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The Influence of Different Specifications of Wages Prices Spirals on the Measure of the NAIRU: the Case of France

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Abstract

This paper investigates the theoretical and empirical issues encountered when estimating the NAIRU and identifying its possible determinants. It more particularly focuses on the differences induced by the choice of a theoretical specification of the wage-price spiral, depending on whether the wage equation is an augmented Phillips-curve or a WS curve.

It is first recalled that the NAIRU derived from a wage spiral based on an augmented Phillips-curve can have no other determinant than the rate of growth of productivity. The wage bargaining theory points out on the contrary that the NAIRU derived from a WS-PS approach a la Layard-Nickel-Jackman (1991) may have other determinants, such as the level of productivity, real capital cost, unemployment benefits in real terms etc... However, sine theoretical arguments may be found in support of both approaches, it seems difficult to discriminate between these two specifications on a purely theoretical basis.

The empirical work conducted on both approaches provides elements that support the WS-PS framework, namely the order of integration of unemployment rate series and the existence of two cointegrating relations between the relevant variables. Moreover, these estimations of wage and price equations allow the calculation of two NAIRUs, which illustrates the quantitative differences between the two approaches: the NAIRU derived from Phillips curve models appears flatter - except in the nineties - than the WS-PS NAIRU. This may be explained by the presence of the real interest rate among the determinants of the NAIRU in the WS-PS approach, which is a new result on French data.

Keywords: NAIRU, wage bargaining, cointegration, dynamic heterogeneity.

Résumé succint

Cet article éclaire les différences de résultats théoriques ou empiriques obtenus par l'utilisation des deux principales approches fournissant des estimations possibles de NAIRU les boucles prix-salaires fondées soit sur la courbe de Phillips soit sur la courbe de salaire en niveau (WS) issue de la théorie de la négociation salariale.

Il est rappelé que le NAIRU dérivé de la courbe de Phillips ne peut avoir d'autres déterminants que le taux de croissance de la productivité. La théorie de la négociation salariale insiste au contraire sur le fait qu'un NAIRU calculé à partir d'une courbe WS peut dépendre d'autres déterminants, tels que le niveau de la productivité, le coût réel du capital, le pouvoir d'achat des indemnités chômage, etc... Toutefois, la théorie économique ne tranche pas entre ces deux approches et le choix de l'une ou de l'autre ne peut se faire sur une telle base.

Les estimations effectuées sur la base des deux approches fournissent des éléments confortant l'approche WS : le taux de chômage est intégré d'ordre un, comme le salaire réel ; il existe deux vecteurs coïntégrants dans l'ensemble des variables pertinentes. Ces estimations permettent par ailleurs le calcul de NAIRU dans les deux cas, ce qui montre aussi les différences obtenues sur le plan quantitatif : le NAIRU-Phillips est plus plat sauf au début des années quatre-vingt-dix. Ces différences sont essentiellement expliquées par la présence des taux d'intérêt réels parmi les déterminants du NAIRU dans l'approche WS-PS, ce qui est un résultat nouveau sur données française.

Mots clé : NAIRU, négociation salariale, coïntégration, hétérogénéité dynamique.

Introduction

The almost continuous rise in European unemployment over the last decades has revived the debate as to the nature of unemployment in Europe. In particular, the share of structural unemployment in this evolution, and the factors responsible for the increase in equilibrium unemployment have been extensively debated. On a more practical level, calculations of output gaps and structural balances generally require estimates of the equilibrium rate of unemployment. However, the question of the level and determinants of the NAIRU in France remains a controversial one. There are a number of reasons for this, but it seems that one important factor is that there is no consensus as to how one should estimate the NAIRU, rince estimating the NAIRU raises a number of theoretical and empirical questions.

This paper carefully examines these questions and investigates the influence on NAIRU estimates derived from wage-price spirals of alternative choices as regards theoretical specifications, handling of data simultaneity and non-stationarity and of dynamic homogeneity . It thus provides an idea on the uncertainty attached to NAIRU estimates.

On a theoretical level, "traditional" representations of the wage-price spiral, basically inspired from Phillips (1958) relationship, have been questioned in recent years by "wage-setting and price setting" models à *la* Layard-Nickel-Jackman (1991). Whereas traditional models are based on an empirical relation between the growth of wages and the level of unemployment, WS-PS approaches generally use a bargaining model to derive a relation between the level of wages that wage setters try to secure and the unemployment rate.

The paper first reviews the arguments of the theoretical debate and presents a standard WS-PS model derived from a bargaining model in the context of a Cobb-Douglas production fonction and imperfect competition.

The second section of the paper underscores the econometric problems that are to be tackled when estimating wage-price equations: specification, identification, data stationarity, simultaneity and dynamic homogeneity. It then presents the results obtained with various specifications on French quarterly data over the 1970-QI - 1992-Q4 period (using Johansen's (1990) procedure).

Finally, the third section of the paper turns to the definition of the long run path, in order to derive NAIRU estimates from the various wage and price equations estimated in the second section. The identification of a set of determinants of the NAIRU also makes it possible to evaluate their respective roles in the evolution of the NAIRU in France over the last 25 years.

I - Wage-price spirals: the theoretical background

Models of the wage-price spiral are usually divided into broad two categories, that differ by the specification of the wage equation rather than that of the price equation. On the one hand, the empirical relation first established by Phillips (1958) postulates a link between the growth rate of wages and the unemployment rate. On the other hand, a more recent and more theoretically-founded approach, largely drawing on Layard-Nickel-Jackman (1991) derives a link between the level of wages and the unemployment rate from an explicit optimization program involving films and unions. These specifications have very different implications as regards the possible determinants of the NAIRU.

1) Wage price spirals based on an augmented Phillips curve

In these models, long **run movements** in wages and prices can be described by the following simplified equations[1]:

$$\begin{cases} \Delta w = c_p . \Delta p + F(u) \\ \Delta p = \Delta w - \Delta p \end{cases} \qquad (1) \text{ and } (2)$$

where w, p, π and F(u) represent respectively the logarithms of nominal wages, prices, labor productivity and a decreasing function of the unemployment rate.

The first equation is an expectation-augmented-Phillips curve which is basically an empirical relation, even if it may also be derived from a theoretical model, as will be seen below. The second equation asserts that

[1] On the long mn path, inflation is by assumption constant, as well as wage growth.

the share of profit in value added should be stable in the long mn (in the long-run), which is consistent with the firm's optimization program (see equation (6) below).

• If the long run coefficient of price inflation on wage inflation is not one ($c_p \neq 1$), the system can be reduced into a single equation:

$$\Delta p = \frac{F(u) - \Delta\pi}{1 - c_p} \qquad (3)$$

which describes the well-known unemployment-inflation dilemma.

• If on the contrary $c_p = 1$, then

$$F(u) = \Delta\pi \qquad (4)$$

which defmes the "Non Accelerating Inflation Rate of Unemployment"[2] (NAIRU). The NAIRU derived from this type of models is therefore a decreasing fonction of the rate of growth of productivity.

This simplistic framework may be enriched with various other elements, such as:

- the rate of growth of labor productivity in the wage equation, which may lead to its disappearing in the reduced system (equation 4), and therefore in the set of determinants of the NAIRU,
- changes in terms of trade, if wages are fixed relative to consumer prices rather than value added prices,
- variations in the wedge between wages and labor costs,
- variations in the unemployment rate, to take into account possible hysteresis effects,
- various variables measuring wage pressure in the wage equation, such as the replacement ratio, the power of unions etc.
- various variables influencing the pricing behavior of the firm (rate of use of productive capacity, interest rates, etc...).

However, it should be noted that these variables will have no impact on the NAIRU unless they are not equal to zero in the long mn. For example, the variation in unemployment will be assumed equal to zero in the long mn, whereas the rate of growth of productivity will not disappear in the long mn equation.

2) Wage price spirals derived from wage-bargaining models

This approach is well documented in Layard-Nickell-Jackman (1991). It consists in modeling wage-setting and price-setting behaviors as the solutions of an optimization program. The firm and the union are supposed to bargain in order to share the 'profit cake'. This game between the two agents is organized as follows (right to manage assumption):

- real wages are first bargained between the firm and the union on the basis of future expected demand and costs;
- output is then determined by firms in order to satisfy the demand, and employment is set to produce the output.

a- Price-setting

As a result of the maximization of profit by the firm, in a context of imperfect competition, the optimal real wage is

$$\frac{W}{P} = \kappa . \frac{\partial f}{\partial N}(K, N) \qquad (PS_{SR}) \qquad (5)$$

where W is the nominal wage, P the price level, κ an indicator of product market competitiveness, f the production function, N the optimal level of employment, and K the optimal level of capital (see Layard-Nickell-Jackman (1991)).

This equation defines the mark-up desired by price-setters, and is thus a semi reduced price-setting equation (PS_{SR}).

[2] or, more accurately, the rate of unemployment compatible with a stability of inflation.

Assuming constant returns to scale and taking for f a Cobb-Douglas function such as $f(K,N) = Z.N^{\alpha}.K^{(1-\alpha)}$, the price-setting equation becomes

$$\frac{W}{P} = \alpha.\kappa.\frac{Y}{N} \qquad (PS_{SR}) \qquad (6)$$

where Y is the optimal level of output.

Similarly:

$$\frac{C}{P} = (1-\alpha).\kappa.\frac{Y}{K} \qquad (7)$$

where C/P is the optimal real cost of capital,
and

$$\Pi = (1-\kappa).Y \qquad (8)$$

where Π is the optimal profit.
Other useful relationships can then be derived:

$$\frac{\Pi}{\frac{W}{P}.N} = \frac{1-\kappa}{\alpha\kappa} \qquad (9)$$

$$\frac{Y}{N} = Z.\left(\frac{K}{N}\right)^{1-\alpha} = Z.\left(\frac{1-\alpha}{\alpha}.\frac{W}{C}\right)^{1-\alpha} \qquad (10)$$

$$\frac{\Pi}{N} = (1-\kappa).\frac{Y}{N} = (1-\kappa).Z.\left(\frac{1-\alpha}{\alpha}.\frac{W}{C}\right)^{1-\alpha} \qquad (11)$$

An interesting reduced form of this price-setting equation when C, A, α and κ are assumed exogenous is:

$$\frac{W}{P} = \alpha.\kappa.Z.\left(\frac{1-\alpha}{\alpha}.\frac{W}{C}\right)^{1-\alpha} \qquad (PS_R) \qquad (12)$$

This relation, the factor price frontier, only depicts the theoretical link between real wages and the real cost of capital resulting from an optimization program. However, if one uses the real interest rate as a proxy for the real cost of capital, equation (12) also describes a possible channel for an influence of real interest rates on real wages (see Cotis-L'Horty (1996) and Cotis, Méary and Sobczak (1996)).

b- Wage bargaining between the firm and the union

• Let us first consider how wages are determined at the firm level.
The objective of the union in the ith firm is to maximize its utility

$$V_i = S_i.\frac{W_i}{P_i} + (1-S_i).A \qquad (13)$$

where S_i is the probability for an employee of firm i of being employed in the same firm next period and A is the expected 'alternative' real income (if the employee leaves the firm)

$$A = (1-\varphi.u).\left(\frac{W}{P}\right)^{e} + \varphi.u.\frac{B}{P} \qquad (14)$$

B/P and $(W/P)^e$ represent respectively real unemployment benefits and the expected 'outside' real wage, which may be obtained in other firms, φ is a constant, related to the probability of becoming unemployed and to the discount rate, and u is the unemployment rate (see Layard-Nickell-Jackman, chap 2 note 11, for further details). If the two parties do not reach an agreement, the firm is supposed to close down, and the utility becomes

$$\bar{V}_i = A \qquad (15).$$

As assumed above, the objective of the firm is to maximize its profit Π_i. If the union and the firm do not agree, the profit is assumed to be

$$\bar{\Pi}_i = 0 \qquad (16).$$

The outcome of the bargaining game is obtained by maximizing the Nash criterion

$$\Omega = (V_i - \bar{V}_i)^{\beta}(\Pi_i - \bar{\Pi}_i) = (V_i - A)^{\beta}\Pi_i = (\frac{W_i}{P_i} - A)^{\beta} S_i^{\beta}\Pi_i \qquad (17)$$

where β is a measure of union power.

We assume for simplicity that S_i is not related with W_i/P_i (see Layard-Nickell-Jackman (1991), chapter 2, for a different and more realistic assumption).

Therefore,

$$\frac{\partial \ln \Omega}{\partial\left(\frac{W_i}{P_i}\right)} = \frac{\beta}{\frac{W_i}{P_i} - A} + \frac{\frac{\partial \Pi_i^e}{\partial\left(\frac{W_i}{P_i}\right)}}{\Pi_i^e} = 0 \qquad (18).$$

Using the envelope theorem, $\frac{\partial \Pi_i^e}{\partial\left(\frac{W_i}{P_i}\right)} = -N_i^e$ (19),

and using the definition of the 'alternative' income A (14),

$$(1 - \varphi.u).\frac{\frac{W_i}{P_i} - \left(\frac{W}{P}\right)^e}{\frac{W_i}{P_i}} + \varphi.u.(1 - \frac{\frac{B}{P}}{\frac{W_i}{P_i}}) = \frac{\beta.\Pi_i^e}{\frac{W_i}{P_i}.N_i^e} \qquad (20).$$

• We now turn to the derivation of the aggregate wage W, and assume for that purpose that all firms are identical.

Therefore,

$$W_i = W,\ P_i = P,\ S_i = S \text{ and } \frac{\Pi_i}{N_i} = \frac{\Pi}{N}$$

(i) <u>Let's first assume for simplicity that all expected values are realized, that is</u>

$$(W/P)^e = W/P,\ \Pi^e = \Pi,\ N^e = N$$

Then,

$$\varphi.u.(1 - \frac{B}{W}) = \frac{\beta.\Pi}{\frac{W}{P}.N} \qquad (21).$$

It's useful at this stage to examine the impact of various assumptions relative to unemployment benefits B.

case 1: if the replacement ratio $\rho = \frac{B}{W}$ is assumed exogenous, one has (using (9))

$$\varphi.u.(1-\rho) = \beta.\frac{1-\kappa}{\alpha\kappa} \qquad (WS_R^\rho) \qquad (22),$$

which is a reduced wage-setting equation (note that W disappears). Instead of using (9), we might use equation (11) (without any change regarding the equilibrium rate of unemployment) and thus obtain the semi-reduced equation:

$$\varphi.u.(1-\rho) = \frac{\beta}{\frac{W}{P}}.(1-\kappa).Z.\left(\frac{1-\alpha}{\alpha}.\frac{W}{C}\right)^{1-\alpha} \qquad (WS_{SR}^\rho)^3 \qquad (23).$$

case 2: if unemployment benefits B/P are exogenous, one obtains the reduced form (using (9))

$$\varphi.u.(1-\frac{B}{W}) = \beta.\frac{1-\kappa}{\alpha\kappa} \qquad (WS_R^B) \qquad (24)$$

or the semi-reduced form (using (11)):

$$\varphi.u.(1-\frac{B}{W}) = \frac{\beta}{\frac{W}{P}}.(1-\kappa).Z.\left(\frac{1-\alpha}{\alpha}.\frac{W}{C}\right)^{1-\alpha} \qquad (WS_{SR}^B) \qquad (25).$$

(ii) If one does not assume that the real wage W/P is perfectly anticipated ($(W/P)^e = W/P$), it's possible, with an alternative and somewhat ad-hoc assumption on wage expectations, to derive a Phillips-curve from the wage bargaining framework presented above. This development is only illustrative: Manning (1993) provides a more refined derivation of the Phillips curve from the precise modeling of the <u>dynamics</u> of the bargaining process..

Let's assume, for example, that, instead of having $(W/P)^e = W/P$, we have

$$\left(\frac{W}{P}\right)^e = \left(\frac{W}{P}\right)_{-1}.(1+\left[\dot{\left(\frac{W}{P}\right)}\right]^e) \hat{=} \left(\frac{W}{P}\right)_{-1}.(1+\frac{1}{\alpha}\dot{Z}_{-1}),^4$$

This assumption could be reflect the idea that the union bargains inside a specific firm but does not know what is going on in other firms. Then, the outside real wage is expected to be equal to the past real wage, augmented with the productivity growth (see (12)), which implies a degree of 'myopia' in the union's expectations.

Using (19), with the assumption of identical firms, one then has

$$(1-\varphi.u).\frac{\left(\frac{W}{P}\right)_{-1}}{\frac{W}{P}}\left(\frac{\frac{W}{P}-\left(\frac{W}{P}\right)_{-1}}{\left(\frac{W}{P}\right)_{-1}} - \frac{\dot{Z}_{-1}}{\alpha.}\right) + \varphi.u.(1-\frac{B}{W}) = \frac{\beta.\Pi^e}{\frac{W}{P}.N^e} \qquad (26).$$

In the case where $\rho = \frac{B}{W}$ is exogenous, using (9) and first order linear approximations, one then obtains a relationship which may be compared with an augmented-Phillips curve (notice the growth of productivity):

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3 or: $\frac{W}{P} = \frac{\beta.(1-\kappa).Y}{\varphi.(1-\rho).N.u}$ using (8), which is another form of (23) linking real wages to observed (endogenous) productivity of labor.

4 Layard-Nickell-Jackman prefer making the assumption: $\left(\frac{W}{P}\right)^e = \left(\frac{W}{P}\right)_{-1}.(1+\left[\dot{\left(\frac{W}{P}\right)}\right]^e) \hat{=} \left(\frac{W}{P}\right)_{-1}.(1+\dot{\left(\frac{W}{P}\right)}_{-1})$. This would lead to show an equation with wage acceleration instead of the Phillips-curve we obtain by making the retained assumption. Note that our assumption is purely ad hoc, and simply means that instead of observing the past wage inflation, the union observes the past growth rate of total productivity and suppose the wage share will not change from the past to the present period.

$$\left(\frac{\overset{\bullet}{W}}{P}\right)=\left[\beta.\frac{1-\kappa}{\alpha\kappa}-\varphi.u.(1-\rho)\right]\Big/(1-\varphi.u)+\frac{\dot{Z}}{\alpha} \qquad (27).$$

c- Derivation of the WS-PS system

This simple theoretical framework provides the basis for the empirical estimations presented in Section 2. Since both systems $\{(WS_R),(PS_R)\}$ and $\{(WS_{SR}),(PS_{SR})\}$ lead to the same equilibrium rate of unemployment, the estimations will focus on the second form of the system, as is usually done.

Taking logarithms, one gets the following forms for $\{(WS_{SR}),(PS_{SR})\}$, where (w-p), (b-p), (c-p) and (z) are the logarithms of real wages, real unemployment benefit, real costs of capital, and total factor productivity respectively:

case 1[5] (the replacement ratio $\rho=\frac{B}{W}$ is exogenous, see (23) and (12)):

$$\begin{cases} w-p=\frac{1}{\alpha}.\left[z-(1-\alpha).(c-p)-u+z_w(\varphi,\rho,\beta,\kappa,\alpha)\right] \\ w-p=\frac{1}{\alpha}.\left[z-(1-\alpha).(c-p)+z_p(\kappa,\alpha)\right] \end{cases} \qquad (WS,PS)$$

case 2[6] (the real unemployment benefits B/P are exogenous, see (24) and (12)):

$$\begin{cases} w-p=b-p-u+z_W(\varphi,\beta,\kappa,\alpha) \\ w-p=\frac{1}{\alpha}.\left[z-(1-\alpha).(c-p)+z_p(\kappa,\alpha)\right] \end{cases} \qquad (WS,PS)$$

The equilibrium rate of unemployment is then calculated by subtracting and reorganizing these equations: it may therefore depend on (c-p), (b-p) and (z).

case 3 (Phillips curve traditional approach, see (1) and (2)):

$$\begin{cases} \Delta w=c_p.\Delta p+F(\underset{(-)}{u}) \\ \Delta p=\Delta w-\Delta\pi \end{cases}$$

case 4 (Phillips curve approach, derived from the previous wage-bargaining framework, see (27) and (12)):

$$\begin{cases} \Delta(w-p)=\frac{1}{\alpha}.\Delta z+F(\underset{(-)}{u}) \\ w-p=\frac{1}{\alpha}.\left[z-(1-\alpha).(c-p)+z_p(\kappa,\alpha)\right] \end{cases}$$

Finally, one may notice that, even though WS-PS systems are usually considered as more theoretically justified than Phillips curves, it may not be so simple to discriminate between the two approaches from a purely theoretical point of view. However, econometric arguments might shed light on the debate. Noting that (u) is integrated of order one (I(1)) (see tables A and B below), a long-run relation containing u should include other unit root variables cointegrated with u. If (w-p) has only one unit root (I(1)), the Phillips curve contains only one non-stationary variable and cannot be interpreted as a long term relationship, whereas the WS equation can be seen as a cointegrating relation between I(1) variables. Alternatively, if (w-p) is I(2), the Phillips curve might be a cointegrating relation between two I(1) variables: Δ(w-p) and u.

5 This system may also be written ((π) is the logarithm of hourly labour productivity):

$$\begin{cases} w-p=\pi-\ln(u)+\ln\left(\frac{\beta.(1-\kappa)}{\varphi.(1-\rho)}\right) & (WS) \\ w-p=\pi+\ln(\alpha.\kappa) & (PS) \end{cases}$$

, which is equivalent for the equilibrium rate of unemployment.

6 the WS equation is here obtained by taking twice the logarithms of (WS_R^B) (24).

As a conclusion, this short theoretical presentation provides possible determinants of the equilibrium rate of unemployment: labor productivity or Solow residuals as a proxy of total factors productivity[7], real capital cost (approximated by a real interest rate), real unemployment benefits (case 2).

II - Empirical Results

1) Econometric issues

Four major econometric problems arise when one wants to estimate wage and price equations: the non-identification of the wage equation, the simultaneity of wage and price determination, the non stationarity of most of the variables involved in wage-price spirals and the specification of the dynamics to ensure dynamic homogeneity.

a) The wage equation WS is unidentified.

Since any linear combination of WS and PS is a possible WS equation, the wage equation in a WS-PS system is clearly unidentified. This problem is not really a binding constraint if one is only interested in the equilibrium rate of unemployment[8] (see Layard-Nickell-Jackman, chap 8 and 9, for such an econometric strategy).However, if one is also interested in identifying the wage setting and price setting behaviors, a solution is to impose exclusion restrictions for some variables. As has been seen in part I, in the case where ρ is exogenous, wages may be excluded from the WS equation and u may be excluded from the PS equation. Another strategy (used by L'Horty-Sobczak (1995)) consists in excluding productivity terms from the wage equation. In this paper, we will choose to identify WS by imposing a constraint which replaces value added prices by consumer prices in the wage equation. The PS equation will simply be identified by the exclusion of the unemployment rate (u).

b) Simultaneous bias:

We addressed the problem of simultaneity in the determination of wages and of prices by a maximization of likelihood method (FIML).

c) Non stationarity of the variables:

Tables A and B in Appendix report the orders of integration (estimated using Schmidt-Phillips (1992) and Kwiatkowski-Phillips-Schmidt-Schin (1991) tests) for the whole set of variables included in the equations. On the basis of these tests, the series almost all appear to be I(1) over the 1970q1-1992q4 period. However, one should notice that the nominal wage might be considered as I(2). The econometric strategy should be particularly careful about this feature of the series which requires appropriate methods in order to test the existence of cointegrating relations between the appropriate variables while estimating equations based on case 1 and 2 of section 1. Three ways of handling this problem are usually proposed:

- the Engle-Granger (1987) procedure, which is basically a two-stage estimation of an error correction model (ECM) (see L'Horty-Sobczak (1995) for an example of implementation of this procedure for WS-PS equations);
- the Boswijk (1993) procedure, which consists in estimating the ECM in one stage and in using a specific test to assert the significance of coefficients when I(1) series are present in the equations (Laffargue-L'Horty (1995)).
- the Johansen (1988) procedure, which tests the number of cointegrating relations among a set of 1(1) series. It also allows for various useful tests when constraints are imposed.

The estimation of wage and price equations in case 3 (based on an augmented Phillips curve) does not raise the same difficulties, as far as all the variables may be considered as stationary. Ordinary least squares are then appropriate. However, as shown in Tables A and B in Appendix, the unemployment rate appears to be 1(1) in France over the period under review. Estimating an augmented-Phillips curve using OLS could therefore only be justified by assuming that this time series property of the unemployment rate is fallacious, and that in fact u is stationary, which is consistent with its being bounded. Another possibility would be to consider the

[7] In the model, we made the assumption of market power. In this case, we know (Hall (1989)) that Solow residuals are not uncorrelated with employment or capital: the Solow residual is therefore only a proxy of total factor productivity.
[8] since this rate is anyway the intersection of WS and PS or of any of their linear combinations.

nominal wage as 1(2) and to interpret the Phillips curve as a cointegrating relationship between the rate of growth of nominal wages and the unemployment rate, which would then both be

d) Dynamic homogeneity:

Last but not least for our purpose (which is to estimate the NAIRU), it is important to ensure that the cointegrated vectors thus determined completely describe the long run path which is defined in a standard fashion by assuming all stationary variables are constant. In other words, the dynamic terms in the VAR should disappear in the long run. More precisely, let us consider an ECM of the form $\Delta x = a.\Delta x^* - b.(x - x^*)_{-1}$, where x (for example real wages) and its long run target x^* are I(1). The ECM ensures that on a long run path (where all stationary variables are assumed to be constant), $\Delta x^* = \Delta x$ (the variable grows at the same rate as its target), and $x - x^* = \Delta x.(a-1)/b = \Delta x^*.(a-1)/b$.

Therefore, the long run relationship is not reduced to the cointegrated vector (x-x*), but includes a constant: $\Delta x^*.(a-1)/b$, which is not equal to zero unless a=1 (dynamic homogeneity), or unless $\Delta x^* = \Delta x = 0$ in the long run.

In other terms, if $a \neq 1$ (dynamic heterogeneity), the long run relationships will include the first differences of I(1) series appearing in the cointegration system.

2) The data[9]

The estimations were carried out using quarterly data over the period 1970q1 - 1992q4. The main data source is quarterly French national accounts as published by the INSEE. They embrace the business sector excluding financial and agricultural sectors. In the result tables, (w), (p), (π), (z) and (pc) stand respectively for the logarithms of hourly wages, value added prices, hourly labor productivity, Solow residual[10] and consumer prices. (u) is the unemployment rate, (t) the employers contributions tax rate for social security scheme, (i) the long-term interest rate and (Δpc^a) the expected inflation rate. This last variable is a linear combination of inflation forecasts from the OECD Economic Outlooks, of past observed inflation and of quarterly average inflation over the previous ten years[11]. We also use (smic) which stands for the logarithm of the minimum legal wage in France, (smicthumb) the discretionary part of the Smic growth[12], (tns) the share of non wage-earners in total employment, (d) the logarithm of average weekly working hours per employee and (b) the logarithm of unemployment benefit[13].

3) Estimation of the WS-PS system

a) The estimation procedure:

In order to ensure that there exists <u>two</u> distinct cointegrating vectors, which should coincide with the WS and PS equations (see case 1 or 2), we will prefer Johansen's procedure rather than the other possible methods mentioned above and that do not test the number of long term relationships among the set of variables. We thus consider the set of I(1) variables {(w-p), (z), ln(1+t), (u), (pc-p), (i - Δpc^a), (smic-pc) or (smicthumb), ln(1-tns), d, b} and look for cointegrating vectors including <u>at least</u> {(w-p), (z), ln(1+t), (u), (i- Δpc^a)} which is our basic set of variables (see theoretical backgrounds). We use Osterwald-Lenum (1992) tables for rank tests.

The lag length in the VAR is determined so as to whiten the residuals: in practice, the serial independence and normality properties of the residuals (see Johansen-Juselius (1990)) are assessed using Box-Pierce (1970) and Jarque-Bera (1980) tests applied to the single equation residuals (Table 1).

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[9] A detailed description of the data is provided in Appendix.

[10] (z) is calculated from its growth rate, using the wage share in value added as an estimate for the elasticity of labour, the growth rate of worked hours and the growth rate of capital. A correction is made to take into account the cyclical intensity of capital utilization: see appendix.

[11] See Dubois-Parisot (1994) fora more detailed description of the construction of this variable.

[12] The minimum legal wage in France (Smic) is constrained (by law) to grow at least at the same rate as consumer prices, augmented with half the growth of real wages in the whole economy; the government may further increase the SMIC in a discretionary way; these further discretionary increases are called SMIC-thumb.

[13] This last series begins in 1981q1.

b) Johansen's procedure results:

Among the basic set of variables, both the trace and maximal eigenvalue tests are consistent with the presence of one cointegrating vector only: see Table 1.1 and 1.2 hereafter.

Table 1.1: Test Statistics for the niid Assumption for the Residuals

	$\Delta(w-p)$	$\Delta(z)$	$\Delta\ln(1+t)$	$\Delta(u)$	$\Delta(i-\Delta pc^a)$
$\tau_1(10)$	20.51	16.66	4.08	8.80	10.02
τ_2	2.59	0.56	1.09	0.29	14.31

where $\tau_1(k) = T.\sum_{i=1}^{k} r_i^2$ is asymptotically a $\chi^2(k)$ distribution (Box-Pierce test),

'ri' is the estimated serial correlation of the residuals of equation, 'T' the number of observations

and $\tau_2 = \frac{T-m}{6}.(sk^2 + \frac{ek^2}{4})$ is asymptotically a $\chi^2(2)$ distribution (Jarque-Bera test).

'm' is the number of independent variables, 'sk' is skewness and 'ek' is excess kurtosis.

Table 1.2:Johansen Maximum Likelihood procedure, No trend in DGP

System: {(w-p), (z), ln(1+t), (u), (i- Δpc^a),

1972q1-1992q4, Maximum lag = 2

Hø:	Trace 95% CV	Trace	Maximum eigenvalue 95% CV	Maximum eigenvalue
$r \leq 4$	3.76	3.37	3.76	3.37
$r \leq 3$	15.41	11.80	14.07	8.43
$r \leq 2$	29.68	24.82	20.97	13.02
$r \leq 1$	47.21	45.36	27.07	20.54
$r \leq 0$	68.52	84.96	33.46	39.60

As there is a strong presumption that wages are influenced by consumer prices rather than value added prices, a terms of trade variable (= - (pc-p)) is added to the basic system[14]. Maximal eigenvalue and trace tests are now consistent with the presence of two cointegrating vectors, and the estimated coefficients appear with the expected signs (Table 2.2 and 3). The residuals of the estimated equations are niid (Table 2.1), except the residuals of Δ(pc-p) which fail the normality test.

Table 2.1: Test Statistics for the niid Assumption for the Residuals

	$\Delta(w-p)$	$\Delta(z)$	$\Delta\ln(1+t)$	$\Delta(u)$	$\Delta(i-\Delta pc^a)$	$\Delta(pc-p)$
$\tau_1(10)$	6.93	11.60	6.14	15.95	16.04	9.82
τ_2	7.03	10.59	0.52	1.44	2.09	147.37(*)

(*) The residuals of the Δ(pc-p) equation fail the normality test at the 5% critical value.

Table 2.2: Johansen Maximum Likelihood procedure, No trend in DGP

System: {(w-p), (z), ln(1+t), (u), (i- Δpc^a), (pc-p)},

19720q1-1992q4, Maximum lag = 1

Hø:	Trace 95% CV	Trace	Maximum eigenvalue 95% CV	Maximum eigenvalue
$r \leq 4$	15.41	9.88	14.07	5.55
$r \leq 3$	29.68	24.01	20.97	14.13
$r \leq 2$	47.21	46.15	27.07	22.14
$r \leq 1$	68.52	79.62	33.46	33.46
$r \leq 0$	94.15	117.08	39.37	37.47

[14] Even though consumer prices play no role in the basic framework outlined above, they cari be introduced if unemployment benefits are indexed on consumer prices instead of value added prices: see Cotis-L'Horty (1996).

Various restrictions on these vectors can then be tested:

- the coefficient of employers social contributions on real wages is not significantly different from one: the constraint (w - p + ln(1+t)) is accepted. This suggests that the union regards these contributions as differed income for the workers, just as the firm does.

- since we expect the long-run coefficient of factor productivity (z) to be $1/\alpha$ (see part I, case 1), where α is the share of wages in value added (its average value is 0.60 in France over the period), the following constraint is tested and accepted: (w - p + ln(1+t) - 1.66.z) (where $1.66 = 1/\alpha$).

These two constraints are then tested simultaneously, by a likelihood ratio test:

$$2.(\,L(H_a) - L(H_0)\,) = 6.49 \leq \chi^2_{0.95}(4) = 9.49. \qquad \text{(T1)}$$

- on the other hand, the exclusion of (pc-p) from the cointegrating vectors is rejected:

$$2.(\,L(H_a) - L(H_0)\,) = 21.84 \geq \chi^2_{0.95}(6) = 12.6. \qquad \text{(T2)}$$

Therefore, (pc-p) should not be excluded from the equation, even though it should be noted that the associated residuals fail the normality test. .

Some complementary results and tests are worth mentioning:

- the intercept should not be constrained to appear in the cointegrating vectors only, since most of the series contain a deterministic trend.

- the presence of quadratic trends in the series is not envisaged here: only the possible presence of a trend in the cointegrating vectors was tested.

- the presence of a deterministic trend among the determinants involved in the cointegrating vectors is rejected at a 2.5% level, but accepted at a 5% level (this test is described in Johansen (1994)).

$$2.(\,L(H_a) - L(H_0)\,) = 7.1 \leq \chi^2_{0.975}(2) = 7.4. \qquad \text{(T3)}$$

As a consequence, and because it is consistent with the theoretical framework detailed in Section 1, we made a conservative choice and retained a 2.5% significance level: in that case, there is no need to include a trend in the cointegrating vectors.

The price equation is then identified by excluding the unemployment rate, and the wage equation by imposing a unitary coefficient for the terms of trade variable (Table 3).

Table 3: Restricted cointegrated Vectors.

$$\left\{ \begin{array}{l} w - p + \underset{\text{restriction}}{1}.\ln(1+t) - \underset{\text{restriction}}{1.66}.z + \underset{\text{constraint}}{0}.u + 2.63.(i - \Delta pc^a) - 2.35.(pc - p) \\ w - p + \underset{\text{restriction}}{1}.\ln(1+t) - \underset{\text{restriction}}{1.66}.z + 0.055.u - 0.56.(i - \Delta pc^a) - \underset{\text{constraint}}{1}.(pc - p) \end{array} \right. \quad \{PS, WS\}$$

restriction: tested ; constraint: identifying condition

At this stage, one may notice that the estimated coefficient of the real interest rate has the expected sign.

In the price equation (PS), the estimated coefficient for terms of trade is more questionable. On the one hand, changes in terms of trade are generally associated with variations in the real costs of inputs. When taking into account the costs of intermediate consumption in a model similar to that presented in section 1, but based on production instead of value added, it can be shown that the mark up of value added prices on labor costs should slightly increase with relative input prices, and therefore increase when terms of trade deteriorate. In that case, the coefficient of (pc-p) in PS should be positive, and not negative as it is the case for the estimated coefficient[15].

On the other hand, changes in terms of trade are also associated with competitiveness effects, and may therefore induce changes in sectoral specialization, towards sectors producing internationnaly traded gonds. If a

[15] On the other hand, the fact that there can be long tags in the adjustment of the production process to shifts in relative prices can lead to a negative relationship between pc-p and the mark-up in the short run. Furthermore, the variations in terms of trade in France over the estimation period largely reflect oit price shocks: if these shocks have not been persistent but have lead to rather long adjustment tags, a negative relationship could appear in PS, even if this effect should prevail only in the short-medium-term, white PS is supposed to be a long terni equation.

deterioration of ternis of trade (for example because foreign prices increase more rapidly than domestic prices) leads to improved competitiveness and subsequently to an increase in the weight of the manufacturing sector in the economy, this could result in a long terni reduction in the mark up since the mark up in the exporting sector is lower than in the rest of the economy. In France, one actually observes a slighltly positive correlation between the detrended share of value added of manufacturing sector in total value added and pc-p. Nevertheless, the magnitude of the coefficient for terms of trade remains questionnable, and might reflect omitted variables.

Finally, the equilibrium rate of unemployment derived from these equations is an increasing function of the real interest rate[16] and a increasing function of terms of trade. These results can be interpreted as follows:

- when the real interest rate goes up, the profitability of production decreases; for a given level of real wage, production decreases and unemployment increases. This is consistent with the sign expected in case 2.
- when terms of trade deteriorate, the price competitiveness increases so that in the long-run, foreign as well as domestic demand increase and the equilibrium rate of unemployment then decreases: this is a demand Bide mechanism. As noted above, the corresponding coefficient is larger than expected, but it should be noted that the contribution of ternis of trade movements to the evolution of the NAIRU is quite limited quantitatively. An additional test has been performed to see whether the coefficient for (pc - p) could be fixed at the value -2.27 in both PS and WS cointegrating vectors. With this value indeed, the critical value of 5% is reached (which is not the case for values between -I and -2.27).

$$2.(L(H_a) - L(H_0)) = 12.6 = \chi^2_{0.95}(6) = 12.6. \qquad \text{(T4)}$$

Then, in this case, we choose to identify WS cointegrating vector with the constraint that the coefficient for the real interest rate is null[17].

c) Further remarks on the dynamic process:

As mentioned above, in the case where there is no dynamic homogeneity, the first differences of any of the I(1) variables present in the long run relations are likely to remain on the long run path.

As far as all the series (including the cointegrating vectors determined by the Johansen procedure) are now I(0), OLS procedures may be used. Therefore, we will now estimate Error Correction Models, in order to determine the short run dynamics of wage and price behaviors. The dependent variable is Δ(w-p) in both cases, the independent ones are any I(0) series among {Δln(1+t), Δz, Δu, Δ(pc-p) and Δ(i - Δpc^a)} and their lags together with the lag of Δ(w-p) (see Table C). The results indicate that there is no dynamic homogeneity: $\hat{z}_p + 1.66.(\hat{w}_p - 1)$ cannot be constrained to equal zero (see table 4).

Moreover, since the associated constraints (noted (c) in table C) are not rejected by the Fisher test, the short mn dynamics process for WS, like the long-mn one, includes (w - pc) instead of (w - p). Furthermore, only the acceleration of the unemployment rate appears in the dynamic process, and not its first variation.

d) The NAIRU derived from a WS-PS model

We can now turn to the derivation of the NAIRU from the WS-PS system estimated above, taking into account the persistent elements of the dynamics which come from the two variables Δ(w - p) and Δz. Indeed, we make here a rather weak assumption considering that in the long run, all other dynamic terms vanish. Then the long-run equations are:

$$\begin{cases} w - p + \ln(1+t) - 1.66.z + \underset{\text{constraint}}{0}.u + 2.63.(i - \Delta pc^a) - 2.35.(pc - p) = -\dfrac{1}{\hat{r}_p}.(\hat{c}_p + \hat{z}_p.\Delta z + (\hat{w}_p - 1).\Delta(w - p)) \\ w - p + \ln(1+t) - 1.66.z + 0.055.u - 0.56.(i - \Delta pc^a) - \underset{\text{constraint}}{1}.(pc - p) = -\dfrac{1}{\hat{r}_w}.(\hat{c}_w + \hat{z}_w.\Delta z + (\hat{w}_w - 1).\Delta(w - p)) \end{cases}$$

(see Table C for values of r_p, r_w, c_p, c_w, z_p, z_w, w_p and w_w).

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16 The influence of the real cost of capital on the equilibrium rate of unemployment in France is also documented independently in a paper by Cotis-Méary-Sobczak.

17 In this case we shall obtain the alternative cointegrating vectors:

$$\begin{cases} w - p + \underset{\text{restriction}}{1}.\ln(1+t) - \underset{\text{restriction}}{1.66}.z + \underset{\text{constraint}}{0}.u + 2.61.(i - \Delta pc^a) - \underset{\text{restriction}}{2.27}.(pc - p) \\ w - p + \underset{\text{restriction}}{1}.\ln(1+t) - \underset{\text{restriction}}{1.66}.z + 0.050.u - \underset{\text{constraint}}{0}.(i - \Delta pc^a) - \underset{\text{restriction}}{2..27}.(pc - p) \end{cases} \qquad \{PS_{bis}, WS_{bis}\}$$

Differentiating these equations in the long run gives Δ(w - p) = 1.66.Δz, and finally:

Table 4: Long-Run WS-PS equations.

$$\begin{cases} w-p+\ln(1+t)-1.66.z+\underset{\text{constraint}}{0}.u+2.63.(i-\Delta pc^a)-2.35.(pc-p)=-\frac{1}{\hat{r}_p}.(\hat{c}_p+[\hat{z}_p+1.66.(\hat{w}_p-1)].\Delta z) \\ w-p+\ln(1+t)-1.66.z+0.055.u-0.56.(i-\Delta pc^a)-\underset{\text{constraint}}{1}.(pc-p)=-\frac{1}{\hat{r}_w}.(\hat{c}_w+[\hat{z}_w+1.66.(\hat{w}_w-1)].\Delta z) \end{cases}$$

{PS,WS}: see Table C for values of r_p, r_W, c_p, c_W, z_p, z_W, w_p and w_W.

The NAIRU is then obtained by eliminating (w - p) between these two equations:

Table 5: The WS-PS-NAIRU[18].

$$NAIRU_{WS-PS} = 6.8 + 58.(i - \Delta pc^a) - 25.(pc - p) - 521.\Delta z$$

To calculate explicitly the value of the NAIRU, it is finally necessary to determine the long-run value of each of its determinants. A first method consists in deriving these values from theoretical models: real interest rates might be related to international potential output growth and terms of trade to equilibrium exchange rates. A second and simpler approach consists in using smoothed variables as a proxy for their long term values. It's the method we used (with a Hodrick-Prescott filter (λ=1600)). The resulting NAIRU is plotted in figure 1.

4) Estimation of the Phillips-curve system

a) Estimation results:

Even if the WS-PS approach seems rather well validated by the data, estimations of case 3 and 4 (Phillips curve approaches) have also been conducted in order to compare the implications of both approaches on NAIRU estimates.

- In case 4, the econometric strategy is quite different since we are now interested in one cointegrating vector only (the PS curve, see equation (12)). We will use the first cointegrating vector of the previous system, without making any identifying restrictions: this new vector will be noted (PS') and is presented in table DI. The results are displayed in Table D2.

The constraint of unitary indexation of wages on prices (which guarantees the existence of a NAIRU in this system, see section 1) is still accepted.

- We also performed estimations for the traditional Phillips curve approach (case 3): this only requires the estimation of the wage equation since the price equation is unchanged (see (4)). As usually done in such a case, no particular cane is taken of simultaneous bias, and only one equation is estimated. Results are presented in Table E. It is noticeable that the indexation of wages is still accepted.

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[18] With PS_{bis}-WS_{bis}, we obtain (after calculating the dynamics): $NAIRU_{WS_{bis}-PS_{bis}} = 7.4 + 52.(i - \Delta pc^a) - 608.\Delta z$

b) The Phillips-NAIRUs

- The long run system and the NAIRU (for the case 4) are derived using the same assumptions as in part 2:

Table 6: Long-Run Phillips-Curve System equations.

$$\begin{cases} w - p + \ln(1+t) - 1.66.z - 0.018.u + 6.7.(i - \Delta pc^a) - 2.8.(pc - p) = -\frac{1}{\hat{r}'_p}.(\hat{c}'_p + [\hat{z}'_p + 1.66.(\hat{w}'_p - 1)].\Delta z) \\ \Delta(w-p) = \frac{1}{1-\hat{w}'_w}(\hat{c}'_w + \hat{u}_w.u) \end{cases}$$

see Tables D1 and D2 for values of r'_p, c'_p, c'_W, u'_W and w'_p. Note that z'_p=0

Table 7: The Phillips-NAIRU.

$$NAIRU_{Phillips} = 10.9 - 1065.\Delta z$$

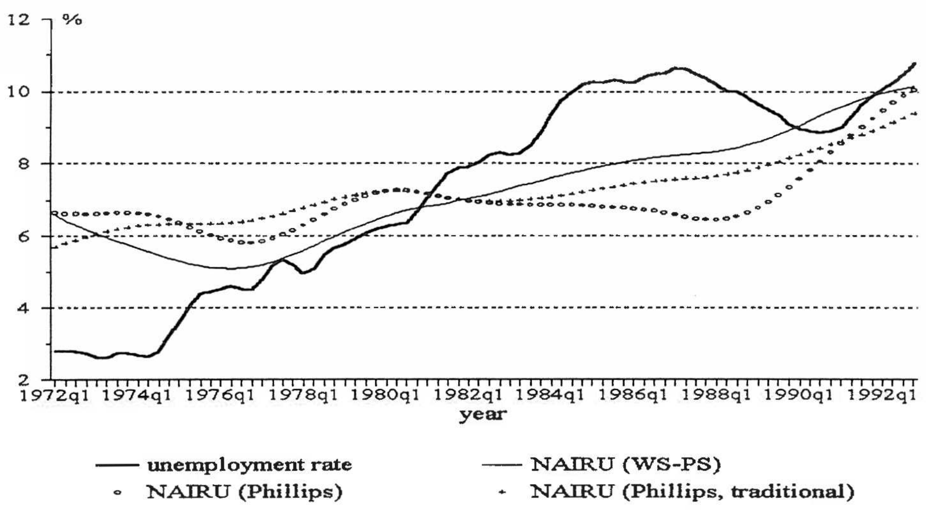
- We also present a calculation of the NAIRU from the traditional estimation procedure (case 3). As shown in part 1, we get:

Table 8: The Phillips-NAIRU (traditionally estimated).

$$NAIRU_{Phillips,\ traditionnal} = 10.6 - 487.\Delta\pi$$

Using the Hodrick-Prescott filter then gives the explicit values of the NAIRU over the period.

Figure 1: The Different NAIRUs.

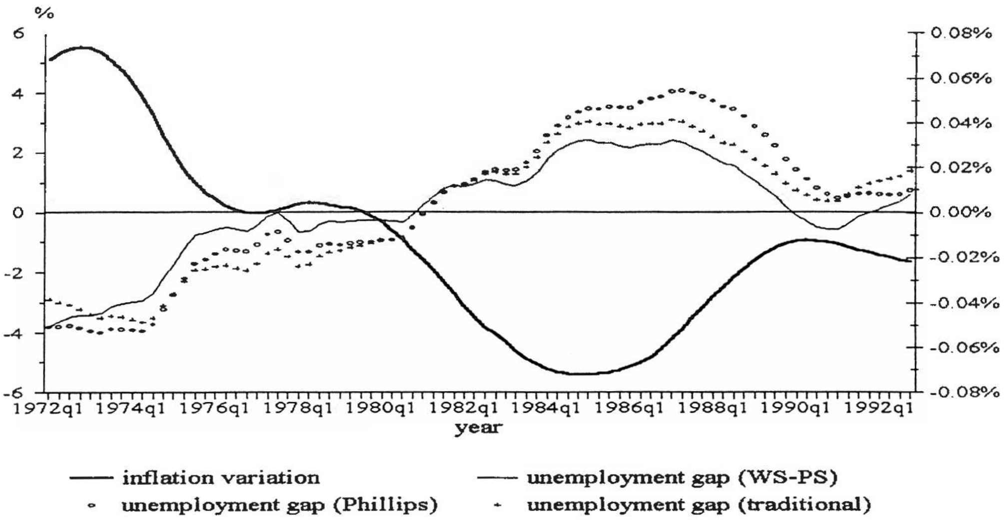


III - Consequences for the NAIRU

It is worth noting that the two NAIRU estimates do not present huge differences and that they are both qualitatively consistent with the evolution of inflation over the period (Figure 2). More precisely, the NAIRUs derived from the Phillips model are generally flatter than the WS-PS NAIRU, except at the end of the period for NAIRU (Phillips), because of an important change in the productivity growth in the nineties[19].

Until 1975 approximately, the unemployment gap (calculated as the difference between the current unemployment rate and the NAIRU) is negative while the inflation of value-added prices keeps on increasing. Between 1975 and 1981, both this gap and the variations of inflation are close to zero, except for the the traditional NAIRU estimate which presents a paradoxically negative unemployment gap: this means that the NAIRU increases at the same pace as the unemployment rate during this particular period, with consequently a stability of inflation. In the eighties, the so-called 'politique de rigueur' aimed at reducing inflation is accompanied by a positive unemployment gap. After 1990, this gap is nearly null for our WS-PS NAIRU, while inflation is stabilized, whereas it is negative for the Phillips NAIRU, whose evolution therefore seems quite paradoxical on these last years.

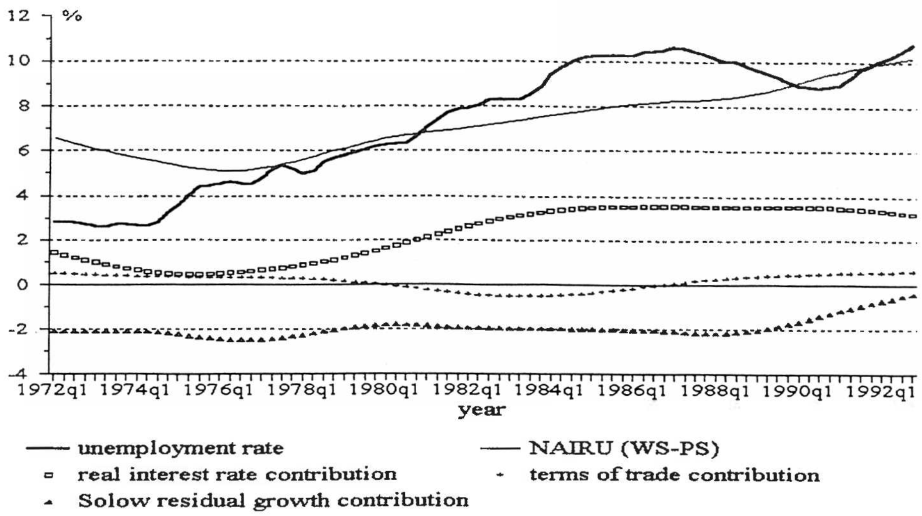
Figure 2: Unemployment Gap and Inflation Variation.



The analysis of the contributions of each of its determinants to the variations of the WS-PS NAIRU gives an idea of the respective roles of the variables under consideration in the evolution of the NAIRU (see figure 3). It appears that the variations of real interest rates have had a strong impact on the movements of the WS-PS NAIRU estimates during the seventies and until the mid-eighties. After 1988, the lower growth of the Solow residual may be responsible for most of the NAIRU' s increase. One may also notice that the movements in price competitiveness are not responsible for major shifts in the NAIRU, which is consistent with the test on its coefficient mentioned above (T4).

[19] This change is however very correlated with change in output growth which cast doubt on the exogeneïty of our corrected Solow residual: corrections we made with capital intensity might not be sufficient. Nevertheless, we used this measure as it is usually done.

Figure 3: Contributions to the WS-PS-NAIRU.



Concluding remarks

This paper provides a detailed discussion of the theoretical and empirical issues raised by the derivation of NAIRU estimates. It more particularly examines the impact of the theoretical specification retained for the wage price spiral and proposes NAIRU estimates associated with each of the two main models. This debate is a rather important one for macro-modeling on an operational basis. Indeed, most of the models used in France for forecasting purposes are of a keynesian nature: the wage-price spiral is based on an augmented Phillips-curve. However, some recent papers suggest that the wage-price spiral could include a WS curve rather than a Phillips curve. But the consequences are very different as far as the NAIRU is concerned.

• So, the first purpose of the paper was indeed to reassess the debate on the theoretical consequences on the NAIRU of various specifications of the wage-price spiral. With a WS-curve (derived for instance from a wage-bargaining model), the NAIRU can be a function of total factor productivity, real capital costs and real unemployment benefits (as well as of many other determinants if the model is more elaborated). On the contrary, with a Phillips-curve, the NAIRU is simply and exclusively a function of the growth of total factor productivity (or alternatively the growth of labor productivity).

• The second purpose of the paper was to provide some elements for the choice between these two approaches. Since the theory does not fully answer the question, econometric analysis was used to go further in the discussion. First of ail, the unemployment rate and the real wage appear to be 1(1) in France over the last twenty years. This suggests that a cointegrating relation should be searched between these two series, giving credit to the WS approach. But, it is also argued that the unemployment rate, as a necessarily bounded variable, should not be I(1) but 1(0), so that the Phillips approach would be natural (linking two 1(0) series: the growth of the real wage and the unemployment rate).

In spite of the fact that this analysis seems to make the WS approach more convincing, both models of the wage-price spiral were estimated. The econometric methods used have endeavoured to take into account the simultaneity of price setting and wage setting. To do so, Johansen's procedure was used to estimate the number and the coefficients of cointegrating relations among the following set of variables: the logarithme of real wages, of total factor productivity and of employers tax rate plus one, an expected real interest rate, the unemployment rate and the logarithm of ternis of trade. Two cointegrating vectors were found and constraints could be imposed to ensure that:

- the employers tax is considered as revenues by workers and therefore has no impact on the NAIRU;

- the level of productivity does not appear in the NAIRU because it intervenes with the same coefficient on wages and prises;

- the level of terms of trade has no significant influence on the NAIRU.

- the NAIRU does not have a deterministic trend because such a trend is rejected accordingly with the theory in the cointegrating vectors (at a 2,8% level).

In order to derive a dynamic form of the wage-price spiral, the long mn equations are first identified and then used in error correction models. Two cointegrating vectors are found, which is another argument in favor of the WS PS mode!. The price equation is identified by the exclusion of the unemployment rate, the wage equation is the vector where the effect of terms of trade on the real wage is one (which means that wages are a fonction of consumer prices rather than value added prices): this is the basis for the long mn of the WS-spiral. To validate the Phillips curve model, one has to consider that there is only one cointegrating vector, for instance because the second cointegrating vector is accepted at a low level of significance. This cointegrating vector can then be considered as the PS equation.

In both approaches, it is worth noting that the long mn prices and wages equation, and consequently the NAIRU, are found to depend on an expected real interest rate (as a simple proxy for the real capital cost) which is a rather new and interesting result on French data.

As regard the WS case, the dynamic homogeneity between the real wage and the total factor productivity is not verified so that the corresponding NAIRU depends on the growth of total factor productivity (just as Phillips-NAIRU).

' Both models lead to the derivation of NAIRU estimates. As is usual in such calculations, the results may be very sensitive to the estimated coefficients. Instead of providing a sensitivity analysis of the coefficients estimates, which could be achieved by mean of Monte-Carlo simulations, the study focuses on the uncertainty in the choice for the wage curve (WS or Phillips). The Phillips-NAIRU then appears to be very flat except for the period of **the nineties when total factor productivity slows down. This strong evolution of total** factor productivity at the end of the period might be over-estimated for a number of reasons: imperfect correction of the cyclical component of productivity, bias induced by the HP filter at the end of the period, sectorial coverage considered here (excluding the agricultural and financial sectors) or other reasons. Consequently, the increase in the NAIRU over this period might be excessive. The WS-PS-NAIRU increases in the eighties in parallel with the real interest rate and is also sensitive to the slowdown of total factor productivity in the nineties but to a lesser extend.

' Finally, the determinants of the NAIRU that were examined here are far from exhaustive. But, this paper showed that they provide results which are consistent with theoretical predictions, if one excepts terms of trade. This work could naturally be completed by adding variables for 'wage pressure'. Nevertheless, this implies collecting (or computing) relevant data, and might pose problems in the Johansen's procedure. It has therefore been left for further research.

This research could also benefit from new identification methods as those implemented by Johansen (1995). An example of such an implementation is already used for some European countries by Heck-Mahy (1996). This could be a way of enriching the cointegrating system, while keeping a relevant economic explanation.

Table A: Schmidt-Phillips Tests for Stationarity

	τ / ρ	Δ τ / ρ	Δ^2 τ / ρ	integration order (+ possibly a trend)
w	-0.41 / -0.34	-2.3 / -10.3	-7.7 / -70.1	I(2)
p	-0.51 / -0.52	-6.2 / -53.3		I(1)
z	-3.5 / -22.5			I(0)
ln(1+t)	-2.3 / -10.5	-10.2 / -93.4		I(1)
u	-0.79 / -1.3	-3.2 / -18.0		I(1)
d	-0.69 / -0.95	-3.9 / -26.3		I(1)
pc	-0.37 / -0.43	-3.2 / -18.1		I(1)
smic	-0.63 / -0.81	-7.9 / -71.7		I(1)
i	-1.1 / -2.5	-5.8 / -48.7		I(1)
ln(1-tns)	-0.57 / -0 .65	-2.7 / -13.5	-7.7 / -70.3	I(2)
w-p	-0.69 / -0.95	-7.0 / -62.2		I(1)
pc-p	-1.9 / -7.0	-7.5 / -67.4		I(1)
$i-\Delta pc^a$	-2.2 / -9.5	-8.8 / -81.4		I(1)

H0: I(1) with possibly a deterministic trend against I(0) with possibly a deterministic trend.
τ: critical value at 5% = -3,06
ρ: critical value at 5% = -17,5

Table B: Kwiatkowski-Phillips-Schmidt-Shin Tests for Stationarity

	$\eta_\mu(0)/\eta_\mu(4)$ $\eta_\tau(0)/\eta_\tau(4)$	Δ $\eta_\mu(0)/\eta_\mu(4)$	integration order
w	2.04 / 0.44 8.10 / 1.72	0.45 / 0.13	I(1) (+ trend)
p	1.99 / 0.43 8.24 / 1.74	0.34 / 0.24	I(1) (+ trend)
z	0.20 / 0.07 8.31 / 1.76	0.02 / 0.04	I(1) (+ trend)
ln(1+t)	0.95 / 0.24 7.86 / 1.67	0.04 / 0.05	I(1) (+ trend)
u	1.53 / 0.32 7.73 / 1.62	0.31 / 0.11	I(1) (+ trend)
d	1.77 / 0.39 7.58 / 1.61	0.12 / 0.05	I(1) (+ trend)
pc	1.99 / 0.43 8.17 / 1.72	0.68 / 0.21	I(1) (+ trend)
smic	1.97 / 0.43 8.08 / 1.72	0.09 / 0.09	I(1) (+ trend)
i	1.48 / 0.33 1.51 / 0.33	0.11 / 0.06	I(1) (+ trend)
ln(1-tns)	0.97 / 0.22 6.07 / 1.37	0.88 / 0.23	I(1) (+ trend) or I(2)
w-p	1.90 / 0.42 7.33 / 1.58	0.16 / 0.13	I(1) (+ trend)
pc-p	1.28 / 0.30 1.28 / 0.30	0.05 / 0.07	I(1) (+ trend)
$i - \Delta pc^a$	0.55 / 0.16 6.35 / 1.42	0.06 / 0.08	I(1) (+ trend)

$H_0(\mu)$: I(0) with no deterministic trend against I(1) with no deterministic trend: critical value for η_μ at 5% = 0,463.
$H_0(\tau)$: I(0) with a deterministic trend against I(1) with a deterministic trend: critical value for η_τ at 5% = 0,146.
$\eta_\mu(4)$ $\eta_\tau(4)$ means that a correction for dependency and for heteroskedasticity was calculated using Newey-West procedure with 4 lags.

Table C: WS-PS with Dynamics

Method:	OLS	OLS
Equation	WS	PS
Dependent Variable	Δ(w-p)	Δ(w-p)
Long-Run Target:		
WS_{-1}	-0.015	-
(see Table 3)	(-6.68)	
	r_w	
PS_{-1}	-	-0.020
(see Table 3)		(-3.17)
		r_p
Constant	-0.0031	-0.012
	(-4.17)	(-3.03)
	c_w	c_p
Dynamic from Target Terms:		
$\Delta(w-p)_{-1}$	0.58	0.77
	(9.30)	(9.74)
	w_w	w_p
Δz	0.060	0.088
	(1.90)	(2.49)
	z_w	z_p
Δu	-0.0057	-
	(-4.42)	
Δu_{-2}	0.0057	-
	(c)	
$\Delta(pc-p)$	-1	0.25
	(c)	(4.53)
$\Delta(pc-p)_{-1}$	-0.58	-
	(c)	
$\Delta(i-\Delta pc^{a})$	-	-0.064
		(-1.84)
Complementary Elements of the Dynamic Process:		
$\Delta^2 pc$	-0.75	-
	(-14.64)	
Δd	-0.87	-0.83
	(-4.77)	(-3.89)
Δd_{-1}	1.09	1.02
	(5.66)	(4.02)
$\Delta^2 p$	-	-0.68
		(-10.58)
Statistics:		
R^2	0.87	0.90
DW	1.92	1.98
SER (%)	0.23	0.26
normality	$\chi^2(2)$=1.06	$\chi^2(2)$=6.08
independence(4 lags)	$\chi^2(4)$=2.65	$\chi^2(4)$=3.38
heteroskedasdicity	$\chi^2(35)$=41,6	$\chi^2(44)$=58.39
heteroskedasdicity (ARCH, 4 lags)	$\chi^2(4)$=3.59	$\chi^2(4)$=2.75

(c): constraint

Table D_1: First Cointegrating Vector.

$$w - p + \ln(1 + t) - 1.66.z - 0.018.u + 6.7.(i - \Delta pc^a) - 2.8.(pc - p) \qquad \{PS'\}$$

Table D_2: Phillips-curve system estimations

Method:	OLS	OLS
Equation	Phillips	PS
Dependent Variable	Δ(w)	Δ(w-p)
PS'_{-1}(see above)	-	-0.064
		(-1.99)
Constant	0.0073	-0.0029
	(6.94)	(-1.61)
$\Delta(w - p)_{-1}$	-	0.76
		(12.03)
Δw_{-1}	0.57	-
	(11.37)	
Δp	1-0.57	-
	(c)	
Δz		0.074
		(2.10)
u	-0.00067	-
	(-5.96)	
Δu	-0.0076	-
	(-3.85)	
$\Delta^2 u$		-0.0063
		(-2.89)
Δ(pc-p)	0.28	0.25
	(6.13)	(4.92)
$\Delta(i-\Delta pc^a)$	-	-
$\Delta^2 d$	-0.74	-0.88
	(-3.85)	(-4.21)
$\Delta^2 d_{-3}$	-0.39	-
	(-2.21)	
$\Delta^2 p$	-	-0.65
		(-12.44)
Statistics:		
R^2	0.91	0.90
DW	2.00	2.05
SER (%)	0.24	0.26
normality	$\chi^2(2)$=2.62	$\chi^2(2)$=5.68
independence(4 lags)	$\chi^2(4)$=0.82	$\chi^2(4)$=3.79
heteroskedasdicity	$\chi^2(20)$=33.72	$\chi^2(35)$=53.36
heteroskedasdicity (ARCH, 4 lags)	$\chi^2(4)$=5.89	$\chi^2(4)$=3.59

(c): constraint

Table E: Traditional Phillips curve estimation.

Method: Equation Dependent Variable	OLS Phillips Δw	OLS Phillips Δw
constant	0.011	0.0074
	(5.20)	(5.87)
u	-0.0040	-0.0041
	(-4.17)	(-4.22)
u_{-2}	0.0097	0.0093
	(4.05)	(3.83)
u_{-3}	-0.0067	-0.0059
	(-3.79)	(-3.37)
Δw_{-1}	0.49	0.60
	(6.47)	(10.06)
Δp	0.43	0.40
	(6.42)	(c)
$\Delta\pi$	0.058	0.059
	(1.92)	(1.94)
Complementary Elements		
$\Delta\ln(1+t)$	-0.15	-0.17
	(-2.17)	(-2.42)
$\Delta^2 pc$	-0.17	-0.18
	(-2.97)	(-3.15)
$\Delta(pc-p)$	0.38	0.40
	(6.24)	(c)
Δd	-0.78	-0.71
	(-3.61)	(-3.54)
Δd_{-1}	0.65	0.75
	(2.17)	(2.50)
Δd_{-2}	0.53	0.69
	(1.67)	(2.21)
Δd_{-3}	-0.94	-1.14
	(-3.16)	(-3.96)
Δd_{-4}	0.55	0.62
	(2.69)	(3.14)
Statistics:		
R^2	0.98	0.89
DW	1.83	1.91
SER (%)	0.21	0.22
normality		$\chi^2(2)=1.50$
independence(4 lags)		$\chi^2(4)=1.14$
heteroskedasdicity (ARCH, 4 lags)		$\chi^2(4)=1.99$

The constraints are not rejected: $F=2.43 < F_{0.95}(2,69)=3.13$

(c): constraint

Appendix: complements on the construction of the data base for the estimations.

The data cover the business sector excluding the financial and agricultural sectors (INSEE: ENFNA). This area was chosen in order to be as close as possible to the production concept which is used to calculate the hourly wages in quarterly accounts.

From the quarterly accounts (base year: 1980) build in July 1995, we defined the following series:
VA=T_PN1_V008-T_PN1_U018-T_PN1_U1B8
VAV=T_PN1_V007-T_PN1_U017-T_PN1_U1B7
PVA=VAV/VA
MS=T_R11_V007-T_R11_U017-T_R11_U1B7
L=T_EFM_V001-T_EFM_U011-T_EFM_U1B1
D=(T_DUM_V001*T_EFM_V001-T_DUM_U011*T_EFM_U011-T_DUM_U1B1*T_EFM_U1B1)/L
W=MS/L
WH=W/D
PRODWH=VA/(L*D)
TCSET=T_R12_TE7/T_R11_TE7
PC=T_P31_V0T6

Then we have:
w = ln(WH)
p = ln(PVA)
π = ln(PRODWH)
d = ln(D)
pc = ln(PC/100)

u = The unemployment rate is the quarterly series calculated from the monthly INSEE-BDM n°045937075 series.

t = The employers contributions tax rate for social security scheme is the quarterly series calculated from the annual accounts in the correct sector and using TCSET as a quarterly indicator.

tns = The non wage-earners is the quarterly series calculated from the INSEE annual series corresponding to the business sector except for agriculture.

i = The nominal interest rate corresponds to the long-run return rate of State obligations (series n° 046168461 from INSEE-BDM).

z = The total factor productivity is an 1980 index calculated from its growth rate, using the wage share in value added as an estimate for the elasticity of labor, the growth rate of worked hours and the growth rate of capital:

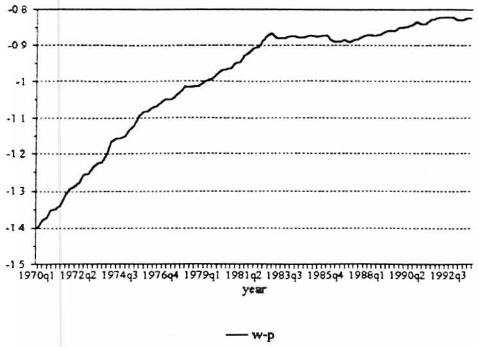
$$\Delta z' = \Delta \ln(VA) - \alpha_{-1}.\Delta \ln(L * D / (1 - tns)) - (1 - \alpha_{-1}).\Delta \ln(K_{-1})$$

where $\alpha = \dfrac{MS.(1+t)}{(1-tns).VAV}$

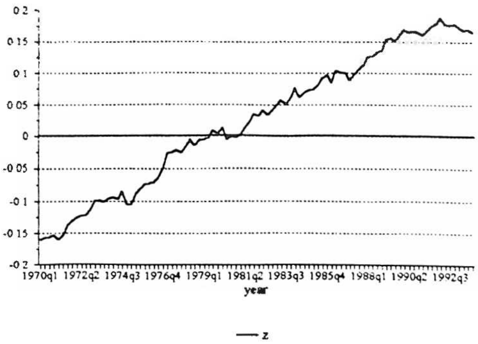
A correction is made to take into account the cyclical intensity of capital utilization, by regressing $\Delta z'$ on a constant and on the growth rate of the capital utilization rate (without hiring): then Δz is the sum of the mean of $\Delta z'$ and of the residuals from the previous regression.

K = The capital is the quarterly series calculated from the INSEE annual series corresponding to the business sector except for agriculture.

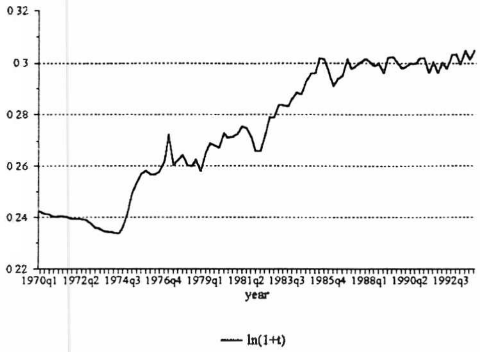
(w - p)



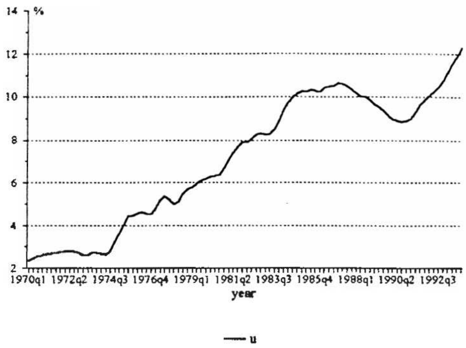
(z)



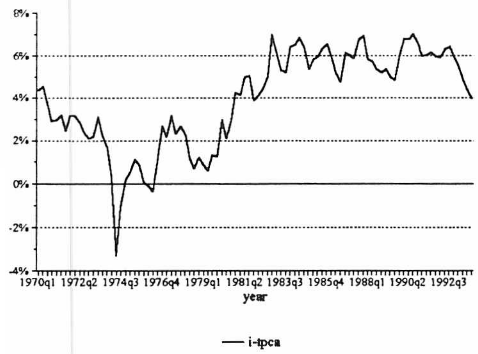
ln(1 + t)



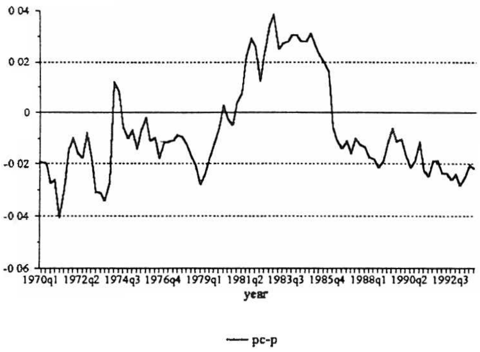
(u)



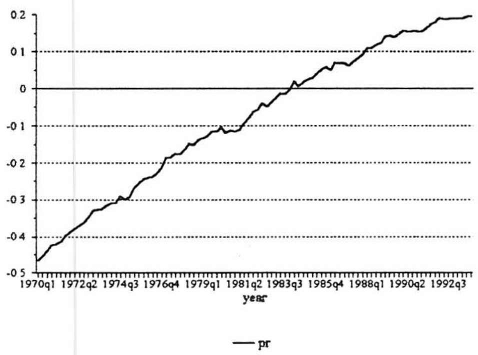
(i - Δpc[a])



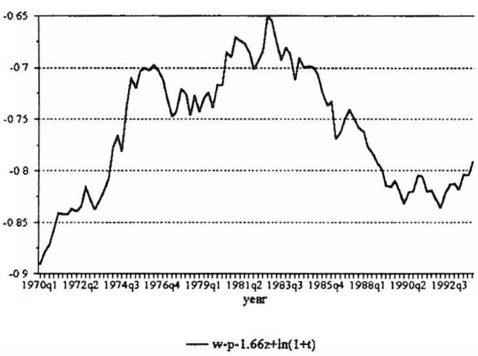
(pc - p)



(π)



(w - p - 1.66.z + ln(1 + t))



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