAGER, [1993]) amounts to assuming that in the long run the markup on production costs is constant (possibly zero), so that the following relationship between V and the other price variables is satisfied:

$$P.Y = \text{cst.}\,(W_u.L_u + W_s.L_s + P_e.E + V.K).$$

Log-linearizing and rearranging yields:

$$s_k \log \frac{V}{P} = \text{cst} - s_u \log \frac{W_u}{P} - s_s \log \frac{W_s}{P} - s_e \log \frac{P_e}{P},$$

By substituting into the productivity equations, we next obtain:

$$(1a) \quad \log \frac{L_u}{Y} = \text{cst} + (\sigma_{uu} - \sigma_{uk}) \, s_u \log \frac{W_u}{P} + (\sigma_{us} - \sigma_{uk}) \, s_s \log \frac{W_s}{P} + (\sigma_{ue} - \sigma_{uk}) \, s_e \log \frac{P_e}{P} \,,$$

$$(1b) \quad \log \frac{L_s}{Y} = \text{cst} + (\sigma_{us} - \sigma_{sk}) \, s_n \log \frac{W_u}{P} + (\sigma_{ss} - \sigma_{sk}) \, s_s \log \frac{W_s}{P} + (\sigma_{se} - \sigma_{sk}) \, s_e \log \frac{P_e}{P} \,,$$

$$(1c) \quad \log \frac{E}{Y} = \text{cste} + (\sigma_{ue} - \sigma_{ek}) \, s_n \log \frac{W_u}{P} + (\sigma_{se} - \sigma_{ek}) \, s_s \log \frac{W_s}{P} + (\sigma_{ee} - \sigma_{ek}) \, s_e \log \frac{P_e}{P} \,.$$

By homogeneity, the sum of the coefficients of each equation is now equal to $-\sigma_{ik}$, $i \in \{u, s, e\}$.

To shift from total output to value-added values, we first rewrite these equations so as to have input shares on the left-hand-side, and then correct for the difference between output and value-added prices by using the approximation $\ln\, P = \text{cst} + (1 - s_e)\ \ln\, P_v + s_e\ \ln\, P_e$, where P_v stands for the price of value-added. We obtain:

$$(2a)\quad \log\, \frac{a_u\, W_u}{P} = \text{cst} + [1 + (\sigma_{uu} - \sigma_{uk})\, s_u]\ \log\, \frac{W_u}{P_v} + (\sigma_{us} - \sigma_{uk})\, s_u\ \log\, \frac{W_s}{P_v} + (\sigma_{ue} - 1)\, s_e\ \log\, \frac{P_e}{P_v}\,,$$

$$(2b)\quad \log\, \frac{a_s\, W_s}{P} = \text{cst} + (\sigma_{us} - \sigma_{sk})\, s_u\ \log\, \frac{W_u}{P_v} + [1 + (\sigma_{ss} - \sigma_{sk})\, s_s]\ \log\, \frac{W_s}{P_v} + (\sigma_{se} - 1)\, s_e\ \log\, \frac{P_e}{P_v}\,,$$

$$(2c)\quad \log\, \frac{bP_e}{P} = \text{cst} + (\sigma_{ue} - \sigma_{ek})\, s_u\ \log\, \frac{W_u}{P_v} + (\sigma_{se} - \sigma_{ek})\, s_s\ \log\, \frac{W_s}{P_v} + [1 + (\sigma_{ee} - 1)\, s_e]\ \log\, \frac{P_e}{P_v}\,,$$

where $a_i = L_i/Y$ and $b = E/Y$. (Unobserved) output shares (on the left-hand-side) are related to (observed) value-added shares by expressions like $s_i = s_{i_v}/(1 - s_e)$, $\forall i$ [2]. Note that the coefficient associated to the real cost of energy in the labor demand equations can be negative even though energy is a substitute to labor; it suffices that the partial elasticity of substitution σ_{ue} or σ_{se} be smaller than 1.

Subtracting (2*b*) from (2*a*) gives the relative unskilled/skilled employment equation:

$$(3)\ \log\, \frac{L_u}{L_s} = \text{cst} + [(\sigma_{uu} - \sigma_{us}) - (\sigma_{uk} - \sigma_{sk})]\, s_u\ \log\, \frac{W_u}{P_v} - [(\sigma_{ss} - \sigma_{us}) - (\sigma_{sk} - \sigma_{uk})]\, s_s\ \log\, \frac{W_s}{P_v} + (\sigma_{ue} - \sigma_{se})\, s_e\ \log\, \frac{P_e}{P_v}\,.$$

2. Total output shares $(s_i, \forall i)$ are related to value-added shares $(s_i, \forall i)$ as follows:

$$1 = s_u + s_s + s_e + s_k \ \text{ and }\ 1 = \frac{s_u}{1 - s_e} + \frac{s_s}{1 - s_e} + \frac{s_k}{1 - s_e} = s_{u_v} + s_{s_v} + s_{k_v}\,.$$

An interesting special case arises when the production function is separable in (skilled and unskilled) labor and other inputs. The elasticity of substitution between labor and other inputs is then the same for skilled and unskilled labor (*i.e.*, $\sigma_{uk} = \sigma_{sk}$ and $\sigma_{ue} = \sigma_{se}$), which can be shown to imply that relative unskilled/skilled employment is only function of relative wages:

$$(3') \qquad \log \frac{L_u}{L_s} = \text{cst} - \sigma \log \frac{W_u}{W_s}, \quad \text{with } \sigma = (\sigma_{us} - \sigma_{uu}).s_u, \\ = (\sigma_{us} - \sigma_{ss}).s_s.$$

The equality (in absolute value) between the unskilled and skilled real wage effects follows from the homogeneity property [3]. Coefficient σ, which measures the elasticity of relative employment to relative wages, is a combination of own- and cross-substitution elasticities, σ_{uu} (or σ_{ss}) and σ_{us}. All these equations can of course be completed to account for exogenous productivity growth.

2.2. Aggregate Employment and the Beveridge Curve

We now consider the determination of output and employment given the technological choices previously made, first at the firm level, next for the aggregate economy. To keep as simple as possible a notation, we represent by a_s, a_u, b and c respectively the quantities of skilled labor, unskilled labor, energy and capital required to produce one unit of output, as determined by the productivity equations of the previous section. To avoid making the empirical model untractable, we shall assume that the supply of unskilled labor and of energy are never binding. Both assumptions are realistic enough. The supply of energy has been binding only once, during the 1973-74 oil crisis. The supply of unskilled labor has never been a lasting constraint. Before 1975, *i.e.* during the period with low unemployment

3. By homogeneity:

$$s_u.\sigma_{uu} + s_s.\sigma_{us} = -(s_e.\sigma_{ue} + s_k.\sigma_{uk}),$$
$$s_u.\sigma_{us} + s_s.\sigma_{ss} = -(s_e.\sigma_{se} + s_k.\sigma_{sk}) = -(s_e.\sigma_{ue} + s_k.\sigma_{uk}),$$

if $\sigma_{ue} = \sigma_{se}$ and $\sigma_{uk} = \sigma_{sk}$. The coefficients of the unskilled and skilled wage variables respectively can then be rearranged as:

$$(\sigma_{uu} - \sigma_{us}).s_u = -(s_e.\sigma_{ue} + s_k.\sigma_{uk})\text{-}(s_u + s_s)\,\sigma_{us} = \sigma,$$
$$(\sigma_{ss} - \sigma_{us}).s_s = -(s_e.\sigma_{ue} + s_k.\sigma_{uk})\text{-}(s_u + s_s)\,\sigma_{us} = \sigma.$$

There is in this case a tight relationship between own and cross substitution elasticities, since $\sigma_{ss} = \sigma_{uu} + ((s_u/s_s) - 1)(\sigma_{uu} - \sigma_{us})$. When there are only two inputs ($s_e = s_k = 0$, so that $s_u + s_s = 1$) or when cross partial substitution elasticities are equal ($\sigma_{us} = \sigma_{ue} = \sigma_{uk}$), one obtains $\sigma = \sigma_{us}$.

rates for both skilled and unskilled workers, supply shortages were quickly eliminated by labor immigration. Allowing for unskilled labor shortages would make the model unnecessarily complicated.

• The Individual Firm

If there are no factor supply shortages, the firm will hire as much skilled and unskilled labor as needed to produce the demanded quantities YD_i. If there are factor supply shortages, actual employment will be lower for both skilled and unskilled workers. When productive capacities are binding, skilled employment is equal to capacity employment LC_{s_i}. When there are skilled labor shortages, employment is supply-determined and equal to LF_{s_i}. At given technical coefficients, unskilled employment (and thus also total employment) is proportional to skilled employment [4]. We summarize these results as follows:

$$\begin{aligned} L_{s_i} &= \mathrm{Min}\,(LD_{s_i},\ LC_{s_i},\ LF_{s_i}), \\ LD_{s_i} &\equiv a_s\, YD_i, \\ LC_{s_i} &\equiv a_s\, YC_i, \\ L_{u_i} &= a_u\, Y_i, \\ &= \frac{a_u}{a_s}\, L_{s_i}, \\ L_i &= L_{s_i} + L_{u_i} = \left[1 + \frac{a_u}{a_s}\right] L_{s_i}, \end{aligned}$$

where Y_i, YD_i and YC_i stand for output, demand for goods and productive capacity respectively.

• Aggregate Skilled Employment

Aggregate skilled employment is the sum of individual employment levels:

(4a)
$$\begin{aligned} L_s &= \Sigma_i\, L_{s_i} \\ &= \Sigma_i\ \mathrm{Min}\,(LD_{s_i},\ LC_{s_i},\ LF_{s_i}) \leq \mathrm{Min}\,(\Sigma_i\, LD_{s_i},\ \Sigma_i\, LC_{s_i},\ \Sigma_i\, LF_{s_i}). \end{aligned}$$

Let us represent the distribution of the LD_{si}, LC_{si} and LF_{s_i} across micromarkets and firms as follows:

(4b)
$$LD_{s_i}, = \frac{LD_s}{N}\, u_i,$$

(4c)
$$LC_{s_i} = \frac{LC_s}{N}\, v_i,$$

(4d)
$$LF_{s_i} = \frac{LF_s}{N}\, w_i,$$

4. We neglect at this stage the effect of adjustment costs and labor hoarding.

where the variables without a subscript i represent aggregate quantities and N is the number of micromarkets and firms; u_i, v_i, w_i represent the deviations with respect to the economy-wide average. If we now assume that the distribution of these deviations can be approximated by a log-normal distribution (with some restrictions; see SNEESSENS, [1983], and LAMBERT, [1988]), aggregate skilled employment can be written as a CES function of aggregate demand-determined employment (LD_s), aggregate capacity employment (LC_s) and aggregate labor supply (LF_s):

$$(5)\qquad L_s = \{\, LD_s^{-\rho} + LC_s^{-\rho} + LF_s^{-\rho} \,\}^{-1/\rho},\ \ 0 < \rho \leq \infty, \\ \leq \text{Min}\,(LD_s,\ LC_s,\ LF_s).$$

Ceteris paribus, aggregate employment is a positive function of ρ. The value of ρ is related to the variances and covariances of the u_i, v_i et w_i; ρ is smaller the larger the variances and the smaller the correlations among the u_i, v_i et w_i. The inverse of ρ can thus be interpreted as a mismatch indicator for the skilled labor market. The proportion of demand-constrained firms is given by:

$$(6)\qquad \Pi_D = \left\{ \frac{LD_s}{L_s} \right\}^{-\rho} = \left\{ \frac{YD}{Y} \right\}^{-\rho},$$

and similarly for the other cases (capacity or skilled-labor constraints).

The aggregate skilled employment function (5) can easily be recast as a Beveridge curve for that market. Without any supply constraint (*i.e.*, with $LF_s \rightarrow \infty$), skilled employment would reach a maximum value LE_s given by:

$$LE_s = [LD_s^{-\rho} + LC_s^{-\rho}]^{-1/\rho}.$$

Substituting LE_s into the skilled employment function and rearranging the terms yields:

$$(7)\qquad 1 = \left\{ \frac{L_s}{LE_s} \right\}^{\rho} + \left\{ \frac{L_s}{LF_s} \right\}^{\rho}, \\ = \{\, 1 - VR_s \,\}^{\rho} + \{\, 1 - UR_s \,\}^{\rho},$$

where VR_s et UR_s are respectively the vacancy rate and the unemployment rate for skilled workers. If we define the frictional unemployment rate as the rate that would prevail when the vacancy and the unemployment rates are equal, one obtains:

$$(24)\qquad \text{skilled frictional unemployment rate} = 1 - 2^{-1/\rho},$$

i.e., the frictional unemployment rate is increasing function in $1/\rho$.

• Aggregate Total Employment

As indicated above, total employment is proportional to skilled employment. This applies both at the micro and the macro level. Aggregate total employment is thus given by:

$$(9)\qquad \begin{aligned} L &= \left(1+\frac{a_u}{a_s}\right) L_s \\ &= \left\{ \left[\left(1+\frac{a_u}{a_s}\right) LD_s\right]^{-\rho} + \left[\left(1+\frac{a_u}{a_s}\right) LC_s\right]^{-\rho} \right. \\ &\quad \left. + \left[\left(1+\frac{a_u}{a_s}\right) LF_s\right]^{-\rho} \right\}^{-1/\rho}, \\ L &= \{ LD^{-\rho} + LC^{-\rho} + [\mu\, LF]^{-\rho} \}^{-1/\rho}. \end{aligned}$$

where:

– $a = a_u + a_s$ is the number of (skilled+unskilled) workers per unit of output;

– $LD = a.YD$ is total (skilled+unskilled) demand-determined employment;

– $LC = a.YC$ is total (skilled+unskilled) capacity employment;

– (the inverse of) parameter μ is defined as:

$$(10)\qquad \begin{aligned} \frac{1}{\mu} &= \frac{L_s/L}{LF_s/LF} \\ &= \frac{1-UR_s}{1-UR} \cong 1 + (UR - UR_s) > 0. \end{aligned}$$

The inverse of μ can be interpreted as a skill mismatch indicator. It compares the proportion of skilled employment in total employment to the proportion of skilled workers in the total labor force. The value of this skill mismatch indicator is directly related to the discrepancy between the aggregate and the skilled unemployment rates.

As was previously done with the aggregate skilled employment function, we can recast the aggregate total (skilled+unskilled) employment function in the form of a Beveridge curve, this time for the whole economy rather than the sole skilled labor market. We obtain in this way:

$$(11)\qquad 1 = \{1 - VR\}^{\rho} + \left\{\frac{1}{\mu}\right\}^{\rho} \{1 - UR\}^{\rho},$$

where VR and UR represent total vacancy and unemployment rates. If we define the structural unemployment rate as the one that would prevail when the vacancy and the unemployment rates are equal, we obtain:

$$(12)\qquad \text{structural unemployment rate} = 1 - \left\{1 + \left(\frac{1}{\mu}\right)^{\rho}\right\}^{-1/\rho}.$$

In other words, *the position of the aggregate Beveridge curve depends on both parameters ρ and μ. The inverse of ρ measures the importance of frictions* *on the skilled labor market; the inverse of μ measures the importance of skill mismatch.* A decrease in the value of either ρ or μ implies an outward shift of the Beveridge curve (with $\mu > 1$).

2.3. **Wage and Price Behaviors**

We follow a now well-established tradition in macroeconomics and assume that prices are set by the monopolistically competitive firms, while wages are negotiated with workers' trade unions. We furthermore assume that there is microeconomic uncertainty, so that the consequences of a given price or wage decision are not known exactly ex ante. The sequence of decisions is as follows. Unskilled wages are set first, by negotiation; the negotiation of skilled wages comes next, before the price decision of the firm. These decisions are taken and announced before the individual sales or input quantity constraints are known. Employment and output levels can be adjusted ex post, as described in the previous section. For presentational purposes, we start with the individual firm's price decision.

• Goods Prices: The Firm's Behavior

Our description of the firm's price behavior closely follows SNEESSENS [1987]. In setting these prices, the firm seeks to maximize its expected profit and takes into account the possibility of a sales constraint, or of a capacity or skilled labor supply constraint. Input prices are given. We write the firm's optimization program as follows:

$$\begin{aligned}
&\mathrm{Max}_{P,W_s}\, E\{\, P_i.Y_i - W_{s_i}.L_{s_i} - W_{u_i}.L_{u_i} - P_e.E_i - \text{fixed costs}\,\}\\
&\text{s.t. } Y_i \le YD_i = \left[\frac{P_i}{P}\right]^{-\varepsilon} \frac{YD}{N}\, u_i \quad \text{(sales constraint)},\\
&\qquad Y_i \le YC_i = \frac{1}{c}\,\frac{KA}{N}\, v_i \quad \text{(capacity constraint)},\\
&\qquad\quad L_{s_i} = a_s\, Y_i \le E\,(LF_{s_i}).w_i \quad \text{(skilled labor constraint)},\\
&\qquad\quad L_{u_i} = a_u\, Y_i,\\
&\qquad\quad E_i = b\, Y_i.
\end{aligned}$$

Remember that YD and KA represent the aggregate demand for domestic goods and the aggregate capital stock respectively. N is the number of firms; $YC_i = KA_i/C$ is the firm's productive capacity. The stochastic terms u_i, v_i, w_i represent unanticipated deviations from the expected value of the corresponding variable, with mean 1. They have the same meaning as in (4). We thus assume that each firm has the same expected productive capacity and can increase its share on the goods market by decreasing its price relative to the others. The price elasticity of individual demands is assumed to be constant and equal to ε (in absolute value). Because prices have to be announced at the beginning of the period while input levels can be adjusted ex post, the optimization program can be written more compactly as:

$$\begin{aligned}
&\mathrm{Max}_{P,\,W_s}\,\{\,P_i - a_s\,W_{s_i} - a_u\,W_{u_i} - bP_e\,\}\,.\,E\,(Y_i)\\
&\text{with } E\,(Y_i) = E\left\{\mathrm{Min}\left(YD_i,\,YC_i,\,\frac{LF_{s_i}}{a_s}\right)\right\},\\
&= \frac{1}{a_s}\,E\,\{\,\mathrm{Min}\,(LD_{s_i},\,LC_{s_i},\,LF_{s_i})\,\},\\
&= \frac{1}{a_s}\,\{\,E\,(LD_{s_i})^{-\rho} + E\,(LC_{s_i})^{-\rho} + E\,(LF_{s_i})^{-\rho}\,\}^{-1/\rho},\\
&= \frac{1}{a_s}\,E\,(L_{s_i}),
\end{aligned}$$

We used the same aggregation result as in the previous section to write the expected value of the minimum as a CES function of the expected values. The probability of a sales constraint is given by:

$$(13)\qquad \Pi_{D_i} = \left\{\frac{E\,(Y_i)}{E\,(YD_i)}\right\}^{\rho} = \left\{\frac{E\,(LD_{s_i})^{-\rho}}{E\,(LD_{s_i})^{-\rho} + E\,(LC_{s_i})^{-\rho} + E\,(LF_{s_i})^{-\rho}}\right\}$$

and similarly for the other cases.

The first order optimality condition for prices is easily shown to imply:

$$(14)\qquad \left[1 - \frac{1}{\varepsilon \Pi_{D_i}}\right] P_i - a_s\,W_{s_i} - a_u\,W_{u_i} - bP_e = 0;$$

The left-hand side represents the net marginal revenue of a one unit increase in expected output obtained by cutting down announced prices. Profit maximization requires that prices be set at a value such that the net marginal revenue is zero. This optimality condition can be recast in the form of the usual price-setting rule:

$$(14')\qquad P_i = (1+\pi_i)\cdot(a_s\,W_{s_i} + a_u\,W_{u_i} + bP_e),\ \text{ with }\ \pi_i \equiv \frac{1}{\eta_{Y.P} - 1}.$$

The markup rate is inversely related to the price elasticity of sales $\eta_{Y.P}$. In a setup with (stochastic) quantity constraints, the price elasticity of sales is equal to the probability of a sales constraint times the price elasticity of the demand for goods, *i.e.*:

$$(15)\qquad \eta_{Y.P} = -\frac{\partial \ln\,E\,(Y_i)}{\partial \ln\,P_i} = \Pi_{D_i}.\varepsilon.$$

In other words, ceteris paribus, the optimal price level increases in a boom, when the probability of a sales constraint decreases.

• Wages: Negotiation between Firms and Trade Unions

Wage negotiations are conducted at the firm (micro-market) level. We assume that skilled and unskilled workers negotiate separately with the firm. When there are several types of labor and unions, the individual union's objective typically includes envy effects that introduce the possibility of wage rivalry effects (wage-wage spiral; see for instance OSWALD, [1979], GYLFASON-LINDBECK, [1984], RISAGER, [1990]). In our setup, skilled and unskilled workers may however have quite different bargaining positions. On the skilled labor market, firms may face skilled labor shortages. Offering or accepting a skilled wage rate larger than its competitors is for the individual firm a means to attract more skilled workers and change the probability of a skilled labor shortage. There is thus room for an efficiency wage behavior on the part of the firm. The situation is quite different for unskilled workers, for whom there is systematic excess labor supply. The role of the union is then crucial in avoiding that competition among unskilled workers leads to too low a real wage rate. In such circumstances, it may be reasonable to consider that the skilled wage rate is primarily set by the firm, while the unskilled wage rate is primarily determined by the union. We thus start with a simple model where the skilled wage rate is set by the firm, given other input prices, while the unskilled wage rate is set by the monopoly union, given the firm's behavior. We next enlarge the setup to allow for bargaining.

Skilled Real Wages

The effect of wage offers on the local supply of skilled labor is represented by:

$$(16) \qquad E\left(LF_{s_i}\right) = \left[\frac{W_{s_i}}{W_s}\right]^{\varepsilon'} \frac{LF_s}{N},$$

which has to be introduced in the firm's optimization program examined before. The wage elasticity of the local skilled labor supply is assumed to be constant and equal to $\varepsilon' > 0$. In this setup, the first order optimality condition for skilled wages is easily shown to imply:

$$(17) \qquad P_i - \left[1 + \frac{1}{\varepsilon' \Pi_{L_i}}\right] a_s\, W_{s_i} - a_u\, W_{u_i} - bP_e = 0.$$

The left-hand side of equation (17) represents the net marginal revenue of a one unit increase in expected output obtained by increasing announced skilled wages, so as to attract additional skilled workers and avoid skilled labor shortages. Profit maximization requires that skilled wages be set at a value such that the net marginal revenue is zero. This first-order optimality condition can be recast in the form of the following skilled-wage-setting rule:

$$(17') \qquad W_{s_i} = (1-\nu_i)\cdot\left(1 - a_u\,\frac{W_{u_i}}{P_i} - b\,\frac{P_e}{P_i}\right).\frac{1}{a_s}.P_i \geq 0,$$
$$\text{with } \nu_i \equiv \frac{1}{1+\eta_{Ls.W}} \leq 1.$$

The optimal efficiency wage is indexed on prices and productivity. At given prices, it is larger, the larger the elasticity of employment to wages ($\eta_{Ls.W}$). In a model with quantity constraints, the wage elasticity of employment (at fixed prices) is equal to the probability of a labor shortage times the wage elasticity of labor supply:

$$(18) \qquad \eta_{Ls.W} \equiv \left.\frac{\partial \ln E(L_{s_i})}{\partial \ln W_{s_i}}\right|_{P_i \text{ cst}} = \Pi_{L_{s_i}}.\varepsilon'$$
$$\text{where } \Pi_{L_{s_i}} \equiv \left(\frac{E(L_{s_i})}{E(LF_{s_i})}\right)^{\rho}.$$

Ceteris paribus, the wage rate offered by a firm increases in a boom, when the probability of a sales constraint decreases and labor shortages become more likely, and conversely in a recession. The cost of the other variable inputs (unskilled labor and energy) has a negative impact on the skilled wage rate, coming from its negative effect on the profitability of the firm (more precisely, the surplus to be shared between firms and skilled workers).

Wage bargaining introduces additional variables and influences, especially envy (with respect to average skilled and unskilled wages in the economy), replacement ratio and tax wedge effects. The net effect of unskilled wages on the negotiated skilled wage rate is now ambiguous; the profitability effect exerts a negative influence, the envy effect a positive one.

Unskilled Real Wages

Let us first consider the case with a monopoly union (at the firm level), whose objective function includes envy, minimum wage (unemployment benefit) and tax wedge effects. The union takes into account the effect of its own behavior on the price and skilled wage levels, as described by equations (14) and (17) above, which determine the employment level. We first show that these two equations can be recast in the form of a *feasible unskilled real wage* equation, which plays the same role as the unskilled labor demand curve would play in a model with price- and wage-taking firms. We next discuss the solution of the trade-union's optimization program.

Equations (14) and (17) summarize the behaviour of the price- and skilled-wage-setting firm. Combining them to eliminate the skilled nominal wage rate and rearranging yields:

$$(19) \quad \left[1 - \frac{1}{\varepsilon \Pi_{D_i}}\right] P_i - a_u W_{u_i} - bP_e = \frac{\Pi_{L_{s_i}}.\varepsilon'}{1+\Pi_{L_{s_i}}.\varepsilon'}\,[P_i - a_u W_{u_i} - bP_e].$$

The left-hand-side is decreasing with output (increasing with Π_{D_i}); the right-hand side is increasing with output (increasing with $\Pi_{L_{s_i}}$). The equality of the two determines the optimal price and output (employment) levels, given the cost of energy and of unskilled workers. Equation (19) thus establishes a relationship between the unskilled wage rate and the employment level. Solving (19) for the unskilled wage rate and replacing the probability constraints by their determinants [5] yields:

$$(20)\quad a_u \frac{W_{u_i}}{P} = \left\{1 - \frac{1}{\Pi_{D_i}\,\varepsilon} - \frac{\Pi_{L_{s_i}}\,\varepsilon'}{\Pi_{D_i}\,\varepsilon} - b\frac{P_e}{P_i}\right\}\frac{P_i}{P},$$

$$= \Phi_u \left\{ \underset{-}{\frac{E(L_{u_i})}{E(LF_{u_i})}},\ \underset{+}{\frac{E(LF_{u_i})}{E(LF_{s_i})}},\ \underset{+}{\frac{E(LC_{s_i})}{E(LF_{s_i})}},\ \underset{-}{b\,\frac{P_e}{P}},\ \underset{+}{\frac{YD}{E(YD_i)}} \right\}.$$

Function $\Phi_u(.)$ implies a negative relationship between the unskilled wage share and the unskilled employment rate; the positive aggregate demand effect comes from the relative price effect and the definition of expected demand.

The optimization program of the union amounts to maximizing an objective function like:

$$\Omega_{u_i} = \Omega_u \left(\underset{+}{\frac{L_{u_i}}{LF_{u_i}}},\ \underset{+}{a_u \frac{W_{u_i}}{P_i}},\ \underset{+}{\frac{W_{\min}}{P}},\ \underset{-}{\frac{W_s}{P}},\ \underset{-}{Tx_u} \right),$$

subject to (20). The optimal unskilled wage rate can thus be written as a function of the following variables:

$$(21)\quad \frac{W_{u_i}}{P} = W_u \left(\underset{+}{\frac{E(LF_{u_i})}{E(LF_{s_i})}},\ \underset{+}{\frac{E(LC_{s_i})}{E(LF_{s_i})}},\ \underset{-}{b\,\frac{P_e}{P}},\ \underset{+}{\frac{YD}{E(YD_i)}},\ \underset{+}{\frac{W_s}{P}},\ \underset{+}{\frac{W_{\min}}{P}},\ \underset{-}{a_u},\ \underset{+}{Tx_u} \right).$$

The sign underneath each variable is indicative of the most likely direction of effect. Allowing explicitly for bargaining would lead to the same list of variables (at least at our level of aggregation).

5. Equation (13) and a similar one for Π_{L_i} imply:

$$\Pi_{D_i} = \frac{\left(\frac{E(LD_{s_i})}{E(LF_{s_i})}\right)^{-\rho}}{\left(\frac{E(LD_{s_i})}{E(LF_{s_i})}\right)^{-\rho} + \left(\frac{E(LC_{s_i})}{E(LF_{s_i})}\right)^{-\rho} + 1} \quad \text{and} \quad \frac{\Pi_{D_i}}{\Pi_{L_{s_i}}} = \left(\frac{E(LD_{s_i})}{E(LF_{s_i})}\right)^{-\rho}.$$

From the expected skilled employment equation, we can furthemore obtain:

$$\left(\frac{E(LD_{s_i})}{E(LF_{s_i})}\right)^{-\rho} = \left(\frac{E(L_{s_i})}{E(LF_{s_i})}\right)^{-\rho} - \left(\frac{E(LC_{s_i})}{E(LF_{s_i})}\right)^{-\rho} - 1,$$

which can be substituted in the expressions for Π_{D_i} and Π_{L_i}. Function $\Phi(.)$ is obtained by using $L_{u_i} = \frac{a_u}{a_s} L_{s_i}$.

• Symmetric Equilibrium and Aggregate Relationships

Our formulation implies that all the micro-markets are ex ante identical. At a symmetric equilibrium, all the firms will have the same expected share of the goods and skilled labor markets; the expected level of output and employment is for each firm equal to the ex post macroeconomic average. The ex ante probability of a sales constraint is equal to the ex post proportion of firms that have effectively been sales-constrained. At a symmetric equilibrium, one will thus obtain the same price and wage rates everywhere, although ex post (when the realized values of the disturbances are known) employment levels may differ.

Equations (14′), (17′) (and its generalization) and (21) thus also apply at the aggregate level, with of course, in eq. (21), $YD/E(YD_i) = 1$, so that there is no aggregate demand effect.

3 Empirical Model

Our objective in this paper is not to estimate the full model (including final demand equations), but rather to concentrate on those equations (productivity, employment, wages and prices) that are crucial to understand observed changes in the skilled vs unskilled (un-)employment rates. These equations will be estimated on French annual data, over the period 1962-89.

The data on skilled and unskilled (un-)employment are taken from the employment surveys of the INSEE, those on skilled and unskilled wage rates from the "annual social data declarations" (DADS, déclarations annuelles de données sociales), also published by the INSEE [6]. The distinction between skilled and unskilled workers is based on professional occupations. The skilled worker group corresponds to professional and managerial workers (categories 3 and 4 of the employment surveys); the unskilled group corresponds to employees and blue collar workers, plus farmers and craftmen (categories 1, 2, 5 and 6) [7]. Unemployed workers are grouped according to their previous occupation; those who never worked before are regarded as unskilled. The interested reader will find more details in MAILLARD-SNEESSENS [1993]. The skilled and unskilled groups so defined are shown to be fairly homogeneous; they in particular correspond to quite different schooling levels. Figures 1 and 2 show the evolution of the unemployment and wage rates for these two categories of workers, from 1962 till 1989. Employment levels per unit of output are reproduced in Figure 3, the value of the skill mismatch indicator $1/\mu$ (see equation (10)) in Figure 4. There is a huge increase in skill mismatch after 1973; the value of the index increases

6. The annual declarations give a net wage rate. We used the official social security contribution rates to get the wage cost.

7. We checked that our results are not crucially affected by our choice of putting farmers and craftmen with unskilled rather than skilled workers.

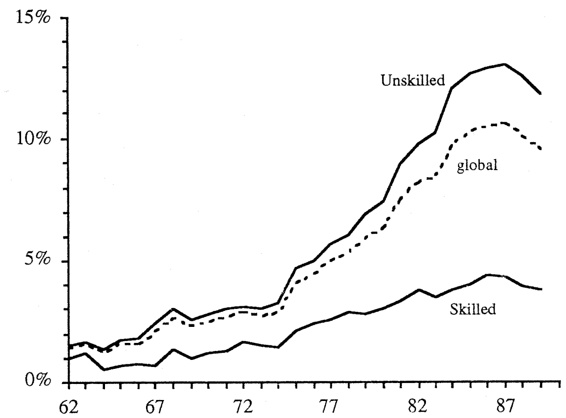

FIGURE 1

Skilled and Unskilled Unemployment Rates, France 1962-89.

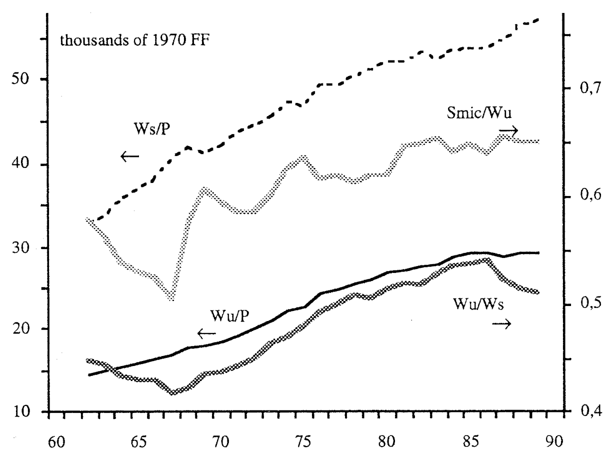

FIGURE 2

Skilled and Unskilled Real Wage Costs, and Ratio of Net Minimum Wage (Smic) to Unskilled Net Wage Rate. France, 1962-89.

from about 1.01 till 1.07 from 1973 to 1983. This means that the discrepancy between the skill composition of labor demand and labor supply increased from 1% to 7% over 10 years, and stabilized afterwards. To understand the factors that caused this evolution, we now examine the determinants of skilled and unskilled labor productivity, employment and wages.

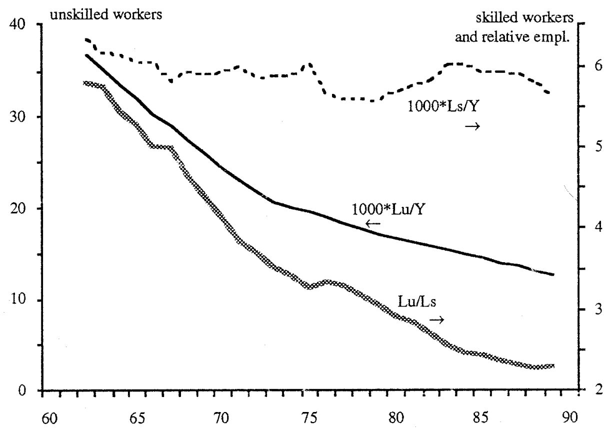

FIGURE 3

Number of Skilled and Unskilled Workers per Unit (millions of 1970 FF) of Output, France 1962-89.

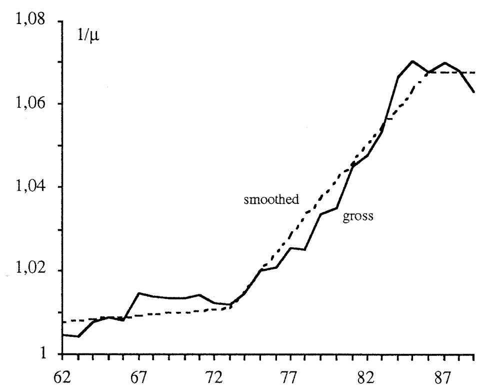

FIGURE 4

Skill Mismatch Indicator, France 1962-89.

3.1. **Productivity Equations**

We estimated three equations of the system (2)-(3), each equation completed with a trend, a trend shift (to account for the unskilled labor productivity slowdown in 1974; see Figure 3) and, in equation (2b) or (3), a 0-1 dummy variable to account for the unexplained apparent drop in skilled employment between 1976 and 1982 (probably due to purely statistical problems; see MAILLARD-SNEESSENS, [1993]). When these trend,

trend shift and dummy effects are taken into account (see PERRON, [1989]), the null hypothesis that these variables (productivity, relative employment, real wages and relative real wage, real energy cost) are integrated of order 1 is easily accepted; the null hypothesis that they are integrated of order 2 is rejected at the 1% level, except for the unskilled real wage rate (ADF t-stat. = –2.35,5% critical value = –2.97). Given the low power of these tests (the probability of rejecting I (2) when I (1) is true is notoriously low), we still proceeded as if the real unskilled wage were I (1).

We first tested the number of independent cointegration relationships and the exogeneity of the explanatory variables with Johansen's ML procedure (with only one lag, to save degrees of freedom). We found (with both the λ-max and the trace tests) three cointegrating vectors; the real price of energy can be regarded as weakly exogenous (with respect to productivities) in the long term relationship, not wage rates. We could not however end up with interpretable parameter estimates. This failure comes partly from the fact that available softwares do not allow zero restrictions on different variables in different equations, and perhaps also because of the too simple lag structure (one lag only, to economize on degrees of freedom). We thus continued the analysis with single equation estimation methods, Hendry's ECM method and Engle-Granger's two-step procedure. The final results are reported in Tables 1 to 3. The set of tests reported at the bottom of each table is a series of mis-specification tests regarding residual autocorrelation, conditional heteroscedasticity, normality and unconditional heteroscedasticity. A dagger indicates a significant test value and rejection of the null hypothesis. Almost all outcomes of the tests are satisfactory at the 5% significance level. The cointegration test reported in the second column is BOSWIJK's [1991] test for cointegration in structural models. It tests the null hypothesis of no error correction mechanism in the conditional model of the endogenous variable, and hence no cointegration. This test statistic was calculated on the basis of the OLS estimates of the corresponding equations (which were not very different from the IVE estimates). BOSWIJK [1991] reports appropriate tables of critical values which were used to determine the outcome for each table. The null is clearly rejected in all tables.

The two methods yield more or less similar results, although the ECM one-step procedure gives faster adjustment speeds. The effect of energy prices on unskilled employment is negative but fairly weak (at fixed output!) –and barely significant–, implying a positive partial elasticity of substitution (σ_{ue} between 0.1 and 0.5, if $s_e = 0.10$). The separability restrictions in the relative employment equation (no energy price effect; equal absolute value of unskilled and skilled wage effects) were easily accepted. The long-run elasticity of relative employment to relative real wages (which, in a simple two-factor CES model, would correspond to the skilled-unskilled substitution elasticity) is estimated at around 0.50 (standard error 0.10). There is after 1974 a significant 2 percentage point decrease in the exogenous rate of growth of the relative unskilled-to-skilled labor productivity. This non-neutral technological change means, ceteris paribus (*i.e.*, at given relative wage *and* output levels), a significant reduction in the rate of substitution between skilled and unskilled labor, which decreases from 4-5% to 2-3% per year.

TABLE 1

Unskilled Employment.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta^2 \log \frac{a_u W_u}{P}$	$\log \frac{a_u W_u}{P}$	$\log \frac{a_u W_u}{P}$	$\Delta \log \frac{a_u W_u}{P}$
$\Delta \log \left(\frac{a_u W_u}{P}\right)_{-1}$	–0.75 (.11)			
$\Delta \log \left(\frac{W_u}{P_v}\right)$	0.87 (.12)			0.88 (.08)
$\Delta \log \left(\frac{W_u}{W_s}\right)$	–0.28 (.16)			
$\Delta \log \left(\frac{P_e}{P_v}\right)$	–0.10 (.01)			–0.09 (.01)
$\Delta TS74$	0.03 (.008)			0.02 (.003)
Δ log DUL				–0.23 (.06)
EG résid$_{-1}$				**–0.72** (.20)
$\mathbf{log} \left(\frac{\mathbf{a}_u \mathbf{W}_u}{\mathbf{P}}\right)_{\mathbf{-1}}$	**–0.97** (.24)	**–1.00***	**–1.00**	
$\mathbf{log} \left(\frac{\mathbf{W}_u}{\mathbf{P}_v}\right)_{\mathbf{-1}}$	0.72 (.24)	**0.74*** (.12)	**0.88**	
$\mathbf{log} \left(\frac{\mathbf{W}_u}{\mathbf{W}_s}\right)_{\mathbf{-1}}$	–0.27 (.12)	**–0.29** (.11)	**–0.10**	
$\mathbf{log} \left(\frac{\mathbf{P}_e}{\mathbf{P}_v}\right)_{\mathbf{-1}}$	–0.04 (.02)	**–0.04*** (.02)	**–0.09**	
$\mathbf{TS\,74_{-1}}$	0.02 (.006)	**0.02*** (.002)	**0.025**	
Trend	–0.04 (.013)	**–0.04*** (.004)	**–0.05**	
$\mathbf{log\,DUL_{-1}}$			**–0.32**	
Constante	–2.78 (.84)	**–2.87*** (.36)	**–3.10**	–0.05 (.003)
Sample	1964-1989		1962-1989	1963-1989
s.e.e.	.006			.006
Cointegrat. Tests	23.76 †		Crdw = 1.27 † DF = –3.54 † ADF_1 = –4.04 †	
Box-Pierce	$\chi^2_4 = 6.55$			$\chi^2_4 = 1.712$
AR (1-4)	$F(4,17) = 1.73$			$F(4,18) = .36$
ARCH (1)	$F(1,12) = .000$			$F(1,19) = .54$
NORM	$\chi^2_2 = 1.45$			$\chi^2_2 = .36$
WHETER				$F(9,11) = .49$

Estimates of equation (2*a*) with PC-Give; standard errors between parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: $\Delta\,\text{DUM}\,76$, $\Delta \log \text{XW}$, lagged values of UR_q, UR_n, DUM 76, and of the logs of XW, L_u/L_s, bP_e/P, $(1-\Pi_D)$, $(1+\text{str})$, $(1+Tx_s)$, $(1+Tx_u)$.

TABLE 2

Skilled-Unskilled Labor Substitution.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta \log \frac{L_u}{L_s}$	$\log \frac{L_u}{L_s}$	$\log \frac{L_u}{L_s}$	$\Delta \log \frac{L_u}{L_s}$
$\Delta \log \frac{W_u}{W_s}$	–.41 (.24)			–0.67 (.16)
$\Delta \mathrm{TS}_{74}$	0.04 (.02)			0.02 (.005)
$\Delta \mathrm{DUM}\,76$	0.05 (.02)			0.08 (.01)
EG resid$_{-1}$				**–0.93** (.22)
$\mathbf{log}\left(\frac{\mathbf{L}_u}{\mathbf{L}_s}\right)_{-1}$	**–.98** (.26)	**–1.00**	**–1.00**	
$\mathbf{log}\left(\frac{\mathbf{W}_u}{\mathbf{W}_s}\right)_{-1}$	–0.53 (.19)	**–0.53*** (.10)	**–0.52**	
Trend	–0.05 (.01)	**–0.05*** (.00)	**–0.05**	
$\mathbf{TS\,74}_{-1}$	0.02 (.006)	**0.02*** (.00)	**0.02**	
$\mathbf{DUM\,76}_{-1}$	0.05 (.01)	**0.06*** (.01)	**0.06**	
Constant	1.37 (.38)	**1.41*** (.09)	**1.40**	–0.05 (.004)
Sample s.e.e.	1963-1989 0.014		1962-1989	1963-1989 0.013
Cointegrat. Tests	29.89 †		Crdw = 1.87 † DF = –4.46 † ADF = –4.10 †	
Box-Pierce	$\chi^2_4 = 3.72$			$\chi^2_4 = 2.13$
AR (1-2)	$F(4,18) = .64$			$F(4,18) = .69$
ARCH (1)	$F(1,16) = .93$			$F(1,20) = .07$
NORM	$\chi^2_2 = 0.09$			$\chi^2_2 = .71$
WHETER				$F(6,15) = .83$

Estimates of equation (3) with PC-Give; standard errors between parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: $\Delta \log \mathrm{XW}$, plus the lagged values of UR_q, UR_n and of the logs of XW, $(1 - \Pi_D)$, $(1 + \mathrm{str})$, bP_e/P, $(1 + Tx_s)$, $(1 + Tx_u)$, (P_e/P_v), $(a_u\, W_u/P)$, (W_u/P_v).

TABLE 3

Energy.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta\ \log\ \frac{bP_e}{P}$	$\log\ \frac{bP_e}{P}$	$\log\ \frac{bP_e}{P}$	$\Delta\ \log\ \frac{bP_e}{P}$
$\Delta\ \log\ \mathrm{DUC}$				0.33 (.15)
$\Delta\,\mathrm{TS}\,74$				–0.02 (.008)
$\Delta\ \log\ \frac{W_u}{P_v}$	0.81 (.20)			0.69 (.25)
$\Delta\ \log\ \frac{P_e}{P_v}$	0.86 (.03)			0.90 (.03)
EG résid.$_{-1}$				**–0.69** (.19)
$\mathbf{log}\left(\frac{\mathbf{bP}_e}{\mathbf{P}}\right)_{-1}$	**–0.63** (.12)	**–1.00***	**–1.00**	
$\mathbf{log}\left(\frac{\mathbf{W}_u}{\mathbf{P}_v}\right)_{-1}$	0.89 (.20)	**1.41*** (.15)	**1.01**	
$\mathbf{log}\left(\frac{\mathbf{W}_u}{\mathbf{W}_s}\right)_{-1}$			**–0.25**	
$\mathbf{log}\left(\frac{\mathbf{P}_e}{\mathbf{P}_v}\right)_{-1}$	0.43 (.10)	**0.69*** (.03)	**0.86**	
$\mathbf{log}\,\mathbf{DUC_1}$			**0.54**	
$\mathbf{TS\,74}_{-1}$			**–0.011**	
Trend	–0.03 (.007)	**–0.05*** (.004)	**–0.029**	
Constant	–4.00 (.84)	**–6.37*** (.39)	**–5.47**	–0.02 (.01)
Sample	1963-1989		1962-1989	1963-1989
s.e.e.	.015			.017
Cointegrat. Tests	39.1 †		Crdw = 1.30 † DF = –3.40 † ADF_2 = –4.77 †	
Box-Pierce	$\chi^2_4 = 7.87$			$\chi^2_4 = 9.02$ †
AR (1-4)	$F\,(4,18) = 2.19$			$F\,(4,18) = 1.68$
ARCH (1)	$F\,(1,18) = 3.63$			$F\,(1,18) = 1.04$
NORM	$\chi^2_2 = 1.004$			$\chi^2_2 = 1.41$
WHETER	$F\,(12,7) = .35$			$F\,(11,8) = .36$

Estimates of equation (2*c*) with PC-Give; standard errors between parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: $\Delta\,\mathrm{DUM}\,76$, $\Delta\ \log\ \mathrm{XW}$, plus the lagged values of $\mathrm{DUM}\,76$, UR_q, UR_s and of the logs of XW, L_u/L_s, $a_u\ W_u/P$, $(1-\Pi_D)$, $(1+\mathrm{str})$, $(1+Tx_s)$, $(1+Tx_u)$.

3.2. **Aggregate Employment and Beveridge Curve**

We estimate equation (9). Because of domestic production shortages, domestic demand YD will not in general be equal to observed GDP. If domestic supply shortages are fully compensated by additional imports, an estimate of the domestic demand for goods can be obtained by subtracting from total final demand FD an estimate of structural (non-cyclical) imports MD. We thus estimated jointly an employment and an import equation. The econometric model is written as follows:

$$(18) \qquad L = \{ LD^{-\rho_t} + LC^{-\rho_t} + [\mu\, LF]^{-\rho_t} \}^{-1/\rho_t}\ x \text{ residual},$$

$$(19) \qquad M = MD. \left[\frac{YD}{aL}\right]^{m_2} x \text{ residual},$$

with:

$$(19) \qquad \begin{aligned} \frac{1}{\rho_t} &= \rho_0 + \rho_1\, t, \\ LD &= \exp\{ \phi\, [\gamma_0 + \ln(a\, YD)] + (1-\phi)\ \ln\ L_{-1} \}, \\ YD &= FD - MD, \\ MD &= m_{0t}\, FD^{m_1} \\ m_{0t} &= \exp\{ m_{00} + m_{01}\, t + m_{02}\, t^2 \\ &\qquad + \Delta(R) \left[m_{03}\ \ln\ \frac{P_m}{P} + m_{04}\ \ln\ \frac{P_e}{P} \right] \Big\} \\ LC &= \exp\left\{ \phi \left[\gamma_0' + \ln\left(\frac{a}{c} K\right) \right] + (1-\phi)\ \ln\ L_{-1} \right\}. \end{aligned}$$

M stands for actual imports, with price P_m. This specification follows almost exactly the one used in an earlier paper by LAMBERT *et al.* [1984]; the main difference is the distinction between skilled and unskilled workers, which introduces the mismatch variable μ. With $\mu < 1$, this amounts to reducing the effective labor supply. The specification of equations (18)-(19) calls for the following comments:

(i) We allow for increased frictions on the skilled labor market by writing parameter $1/\rho$ as a linear function of time.

(ii) The effect of adjustment costs on labor demand is taken into account by simply using an ad hoc partial ajustment model $(0 \leq \phi \leq 1)$.

(iii) Imports are a positive function of total final demand and of the domestic production shortage (measured by YD/aL, where YD is unobservable). We use a trend and a trend squared to represent the progressive opening of the French economy to world trade. The demand for imports is affected by relative price changes. We introduce separately the price of energy, to distinguish relative price changes due to oil prices from others. The effect of a relative price change takes place slowly; the dynamics are given by the lag polynomial:

$$\Delta(R) = \delta_0 + \delta_1\, R + \delta_2\, R^2, \quad \text{and } \delta_0 + \delta_1 + \delta_2 = 1,$$

where R is the lag operator.

TABLE 4

EMPLOYMENT			IMPORTS		
	unconstr.	constr.		unconstr.	constr.
γ_0	–0.0191	–0.0147	m_1	0.9974	1.0000
	(0.0065)	(0.0067)		(0.0056)	–
γ_0'	–0.0078	0.0000	m_2	1.4336	1.5877
	(0.0441)	–		(0.1752)	(0.1811)
ϕ	0.3292	0.3194	m_{00}	–3.1433	–3.1244
	(0.0884)	(0.0483)		(0.0381)	(0.0341)
ρ_0	0.0058	0.0059	m_{01}	0.0745	0.0745
	(0.0040)	(0.0028)		(0.0023)	(0.0024)
ρ_1	29.10^{-5}	36.10^{-5}	m_{02}	–0.0009	–0.0011
	(20.10^{-5})	(9.10^{-5})		(5.10^{-5})	(4.10^{-5})
			m_{03}	–0.1424	–0.5776
				(0.1169)	(0.1129)
			m_{04}	0.0701	0.2273
				(0.0555)	(0.0437)
			δ_0	1.0174	0.0000
				(0.9733)	–
			δ_2	–3.2548	0.0000
				(3.4117)	–
SEE	0.0028	0.0030	SEE	0.0137	0.0144
D.W.	1.8286	1.7825	D.W.	1.6736	1.6203

ML parameter estimates (asymptotic standard errors between parentheses).

The ML estimates of the parameters are reproduced in Table 4. To avoid simultaneity biases, labor (a) and capital (c) productivity, skill mismatch $(1/\mu)$ and total labor force (LF) have been instrumented by (piecewise log-) linear trends and total population of working age. Let us stress the following two results:

(i) The value of parameter ρ_1 (the trend coefficient for the friction variable $1/\rho_t$) is positive and significantly different from zero, indicating a slight increase of frictions on the skilled labor market. The frictional unemployment rate on the skilled labor market (as defined in (8)) has thus increased from 0.66% in 1962 to 1.32% in 1989 (actual skilled unemployment rose from 0.7% to 4%).

(ii) These values of $1/\rho_t$, combined to those of $1/\mu_t$, imply a substantial increase in the aggregate structural unemployment rate (as defined in (12)), from 1.05% in 1962 to 6.01% in 1989 (actual aggregate unemployment rose from 1.42% to 9.51%). This implies substantial shifts in the aggregate Beveridge curve (equation (11)), illustrated in Figure 5. The figure looks remarkably similar to the one obtained with official vacancy data, although the latter were not used for estimation.

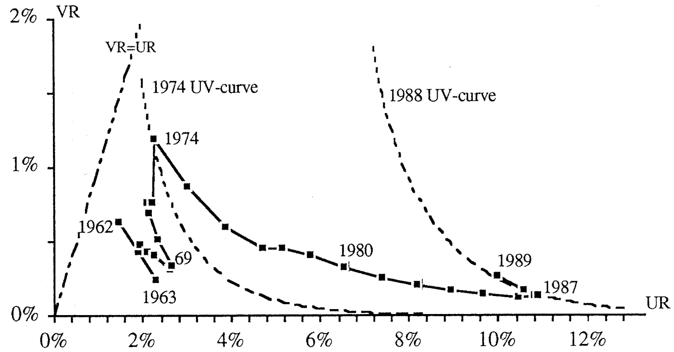

FIGURE 5

Shitfs in the Aggregate Beveridge Curve, as Estimated from the Employment Equation (18), France 1962-89.

3.3. Wage and Price Equations

We estimate equations (14′), (17′) and (21), sligthly amended to account for the use of value-added rather than output data (equation (14′)) and to account for wage bargaining rather than straight monopoly behavior (equations (17′) and (21)). To recast equation (14′) in value-added form, we represent the value-added to output ratio by a function of the relative price of energy and a time trend, and use again the approximation $\ln\, P = \mathrm{cst} + (1 - s_e)\, \ln\, P_v + s_e\, \ln\, P_e$, where P_v stands for the price of value-added and s_e is the energy share. We add the short term real interest rate (str) to account for financial charges. In aggregate models, generalizing wage equations to the bargaining case gives few additional explanatory variables, except for union power. We proxy the latter by the proportion of unionized workers, UP. When introduced in the unskilled wage equation, this variable makes the unskilled unemployment rate insignificant. We allow a tax wedge effect in the skilled as well as the unskilled wage equations, to introduce workers' concern for net rather than gross wage income. The three equations were estimated in two ways, with Hendry's one step ECM estimation procedure and with Engle-Granger's two step estimation procedure. The two procedure give more or less similar results.

The final estimation results are reported in Tables 5 to 7. The key findings can be summarized as follows. *In the price equation*, the homogeneity restriction is easily accepted; demand pressure seems to have a significant although mild positive effect on markups; financial costs have a positive significant effect. *In the skilled wage equation*, we obtain, as suggested by the efficiency wage equation (17′), a positive demand pressure effect (at least with the one-step estimation procedure) as well as a negative effect from other factor costs; this implies in particular that the negative profitability effect induced by an unskilled wage increase outweighs the (positive) envy effect that may come from union demands. Note though that tax wedge increases are fully passed on to wage costs, which does suggest a strong

TABLE 5

Price Equation.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta^2 \log P_v$	$\log P_v$	$\log\left(\frac{a_v\, W + b_v\, P_e}{P_v}\right)$	$\Delta \log P_v$
$\Delta \log P_{v_{-1}}$	–0.59 (.10)			
$\Delta \log(a_v\, W + b_v\, P_e)$	0.74 (.10)			0.97 (.07)
$\Delta \log P_e$	–0.13 (.02)			–0.16 (.02)
$\Delta \log(1-\Pi_D)$	0.02 (.01)			
$\Delta \log(1+\mathrm{str})$				–0.09 (.008)
EG resid₋₁				**0.84** (0.17)
$\mathbf{log}\left(\frac{\mathbf{a}_v\, \mathbf{W} + \mathbf{b}_v\, \mathbf{P}_e}{\mathbf{P}_v}\right)_{-1}$	**0.77** (.13)		**1.00**	
$\mathbf{log}\left(\frac{\mathbf{a}_v\, \mathbf{W} + \mathbf{b}_v\, \mathbf{P}_e}{\mathbf{P}_e}\right)_{-1}$	0.17 (.03)		**0.23**	
$\mathbf{log}\, \mathbf{P}_{v-1}$		**–1.00***		
$\mathbf{log}\,(\mathbf{a}_v\, \mathbf{W} + \mathbf{b}_v\, \mathbf{P}_e)_{-1}$		**1.02*** (.08)		
$\mathbf{log}\, \mathbf{P}_{e_{-1}}$		**–0.13*** (.04)		
$\mathbf{log}\,(\mathbf{1}-\mathbf{\Pi_D})_{-1}$	0.03 (0.01)	**0.03*** (.01)	**0.02**	
$\mathbf{log}\,(\mathbf{1}+\mathbf{str})_{-1}$	0.44 (0.08)	**0.46*** (.15)	**0.21**	
trend	0.002 (.001)	**0.01*** (.003)	**0.003**	
Constant	0.22 (.03)	**0.18*** (.05)	**0.28**	0.02 (.003)
Sample	1964-1989		1962-1989	1963-1989
s.e.e.	.006			.008
Cointegrat. Tests	70.54 †		Crdw = 1.86 † DF = –4.79 † ADF_1 = –3.36 †	
Box-Pierce	$\chi^2_4 = 2.84$			$\chi^2_4 = 2.38$
AR (1-4)	$F(4,17) = 0.45$			$F(4,18) = 0.41$
ARCH (1)	$F(1,14) = 0.40$			$F(1,20) = 1.11$
NORM	$\chi^2_2 = 0.52$			$\chi^2_2 = 1.69$
WHETER				$F(8,13) = .50$

Estimated with PC-Give; standard errors between parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: $\Delta\,\mathrm{TS}\,74$, $\Delta\,\mathrm{DUM}\,76$, $\Delta \log \mathrm{XW}$, plus the lagged values of $\mathrm{TS}\,74$, $\mathrm{DUM}\,76$, UR_q, UR_n and of the logs of XW, L_u/L_s, $a_u\, W_u/P$, bP_e/P, $(1-\Pi_D)$, $(1+\mathrm{str})$, $(1+Tx_u)$, $(1+Tx_s)$, P_e/P_v, W_u/P_v, W_u/W_s.

TABLE 6

Skilled Wage Equation.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta \log \frac{a_s W_s}{P}$	$\log \left(\frac{a_s W_s}{P}\right)$	$\log \left(\frac{a_s W_s}{P}\right)$	$\Delta \log \frac{a_s W_s}{P}$
$\Delta \log \frac{bP_e}{P}$	–0.10 (.03)			–0.12 (.02)
$\Delta \log(1+Tx_s)$	0.79 (.25)			0.53 (.19)
$\Delta \Pi^2_{L_s}$	0.27 (.09)			0.19 (.05)
$\Delta \log UP$	0.24 (.09)			0.23 (.06)
EG resid$_{-1}$				**–0.68** (0.16)
$\mathbf{\log \left(\frac{a_s W_s}{P}\right)_{-1}}$	**–0.72** (.17)	**–1.00**	**–1.00**	
$\mathbf{\log \left(\frac{a_u W_u}{P}\right)_{-1}}$	–0.41 (.17)	**–0.59** (0.19)	**–0.92**	
$\mathbf{\log \left(\frac{bP_e}{P}\right)_{-1}}$	–0.06 (.03)	**–0.08*** (0.03)	**–0.08**	
$\mathbf{\log(1+Tx_s)_{-1}}$	0.80 (.31)	**1.11*** (.36)	**0.79**	
$\Pi_{L_{s-1}}$	–0.30 (.16)	**–0.38** (.28)		
$\Pi^2_{L_{s-1}}$	0.53 (.22)	**0.70** (.37)		
$\mathbf{\log UP_{-1}}$	0.19 (.07)	**0.25*** (.08)	**0.18**	
Constant	–1.51 (.41)	**–2.11*** (.17)	**–2.46**	0.02 (.003)
Sample s.e.e.	1963-1989 .011		1962-1989	1963-1989 .013
Cointegrat. Tests	30.46 †		Crdw = 1.41 † DF = –3.47 † ADF_2 = –3.46 †	
Box-Pierce	$\chi^2_4 = 4.05$			$\chi^2_4 = 1.9$
AR (1-4)	$F(4,18) = 1.7$			$F(4,18) = 0.83$
ARCH (1)	$F(1,13) = 0.30$			$F(1,19) = 1.04$
NORM	$\chi^2_2 = 0.11$			$\chi^2_2 = 1.16$
WHETER				$F(10,10) = .28$

Estimated with PC-Give; standard errors in parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: trend, Δ TS 74, Δ DUM 76, $\Delta \log$ XW, lagged values of TS 74, DUM 76, UR_q, UR_n, and of the logs of XW, L_u/L_s, $(1-\Pi_D)$, $(1+\text{str})$, $(1+Tx_u)$, P_e/P_v, W_u/P_v.

TABLE 7

Unskilled Wage Equation.

	Error Correction Model à la HENDRY		Error Correction Model à la ENGLE-GRANGER	
	ECM (IVE)	implied coint. vector	cointegrating regression	ECM (IVE)
Variables: depend.→ explan.↓	$\Delta \log \frac{W_u}{(1+Tx_u)\,P_C}$	$\log \frac{W_u}{(1+Tx_u)\,P_C}$	$\log \frac{W_u}{(1+Tx_u)\,P_C}$	$\Delta \log \frac{W_u}{(1+Tx_u)\,P_C}$
$\Delta \log \frac{W_s}{(1+Tx_s)\,P_C}$	0.75 (.16)			0.62 (.12)
$\Delta \log \frac{W_m}{(1+Tx_m)\,P_C}$	0.20 (.07)			0.24 (.06)
EG resid$_{-1}$				**–0.35** (0.12)
$\mathbf{log} \left(\frac{\mathbf{W}_u}{(\mathbf{1+Tx}_u)\,\mathbf{P_C}}\right)_{-1}$	–0.27 (.11)	**–1.00***	**–1.00**	
$\mathbf{log} \left(\frac{\mathbf{W}_s}{(\mathbf{1+Tx}_s)\,\mathbf{P_C}}\right)_{-1}$	0.10 (.08)	**0.51*** (0.29)	**0.48**	
$\mathbf{log} \left(\frac{\mathbf{W}_m}{(\mathbf{1+Tx}_m)\,\mathbf{P_C}}\right)_{-1}$	0.16 (.06)	**0.53*** (.16)	**0.52**	
$\mathbf{log\,UP}_{-1}$	0.05 (.02)	**0.21*** (.14)	**–0.04**	
Constant	0.08 (.16)	**–0.08** (.69)	**–0.16**	0.005 (.003)
Sample s.e.e.	1963-1989 .010		1962-1989	1963-1989 .012
Cointegrat. Tests	24.93 †		Crdw = 0.73 DF = –2.25 ADF_1 = –2.77	
Box-Pierce	$\chi^2_4 = 3.27$			$\chi^2_4 = 3.74$
AR (1-4)	$F(4, 18) = 1.4$			$F(4, 18) = 0.67$
ARCH (1)	$F(1, 18) = 0.12$			$F(1, 21) = 0.44$
NORM	$\chi^2_2 = 0.88$			$\chi^2_2 = 0.54$
WHETER	$F(12, 7) = 0.53$			$F(6, 16) = .90$

Estimated with PC-Give; standard errors in parentheses; a star indicates the joint significance of the variable's lag polynomial; additional instruments: trend, $\Delta\,\mathrm{TS}\,74$, $\Delta\,\mathrm{DUM}\,76$, $\Delta \log \mathrm{XW}$, lagged values of $\mathrm{TS}\,74$, $\mathrm{DUM}\,76$, UR_q, UR_n, and of the logarithms of XW, L_u/L_s, $a_u\;W_u/P$, bP_e/P, $(1-\Pi_D)$, $(1+\mathrm{str})$, $(1+Tx_u)$, $(1+Tx_s)$, P_e/P_v, W_u/P_v.

4 Equilibrium Unemployment and Skill Mismatch

The theoretical model developed is Section 2 and estimated in Section 3 is highly non-linear. To simplify the analysis of the determinants of equilibrium unemployment and skill mismatch, we shall in the rest of the paper rely on a log-linearized and condensed version of the model. The model is made of three main blocks, respectively (i) input-output ratios, (ii) employment levels and skill mismatch, (iii) price and wage behaviours. We keep explicitly in the log-linearized version of the model the equations coming from the first and last blocks (three input-output equations, plus one price and two wage equations), and use the employment equation of the second blok to substitute out the tension variables appearing in the price and wage equations. As our main interest is on equilibrium unemployment and skill mismatch rather than the dynamics of the model, we eliminate all the dynamic terms used in the econometric part and write the equations in their static long term form. Given the econometric parameter estimates previously obtained, the static log-linearized and condensed model now appears as follows:

Unskilled Labor-Output Ratio:

$$\begin{aligned}
\underline{\text{b. 1974 :}}\ \log \frac{a_u W_u}{P} &= \text{cst} - 0.049\,\text{Trend} + 0.78\,\log \frac{W_u}{P_v} \\
&\quad + 0.10\,\log \frac{W_s}{P_v} - 0.09\,\log \frac{P_e}{P_v}, \\
\underline{\text{a. 1974 :}}\qquad\qquad &= \text{cst} - 0.024\,\text{Trend} + 0.78\,\log \frac{W_u}{P_v} \\
&\quad + 0.10\,\log \frac{W_s}{P_v} - 0.09\,\log \frac{P_e}{P_v};
\end{aligned}$$

Skilled Labor-Output Ratio:

$$\begin{aligned}
\underline{\text{b. 1974 :}}\ \log \frac{a_s W_s}{P} &= \text{cst} + \log \frac{a_u W_u}{P} + 0.049\,\text{Trend} - 0.48\,\log \frac{W_u}{W_s}, \\
\underline{\text{a. 1974 :}}\qquad\qquad &= \text{cst} + \log \frac{a_u W_u}{P} + 0.024\,\text{Trend} - 0.48\,\log \frac{W_u}{W_s};
\end{aligned}$$

Energy-Output Ratio:

$$\underline{\text{b. } 1974:}\ \log \frac{bP_e}{P} = \text{cst} - 0.029\,\text{Trend} + 0.76\ \log \frac{W_u}{P_v} + 0.25\ \log \frac{W_s}{P_v} + 0.86\ \log \frac{P_e}{P_v},$$

$$\underline{\text{a. } 1974:}\ = \text{cst} - 0.040\,\text{Trend} + 0.76\ \log \frac{W_u}{P_v} + 0.25\ \log \frac{W_s}{P_v} + 0.86\ \log \frac{P_e}{P_v};$$

Price Equation:

$$1 = \text{cst} + 1.95\ \log(1 - UR_s) + 0.049\ \log(1/\rho) + 0.03\ \log\left(1 + \left[\frac{LC_s}{LF_s}\right]^{-\rho}\right) + 0.53\ \log \frac{a_u W_u}{P} + 0.34\ \log \frac{a_s W_s}{P} + 0.13\ \log \frac{bP_e}{P} + 0.21\,\text{str};$$

Skilled Wage:

$$\log \frac{a_s W_s}{P} = \text{cst} + 1.04\ \log(1 - UR_s) + 0.026\ \log(1/\rho) - 0.92\ \log \frac{a_u W_u}{P} - 0.08\ \log \frac{bP_e}{P} + 1.00\ \log(1 + Tx_s) + 0.18 \log UP;$$

Unskilled Wage:

$$\log \frac{W_u}{(1 + Tx_u)\,P_v} = \text{cst} + 0.00\ \log \frac{P_v}{P_C} + 0.35\ \log \frac{W_s}{(1+Tx_s)\,P_v} + 0.65\ \log \frac{W_m}{(1 + Tx_m)\,P_v} + 0.00\ \log\ UP.$$

A few comments are in order. First, in the input-output equations, we wrote explicitly and separately the relationship applying to the periods before and after 1974. The distinction comes from the structural break in the exogenous productivity growths. Second, in the price equation, we normalized the equation by dividing both sides of the equation by the price level and using the homogeneity restriction. The demand pressure effect (a positive function of the proportion of firms that are not sales-constrained) has been recast as a function of the skilled employment rate $(1 - UR_s)$, of frictions $(1/\rho)$, and of the skilled capacity employment rate (LC_s/LF_s), by using the employment equation, as indicated before. Similarly, in the skilled wage equation, the demand pressure effect has been recast as a function of skilled unemployment and of frictions. Third, the numerical values of the coefficients are based on the long-run Engle-Granger parameter estimates. There are two exceptions: (i) we kept a moderate demand pressure effect, as suggested by the one-step Hendry estimates; (ii) in order to obtain a satisfactory long term fit (see Table 9), we raised the coefficient of minimum wages in the unskilled wage equation to 0.65, instead of 0.52. This value 0.65 is close to the one-step Hendry estimate (0.59), and is unlikely to be significantly different from 0.52.

In an open economy where wage demands are indexed on consumption prices rather than domestic goods prices, demand shocks will in general affect the equilibrium unemployment rate. In our case, the relative consumption to value-added price index appears only in the unskilled wage equation. However, because this equation is homogeneous of degree one in the skilled and the minimum wage rates, the associated coefficient is zero. When introduced in the skilled wage equation, the variable was found insignificant. As a result, demand shock will have no effect on equilibrium unemployment, except indirectly via investment and the capital gap (not modelled here).

This log-linearized system of structural equations can be solved for the endogenous variables, in particular the (skilled and unskilled) unemployment and real wage rates, and be used to examine the long-run effects of permanent changes in the exogenous variables. By definition of the skill mismatch indicator (equation (10)), aggregate unemployment rate changes are the sum of skill mismatch and skilled unemployment rate changes. The estimated values of the long run reduced form multipliers are reproduced in Table 8. The table deserves the following comments:

1. A decrease in the exogenous rate of unskilled *labor productivity* (as the one that occured in 1974) decreases the rate of growth of real wages, especially so for skilled workers. It also decreases skill mismatch and aggregate unemployment.

2. In the long run, about 40% of an increase in the net *minimum real wage* rate is passed on to average unskilled wages. There is however a 100% effect on relative wages ($\Delta \log (W_u/W_s) = 1.1$), hence a strong effect on skill mismatch. A 10% minimum wage increase adds 4.5 percentage points to the aggregate unemployment rate, almost exclusively via skill mismatch and the unskilled unemployment rate.

3. Not surprisingly, a general *tax wedge* uncrease ($\Delta \log (1 + Tx_s) = \Delta \log (1+Tx_u)$) has a positive effect on both real wage costs and aggregate unemployment. However, because of the larger sensitivity of the skilled wage rate to unemployment, the relative unskilled to skilled wage rate is increased, which generates skill mismatch. Financing social security expenses by wage taxes has thus an asymmetric effect on skilled and unskilled employment.

4. A 10% reduction in *unskilled* social security contributions would eventually decrease skill mismatch and aggregate unemployment by 6.4

and 6.9 percentage points [8]. It is worth noting that a decrease in the sole unskilled contribution rate will have a much larger effect than a decrease in both the skilled and unskilled rates, because the associated multipliers are of opposite signs.

5. Increased *frictions* on the skilled labor market $(\Delta \log(1/\rho) > 0)$ have negligeable effects on real wages and skilled mismatch; there is a positive effect on skilled unemployment. The long run multiplier of Table 9 implies that a 1 percentage point increase in (skilled) frictional unemployment (*i.e.*, $\Delta \ln(1/\rho) \cong \ln 2$ for $\rho_0 \cong 70$); see eq. (8)) increases skilled unemployment by about 1.7 percentage points. The total effect is thus more than proportional, because direct effects are exacerbated by wage-price interactions. It is also strongly non-linear and increases with frictions.

TABLE 8

Long-Run Reduced-Form Multipliers.

Exogenous changes	Effect on:				
	$\log \frac{W_u}{P_v}$	$\log \frac{W_s}{P_v}$	Skill mismatch	UR_s	UR
γ_u	0.315	0.901	0.508	–0.042	0.466
γ_s	0.310	0.885	–0.949	0.052	–0.897
γ_e	0.039	0.112	–0.028	–0.038	–0.066
$\log \frac{W_m}{(1+Tx_m)P_v}$	0.410	–0.685	0.416	0.030	0.446
sub-total	**1.074**	**1.213**	**–0.053**	**0.002**	**–0.051**
$\log \frac{LF_s}{LF}$	0.000	0.000	–1.000	0.000	–1.000
$\log(1+Tx_u)$	0.631	–1.053	0.640	0.046	0.686
$\log(1+Tx_s)$	0.041	1.118	–0.409	0.175	–0.234
sub-total: $\log(1+\mathbf{Tx})$	**0.672**	**0.065**	**0.231**	**0.221**	**0.452**
$\log(UP)$	0.047	0.135	–0.023	0.034	0.011
$\log \frac{Pe}{P_v}$	0.023	0.065	–0.016	0.034	0.018
str	–0.029	–0.084	0.021	0.086	0.107
$\log(1/\rho)$	0.000	0.000	0.000	0.025	0.025
$\log\left[1+\left(\frac{LC_s}{LF_s}\right)^{-\rho}\right]$	–0.004	–0.012	0.003	0.012	0.015

8. The 1989 values of Tx_s and Tx_u are 0.66 and 0.72 respectively.

6. *Capacity employment* has a sizeable, non-linear effect. If initially capacity employment is equal to full-employment $(LC_s = LF_s)$, a 1.0 (resp. 10.0) percentage point decrease in the (skilled) capacity employment rate (LC_s/LF_s) increases skilled unemployment by 1.2 (resp. 7.6) percentage points. Because of relative wage changes and skill mismatch, aggregate unemployment increases more than proportionately (respectively 1.6 and 9.5 percentage point increases).

7. Real *energy prices* have a positive effect on both real wages and aggregate unemployment. The positive effect on real wages is somewhat surprising. It comes from the negative coefficient associated to real energy prices in the unskilled labor demand equation. The coefficient is however not significantly different from zero. Setting it equal to zero yields the more usual negative reduced form effect on real wages and also changes the sign of the skill mismatch effect. Anyway, energy prices seem to play little role, so that these changes are of little consequence.

8. *Financial costs* (short term real interest rate) have a positive effect on aggregate unemployment and skill mismatch, and a negative effect on real wages. The effect, although limited, is not negligeable. A 1 percentage point increase in the short term real interest rate increases unemployment by 0.11 percentage point.

In Table 9, we use the long run multiplier of Table 8 to propose a tentative interpretation of the changes observed in France over the period 1962-1989 (1962-74 between parentheses). The table calculates the effects of observed exogenous changes on the four main endogenous variables of the model. We want to emphasize the following results for the period 1962-1989:

1. The asymmetry in the exogenous rate of *productivity growth* between skilled and unskilled labor $(\gamma_u > \gamma_s = 0)$ has a strong positive effect on skill mismatch and aggregate unemployment (lines (1)+(2)+(3)); the latter has however been more than compensated by changes in the *skill composition of the labor force* (lines (1)+(2)+(3)+(4)). This result assumes a constant real minimum wage, which is of course an extreme and unrealistic assumption in the context of a growing economy.

2. Not surprisingly, *minimum wage* increases (line (5)) increase both skill mismatch and aggregate unemployment. The total effect (exogenous productivity growth + skill composition of the labor force + minimum wage increases) is to increase skill mismatch by 4.5%, and decrease aggregate unemployment by about 1%.

3. The observed huge *tax wedge* increase has increased aggregate unemployment by 4.4%. We noted before that proportionate changes in unskilled and skilled tax wedges do increase skill mismatch. This asymmetric effect of labor taxes has been here compensated by larger skilled tax wedge increases.

4. The five remaining factors (union power, real energy prices, short term real interest rate, frictions, capital gap) altogether have a sizeable influence on real wages and unemployment. Skill mismatch is increased by 1.8%, arising mainly from a union power effect (the decline in union power has a larger negative effect on skilled real wages). Aggregate unemployment is increased by 4.7%, arising mainly from increased frictions and capital gap.

TABLE 9

Long Run Effects of Changes in the Exogenous Variables observed in France over the Period 1962-1989 (Percentage Points; 1962-74 between Parentheses).

	change ×100	effect on				
	1962-89 (1962-74)	$\log \frac{W_u}{P_v}$	$\log \frac{W_s}{P_v}$	Skill mis-match	UR_s	UR
(1) γ_u Trend	92.78	29.26	83.59	47.10	–3.88	43.22
	(56.33)	(17.76)	(50.75)	(28.60)	(–2.36)	(26.24)
(2) γ_s Trend	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
(3) γ_e Trend	95.90	3.76	10.73	–2.64	–3.66	–6.30
	(35.90)	(1.41)	(4.02)	(–0.99)	(–1.37)	(–2.36)
(4) $\log \frac{LF_s}{LF}$	67.23	0.00	0.00	–67.23	0.00	–67.23
	(42.17)	(0.00)	(0.00)	(–42.17)	(0.00)	(–42.17)
(5) $\log \frac{W_m}{(1+Tx_m)\,P_v}$	65.71	26.97	–44.99	27.31	1.97	29.28
	(48.92)	(20.08)	(–33.49)	(20.33)	(1.47)	(21.80)
(1)+(2)+(3) +(4)+(5)		***59.98***	***49.33***	***4.54***	***–5.57***	***–1.03***
		(39.25)	***(21.28)***	***(5.77)***	***(–2.26)***	***(3.51)***
(6) $\log(1+Tx_u)$	15.03	9.49	–15.83	9.61	0.69	10.30
	(0.67)	(0.43)	(–0.71)	(0.43)	(0.03)	(0.46)
(7) $\log(1+Tx_s)$	25.22	1.04	28.19	–10.30	4.41	–5.89
	(2.30)	(0.09)	(2.57)	(–0.94)	(0.40)	(–0.54)
(6)+(7)		***10.53***	***12.36***	***–0.69***	***5.10***	***4.41***
		(0.52)	***(1.86)***	***(–0.51)***	***(0.43)***	***(–0.08)***
(8) $\log UP$	–39.94	–1.88	–5.39	1.32	–1.37	–0.05
	(14.53)	(0.69)	(1.96)	(–0.48)	(0.50)	(0.02)
(9) $\log \frac{Pe}{P_v}$	5.18	0.12	0.33	–0.08	0.17	0.09
	(25.11)	(0.57)	(1.62)	(–0.40)	(0.85)	(0.45)
(10) str	6.78	–0.20	–0.58	0.14	0.59	0.73
	(3.03)	(–0.09)	(–0.25)	(0.06)	(0.26)	(0.32)
(11) $\log(1/\rho)$	70.47	0.00	0.00	0.00	1.76	1.76
	(37.48)	(0.00)	(0.00)	(–0.00)	(0.94)	(0.94)
(12) $\log \left[1+\left(\frac{LC_s}{LF_s}\right)^{-\rho}\right]$	142.23	–0.60	–1.70	0.42	1.75	2.17
	(0.58)	(–0.00)	(–0.01)	(0.00)	(0.01)	(0.01)
(8)+(9)+(10) +(11)+(12)		***–2.56***	***–7.34***	***1.80***	***2.90***	***4.70***
		(1.17)	***(3.32)***	***(–0.82)***	***(2.56)***	***(1.74)***
TOTAL		**67.95**	**54.35**	**5.65**	**2.43**	**8.09**
		(40.94)	**(26.46)**	**(4.44)**	**(0.73)**	**(5.17)**
ACTUAL		69.06	55.88	5.26	2.83	8.09
		(41.71)	(36.69)	(0.97)	(0.48)	(1.45)

The comparison of the pre- and post-1974 periods suggests the following four additional comments:

5. The slowdown in unskilled *productivity growth* after 1974 had a favorable (negative) impact on aggregate unemployment.

6. Most of the positive effect of *minimum wages* on skill mismatch was already in the system in 1974 (a result of the huge surge observed in 1968), even though it had probably not materialized yet.

7. The *tax wedge* effect on aggregate unemployment appears only after 1974.

8. The decline in *union power* occurs after 1974; the resulting negative effect on skilled unemployment is more than offset by increased *frictions and capital gap*.

5 Conclusions

We have developed a model of equilibrium unemployment with endogenous real wages and productivity. By using a framework with explicit quantity constraints and aggregation over micromarkets, we could derive a Beveridge curve and discuss the relationship between equilibrium unemployment and shifts in the Beveridge curve. We also distinguished skilled and unskilled labor, so that shifts in the aggregate UV-curve can be the outcome either of frictions on the skilled labor market or of skill mismatch. In this framework, the appropriate skill mismatch indicator is the ratio of skilled to total employment rates. Frictions are assumed to be exogenous and are estimated by a linear trend. Skill mismatch is endogenous and depends, a.o., on the skilled/unskilled relative wage, given exogenous productivity growth and labor force skill composition. There is a tight relationship and interaction between skill mismatch and equilibrium unemployment.

We estimated the model on French annual data, over the period 1962-89. In this framework, the rise in aggregate unemployment and skill mismatch seems to be the net outcome of a variety of factors, including of course tax wedges and minimum wages. Exogenous productivity growth plays systematically against unskilled labor employment, although much less so after 1974. This productivity effect has however been more than compensated by the exogenous (in our model) change in the skill composition of the labor force. The net effect of these two factors (productivity and labor force composition) together with minimum wages and tax wedges has been to increase skill mismatch and aggregate unemployment by respectively 3.9 and 3.4 percentage points. The effect of other factors like union power, frictions, productive capacities and real interest rates should not be neglected. These four factors together may have produced an increase of respectively 1.7 and 4.6 percentage points in skill mismatch and aggregate unemployment, out of a total of 5.7 and 8.1 respectively.

There are in the model three policy variables, namely the minimum wage and the two rates of social security contributions. Our estimates imply that a 10% reduction in unskilled social contributions (*i.e.*, a 17 percentage point decrease in the unskilled contribution rate, representing approximately 5% of GDP) would decrease the skilled and aggregate unemployment rates by respectively 0.5 and 6.9 percentage points, implying a skill mismatch reduction of 6.4 percentage points. It would also change skilled and unskilled real wage costs by respectively +10.5% and –6.3% (relative wage change: 16.8%), implying larger net wages for both (respectively +10.5 and +3.7). The same skill mismatch and unemployment changes could be obtained by a 15.4% cut in the net real minimum wage; the latter policy still implies eventually a 10.5% increase in skilled real wages, but at the same time a 6.31% real wage loss for unskilled workers. The social costs of the two policies are thus quite different. This calculation does not include the effect of the alternative taxes needed to compensate the wage tax cut. A detailed calculation should also take into account the decrease in unemployment benefit expenditures, as well as the automatic increase in income and VAT tax receipts following the increase in GDP.

The calculations behind this policy scenario of course rely on the estimated price and wage equations. The robustness of these calculations depends on the robustness of these equations. Part of our results however remain true whatever the wage and price formation process. The whole model is made of three blocks, namely (i) the technological equations, (ii) the employment equation and the Beveridge curve, and finally (iii) the wage-price equations. The finding that "technological progress" (a general term which actually summarizes the net effect of foreign competition, deindustrialization and pure technological progress) has had an asymmetric effect on skilled and unskilled employment and that a 17% relative wage change would be needed today to eliminate skill mismatch seems fairly robust. Our confidence in this result is reinforced by the fact that the estimated Beveridge curve mimics pretty well the shifts observed in the actual UV-relationship.

This work should of course be extended in several directions. The skill composition of the labor force, which we always regarded as given, should rather be treated as an endogenous decision variable. It is certainly, to some extent, the result of voluntary individual choices. Because our main interest was on the effect of supply-side variables, we downplayed the effect of demand shocks, although they may, in open economies, have long lasting effects. Capacity employment changes should also be explained; they may be the result of both demand and supply shocks. Finally, it would be worthwhile estimating the same model on other data sets, to check to what extent the same story can be told for other, for example European, countries. We leave these topics for future research.

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